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Los Angeles

Communicating the Benefits of a Full Sequence of High School Science Courses

A dissertation submitted in partial satisfaction of the

Requirements for the degree of Doctorate in Education

by

Catherine Marie Nicholas

2014

ABSTACT OF THE DISSERTATION

Communicating the Benefits of a Full Sequence of High School Science Courses

by

Catherine Marie Nicholas

Doctor of Education

University of California, Los Angeles, 2014

Professor Mark Kevin Eagan, Co-Chair

Professor Eugene Tucker, Co-Chair

High school students are generally uninformed about the benefits of enrolling in a full sequence of science courses, therefore only about a third of our nation's high school graduates have completed the science sequence of Biology, Chemistry and Physics. The lack of students completing a full sequence of science courses contributes to the deficit in the STEM degree production rate needed to fill the demand of the current job market and remain competitive as a nation. The purpose of the study was to make a difference in the number of students who have access to information about the benefits of completing a full sequence of science courses.

This dissertation study employed qualitative research methodology to gain a broad perspective of staff through a questionnaire and document review and then a deeper understanding through semi-structured interview protocol. The data revealed that a universal sequence of science

courses in the high school district did not exist. It also showed that not all students had access to all science courses; students were sorted and tracked according to prerequisites that did not necessarily match the skill set needed for the courses. In addition, the study showed a desire for more support and direction from the district office. It was also apparent that there was a disconnect that existed between who staff members believed should enroll in a full sequence of science courses and who actually enrolled. Finally, communication about science was shown to occur mainly through counseling and peers.

A common science sequence, detracking of science courses, increased communication about the postsecondary and academic benefits of a science education, increased district direction and realistic mathematics alignment were all discussed as solutions to the problem.

This dissertation of Catherine Marie Nicholas is approved.

Linda J. Sax

James Stigler

Mark Kevin Eagan, Committee Co-Chair

Eugene Tucker, Committee Co-Chair

University of California, Los Angeles, 2014

DEDICATION PAGE

My four children, Catherine, Frankie, Michelangelo and Joe, have taught me more about science education, and education in general, than any book, article or program and for that I dedicate this work to them. I am so proud of who they are, the effort they put forth and their academic achievements. I know that they will each make an incredible contribution to our society through a STEM field, children, or both. They represent what all students can accomplish with the right support.

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ACKNOWLEDGEMENTS

Pursuing a doctorate degree has been a goal of mine for a very long time. These past three years have been the most challenging stretch of my life - my mom's struggle with her health began just as I started the ELP program. I went from her helping me raise my family to me helping care for her every spare moment I had. She became sicker over the three years, spending a lot of time in the hospital. She lost the fight in November. My mom was supportive throughout my career and educational endeavors and it was because of her support that I was able to dedicate my life to education and continue my schooling while raising four children. I wish she were here to celebrate this final, terminal degree. I got my strong desire to make a difference in the lives of others and my love for children from my mom and my grit and strong work ethic from my dad. I thank them both for my lifetime filled with support and opportunities.

Between classes, writing, and hospital visits my family has scarified a lot during this process. I started the program the same time my youngest son Joe started high school. He had to grow up very fast and had to take care of himself quite a bit. Another challenge was having my son Michelangelo out of the country this past year while he was finishing his college education and traveling Europe. I look forward to celebrating his graduation along with my own. One of the most exciting things about starting the ELP program was being a Bruin on the same campus as my first son Frankie. I know I enjoyed sharing the campus a lot more than he did; Frankie was a lifesaver on those late, frustrating nights when I needed help navigating the road closures in West L.A. Having him at UCLA made my first year extra special. My daughter Catherine is already making a difference in science education. Someone recently equated her passion for science education like mine on steroids - I couldn't be more proud. My husband George showed his support the way Greeks do - through food. He has also been instrumental in supporting my

dad (and feeding him) during this difficult time. I know he looks forward to me having free time again.

I had the pleasure to be supported and inspired by the strength and intellect of the amazing educators Deborah, Jeanne, Chao and Kenny. I treasured our time together as our friendships grew and developed. I look forward to seeing what great things they will continue to do for students. I enjoyed being mom #2 to Julie, friends with my Asian twin Lindsey, and my before class sessions with Andrew and Liz.

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I had the great privilege and honor of working with my other committee members Dr. Sax and Dr. Stigler. I am so inspired by the work of these incredible individuals as educators and researchers who continue to make a difference in learning opportunities for students.

I am grateful to the research district and the talented, hardworking administrators, counselors and science educators who serve students and gave their time to share their perspectives with me and contribute to my study. Spending time on high school campuses renewed my faith in our secondary education system and strengthened my passion and desire to help ensure more students have the opportunity to experience a full science education.

VITA

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CHAPTER ONE
PROBLEM STATEMENT

Introduction

Remaining cutting edge in the fields of science and technology is critical for our nation to compete in today's global economy. By 2014, researchers predict 15 out of the 20 fastest growing occupations will require significant mathematics and scientific knowledge for job success (Robinson & Ochs, 2008b). However, our current postsecondary system is not producing enough graduates in science, technology, engineering and mathematics (STEM) fields in order to meet current and future global needs. Although part of the deficit in STEM degree production is due to attrition in STEM majors in college (Sadler, Sonnert, Hazari, & Tai, 2012), substantial talent is lost among high school students who do not take advanced science courses that would prepare them for STEM majors in college. High school students are generally uninformed about the benefits of enrolling in a full sequence of high school science courses; as a result, many high school graduates do not complete the entire science sequence of Biology, Chemistry, and Physics. This study examines the role that high school science teachers, counselors, and administrators play in communicating to high school students the future educational and career advantages of taking a full science sequence of courses.

The percentage of students pursuing a STEM major in college has remained relatively stable over the past several decades (Hurtado, Chang, Eagan, & Gasiewski, 2010). Most college students who start out as a STEM major do not gradate with a STEM degree. In 2001 the Center for Data Exchange and Analysis followed students who entered college as a STEM major in the 1993-1994 school year and found that only 38% of the students graduated within six year with a bachelor's degree in a STEM-related field, and this figure has not changed in the last decade (Hurtado et al., 2010). Students who are ill-prepared for the rigors of a postsecondary STEM

major either drop out of college or change their college major and complete college with a non-STEM degree. The more students who take the necessary course work in high school, the more students will be prepared for rigorous STEM college programs (Aud et al., 2012).

Background Information on the Problem

Effective STEM education will determine whether the United States will remain a world leader and continue to be able to face future challenges in the area of energy, health, environmental issues and national security (Venkataraman, Olson, & Riordan, 2010). The pre-college years are a critical time for encouraging and educating students about the benefits of entering the science pipeline (Muller, Stage, & Kinzie, 2001). High school is an important time for students to develop a disciplinary focus, and it is the time when their STEM career intentions begin to evolve or dwindle (Sadler et al., 2012). In order to major in a STEM field in college, students are required to take a rigorous science and math sequence in high school, a sequence most commonly consisting of Biology, Chemistry, Physics, and calculus courses. Biology is the class that almost all students complete; however, not all students have access to Chemistry and Physics (Watanabe, Nunes, Mebane, Scalise, & Claesgens, 2007). Chemistry and Physics classes are often reserved for the "elite" students who are highly motivated, have exceptional mathematics skills, and have completed the necessary prerequisite courses (Watanabe et al., 2007). Chemistry, Physics, and strong mathematical skills are necessary for students who wish to pursue a postsecondary science education and career. Without these two classes, students are highly unlikely to major in a STEM field. Therefore, completing Chemistry in high school is an essential prerequisite for college entrance into STEM majors (Watanabe et al., 2007). Furthermore, both Physics and Chemistry are gateway courses for a postsecondary education in science and are essential for the development of students' scientific literacy skills. Taking both

Physics and calculus in high school are generally key indicators for students pursuing a STEM career (Kelly & Sheppard, 2009). In fact, for girls, eighth grade math scores are an indicator of a future STEM major, and for boys, completing high school Physics is a strong indicator (Trusty, 2002).

Schools across the nation have increased access and completion rate of science classes for students by detracking and altering the traditional order of the science sequence taught. Detracking is an educational movement to eliminate tracking practices at a school site. Detracked classes consist of heterogeneously grouped students and are available to all students. Schools that have successfully detracked their classrooms have brought equitable access to a rigorous curriculum and dramatically reduced the achievement gap between subgroups (Oaks, 2008). In the traditional tracked model, which most schools follow, high-tracked students engage in hands-on learning and are required to demonstrate higher-order thinking skills that are not expected in most low-tracked classrooms (Heath, 2000).

South Side High School in Rockville, New York eliminated homogeneous classes and their detracked approach to course offerings has afforded their diverse student population impressive academic success with 60% of their senior class enrolled in Advanced Placement (AP) classes (Delia, 2004). Another successful detracking example is exemplified in a study of two public high schools in California where Chemistry is taught in heterogeneous classes instead of classes for the higher-achieving students (Watanabe et al., 2007). The goal of heterogeneous grouping is to increase the quality of instruction for all students and offering heterogeneous grouping requires both cultural and structural changes at a school site (Heath, 2000). According to Spade, Columba and Vanfossen (1997), "Course tracking is the most powerful factor affecting students' achievement that is under a schools' control" (p.125). In addition to detracking, some

programs alter the way in which traditional science courses are taught, placing Physics before other science courses, which increases the access to courses traditionally unavailable to most students and increases the number of students who complete a full science sequence. Physics First is a new movement in the science education community. For example, all freshmen at Boston's Weston High enroll in either honors or college prep Physics (Korsunsky & Huckins, 2011). Placing Physics first ensures that all students complete Physics instead of the traditional way that allows students to delay or even eliminate this course from their studies, resulting in a national average of less than a third of the student population completing a Physics course in high school.

Another successful strategy for students to complete more science courses has been to increase the overall number of courses required for graduation. By raising the bar for course taking requirements in many states, science course completion has increased more than any other subject with most growth in Physical Science, Earth science, and Chemistry I (Clune & White, 1992). Although the change in policy has been a disappointment in achievement gains, course completion rates have increased. The above strategies were found in the literature as ways to increase enrollment in a full sequence of science courses for high school students. The schools included in this study currently do not have Physics first nor do they have a general detracking philosophy.

Enrolling students in a full sequence of science courses is only part of the challenge; inspiring students to pursue STEM majors and encouraging them to consider a STEM future is the true challenge for educators. In a recent study of 33 high school students, 45% of the students that had planned to pursue a science, engineering or mathematics (SEM) major or career in the 10th grade changed their minds by the end of high school (Aschbacher, Li, & Roth, 2009). It is

well documented that students' interests in pursuing STEM majors or careers decline over time (Aschbacher et al., 2009; George, 2000). During the transition from middle school to high school, students' attitudes about science decline (George, 2000). Students' self concepts were found to be the strongest predictor of their attitudes towards science however, teacher encouragement and peer attitudes also had a significant impact on a student's attitude towards science (George, 2000). Some students lose interest and leave the science pipeline because they are not scheduled into rigorous science courses. For example, students in Aschebacher's study who left the pipeline were told "science is not for everyone" by their guidance counselor and were scheduled into Meteorology instead of Chemistry (Aschbacher et al., 2009). Gatekeeping practices are prevalent in most American schools, and the tracks on which students are placed are often predetermined prior to the students' entrance to high school. Most students are sorted into different levels based on judgments about students' academic levels (Oaks, 2008). Advanced science classes, like Physics, are often open to a few students, often higher-performing individuals, who have completed prerequisite courses (Angela Kelly & Sheppard, 2008).

Success in school is correlated to both cognitive and noncognitive skills such as persistence, self-control, curiosity, conscientiousness, grit, and self-confidence (Tough, 2012). In fact, according to the research done by Tough (2012), the noncognitive skills are more crucial than intellect as far as success in rigorous high school courses and in determining college success and persistence. Students who take more challenging and rigorous science courses do better in school overall; in fact, seniors who completed Chemistry, for example, scored 27 points higher on the National Assessment of Educational Progress (NAEP)[1] than those who completed a less rigorous course, such as Earth Science (Nord et al., 2011a). High school Physics is a gateway

[1] NAEP or the National Assessment of Educational Progress is an assessment of student progress given conducted in the U.S. by the National Center for Educational Statistics.

course for students who choose a postsecondary path in science and is a course that is considered a vital component in the formation of scientific literacy (Kelly & Sheppard, 2009). Thus, students who take high school Physics are academically more successful in college Physics compared with students who did not take high school Physics. Where students lack the basic information about the benefits of taking advanced science courses, counselors and teachers have an opportunity to direct these students into such advanced courses.

Counselors are positioned to play a vital role in high school course-taking decisions and are the most important people to improve college enrollment (McDonough, 2005). Students who take advanced, rigorous courses in high school have higher academic achievement (Leow, Marcus, Zanutto, & Boruch, 2004). Socioeconomically advantaged students oftentimes have the support and guidance of family members who influence them to pursue STEM fields. Students who do not have that support must rely on counselors to encourage them to enroll in AP science and math courses (Robinson, 2003). Underrepresented students who receive counseling interventions benefit in similar ways as the students who have parental support (McDonough, 2005). Parental encouragement has a direct effect on efficacy, career interests, and expectations in math and science (Turner, Steward, & Lapan, 2004).

Numerous studies have identified a gender gap in the sciences, particularly in the physical sciences. Although males and females earn similar grades in the sciences, females have less positive attitudes towards science, engage in fewer science-related activities, and enroll in fewer science courses than their male counterparts (Gilmartin, Denson, Li, Bryant, & Aschbacher, 2007). Other studies have examined the low enrollment of minorities in high school Physics classes (White & Langer-Tesfaye, 2011a). However, limited research has investigated how counselors, educators, and secondary education administrators encourage and support

capable[2] students to take a full science sequence (Biology, Chemistry, and Physics) in high school.

Problem Statement and Research Questions

Our nation's economic future depends on our ability to educate more of our current students in STEM disciplines (Venkataraman et al., 2010). Our nation lags behind other nations in STEM education at the elementary and secondary levels. On the NAEP, less than one-third of our nation's eighth graders were proficient in mathematics and science. The STEM issue in our nation is two fold; American students lack both science proficiency and interest in STEM fields (Venkataraman et al., 2010). Many more capable students would benefit from taking a full science sequence in high school if they were given information on the advantages of doing so.

Taking more science courses in high school not only satisfies college entrance requirements and increases a students' scientific literacy but such course completions also increase the odds of students accessing a postsecondary STEM major or jobs after high school. Many students avoid taking STEM related classes because they think of them as too difficult, boring, and uninviting (Venkataraman et al., 2010). Furthermore, students who pursue the sciences oftentimes acquire their inspiration and motivation more from family members rather than from school personnel (Gilmartin, Li, Aschbacher, & McPhee, 2005). Counselors, however, play a vital role in helping to create a college-going culture at a high school and oftentimes are solely responsible to schedule students into courses. No school personnel are more important in improving college enrollment than high school counselors (McDonough, 2005). In addition to school counselors, science teachers can be instrumental in providing information and guidance to

[2] A capable student is a philosophical belief that all students, placed in mainstream science courses, can learn at high levels and teachers have the power and ability to ensure that happens.

students regarding the recommended sequence of sciences classes and information about future career opportunities in STEM fields.

This study examined the role that high school science teachers, counselors, and administrators played in communicating to students the benefits of taking a full science sequence, consisting of Biology, Chemistry, and Physics in high school.

The following research questions guided this study:

1. What are the perceptions of high school science teachers and counselors regarding the factors that contribute to students taking a complete, rigorous science sequence?
    a. What do science teachers/counselors consider to be a full science sequence?
    b. According to teachers/counselors what types of students are most likely to successfully complete a full science sequence?
    c. According to teachers/ counselors how would teaching and advising strategies need to be changed if the full science sequence became more accessible?
2. What do high school science teachers and counselors along with school administrators recommend can be done to encourage more students to enroll and be successful in a full science sequence?
    a. What individual and institutional barriers do teachers/counselors perceive as prevalent in keeping more students from taking a full science sequence?
    b. What do teachers/counselors/administrators recommend in order to change school/district policies or encourage individuals to overcome these obstacles?
    c. What role do science teachers, counselors and school administrators perceive themselves as having in enacting reform to make the full science sequence available to more students?

3. What currently exists to inform students about the processes, benefits and requirements of science course taking in high school?

Research Sites

I did my research at a high-performing secondary, 7-12 school district, where the Academic Performance Index [API][3] is 841 (well above the state average of 757 for a secondary, 7-12 school district). The district is ranked high in academic achievement when compared to all high school districts in California, with at least 20,000 students in seventh through 12th grade. The district consists of 16 schools: six comprehensive middle schools, six comprehensive high schools, one continuation high school, one alternative special education school, one on-line school, and one early college school. It is located in a suburban community located in North Los Angeles County and currently serves approximately 23,000 students. I conducted my research study at three, grade 9-12, comprehensive high school sites in the district. The sites varied demographically, ethnically, socioeconomically, culturally and in their academic achievement. The first site, Canyon Grove High School, is the most diverse school in the research district. The second site, Northbrook High School, has the least amount of diversity and the third site, Southridge High School, represents a diversity balance for the district.

I chose this particular district and these particular high school sites because the problem I researched exists systemically throughout our nation. The district and high schools represent a microcosmic view of the issue; a majority of high school graduates are not completing a full sequence of science courses and are not informed about the benefits of a STEM future. The

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[3] The API, or Academic Performance Index, is a measurement of academic performance and progress if schools in California. It is one of the main components of the Public School Accountability Act. The API ranges from 200 to 1000. API scores are based on California Standards Tests (CSTs) and California High School Exit Exam (CAHSEE) scores.

school sites I chose are diverse and are located in different socioeconomic areas of the community. The high schools in this district are particularly interesting to study because the schools are high performing and most students have the academic ability to take grade-level courses. Although, district-wide, 13% of the students are English Language Learners, the percentage at the school sites is well below the state's average of 32%. According to National Center for Educational Statistics, in 2009, 30% of US students completed the Biology, Chemistry, and Physics sequence, up from 19% in 1990 (Aud et al., 2012). The district is approaching the national average of science course completion rates of about 30%. Currently, students are finishing the complete science sequence at the rate of 26.7% at the research district.

Research Design

My study involved the counselors, science teachers, and administrators at three of the high schools in a suburban district. I conducted a qualitative study that entailed a questionnaire, semi-structured interviews, and artifact examination. I collected preliminary data by way of an online questionnaire to gain an understanding of the perceptions that science teachers, counselors, and administrators had regarding the access students have to the science sequence and how important they believed it was that students enrolled in the high school science courses. I interviewed high school counselors and high school science teachers regarding their knowledge about the benefits of students taking a full sequence of science courses and the barriers that exist that currently prevented students from completing the sequence. In addition, I examined their perceptions of who (what type of students) should take rigorous science courses. I examined school artifacts such as course registration materials and school websites to analyze the communication tools that students used to gain knowledge about their access to science courses and science sequence information. Through triangulation of the data collected by the

questionnaire, the interview protocol, and the documentation review, I examined the extent to which a full science sequence was accessible to all capable students. When gatekeeping occurred, I examined how it manifests itself in the sciences at the high school level. I was supported and sponsored by the Department Chairs at the high schools, the Director of Special Programs, the Director of Curriculum and Assessment, and the Assistant Superintendent.

Significance of the Research for Solving the Problem and Public Engagement

The purpose of this study was to create positive change and make a difference in the number of students who have access to information about the benefits of taking a complete sequence of science courses. Along with science teacher leaders, administrators, and counselors from the research school sites, I, in collaboration with an advisory panel, will develop a plan of action and recommendations to be implemented district-wide. The information will be disseminated to students in a way the team deems most efficient and productive. The ultimate long-range changes resulting from this study will be that each year, more students, if not all capable students, will enroll in, and complete the full science sequence of Biology, Chemistry, and Physics. In addition to information sharing, the study uncovered cultural aspects of the plan unique to individual sites that will need to be addressed. For example, some sites had policies that perpetuate gatekeeping in the sciences, some had intervention needs, or some sites had staffing needs to name a few. More students learning a full sequence of science may increase the number of students pursuing postsecondary STEM opportunities and subsequently graduating with STEM degrees. To meet our needs for a STEM-capable citizenry and STEM proficient workforce we must prepare all students to be proficient in STEM subjects and we must inspire all students to learn STEM, and in the process motivate many of them to pursue careers in the STEM field (Venkataraman et al., 2010).

I will present my findings to appropriate stakeholders (science department chairs, district curriculum and instruction personnel, and principals) via a presentation and report. My goal was to do a study that will have a positive impact on science education for all students in my district and hopefully beyond. I realize that not all students who take a full sequence of science courses in high school will go on to study science in college and go on to become scientists. However, it is my hope that more students will be scientifically literate and will be given this option in the future.

CHAPTER TWO
LITERATURE REVIEW

Introduction

Variation exists across U.S. high schools regarding the information students have as to both the benefits of taking a full sequence of science courses as well as how best to navigate enrolling in these course; as a result, many high school graduates do not complete the entire science sequence of Biology, Chemistry, and Physics. Specifically, this study examined the role that high school science teachers, counselors, and administrators in a school district in southern California play in communicating to high school students their future educational and career advantages of taking a full science sequence of courses. From the results of this research project, recommendations and a plan of action intended to educate students on the benefits of STEM education for their futures, with the ultimate goal of increasing the number of students that take a full sequence of science courses, will be presented and ideally implemented district-wide.

This chapter synthesizes the current research related to the growing need for American students to pursue post-secondary STEM majors and careers. I then review several theoretical and conceptual frameworks that help situate the study, including self-efficacy theory and the concept of social and cultural capital. I also examine the importance of high school as the formative years for students as their career interests develop. Next, I examine the literature regarding the traditional science sequence in our nation and what some schools and districts have done to increase access to science courses for their students. Furthermore, I synthesize the research related to students' interests in science education and their future in STEM fields. I discuss the trend of students' loss of interest in science as they matriculate through school followed by an evaluation of the research related to the correlation between students taking more

rigorous course work and their academic success. I end with a discussion on the important roles that families, counselors and teachers play in science education, underscoring the need for my study.

The Need for STEM in the US

Effective STEM education will determine whether the United States will remain a world leader and continue to be able to face future challenges in the area of energy, health, environmental issues, and national security (Venkataraman et al., 2010). Currently, approximately one-third of the American postsecondary degrees are in the STEM fields, whereas half the degrees in China and two-thirds of the degrees in Japan are STEM related (Venkataraman et al., 2010). In fact, foreign students earned one-third of doctoral level STEM degrees awarded in the U.S. in 2003 (Kuenzi, 2008). Over the past three decades, approximately 17% of college degrees were granted in the STEM fields[4] in the nation. There has been a consistent decline since the 1970's in math and physical science degrees, a decline in engineering degrees and an increase in computer science degrees since the 1980's (Kuenzi, 2008). The U.S. Labor Department predicts there will be a 22% growth in jobs for fields related to STEM (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011) and this increased demand for STEM talent may go unmet given the low rate of STEM degree production (Venkataraman et al., 2010). The problem concerns both STEM enrollment and retention issues. Given that most American students do not take a comprehensive sequence of science courses in high school, they are ill-prepared to enter a postsecondary environment prepared to study STEM.

According to the High School Transcript study (Nord et. al, 2011a), there are three different curricular levels that our nation's high school students have the option to complete. The

[4] STEM fields – education and careers in Chemistry, computer and information technology science, engineering, geosciences, life sciences, mathematical sciences, Physics and astronomy

curricular levels differ according to the number of course credits earned by graduates in specific high school classes. The curricular levels are standard, midlevel, and rigorous (Nord et al., 2011a). High schools, on average, only require students to complete the standard curriculum, which includes two years of science, in order to graduate with a high school diploma (Nord et al., 2011a); these classes typically include Biology and either Earth Science or a physical science. Chemistry and Physics are viewed as classes for the high-achieving students (Watanabe et al., 2007). These classes are often reserved for the highly motivated students who have exceptional mathematics skills and who have completed the necessary prerequisite courses. They are also courses where gatekeeping practices take place; not every high school student has access to advanced science courses and these advanced courses are only offered at the midlevel and rigorous curricular level. Chemistry is a traditional class offered at 95% of high schools across the nation (Smith, 2002); Physics, on the other hand, is a class that not all students have equal access to enrollment (Kelly & Sheppard, 2009). In order for a student to attain a midlevel curriculum, he or she must meet three additional requirements that include additional math, science, and foreign language. To attain a rigorous curriculum, a high school graduate must add three additional requirements on top of the midlevel requirements that include the full science sequence of Biology, Chemistry, and Physics (Nord et al., 2011a).

Our National Report Card describes science as the main gatekeeper to accessing and succeeding in a more advanced curricular level, and science often serves as the determining factor in whether or not a student will meet the college prerequisites (Nord et al., 2011a). In 2009, 35% of high school graduates attained a standard curriculum instead of a midlevel curriculum because of a missing science requirement whereas 19% of graduates were missing the math requirement and 29% were the foreign language requirement (Nord et al., 2011a).

Motivating students to take more science than is required for graduation is necessary for the U.S. to have a scientifically literate citizenries and for our country's economic goals and world competitiveness (Robinson & Ochs, 2008b). Students who enroll in additional science courses typically come from educated families, who are not socioeconomically disadvantaged and have social/cultural capital that underrepresented students oftentimes lack, widening the economic and education gaps even more. Currently, science courses are holding our nation's youth back from graduating with a standard or above curriculum, and are often the road block to a student accessing a postsecondary opportunity (Institute of Education Sciences, National Assessment of Educational Progress, & Educational Testing Service, 2011).

The precollege years are a critical period for encouraging students to enter the science pipeline[5] (Muller et al., 2001). Research on when those who pursued a STEM-related career developed their disciplinary focus suggests that high school is the most critical time for the majority of engineers and future scientists (Sadler et al., 2012). The key to determining if a student is interested in STEM at the end of high school is to see if they were interested in STEM at that the start of high school (Sadler et al., 2012). Unfortunately, the pipeline is "leaky," and students lose interest as they matriculate through the grades. The leakiness of the science pipeline occurs for all students but is more prevalent for females (Sadler et al., 2012) as well as for underrepresented racial minority students (White & Langer-Tesfaye, 2011). In fact, there has been a steady increase of female students and underrepresented racial minority students enrolling in rigorous science courses; in 2009, 25% of Black and Hispanic high school students took Physics, up from 10% in 1990 (White & Langer-Tesfaye, 2011b). High school is a vital time for

[5] Science pipeline – the system of curricular and extracurricular behaviors, beliefs, attitudes, and choices that help to prepare students for postsecondary school or careers in the STEM fields. The "leaky pipeline" is the metaphor used for the students that lose interest in science as they matriculate through the educational system.

students to develop curricular focus and those with STEM intentions begin to evolve during high school (Sadler et al., 2012). Furthermore, enrolling in science courses and higher level math (calculus) is a predictor of persistence in engineering (Sadler et al., 2012).

Theoretical Frames

I examined high school students' science course taking patterns through the two frames: self-efficacy theory and social/cultural capital. The literature emphasizes that students who continue on to take a full sequence of science courses are motivated and have the self-confidence needed to be successful in the courses. Academic proficiency and self-efficacy are the strongest predictors for future science and engineer careers (Mau, 2003). Bandura defines self-efficacy as a person's perceived capabilities for learning or performing tasks (Bandura, 1997). Self-efficacy is grounded in a larger theoretical framework known as social cognitive theory, which assumes that achievement depends on the interaction between one's behavior, personal factors, and environmental conditions (Bandura, 1997). Students with high self-efficacy perform better in school and show a greater interest in learning. Choices a student makes and how much effort they are willing to put forth are influenced by self-efficacy; people with strong self-efficacy look at difficult tasks as challenges to be mastered, not threats to be avoided (Wentzel & Wigfield, 2009). According to Tough, the noncognitive skills such as self-confidence, self control, persistence, and grit indicate success more so than cognitive skills (2012). Self-efficacy influences academic motivation, learning, and achievement. Self-efficacy plays a role in whether or not students enroll in Physics and Chemistry, especially girls who wonder if they are "good enough" to cope with the rigors of the course (Lyons, 2006). Students form self-efficacy beliefs about science from four different areas: mastery experiences in science, observing others

perform science tasks, social persuasion or messages about science, and their personal, psychological state regarding the subject (Britner, 2008).

Students without strong self-efficacy lack the confidence to enroll in rigorous courses. Students with high self-efficacy about science have lower anxiety when it comes to performance assessments in science and see the purpose for studying science, even if the sciences are not included in their future career goals (Glynn, Taasoobshirazi, & Brickman, 2009). In middle school, science self-efficacy predicts science achievement, and, among high school students, science self-efficacy is a better predictor of science achievement than gender, ethnicity, or parental background (Britner, 2008). Once in college, science self-efficacy predicts not only achievement but also persistence in science related majors and careers (Britner, 2008). STEM-related careers are pursued by students who are interested and engaged in science and who have the self-perception that they will be successful in the field (Sadler et al., 2012). There is a positive correlation between self-efficacy and academic performance; results are higher in mathematics than in other academic areas such as reading and writing (Pajares, 1996). Students who have strong self-efficacy are poised to do better socially and academically in a school setting.

Social capital is an intangible resource that either emerges or fails to emerge from the social relations that exist (Plagens, 2011). The term, *social capital*, has been traced back to John Dewey's writings and the idea that schools are fundamentally social environments (Plagens, 2011). Social capital can also be defined as the resources imbedded in the social structure relations that facilitate collective action; resources may include trust, norms and networks of people that gather for a common purpose. According to Acar, social capital is the "glue that holds societies together" (Acar, 2011, p. 456). Social capital contains three components:

resources that are embedded into the structure, the resources that are accessible to the individual and the resources that are used for a purpose (Lin & Erickson, 2008). Cultural capital is the general cultural background, knowledge, disposition, and skills that are passed on from one generation to the next. Students from underrepresented backgrounds, who do not typically have the social capital necessary to navigate the educational system in a way that sets them on a postsecondary pathway, rely more heavily on others as mentors for guidance and information. In order for high school students to meet the social and academic demands, they must have resource-rich relationships, mentors, pro-academic peers and "institutional agents" that exists in all aspects of their lives, both inside and outside of school (Stanton-Salazar, 2010). "Institutional agents," according to Stanton-Salazar, are high-status individuals who possess a high degree of human, cultural and social capital and who are not related to students; institutional agents hold positions in the system that enable them to provide key forms of social capital and institutional support to help students succeed (2010).

Both social and cultural capital affect student achievement and the way they navigate and access information in an academic setting. Cultural capital that affects a student's achievement is the language practices they are exposed to, the objects in physical surroundings (for example being exposed to art work and books), and the institutional capital (Kim & Kim, 2009). Bourdieu argues that the more cultural and social capital a student has, the better they will do in school. Bourdieu also theorized that people who are in the same social fields share the same habitus (Mendoza, Kuntz, & Berger, 2012). Habitus is explained as a system of integrated past experiences, perceptions, and dispositions that gives a person with capital a common shared worldview (Mendoza et al., 2012). People unconsciously classify themselves with others based on common preferences and expectations depending on the amount of capital he or she possesses

(Mendoza et al., 2012). The more social and cultural capital a students has access to, the greater the likelihood that they will reach postsecondary status, especially if this is an expectation of his or her parent (Coleman, 1988). Social capital is linked to higher student and school performance (Plagens, 2011). Social capital's educational benefits include higher graduation rates, lower drop out rates, higher achievement on assessments, higher college enrollment, and greater community and school participation (Acar, 2011). When institutional support and social capital is provided to underrepresented students by institutional agents, they are able to overcome the odds and succeed in school (Stanton-Salazar, 2010).

Equity Issues in American High Schools

Not all students currently have access to a full sequence of science courses. Students with less capital, have less access. According to the American Institute of Physics (AIP) findings, 92% of all seniors, and 99% of seniors nation-wide at schools with more than 500 students, attended high schools that offered Physics courses (S. White & Langer Tesfaye, 2010). On the other hand, the 2000 National Survey of Science and Mathematic Education study concluded 88% of U.S. students have access to Physics. Kelly and Sheppard (2009) conclude that approximately 77% of New York City's students have the option to take Physics; however, 23% of New York City students cannot take Physics because the course is simply not offered at the school they attend. The larger the school size and the larger the percentage of seniors attending that school, the more likely the school would offer a Physics class (S. White & Langer Tesfaye, 2010). Large schools almost always offer Physics.

According to these three key studies, the size of the school is also a determining factor as to whether Advanced Placement (AP) Physics is offered, a class instrumental in preparation for a future a postsecondary STEM major. According to the AIP, 37% of U.S. high school students

who graduated during the 2008-2009 school year had taken at least one Physics course, and 13% of those students, or 4.8% of the total population, were enrolled in AP or second year Physics (S. White & Langer-Tesfaye, 2010). On the other hand, a second year of Chemistry is offered in 50% of high schools, with AP Chemistry offered in 33% of high schools (Smith, 2002). All students do not have access to the same science curricular opportunities, nation-wide and at times, within the same district. There is a discrepancy between the percentage of high schools offering AP Physics and AP Chemistry and the percentage of high school students with access to the courses. This inequity in access for both courses correlates with high school size; the larger the high school, the greater the probability it offers AP Physics and/or AP Chemistry to its student population. The lack of AP science offerings leads to a student population that is less prepared, and less likely, to enter the university system as a STEM major. For the high schools that do offer a full sequence of science courses, the majority of students do not graduate having completed the full science sequence.

Ethnic and Socioeconomic Inequities in Science Access

Discrepancies in science access directly correlate with high school size but also correlate with the percentages of ethnic minorities and socio-economic disadvantaged students at a school site. The inequities in course offerings amongst our nation's schools show alarming ethnic inequities in Chemistry and Physics access and enrollment. Fifteen State Departments of Education reported that 62% of White students completed Chemistry as compared to 46% of Black students and 37% of Hispanic students (Watanabe et al., 2007). The Physics data show similar discrepancies. According to a study by Kelly and Sheppard (2008) on Physics access in New York City schools, campuses that serve mainly White and Asian students are three times more likely to offer Physics than a school that served Black and Hispanic students. Black and

Hispanic students continue to perform far below White and Asian students on precollege science assessments; their final 12th grade achievement level is below the initial 8th grade achievement level of their White and Asian peers (Muller et al., 2001).

Underrepresented students have made some progress in the sciences. According to White and Langer Tesfaye, the number of Black and Hispanic students who are enrolled in a Physics course has risen from 10% in 1990 to 25% in 2009. However, according to *2008-2009 Nationwide Survey of High School Physics Teachers*, the Physics-taking percentage for Asian students is 52% and for White students is 41% (S. White & Langer Tesfaye, 2011); thus, the gap amongst the ethnic groups remains alarming. Although more students across all ethnic groups are enrolling in Physics, the gap has remained relatively constant over time (White & Langer-Tesfaye, 2011b). Even with the increase in Black and Hispanic students taking Physics, the percentages of students accessing the challenging science courses are still far below their White and Asian peers. Ethnically, schools that have higher percentages of White and Asian students, and a lower percentages of Hispanic and Black students offer more rigorous science courses such as Physics. Most of the schools that did not offer the high-level science courses served a high percentage of Black and Hispanic students and a low percentage of White and Asian students (Angela Kelly & Sheppard, 2008).

Science is often the gatekeeping subject that prohibits students from graduating with a curricular level that would afford them the option to pursue a postsecondary education upon completing high school. According to *The Nation's Report Card*, over 40% of White, Black, and Hispanic graduates, and one-third of Asian graduates, complete a below standard or standard curriculum; over half of these students' deficit is due to the fact they are missing only the science requirement necessary to move up to the next curricular level, either to the standard or midlevel

curriculum (Nord et al., 2011b). One additional science course for a student could make the difference between meeting the pre-college eligibility criteria, or not. According to the 2007 Trends in International Math and Science Study (TIMSS) report, the effect sizes of the difference in average science achievement between White, Black, and Hispanic students in the United States, is greater than the difference between the entire United State and students in the top-ranked science nation, Singapore (Gonzales & National Center for Education Statistics., 2009).

Glaring achievement gaps amongst ethnic and socio-economic groups permeate the sciences. White and Langer Tesfaye (2011), after close examination of the research data on *Under-Represented Minorities in High School Physics*, concluded that the differences in Physics-taking percentages had more to do with socioeconomic status than race. The gaps in achievement could be correlated with the fact that students bring different levels of social and cultural capital with them to school. Fewer students take Physics at socio-economically "worse off" schools, as determined by the number of students who are receive free and reduced lunch, and the types of Physics classes taken differ according to socio-economic factors (White & Langer-Tesfaye, 2011a). Approximately 10% of students at socio-economically "worse off" schools take AP Physics and twice as many, 20%, of students at socio-economically "better off" schools take AP Physics (S. White & Langer Tesfaye, 2011). Because Physics is a college prep course, "better off" schools with a college-going culture have more students enrolled in Physics courses. Additionally, the number of advanced courses offered in science and mathematics increases along with the social class of the students at the school (Spade, Columba, & Vanfossen, 1997).

At the three research high schools, the cultures, A-G completion rates, and science course offerings vary. Northbrook High School, the site that has the least amount of diversity and the lowest percentage of socioeconomically disadvantaged students, has the highest A-G completion

rate. Canyon Grove High School, on the other hand, has the most diverse student population and the highest rate of socioeconomically disadvantaged students, and the lowest A-G completion rate. The study investigated how the science course offerings vary and compared to this data.

A National Priority

Closing the achievement gap amongst subgroups in all areas is a goal for our nation's educational system and the driving force behind No Child Left Behind (NCLB). Our government has recognized the link between the educational system and the creation of scientists necessary for our nation to become competitive in fields of science, technology, engineering, and mathematics. Our recent past presidents, as well as President Obama, have all initiated policies to support science education. In 2010, a group of Senators and members of Congress asked the National Academies, Rising Above the Gathering Storm Committee, to respond to the following questions: What are the top 10 actions, in priority order, that the federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century? What strategy, with several concrete steps, could be used to implement each of these actions?

The Gathering the Storm is a report by a Committee that formed and compiled recommendations for the United States to follow in order to continue to compete in the twenty-first century, technologically innovative, global economy. Two out of the four solutions rely heavily on our school systems' abilities to provide our youth with a thorough, high quality, science education. The first and second committee recommendations were related to recruiting science teachers and strengthening the science teachers already in the classroom; the third recommendation, known as the "Best and Brightest," was to encourage more United States citizens to pursue careers in mathematics, science, and engineering. The focus of the third

recommendation was for higher education; however, without the proper foundation and K-12 curricula, we cannot maintain the number of American undergraduates in the sciences (Rising Above the Gathering Storm Committee, National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2010). If students enter college uninterested in science education and/or unprepared for the academic rigor they will be faced with, reforming STEM in higher education will come at a point where we have already lost substantial talent in the sciences. Investing in science education in the elementary and secondary school system by providing counselors and teachers with the knowledge and skills needed to prepare their students for postsecondary STEM opportunities would increase the number of students who would have the self-efficacy and social capital needed to be successful at the next level in the STEM pipeline.

In addition to *Rising Above the Gathering Storm*, in 2009, The President's Council of Advisors on Science and Technology provided an executive report that included the seven key recommendations for K-12 STEM education. The recommendations included supporting the state-led science and math standards, recruiting and training and rewarding STEM teachers, creating STEM-focused schools, creating a research projects agency, creating opportunities for students to have experiences outside of the classroom, and ensuring strong national leadership. (Venkataraman et al., 2010). Our government recognizes the important role education plays in increasing the number of citizens that pursue a career in the STEM fields. In addition, it realizes that the work needs to start taking place in the K-12 system.

The Benefits of Taking a Full Sequence of Science Courses

Students who take a full sequence of science courses benefit academically by being more prepared for the rigors of college and are more likely to pursue a STEM career. Public schools

offer more choices in the curriculum than do private schools that offer a constrained curriculum[6] (Lee, Croninger, & Smith, 1997). According to a study done to determine why students take more science courses than are required, students indicated that altering the way science was taught served as a motivator to enroll in more science courses (Robinson & Ochs, 2008b). In schools where most students follow the same curricular program, achievement is more equally distributed across all subgroups (Lee et al., 1997). In the case of science, private schools offer fewer choices in sciences and more students complete the sequence of Biology, Chemistry, and Physics. When given the choice, students choose to take advanced courses for numerous reasons including their future aspirations, their ability level and what is offered at their school (Leow et al., 2004). Taking advanced courses is consistently associated with higher achievement in school (Leow et al., 2004). In fact, students who take more rigorous mathematics and science courses in high school score higher on the math portion of the SAT (Trusty, 2002). In addition, students that who complete a more rigorous course of study in high school are more likely to graduate from college (Trusty, 2002).

Some students enroll in Chemistry and Physics for the strategic value of enhancing their chances of getting into a university or to help with their future career aspirations, and this may indicate the presence of social and cultural capital, as such students understand the benefits of taking these courses (Lyons, 2006; Trumper, 2006). On the other hand, students tend to enroll in biological sciences for intrinsic reasons, for enjoyment and interest (Lyons, 2006). Students who take high school AP Physics are more likely to pursue STEM-related programs at the university

[6] Constrained curriculum is a phrase used to describe curriculum that is uniform for all students. Students are not given a choice of courses and the curriculum is rigorous and designed to prepare students for college. It is typically found in private prep schools.

level than students who do not enroll in AP Physics (Robinson, 2003). Science course taking in high school influences college major selection more so for women than men (Trusty, 2002).

Both Physics and Chemistry are gateway courses for a postsecondary education in science and are essential for the development of a student's scientific literacy skills. Completing Chemistry in high school is an essential prerequisite for college entrance for all students (Watanabe et al., 2007). Restricting science course opportunities by having strict prerequisite requirements results in inequitable participation and causes barriers for students who wish to access a postsecondary education. In turn, students are often sheltered from future STEM-related majors and therefore have greatly decreased possibilities for pursuing future STEM-related careers (Kelly & Sheppard, 2009). The hope was that high school would be a "gateway to choice," not a gatekeeper that would limit a student's future opportunities (Robinson & Ochs, 2008a).

Students with more social and cultural capital and a high level of self-efficacy take more challenging courses. The National Commission on the High School Senior Year proposed that the college preparatory track be the learning track for all students, giving all students the rigorous classroom experience they needed to be prepared to succeed in a postsecondary setting (Robinson, 2003). When classes are tracked, rigorous classes tend to use higher-order thinking skills and have a richer, more contextualized curriculum, whereas less rigorous classes tend to have behavioral issues and typically use lower-order thinking skills (Heath, 2000). Lower tracked students have a higher failure rate, not because of the intelligence the students enrolled but because of their negative attitude toward school (Heath, 2000).

In addition, students who have taken rigorous high school courses such as Physics (in addition to Biology and Chemistry) are much more prepared to be successful in postsecondary

science (A. Kelly, 2009). Currently, Physics has the lowest enrollment of any high school science course in our nation (Feder, 1999). About twice as many students complete Chemistry than do Physics, and only about one percent of students complete two years of Physics (Feder, 1999).

Students who take AP calculus and AP Physics and/or AP Chemistry are more likely to pursue engineering in college (Robinson, 2003). In addition to predicting greater interest and success in science in college, more rigorous science curricula in high school also connect with increased interest in and commitment to STEM-related careers (Mau, 2003). Enrolling in the courses increases the chances of students pursuing a postsecondary STEM options; additionally students also perform better in rigorous colleges course once there. According to a study conducted at Florida State University, students who took high school Physics had significantly higher grades in college Physics (Alters, 1995).

The job market in our nation has a need for STEM-trained employees, and the K-12 system has an obligation to educate our youth in order to prepare them for a STEM future. Most students start to develop an interest in a STEM career around the fifth or sixth grade (Lindner et al., 2004). The key factor predicting a continuing STEM career interest at the conclusion of high school was interest at the start of high school (Sadler et al., 2012). Key factors for persistence in science and engineering career interest for students also include academic achievement and confidence (Mau, 2003). Education contributes substantially to one's income and economic mobility across generations (Haskins, 2006). Students who complete a degree in STEM earn a degree that can get them a job with a higher-than-average starting salary. According to a new salary survey from the National Association of Colleges and Employers (NACE), engineering majors dominate the list of postsecondary degrees that pay the highest salaries to new graduates

(Adams, 2013). For underrepresented students whose families did not go to college, the potential for future economic mobility can be motivating (Haskins, 2006). Out of the top 10 majors, reported in Forbes with the highest starting salaries, six are in the field of engineering, yet the supply of America graduates in the engineering fields is low (Adams, 2013).

Possible Solutions to the Problem – Detracking and Physics First

One solution to ensure more students will take a full sequence of science courses is to detrack courses and make them accessible to all students. Most middle and high schools sort students into classes at different levels based on judgments about students' academic abilities (Oaks, 2008). High-tracked students are more likely to engage in experience-based learning, hands-on activity and in lessons that require critical thinking (Heath, 2000). The goal of detracking, or heterogeneous grouping is to take away the prerequisite barriers and increase the quality of instruction for all students. In addition, a detracked, heterogeneous group of students must be taught differently. A study was conducted at Highlander High School in California on their detracted, heterogeneously grouped, Chemistry program, where all students, regardless of their mathematics levels, took Chemistry. While Chemistry is traditionally taught to an "elite" group of pre-selected students who are typically quick, auditory learners with exemplary mathematics skills, Highlander High School held professional development training and worked with teachers on strategies that would allow all learners to access and master the Chemistry curriculum. Therefore, detracking a subject like Chemistry, allowing all students to enroll, and making the instructional changes necessary to support student learning, could unlock and open the gate that has been traditionally closed, keeping students from university admissions opportunities (Watanabe et al., 2007). Detracking creates a need for additional science educators,

professional development for teachers on differentiated instruction and targeted interventions for struggling learners.

Another successful school with the philosophy to detrack and make their classes accessible to all is South Side High School in Rockville Centre, New York. South Side eliminated homogeneous grouping and has seen incredible academic success with their diverse student population (Delia, 2004). In the late 1980's, the once multi-tracked school was reduced to two tracks, Regents and Advanced, and by 1999 the school had moved to a single, high-level track in English, social studies, foreign language, and science. There were two levels in math until 2001; now, there is one, high level, heterogeneously grouped course for all subjects (Delia, 2004). Students who need extra help with academics are enrolled in support classes. Sixty percent of South Side's senior class is enrolled in Advanced Placement (AP) Calculus, including 40 percent of the school's minority population. The percentage of socioeconomically disadvantaged students passing the state's Regents' Exam went up from 22 percent to 71 percent after three years of heterogeneously grouping classes, narrowing the Regents diploma gap for all subgroups (Delia, 2004). Counselors and parents often choose the lower track for students rather than risk failure in a rigorous course. The goal of Rockville Centre's superintendent was clear: all students earn a Regents diploma and participate in AP Calculus. In order to reach this goal, all students needed access to a rigorous curriculum (Delia, 2004).

Another strategy to enroll more students in Physics is to alter the traditional order of the science sequence (Biology, Chemistry then Physics) that was originally set up over a century ago by The Committee of Ten (CoT) [7]. Traditionally, science is taught in the order of Biology,

[7] The Committee of Ten, CoT, is a national education committee that makes decisions for U.S. education. The committee was formed in 1892 and that is when it recommended that science be taught in the order of Biology, Chemistry and then Physics.

Chemistry and then Physics. This order is unique to the United States and stems from the practice of teaching courses as isolated subjects, one year at time, in a fixed order (Sheppard & Robbins, 2006). On average, less than a third of American high school students complete this traditional science sequence. Schools across the nation are teaching their 9th grade students

Physics First

Approximately 4% of public high schools and 8% of private schools began to implement a Physics First curriculum in 2005 and since then, that number has remained constant (S. White & Langer-Tesfaye, 2010). Physics First is a relatively recent movement in the science education community and is supported by some educators in the other science disciplines (Sheppard & Robbins, 2009). Placing Physics before the other science courses opens the access to a course historically unavailable to most students and increases the number of students who complete a full science sequence. Placing Physics at the beginning of the sequence creates a more active, conceptual Physics course; students write, present to classmates, and solve real-world problems (Lawrenz, Wood, Kirchhoff, Kim, & Eisenkraft, 2009). Science has changed tremendously since the CoT's original recommendations; Biology has become much more analytical, and the content that Physics students learn in 9th grade, supports the concepts they will study in both Chemistry and Biology in later grades (Goodman & Etkina, 2008). Placing Physics first ensures that all students complete Physics instead of the traditional order that allows students to delay or even eliminate this course from their studies, resulting in the national average of less than a third of the student population completing their secondary Physics education.

Besides having more students complete Physics, Physics First not only affects the entire science curriculum but it also has a positive impact on math as well (Korsunsky & Agar, 2008). Traditionally, Physics is taught to third-year students and approximately 10-15% of the

curriculum relies on students knowing and understanding trigonometry. In Physics First, Physics is taught using algebra skills, which are 9th grade standards that students are expected to have either mastered or are working on mastering. Supporters of Physics First argue that inverting the sequence strengthens students' math skills because they use the necessary algebra while they learning algebra, not calculus (Glasser, 2012). Physics provides the context for the algebra and reinforces a student's skills (Goodman & Etkina, 2008). A comparison study was done at a school in Philadelphia where PSAT math scores of students that took the Biology, Chemistry, and Physics sequence to those that took the Physics, Chemistry and Biology sequence. Students who took Physics First did significantly better on the standardized math test than the students that took the traditional sequence (Glasser, 2012). Supporter of Physics First argue that inverting the science sequence strengthens both the students' knowledge and abilities in both mathematics and science (Glasser, 2012). Increasing knowledge and skills provides students with the self-confidence and self-efficacy necessary to continue along on the science pipeline. None of the district's research sites currently offer Physics First however, the schools across the nation who have adopted this approach have more students completing the full science sequence.

People Who Influence Science Course Taking

Daily social interactions with parents, peers, teachers, and counselors send messages to students about what science entails, its value and whether or not students are capable of engaging in science (Aschbacher et al., 2009). All of the interactions students have with others help them to form their science identity. Institutional agents in an academic setting play a vital role in mentoring students (Stanton-Salazar, 2010). Students with a strong science identity feel confident about their science ability, enjoy participating in science activities, and feel a sense of belonging to the a scientific world (Gilmartin et al., 2007). Besides identity, teachers, parents,

and other family members can also influence a student's science career choices (Lindner et al., 2004). Parents and teachers are perceived to have an influence on students choosing careers in engineering or science more than any other career (Dick & Rallis, 1991). The communication students receive on selecting their high school curriculum courses most likely comes from both home and school (Lee & Ekstrom, 1987). Teachers and counselors can help students become more aware of the value of taking more science courses as well as guide them with science course selections (Robinson & Ochs, 2008b). Currently, students often rely on their peer group for advice and motivation (Rop, 1999).

Counselors

Counselors can greatly influence interested, science-minded students to remain in the science pipeline. The primary resource in the American public high school to assist students in making informed decisions about course taking is guidance counseling (Lee & Ekstrom, 1987). Advising students about postsecondary preparation and options is a very important role of counselors; students need to start preparing for college in middle school and counselors are the most important people at a school site to improve college enrollment (McDonough, 2005). Early college plans substantially increases the likelihood of taking college prep classes and enrolling in college (McClafferty Jarsky, McDonough, & Núñez, 2009). The signals[8] that counselors send to students about the standards of a postsecondary education must be clear and consistent and will enhance "college knowledge" (Kirst, 2008). The signals about science that counselors send out are powerful. Clear signals, sent out to everyone, equalizes the playing field (Venezia & Kirst, 2005). In the study conducted in *Is Science Me?,* students who were once interested in pursuing STEM careers but lost interest while in high school are given the name "lost potentials." The lost

[8] Signals – information that is transmitted about a subject or college

potentials claimed that counselors described science as hard and told them that it was "not for everyone" (Aschbacher et al., 2009). The message that counselors sent to students was that science was an elite subject and although they had an interest in it, they did not measure up to the rigor. Students stated they were advised to take less demanding classes; one student said her counselor advised her to take Meteorology over Chemistry because she showed an interest in business (Aschbacher et al., 2009). Counselors can identify students with aspirations in science and guide them through the pipeline (Mau, 2003). During elementary school and middle school, students go through what is called a predisposition stage where they begin to develop occupational and educational aspirations (McDonough, 2005). Counselors need to begin having these discussions with students about postsecondary education and future careers during the predisposition stage of their life. Self-efficacy plays a vital role in a student's ability to hold on to his or her STEM aspirations; career counselors can develop interventions that build students' confidence, especially confidence among minority students and females (Mau, 2003). However, according to research on rigorous course-taking (Nord et al., 2011a), students benefit from a full sequence of science courses regardless if they have future STEM aspirations.

High school counselors face multiple barriers when it comes to their serving students on their caseload. One is the major disconnect between what secondary education is doing and what postsecondary education expects (Kirst, 2008). According to Kirst, a major cause of inadequate college preparation is the disjuncture between K-12 and higher education in the areas of policy, academic standards, finance, and communication (2008). Another barrier is the student-to-counselor ratio, limiting the college-related counseling that counselor are capable of doing with high school students (Perna et al., 2008). Often times, first-generation students and their parents who are least informed are least likely to get college related information due to the fact that they

lack social and cultural capital and do not know to ask for it (Perna et al., 2008). Students from families of lower socioeconomic status, minority students and students from small, rural schools are less likely to have access to guidance counseling; the lack of counseling makes it more likely for students to be placed on a lower academic track and take fewer math and science classes (Lee & Ekstrom, 1987). The counseling-to-student ratios at the research sites range from 400:1 to 500:1, well above the prescribed, recommended ratio of 100:1. Counselors typically focus on giving the honors students, not all students, the "college knowledge" (Venezia & Kirst, 2005).

Teachers

Science teachers are another important group that send strong signals when it comes to science education. Teachers are the single most important factor in the K-12 system (Venkataraman et al., 2010). Teachers often take the informal roles of co-parent, advocate, counselor, [informal] social worker, and mentor (Stanton-Salazar, 2010). Although the home and school setting mutually support a students' outcome in the sciences, the classroom environment is the main factor that significantly impacts science achievement scores (Fraser & Kahle, 2007). A teacher who is encouraging can have a positive effect on students' attitudes toward science (George, 2000). Students describe "good" science teachers as teachers who are energetic, caring, passionate, patient and who have high expectations for all students (Gilmartin et al., 2007). Students want to be challenged in science and want teachers as mentors that can share real-world science experiences. One of the barriers, according to Kirst, is once again the disconnect between secondary education and postsecondary education; high school science teachers consistently rate teaching science content as most important and their postsecondary counterparts rate teaching scientific skills most important (2008). Students generally aspire to attend a postsecondary institution following high school; however, because of the many systemic problems and

inequities, they are unprepared. State systems and institutions have created unnecessary barriers between high schools and colleges that undermine high school students' aspirations (Venezia & Kirst, 2005). In order to create a smooth and successful transition from the K-12 setting to a postsecondary environment, the two systems must collaborate. Venezia and Kirst recommend that secondary schools provide all students, families, and educators with accurate information about college-level standards (2005). It is also recommended that the focus is shifted to the institutions that serve underrepresented minority students and shifted from getting into college to how to be a college ready (Venezia & Kirst, 2005). Another barrier is that not all teachers and administrators are properly trained in college-going knowledge, especially classroom teachers and those who serve underrepresented populations (McClafferty Jarsky et al., 2009).

Families

Besides counselor and science teachers, parents play a vital role in whether or not their children will pursue the sciences in the future. Parental support and encouragement has a direct effect on self-efficacy and outcome expectations in math and science (Turner et al., 2004). The role that the family plays in the adolescents forming their attitudes about life and their future career aspirations is irreplaceable (Lindner et al., 2004). Parents /guardians, teachers, and other family members are the three most influential information sources where students gather information about future science career choices (Lindner et al., 2004). Parents play a vital role in course enrollment. A student's decision to enroll in physical science courses is associated with social and cultural capital within their families (Lyons, 2006). The amount of human capital (adult attention in the family) children gain from their parents and the amount of social capital a student has, effects their academic outcomes such as high school dropout rates and college going rates (Coleman, 1988). Another indicator of school success is the mother's expectation for the

child to attend college; the greater the expectation, the more cultural capital children possess (Coleman, 1988). In a study done in Australia, students were not enrolling in the physical sciences; the school discovered that parents were encouraging them to enroll in courses they enjoyed or that they were good at as long as they were happy. The school coined it the "as long as you're happy syndrome" (Lyons, 2006, p. 300).

Conclusion

The primary objective of this study is to examine how science teachers, high school counselors, and administrators communicate to students the benefits of taking a full sequence of science courses in the high school system. Science course enrollment was examined through the lens of self-efficacy and social/cultural capital. The research clearly points to the inequities across our nation as far as access to rigorous science courses. The size of a school a student is assigned to, their socioeconomic status, and their ethnicity all are determining factors in the access a student will have to rigorous science courses at their high school, and the opportunities they will be afforded beyond high school.

Closing achievement gaps is a national priority and STEM education has become a presidential policy focus for the past several years. International studies show the United States is no longer a world leader in the field of science and technology. Internationally, according to Program for Student Assessment (PISA), America ranks 20th out of 40 countries in science performance. TIMSS ranks the U.S. 11th out of 48th in a study that compared 8th graders internationally (Gonzales & National Center for Education Statistics., 2009). We know as a nation we need more scientists; therefore, we need to graduate more students who major in science in college, and we need to help more students pursue a post-secondary education in the fields of science, engineering and technology.

We must begin to serve our students in the K–12 educational setting by offering them all access to a science sequence and curriculum they need for their future and deserve as American citizens. Our nation's economy is relying on a scientifically literate public, which can only be accomplished thorough science education. We can begin this process by communicating to our nation's high school students the benefits of taking the full science sequence.

CHAPTER THREE
RESEARCH DESIGN AND METHODS

Introduction

In the preceding chapters, I argued the educational and career benefits of high school students taking a full sequence of science courses—Biology, Chemistry and Physics. High school students are generally uninformed about the benefits and this study examines the role that science teachers, counselors and administrators play in communicating the benefits to the students at high school sites. Future job forecasts predict that 75% of the fastest growing occupations will require that students are mathematically and scientifically literate in order to be successful (Robinson & Ochs, 2008b). However, our nation's university system is not able to meet the high demand by graduating an adequate number of people with degrees in science, technology, engineering, and mathematics (STEM). Part of the deficit is due to attrition of STEM majors in college; however, substantial talent is also lost among high school students who do not take advanced science courses and do not enter postsecondary education in STEM disciplines.

The goal of this project was to contribute to the body of research that already exists concerning the need to increase the number of students who choose to enter the STEM field as a postsecondary or career option. This study differed from past research in that it focused on the science sequence and the communication that students receive regarding the benefits of completing the full science sequence as well as the perceptions of high school science teachers, counselors, and school administrators regarding what a full science sequence was and who should enroll in the courses. This study employed a variety of qualitative methods to examine the perceptions that exist among the staff members on campus. In addition, the study used qualitative

methods to examine the current documents that exist to communicate the benefits of taking a full sequence of science courses in high school.

To address the issues stated above, the following research questions guided my study:

1. What are the perceptions of high school science teachers and counselors regarding the factors that contribute to students taking a complete, rigorous science sequence?
    a. What do science teachers/counselors consider to be a full science sequence?
    b. According to teachers/counselors what types of students are most likely to successfully complete a full science sequence?
    c. According to teachers/ counselors how would teaching and advising strategies need to be changed if the full science sequence became more accessible?
2. What do high school science teachers and counselors along with school administrators recommend can be done to encourage more students to enroll and be successful in a full science sequence?
    a. What individual and institutional barriers do teachers/counselors see as prevalent in keeping more students from taking a full science sequence?
    b. What recommendations do teachers/counselors/administrators have for changing school/district policies or encouraging individuals to overcome these obstacles?
    c. What role do science teachers, counselors and school administrators see themselves as having in enacting reform to make the full science sequence available to more students?
3. What currently exists to inform students about the processes, benefits and requirements of science course taking in high school?

Research Design

For my research design, I selected a qualitative approach that included a questionnaire component in which I analyzed some basic quantitative data using SurveyMonkey's crosstab analysis and filtered responses capabilities. In addition, I conducted qualitative research and analyzed data derived from interviewing key stakeholders and collecting information from reviewing relevant documents. This qualitative study aspired to first understand what the full science sequence entailed at each school site, second to understand how high school staff currently communicate information to students regarding the benefits of taking a full sequence of science courses, and third to understand what the perceptions are that staff members hold regarding the type of student who should be enrolled in science courses. It also aimed to understand how, if any, gatekeeping in the sciences occurs at the school sites. The most effective way to truly understand what is currently happening at the site level, at the depth necessary for this study, was through the qualitative practices of first gathering information via a questionnaire, and then through interviewing key stakeholders (high school counselors, science teachers and administrators) and reviewing existing documents. Collecting data by using a variety of qualitative methods enabled me to triangulate the data and avoid any biases that may exist in the study.

My study was a qualitative research design with the goal of addressing the problem of students receiving ample communication regarding the benefits of taking a full sequence of science courses in high school. At the beginning of my research study, I organized an advisory panel comprised of science teachers and the Director of Curriculum and Instruction to examine the problem. After I have gathered, analyzed and synthesized the data, the panel will reconvene and will collaborate to design a plan that will allow more students access to a full sequence of

science courses across the district and a plan to communicate to students the academic, career, and postsecondary benefits of taking a full sequence of science courses in high school. The plan will be designed for the study sites and shared first with district leadership and then with the high schools district-wide. The goal of the study was to address the communication and enrollment problem in the school setting, and involve the stakeholders in the process to ultimately improve practice and have more students complete the full science sequence (Maxwell, 2013). The qualitative research design enabled me to understand what currently took place at the individual school site level and allowed me to tap into philosophical views about school personnel's perceptions as to who should enroll in particular science courses. The most effective way to obtain this type of understanding was through face-to-face, in-depth conversations based on semi-structured interviews that allowed for follow-up questioning when needed. I will share my findings with the advisory panel first, and with their input I will design a plan of action to be presented to school sites and the district. This plan will include course-sequencing recommendations. At the culmination of my project, I plan to present my recommendations to the board of education.

Site Selection

I selected a district in California and studied three out of its six high schools (Canyon Grove High School, Northbrook High School and Southridge High School) because the problem I researched exists systemically throughout our state and nation. The district and high schools represented a microcosmic view of the issue; a majority of high school graduates were not completing a full sequence of science courses and were not informed about the benefits of a STEM future. The three school sites I chose are ethnically and socioeconomically diverse and are located in different geographic regions of the community. The high schools in this district

were particularly interesting to study because the schools are high performing and most students have the academic and mathematical needed to take a full sequence of courses. Yet, the district mimics the national average of science course completion rates, with approximately less than 30% of the students completing the sequence.

I surveyed science teachers, counselors and administrators at all six high district high school by administering a questionnaire. In addition, I conducted interviews and document reviews at the school sites that had a student population at both ends of the ethic and socioeconomic spectrum as well as the school site with a large percentage of students in the middle range. The district as a whole is a high-performing secondary, 7-12 school district, (where the Academic Performance Index (API)[9] is 841, well above the state average of 757 for a secondary, 7-12 school district). The district is ranked high in academic achievement when compared to all high school districts in California, with at least 20,000 students in seventh through twelfth grade students. The district consists of 16 schools: six middle schools, six high schools, one continuation high, one alternative special education school, one on-line school and one early college school. It is located in a suburban community located in North Los Angeles County and currently serves approximately 23,000 students.

All three high schools are four-year, comprehensive high schools that have grades nine through twelve. The first school I conducted research at was Canyon Grove High School. I chose this school because it most closely mimicked the state's demographics as far as its socioeconomic and ethnic make-up. Canyon Grove High School has 2,184 students and an API

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[9] The API, or Academic Performance Index, is a measurement of academic performance and progress if schools in California. It is one of the main components of the Public School Accountability Act. The API ranges from 200 to 1000. API scores are based on California Standards Tests (CSTs) and California High School Exit Exam (CAHSEE) scores.

of 772; it is the most radically diverse school in the district with 50% of the student population being Hispanic, 9% African American, 13% Asian American/Filipino and 26% White. Based on the number of students who qualify for, and receive, free and reduced lunch services, Canyon Grove High School also has the highest percentage, 39%, of socioeconomically disadvantaged students in the district. It was reported, by students, that 69% of the students' parents had at least "some college."

There are two schools in the research district with demographics in the middle range. I conducted research at one of the two schools, Southridge High School. Southridge High School is the oldest high school in the research district; it is deeply rooted in tradition and culture with 2,173 students and an API of 833. Southridge High School has a diverse student population and a wide socioeconomic spread; half, 50% of the students are White, 2% are African American, 6% are Asian American/Filipino and 39% are Hispanic. According to the low-income indictor of students who receive free and reduced lunch, 25% of the students at Southridge High School are socioeconomically disadvantaged, a number well below the state average. It was reported, by students, that 76% of the students' parents have at least "some college."

The final school, Northbrook High School is the largest school in the district with 3,050 students and the highest API, 855, of a comprehensive high school in with district. It not only has the largest student population but it also has one of the largest special education populations with the most regionalized programs in the district. Northbrook High School is situated on the North side of town and is the least socioeconomically diverse high school in the district. It also has a lower percentage of Hispanic students than the other high schools. The student population is comprised of 16% Asian American/Filipino, 23% Hispanics, 5% African Americans and 54% Whites. Only 8% of the students at Northbrook High School receive free and reduced lunch and

are considered socioeconomically disadvantaged. It is reported, by students, that 91% of the students' parents have at least "some college".

Sample Selection

I administered the questionnaire, found in Appendix A, to all 621 certificated staff members to include high school science teachers, counselors, and administrators at the comprehensive high schools in the research district. After gaining a broad perspective from all of the key school personnel with whom high school students come into contact, next, I interviewed personnel that influence the master schedule, student placement and had input in students having accesses to the full science sequence. I administered targeted, semi-structured interviews with assistant principals who are in charge of science; the assistant principals in charge of the master schedule (sometimes this is the same person, sometimes a counselor does master schedule); the site principals who are in charge of staff hiring; the counselors in charge of master scheduling, science, and/or the lead counselors; and at least two science teachers, including the department chairs and the Physics and / or Chemistry teachers who have prerequisite requirements. I conducted seven interviews at each site that included two administrators, one counselor and four science teachers. The interview protocol can be found in Appendix B.

Data Collection Methods

I administered a questionnaire at the beginning of my research to establish a broad sense of what the high school counselors, science teachers, and administrators in the research district perceived the science sequence consisted of, what was being communicated to the students and how that communication was taking place, how staff communicated information to students about the full sequence science, and staff members perceptions to whom should enroll in the courses. I administered the questionnaire at all six high school sites in the research district to all

621 site teachers, counselors, and administrators. The questionnaires were delivered online through SurveyMonkey through the district's Novell email system. There were 18 survey questions in the questionnaire, one of which was a free response (Appendix A). I received 208 back for a 35% response rate. At three of the sites, principals sent out a friendly reminder to their staff, asking them personally to participate in my study. These three schools had a higher response rate than the other three, only one of which, Southridge, was a targeted research site. Southridge had the highest return at 46%, followed by Cedermont at 43% and Eastbluff at 41%. I received fewer responses from the sites without the principal's encouragement. Oakpath had a return rate of 29%, whereas Northbrook, a target research site, had a 24% return rate. The lowest return rate came from the research site Canyon Grove with a return rate of 18%.

In addition, the questionnaire helped me understand what the staff perceived a full sequence of science courses looked like in a high school setting and who (what type of students) should enroll in those courses. I administered the questionnaire online via the district's Novell email system. The questionnaire's 18 questions took approximately 10 minutes for participants complete. The questions varied in format: Likert-like scale; categorical demographical, and background items; and multiple choice. The questionnaire results were returned directly to the SurveyMonkey program under my study for easy access and data analysis immediately upon participants' completion. An email was sent out with a link to the consent, and explanation of the study, and the questionnaire. A follow-up reminder email was sent out one week later.

As a continuing part of my qualitative research methods, I concurrently conducted document reviews at Northbrook, Canyon Grove, and Southridge High Schools. I studied their course catalogs, science department websites, science teacher websites, master schedule, science prerequisite descriptions, student four-year plans, course descriptions, AP information, School

Accountability Report Cards (SARCS) and any other science communications the schools had for their students to access on site or online. Such documents provided me with a current picture of what the science department had to offer students and what science course communication tools were available for students in the district. Notes were recorded on document review recording sheets that are found in Appendix C. Once I completed the document reviews and questionnaires, I began the semi-structured interview process.

I conducted semi-structured interviews with high school teachers, counselors and administrators at Northbrook, Canyon Grove and Southridge High Schools. The interview protocol allowed for the flexibility of follow-up questions and interviewees were able to articulate clearly their beliefs, perceptions and ideas about students, ideas about the science sequence and the science courses at their school site and in their classrooms. I conducted these interviews at participants' school sites, in the comfort of their office or classroom, and at their convenience. I brought small gifts to each interview as tokens of appreciation for participating in my study. To keep with the theme of science education, the gifts were coffee mugs that looked like beakers with handles. I used a digital voice recorder and an iPad recording App as back-up to audiotape the interviews. During the interviews, I took notes on my iPad and used a semi-structured process where I had nine predetermined main questions and sub-question suggestions for elaboration, but probed interviewees for a deeper understanding of what was being asked. The interviews took approximately 45 minutes to conduct. I had contact information and permission to contact the interviewee at a later date if I needed additional information or clarification during the analysis phase of my research. After the interviews, I had all of the interviews transcribed verbatim for coding and analysis purposes.

Data Analysis Methods

Once I completed my questionnaire, I began my data analysis. I used the program SurveyMonkey to electronically create the questionnaire and disaggregate the data. I used frequency distributions and cross tabulations to identify themes in order to determine the perceptions on a broad basis of how the benefits of taking a full sequence of science are communicated to high school students and who should enroll in science courses. The document review consisted of collecting documents and artifacts from the same three high schools where the interviews were conducted. I collected documents that involved school demographics, science education and communication about science course information; examples included science department websites, science teacher websites, course catalogs, four-year plans, and AP information.

The questionnaires, interviews and document reviews were coded in order to bring meaning to information gathered (Creswell, 2009). I thematically coded the documents based upon emergent themes in order for categories or themes and patterns to naturally emerge from the data that revealed how students receive communication about the benefits of taking a full sequence of science courses. First, all the data generated by the participants was organized and thoroughly read for an overall understanding of what the data means. Next, the coding process began where the data was sorted into segments and those segments were later given a category or theme name (Creswell, 2009). In order to have the most relevant categories or themes best suited for the study, the names of the categories or themes emerged from what I saw in the data (Merriam, 2009). Starting with 11, I narrowed down categories or themes that emerge to a eight to analyze and discuss in findings (Creswell, 2003). The eight themes that emerged from the data that helped me answer my research questions were: full sequence; enrollment decisions: who

does and who should take science, barriers, solutions, and recommendations to overcome the barriers; changes in advising and teaching; benefits to taking science; and communicating the benefits. School politics regarding who can enroll in science courses emerged as well. The categories or themes that emerge from the excerpts generated descriptors for my five main findings or themes. I triangulated the data gathered from the questionnaires, document review and the semi-structured interviews in order to draw conclusions and proposed answer questions.

Credibility / Trustworthiness

I made every effort possible to ensure my study was credible. In my study, the largest issue was my own bias regarding who should enroll in a full sequence. I think every "capable" student should graduate with Biology, Chemistry and Physics and that school personnel should be communicating the benefits to students loud and clear; science helps their academic, postsecondary and career future and America's future. I checked transcripts to ensure there were no obvious mistakes made during transcription. In addition, I constantly compared data during the coding process to help ensure there was no drift in the definition or meaning of codes (Creswell, 2009). I hired someone to transcribe my interviews to help mitigate my misquoting someone. I triangulated the data generated by comparing the collected data from the questionnaires, semi-structured interviews, and document/records review. The schools I worked with were a microcosm of a problem in science education that exists in high schools throughout our nation. With that being said, a threat to the study's credibility may be the difficulty of generalizing the findings to all high schools nation-wide. Since education is a function of the state, it could be generalized to the entire district I work with, and possibly the state. Each state has different graduation requirements and therefore it may be difficult to generalize. With the national movement of the Common Core Standards and The Next Generation Science Standards,

generalizing may become more doable in the near future. Bias and reactivity may create other threats to my study because I worked in the district where I conducted my research. I spent ample time, prior to conducting my interviews, building relationships with the counselors, science teachers, and administrators who took part in the semi-structured interview portion of my study. In time, people reverted to normal behavior and the risk of reactivity was lowered, and I feel they were honest with me in their responses. I am an assistant principal in the district and was a former district science teacher. The people I interviewed know who I am because of my position and former involvement with district-wide science education.

Summary

I had an advisory panel composed of myself, several science teachers and a the Director of Curriculum and Instruction who will examine the data from this research study and I will present the findings and recommendation to our school district's leadership. The goal is to improve and increase the students' science education along with the communication students receive regarding the academic, postsecondary and career benefits of taking the full sequence of science courses in high school. If communication is increased, hopefully more students will access the courses.

CHAPTER FOUR
FINDINGS

Introduction

Data from questionnaires, interviews and document reviews were used to shape a number of key themes regarding the perceptions that teachers, counselors and administrators had about the benefits of students taking a full sequence of science courses. Through the various research methods, and research sites, my goal was to gain a broad perspective of what staff members perceive comprised a full science sequence; what type of students completed the sequence; what barriers existed that prevented students from accessing science and what were some solutions to overcoming those barriers, and how were the benefits of science communicated. Specifically, I sought to answer the following questions:

1. What are the perceptions of high school science teachers and counselors regarding the factors that contribute to students taking a complete, rigorous science sequence?
    a. What do science teachers/counselors consider to be a full science sequence?
    b. According to teachers/counselors what types of students are most likely to successfully complete a full science sequence?
    c. According to teachers/ counselors how would teaching and advising strategies need to be changed if the full science sequence became more accessible?
2. What do high school science teachers and counselors along with school administrators recommend can be done to encourage more students to enroll and be successful in a full science sequence?
    a. What individual and institutional barriers do teachers/counselors see as prevalent in keeping more students from taking a full science sequence?

b. What recommendations do teachers/counselors/administrators have for changing school/district policies or encouraging individuals to overcome these obstacles?

c. What role do science teachers, counselors and school administrators see themselves as having in enacting reform to make the full science sequence available to more students?

3. What currently exists to inform students about the processes, benefits and requirements of science course taking in high school?

The findings from the 21 interviews and 208 questionnaires were coded into themes that organically emerged and were then analyzed through the lens of the theoretical frameworks presented in chapter two, self-efficacy and social/cultural capital. Visiting the school sites to conduct the interviews was an insightful experience. Although the research sites had very different science programs and course sequences in place, overall the science education at all three high schools appeared to be comprehensive and high in quality. All staff that participated in the interview process, administrators, counselors and science educators, were well versed on the school site's science program and all talked about continuously improving what already existed on campus in relation to the sciences.

This chapter first describes the three research sites – their demographics, API (achievement data), and background information about the science program at the school site. It then presents the themes that emerged during data analysis and triangulation. There were five themes that naturally emerged as significant findings and were able to help guide conclusions to my research questions: 1. There is no universal high school science sequence, 2. A disconnect exists between whom staff members think *should* complete a complete science sequence and whom they perceive *actually* completes a full sequence of science courses, 3. Students are sorted

and tracked according to prerequisites that do not necessarily match the needed skill set for science courses, 4. There is a desire for more direction, support, and higher expectations from the district office, and 5. The benefits of students taking science courses are mainly communicated through counseling, peer interactions and in students' current science classroom. Questionnaire, interview, and document review data were used to demonstrate where the sites differed and were similar in perceptions regarding the sequence of science courses, barriers to students accessing science courses and communications about the benefits of science in high school.

Overview of Research Sites

My research was conducted at a high performing secondary (7-12) school district. Although the district consists of 16 schools, my research was limited to the six comprehensive high schools in the district. In the fall of 2013, a questionnaire was sent out to all 621 targeted, certificated staff members (all teachers, counselors and administrators) at the six comprehensive high schools in the research district. I had a 35% return rate and received 208 questionnaires back for analysis. Three of the schools had a higher response rate than the other three due to an email sent out by their site principals encouraging staff members to participate in my study; only one of which, Southridge, was a targeted research site. Southridge had the highest return at 46%, followed by Cedermont at 43% and Eastbluff at 41%. I received fewer responses from the sites without the principal's reinforcement. Oakpath had a return rate of 29%, whereas Northbrook, a target research site, had a 24% return rate. The lowest return rate came from the research site Canyon Grove with a return rate of 18%. In addition, a counselor, an assistant principal, the principal, and four science teachers at each of the three targeted research sites participated in semi-structured interviews. The targeted research sites, Canyon Grove High School, Northbrook

High School, and Southridge High School, were ethnically and socioeconomically diverse. Their science departments and course offerings were also diversified.

Canyon Grove High School

The first site I visited to conduct my semi-structured interviews was Canyon Grove High School. Canyon Grove was the most ethnically diverse school in the district and closely mimicked the demographics of the State of California. A quarter of the 2,184 students at Canyon Grove are English Language Learners and 39% of the students are classified as socioeconomically disadvantaged; it is the comprehensive high school with highest percentage of need in the district. Ethnically, half the student population is Hispanic, 13% is Asian/Pacific Islander, 26% is White, and 9% is African American. There are several regionalized special education programs at this school site and special education students make up 14% of the school's student population.

The data were reflective of the demographics that the staff was working with at Canyon Grove High School. Funding as well as students' academic struggles were among factors staff members talked about during the interview process. There were 10 staff members that taught 11 different science offerings in the master schedule at Canyon Grove High School – six listed under the physical sciences and 5 under the life sciences. Four different AP science courses were offered: Biology, Environmental Science, Chemistry, and Physics and one honors level course in Human Anatomy and Physiology. Specially Designed Academic Instruction in English (SDAIE)[10] Biology was also taught to the English Language Learners.

[10] SDAIE – Specially Designed Academic Instruction in English is a teaching approach intended for teaching various academic content in English to students who are still learning the language. SDAIE strategies require students have intermediate proficiency in English and mastery of their native language.

Another program often referred to and coordinated by a science teacher, Suzanne, and an administrator, Elizabeth, was the school's Golden Opportunity for Academic Learning and Success (GOALS) program. GOALS students entered Canyon Grove credit deficient and with the support of a team of staff members. GOALS students were mentored, nurtured and placed on a path towards success, which included a special GOALS class where they learned life skills and study skills. Additionally, they were placed in Suzanne's Chemistry class as 10th graders, not a traditional placement for credit-deficient, unsuccessful students. Talking to Suzanne, it became evident that she believed deeply in her GOALS students. Referring to a student who walked in during my interview with her " …the one right there, takes the train from [a town an hour away] every day, is one of our GOALS kids – every day, rides the train since the end of 9th grade to stay at this school and to get the support of this program. He's amazing." She went on to say, "He's an amazing young man. And he rocks Chemistry. Rocks Chemistry and would have never gone into Chemistry." The GOALS and SDAIE programs were in response to the academic and demographic needs at Canyon Grove. The 2013 API at Canyon Grove was 772, and like the other two research sites, 59% of the students scored proficient or advance on the science portion of the California Standards Test (CST).

Canyon Grove was the only one of the three research sites that strategically placed all students in a life science in the 10th grade because of the federally mandated life science tests that take place. The accountability system drives their placement of Biology in the science sequence; students are tracked into Biology II, Biology I or AP Biology depending on their mathematics level. According to the 2012-2013 School Accountability Report Card (SARC) (2014), Canyon Grove has 9% of its student population participating in the AP program. Also according to the

SARC, 19% of Canyon Grove's students participated in Career Technical Education (CTE). The CTE programs and classes were specifically designed to focus on career preparation.

Northbrook High School

The second site I visited was Northbrook High School, the largest and least socioeconomically disadvantaged high school in the research district. Northbrook has 2,965 students, only 6% of whom are classified as English Language Learners and 8% are considered socioeconomically disadvantaged, the lowest numbers for a comprehensive high school in the district. Ethnically, 22% of the students at Northbrook are Hispanic, 53% are White, 16% are Asian/Pacific Islanders, and 5% are African American. There are several regionalized special education programs at this school site as well, and special education students make up 13% of the school's population.

Once a much larger school at 3,500 students, according to Maria, the school's counselor, instead of releasing several science and mathematics teachers when the enrollment at Northbrook dropped, they devised a plan that would benefit students academically and restructured their priorities in the master schedule. Northbrook implemented a waiver system where all students were mandated to go beyond the School Board policy of two years of mathematics and science to meet graduation requirements and take four year of mathematics and science. If students chose not to take mathematics their junior or senior year, a phone call went home explaining the importance of the courses to their future and a waiver had to be signed by the student's parents.

This movement shifted the courses students took at the high school. There are 15 science teachers at the school who teach a variety of courses. The school offers the traditional series of Biology, Chemistry, Physics and Earth Science; it also offers four different AP science courses in Environmental Science, Biology, Chemistry and Physics. All three research sites also offered

Anatomy and Physiology. What sets Northbrook a part from the other research sites is the wide variety of elective science courses available to students. Northbrook had the following science courses in its master schedule: Astronomy, Meteorology, Honors Nanoscience, Microbiology, Genetics, and Materials Science. Staff members at Southridge and Canyon Grove mentioned how they wish they had the staffing to grow their science programs and offer courses like the ones available at Northbrook.

Northbrook has an API of 855 and like the other two research sites, 59% of the students scored proficient or advanced on science CST. Northbrook requires that all freshmen take the same level of Biology, with the exception of the advanced learners who take AP Biology, even though the federally mandated assessment for life science is given in the spring to all 10th graders. The principal, John, made it clear that he does not allow the test to dictate the science sequence. When asked about the 10th grade life science test and its effect on the sequence he replied, "No, I'm not going to drive by that test…our students have done well on that test, so to me, it's just kind of silly to do that."

Approximately 7% of the student population participated in the AP program at Northbrook. Northbrook had the lowest percentage of AP students out of the three research sites, yet it was the high school with the highest API. Career Technical Education was an obvious focus at Northbrook. According to the SARC released in February 2014, 38% of the student population participated in CTE programs, 19% higher participation than at Canyon Grove and slightly higher (4%) than the participation at Southridge High School. Northbrook has well-established career paths, several related to STEM fields: Environmental Studies, Health Sciences, Engineering, and Sports Medicine. The other two research sites are working in collaboration with the district office and were in the process of developing their school to career

programs. In addition, Northbrook had a variety of extracurricular science activities and clubs for students to participate in: STEMS (Science, Technology, Engineering & Math Students), Robotics, Ecology, SAVES (Student ActiVists for Endangered Species), Green Team, and Green. The school also has a competitive Science Olympiad team that competes at the county's regional science competitions.

Southridge High School

The third and final site I visited to conduct my interviews was Southridge High School. Southridge is a school that has a student population of 2173; it is a school that is in the middle range in the district as far as socioeconomic and ethnic diversity. English Language Learners constituted 20% of the student body and 25% are considered socioeconomically disadvantaged. The student population is 39% Hispanic, 6% Asian/Pacific Islander, 50% White and 2% African American. Special education students make up 10% of the school's population.

There were 12 teachers that made up the science department at Southridge High School. A traditional, yet rigorous course of study was offered at the school site. Biology, Chemistry, Earth Science, Anatomy and Physiology were available in the master schedule along with AP courses in Environmental Science, Chemistry, Physics and Biology. The unique attribute about Southridge was the popularity of AP Physics at the school site. There were five sections of the course this year and last year the teacher said he had six, giving up his preparation period to meet the demand of the course. According to the teacher, Carl, he let any student who wished to take the course in and his only prerequisite for AP Physics C was that the student took AP Physics B. "Last year, I had classes at 50, they won't let me do that anymore. Now I am at 39." Almost 10% of the student population at Southridge participated in the AP program; it was the highest participation among the three research sites.

The API at Southridge is 831, and 59% of the students, the same as the other two research sites, scored proficient or advanced on the science portion of the CST. Most freshmen took Biology at Southridge; some however were tracked into Earth Science or AP Environmental Science depending on their 8th grade mathematics level. The federally mandated 10th grade assessment did not drive sequencing decisions at Southridge.

Introduction to the Findings

From the data collected, five themes emerged overall and three stood out as most significant. First, no universal high school science sequence existed. There were varying views amongst teachers and school sites on what courses made up a full science sequence in high school. In addition, course offering varied, often time in substantial ways, amongst the research sites. The second and third themes are related; students are sorted and tracked according to prerequisites that do not necessarily match the needed skill set for the course and there is a disconnect that exists between whom staff members think *should* complete the science sequence and whom they perceive *actually* completes a full sequence of science courses. Additionally, I explored the desire for more direction, support and higher expectations from the district office and examined the ways that the benefits of science are communicated to the students.

Theme #1: There is no universal high school science sequence. (Research Question:1a)

My first research question examined what factors contribute to taking a full sequence of science courses. Through examination of my questionnaire data across six district high schools and interviews at three of the sites, it became evident that there was not a universal high school science sequence at a single high school, let alone at the district.

The following quote from a Biology teacher at Canyon Grove High School is illustrative of the varied thinking of what constitutes a full science sequence.

> Introductory physical science, whether it be Earth Science or Chemistry, followed by life science; we have three levels of that kids can take – Bio.2, Bio. 1 and AP Bio. Junior year, they take either a higher level physical science, which is a higher level Chemistry, AP Chemistry – perhaps Physics, if they want. Their senior year, they take either AP Chemistry, AP Physics, perhaps Honors Anatomy or even just regular Human Anatomy. (Juan, Biology teacher at Canyon Grove High School).

All 10th grade students take a life science course (different levels of Biology depending on mathematics level) at Canyon Grove High School because of the federally mandated life science test that all 10th graders take. The other school sites stated that the 10th grade life science test did not drive their science course sequence. A counselor from Northbook High School, Maria, said:

> Most students start with Biology and Chemistry and then depending on their area of interest, they need to finish with either Physics, AP Chem., AP Bio., Environmental Science and then if they have a real specialty in the areas of Marine Studies or Microbiology or Molecular Genetics. Some of our students, however will start with Earth Science, so their full range will start with Earth Science, Bio,, Chem., and then an advanced elective in science."

Northbook had the widest variety of science courses, the largest student population, and the largest science department. It was also the only site that started all students off in the same course Biology. Some advanced students started in AP Biology. A counselor, Ann, at Southridge High School across town added

> We always make sure they get through a biological science and a physical science. It depends on where the kids come in with their math levels and ability, but if they are on the lower end, then they would start with an Earth Science, then go to Bio., then possibly take Anatomy, and then Chemistry or Physics after that. That would be their four years. If they're coming in on a little bit higher level, then they'll probably come in starting with bio or an AP Environmental Science. Then from there, we just sit with them and make decisions based on what they're thinking of majoring in in college. Some of the kids will take two years of Physics, Anatomy, and Chemistry.

Southridge adjusts their course offering according to staff availability and therefore the sequence is adjusted. The principal of the school, Michael, shared, "I know we've had a crunch because of staffing and we've had a crunch because of Chemistry and Physics in the last years. Priority has been given to upper classmen…" The courses and sequences at the research district

high schools varied a great deal depending on the staff members available for course sections and what sciences they were credentialed to teach at that particular site. The order of the courses varied a great deal across the research sites as well. At Canyon Grove High School, their website clearly delineated the science sequence and tracks for students in science; there was a track for students who planned to go straight to a highly competitive four year university and had excellent school history, one for those who planned on attending a four-year college and had a good school history and a track for those who had no current plans on attending college and who are mainly interested in completing high school graduation requirements. Through examination of the Science Course Path from Canyon Grove High School, it appeared that enrollment and course selection would be dictated solely be postsecondary plans. In reality, through the interview process and further examination of documents and prerequisite requirements, it is also driven by math placement. Figure 1 is the Science Course Path from Canyon Grove High School's webpage.

Possible Science Course Paths:
If you plan to go straight to a highly competitive 4 year UC/CalState style university and have an excellent school history:

- 9th Grade: AP Environmental Science
- 10th Grade: AP Biology
- 11th Grade: AP Chemistry or AP Physics offered in alternating years
- 12th Grade: AP Physics or AP Chemistry offered in alternating years

If you plan to prepare for a 4 year college, are not looking at a highly competitive 4 year university and have a good school history:

- 9th Grade: Chemistry
- 10th Grade: Biology I
- 11th Grade: Physics
- 12th Grade: Science Elective or AP Science

If you have no current plans on going to college, may in the future and are mainly interested in completing your high school graduation requirements:

- 9th Grade: Earth Science
- 10th Grade: Biology 1 or 2
- 11th Grade: Chemistry, Physics, Science Elective or AP Science
- 12th Grade: Chemistry, Physics, Science Elective or AP Science

Figure 1

Science Course Path

Nearly all of the interviewees (19 out of 21) explained how not all students should take the same science sequence of courses; instead, students should take science courses that complemented their ability levels as well as their interests. Most staff members felt that students should follow a path that matched their postsecondary aspirations, future career interests and math ability in particular. Two expressed that the same sequence for all would be ideal, however not realistic. For example, Adam, a teacher at Canyon Grove High School expressed that:

> Philosophically, they should all take the same sequence; realistically, that would not happen, just because…I mentioned the resources before, but there are also differences in students. Students like different things. Students may like to take advanced classes in some subjects and non-advanced classes in others. You have to go with what they students would like to do with their careers and with feedback or help from the counselors and the parents.

Many participants, like Adam, discussed what students "like" and want to take as the reason for the varied sequences in schools when it comes to the sciences.

The questionnaire data revealed which courses make up a science sequence and how they differ. There are preconceived notions regarding who should enroll in certain courses; district-wide 93% of the respondents felt that all students should be required to enrolled in Biology, 33% felt all students should enroll in Chemistry, and 16% felt that Physics should be required. Perceptions of what courses should constitute a full science sequence differed in substantive ways across school sites.

A crosstab analysis across research school sites illustrated the differences in what is perceived to make up a science sequence. Southridge High School for example, offers the most sections of AP Physics in the district; 73% of Southridge questionnaire participants agreed that Physics should be open to all students who want to take the course compared to 53% at Canyon Grove and 59% at Northbrook who felt that Physics should be available to all students. This philosophy was in line with the Physics teacher at the school site. "I have no prerequisites; you can take this class, whoever you are, which mean that those kids have a chance" (Carl, Southridge High School, Physics teacher). The school's overall AP participate rate, almost 10% according to the SARC (2014), is the highest of the three research schools as well.

By contrast, at Canyon Grove, Northbrook High Schools and Southridge High Schools roughly half as many teachers believed that Physics was an essential component to the science

curriculum as those who believed biology was essential. Similarly at Southridge High School where "they had more kids wanting to take Chem. than they had spots so seniors got priority..." only 49% said Chemistry was essential to the science sequence. On the other hand, 67% of the respondents at Canyon Grove and 81% of the respondents at Northbrook said Chemistry was essential. There were similar discrepancies in Biology; fewer staff member at Southridge, 73%, felt Biology was an essential component of the science sequence than the respondent at Canyon Grove and Northbrook. When the data were analyzed across positions, only 30% of counselors felt Physics was essential, yet 71% of administrators and 51% of science teachers felt Physics was an essential part of the complete sequence.

Table 1

Percentage of staff members by research site who felt these courses were essential competent to a complete high school science sequence.

Course considered essential	Southridge	Canyon Grove	Northbrook
Earth Science	46	35	36
Biology	73	94	92
Chemistry	49	67	81
Physics	33	56	40
Anatomy and Physiology	26	50	19

Not only did the science courses in the sequence vary among the research sites and participants, how many courses should make up the sequence also differed. In a crosstab analysis across school sites, the questionnaire data showed that 89% of the respondents at Canyon Grove said students should take four science courses in high school. The numbers were surprisingly different at the more socioeconomically advantaged schools that have the waiver in place where students have to get parental permission not to take a third and/or fourth year of math or science. At Northbrook 71% said students should take four years of science, and at Southridge the response was even more of a surprise; 55% of respondents felt that four science courses should be required. Analyzing this sentiment across positions revealed that the majority counselors

(92%) believed students should take four years of science, followed by science teachers (69%) and administrators (64%).

Table 2

How many science courses do you think students should take in high school? Percent response for each group:

Choices	All staff	Admin.	Counselors	Sci. Teachers	Other Teachers	Canyon Grove	North-brook	South-ridge
1 course	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 courses	3.1	0.0	0.0	0.0	4.7	0.0	3.6	2.5
3 courses	25.5	21.4	8.3	16.7	29.2	11.1	21.4	32.5
4 courses	63.3	64.3	91.7	69.0	61.2	88.9	71.4	55.0
5 or more	8.2	14.3	0.0	14.5	4.7	0.0	3.6	10.0

Physics is the science class that is traditionally reserved for the elite students. In the crosstab analysis of the questionnaire, 100% of the counselors said Biology should be a course required by all students, yet only 15% said Physics should be a required course. During the interviewing process, most people talked about Physics as a course to be taken at the end of the sequence and primarily for the advanced students. All three Physics teachers however mentioned the concepts of Physics First, having students start off with Physics as their first high school science course.

Physics First is an inquiry-based, educational program that teaches 9th grade students basic, conceptual Physics at the algebra level. Physics First does not exist at any school site in the research district; however, all three Physics teachers were aware of the course and research behind Physics First. All three Physics teachers mentioned it in their interviews. Adam, from Canyon Grove, reported, “I do somewhat believe in the “Physics first” philosophy where a Physics component should be first; unfortunately, I also think Physics should be taught at a higher math level.” He went on to talk about the resource issues that occur in a Physics First program:

> Resources-wise, that would be a Herculean task; not just because of actual things, equipment, or lab equipment, but administratively, I think it'd be a big burden for administration- maybe bigger than they can handle. Freshmen go through equipment much faster than juniors and seniors and it's always hard to get the science budgets.

Physics teachers discussed the fact that having all freshmen enrolled in a hands-on Physics course would require a large monetary investment in equipment and the need to hire addition, quality Physics teachers. Another Physics teacher alluded to the instructional benefits and economic concerns of a Physics First program; Ken said, "pedagogically you should do Physics first, economically, you should do Physics last." Carl shared that he "…thinks Physics First is a nice way of introducing kids to easy, conceptual Physics." Carl went on to say he would have to assume his AP Physics students had no Physics background coming from Physics First unless he was confident it was taught properly and students were not spoon-fed answers. All three made it clear that Physics First would not replace higher-level AP Physics courses and that offering even more Physics would be yet another barrier that schools would need to negotiate.

Theme #2: A disconnect exists between whom staff members think *should* complete a complete science sequence and whom they perceive *actually* completes a full sequence of science courses. (Research Question: 1b)

It was clear that staff members think it benefits students to learn science. One administrator, Richard, described the courses as allowing students to "…make sense out of the world and have habits of mind that make you stronger, more confidant, and empowered." A counselor, Ann, from Southridge High School, explained that students "…are definitely much better prepared to go onto whatever they do after high school because it's not just about the science; it's about getting them those skills, those critical thinking skills they need to survive in the world." Through questionnaires and interviews, teachers, counselors, and administrators predominantly felt all students should have access to a full sequence of science courses. However, when probed in the interview and asked who *actually* complete the sequence,

participants described students who were motivated, academically high-achieving students, planning to attend a four-year university, oftentimes from upper-middle class families with educated, involved family members. They used character traits such as persistence, intellectual curiosity, self-advocacy skills, and good time managers to describe these students. They were not describing "all" students or even a set of characteristics that characterized the "typical" or "average" student enrolled at the high school. For example, Barry, a counselor from Canyon Grove High School, described who completes the full sequence at his school:

> They'll come in – probably at least be in Geometry – and they'll take Chemistry as a freshman. They'll have a foreign language. They'll start their core A through G right away – they're already on track. They're probably in Honors English, they're in sports, and they're active in ASB or other clubs on campus. Typically their parents are involved.

According to the questionnaire data, meeting A-G requirements and having the ability to apply to a four-year college or university was the number one motivating factor for students to enroll in a complete science education. When it came to what staff members perceived impacted a student's ability to succeed in science, the following factors, in order, where selected as affecting students a great degree: study habits (95%), motivation (89%), literacy/math skills (70%) and teacher's belief that all students could learn science (69%). Factors not found as having as much of an impact were family support (43%), students' future career aspirations (36%) and intelligence (25%).

Adam, a Biology teacher from Canyon Grove High School described the students he sees as completing a full sequence as:

> Number one, an interest in going into a STEM field once they graduate from high school – that's first and foremost. They already know that they want to be a doctor or an engineer of some sort, or a researcher …they are students who enjoy school, they're very good at managing their time and the amount of studying that it takes to do well in science courses.

He described students that complete the full sequence as the future STEM majors and college bound students. His school, Canyon Grove, has a four-year science path (see Figure 1) outlined for all students, regardless of their postsecondary goals. Suzanne, a Chemistry teacher from the same site shared her perception of the students that complete a full sequence: "They are upper middle class with educated parent." She went on to say, "They need to have a willingness to work hard, a self-confidence, they need literacy skills, they have to be able to read and write." Suzanne also works with a special group of credit deficient students who she mentors and welcomes into her Chemistry courses through the GOALS program.

On the other hand, Ken, a Physics teacher from a more affluent site described two types of students who complete the sequence. The first type Ken described as, "Motivated, loves to learn, hates busy work, intellectual curiosity for how things really work, is one group. You certainly get another group of 'I take this because I'm told that's what's supposed to be on the transcript to get into an ultra-competitive school.'" All three teachers described college-bound, motivated students who knew science would benefit their future goals.

Northbrook high school required parents to sign a waiver to opt out of their third or fourth year of mathematics and/or science, above the two years required per Board Policy to meet graduation requirements. With the exception of their extensive special education population, it has become the school culture over the past several years that students are expected to take three, preferably four, years of science. A similar policy exists at Southridge High School however it was not talked about as much and did not seem to infiltrate the campus culture like it did at Northbrook High School. William, an administrator at the site explained,

> The parent has to sign a waiver to drop [a math or science class], they're going to get a phone call from either an assistant principal or a counselor, and they're going to know that dropping the science A could take them out of the UC/Cal State admission process, or it could make their admissions weaker than another student that stays in the four complement of courses.

According to the principal at the site, John, very few waivers were signed. He shared, "Occasionally you get a student that does not want to take a math or science class in the 12th grade, but usually once you have a conversation with the student or the parent, they understand the importance." When I asked the counselor, Maria, who was instrumental in imposing the waiver at the school site, how she encouraged students to take additional science courses, she said, "I just don't give them an option- they have to work really hard to convince me, personally, that they're not going to take science, even my special ed. kids. You just need to take one more year." She went on to explain that the students, who do take the full sequence, are:

> Primarily, about 96% of them who are aiming to do that are the kids who are going to some kind of after-school/post-graduate program, whether it's a two-year college, whether it's a trade school, whether it's a four-year university – those kids who are planning, those are the kids that are striving. The ones who are looking to go into the military, many of them still plan to take a forth year, but would be most of our students, except for our lower and special ed., are the ones who would do that.

The questionnaire data revealed almost all respondents, 175 out of 183 (96%), strongly agreed or agreed somewhat with the statement "All students should take a full sequence of science courses in high school." In addition, 160 of the certificated staff surveyed, or 89% agreed with the statement, "All general education students have the ability to access high level science standards."

Table 3

Who Should Take Science

Staff members were asked to rate their agreement with each of the following statement:

Statement	Strongly Agree	Agree Somewhat	Disagree Somewhat	Strongly Disagree
All general education students have the ability to access high-level science standards.	64%	32%	4%	0%
All students should take a full sequence of science courses in high school.	46%	43%	10%	1%

When science teachers, counselors, assistant principals, and principals were asked during the interviews who should complete the complete science sequence, the majority of the participants involved all students in their answer. This is the response from a teacher Debra who teaches an AP course:

> Honestly, I don't see why any student shouldn't [enroll in the full sequence of science courses]. I think the benefit of this being hands-on, or just science in general, hands-on, and being so generally applicable to outside life and the fact that it encompasses their English needs, their math needs, and even the history part – I just feel that science creates really well-rounded individuals. (Debra, AP Biology, Southridge).

However, some of those interviewed felt the complete sequence is reserved for the motivated, college-bound students who are academically successful. Another teacher, Melinda, also from Southridge, shared a different perspective from Debra's when asked who should enroll in a full science sequence:

> Well, probably kids, who are, I would say, have better academic background. We have a lot of students here who come from other countries and they don't have good academic backgrounds. We put them in a science class where they're required to know a lot of vocabulary; a lot of critical thinking skills are required…

She added that her school allows any student to challenge any AP course, meaning any student can enroll in the course even if they do not meet the prerequisites. Her feeling is "that brings down the rigor of the classroom." She said she "would allow any student to enroll in an AP class,

but if they can't keep up at the very beginning of class, I would highly recommend to them, personally, that they drop the class and pick up one that they can be more successful in so that they don't pull down the class." Her colleague John, who is an AP science teacher at the same site, believes any student who wants to challenge themself in an AP course should be give the opportunity.

Discrepancies occurred when interview responses were compared to the crosstab analysis across school sites. At Northbrook High School, 50% of the respondents strongly agreed that all general education students could access high-level science standards; 47% agreed with the statement from Southridge and 29% from Canyon Grove. The results were in line with how academically prepared the staff felt their students were at Canyon Grove High School. The counselor, Barry shared, "Our school is going to be different than another high school in another side of town. We typically have a larger number of students who get D's and F's – a higher at-risk population. So I would say that our number of kids going into a third year of science are lower than Northbrook or [other high achieving schools in the district]." Canyon Grove also has the largest population of English Language Learners that they serve in their science courses. Elizabeth, the administrator who oversees science at the school site, shared her frustration with the district's A-G rates, explaining that many of their special education and EL students are not even eligible for A-G courses. "We've done SDAIE Bio., we've done SDAIE Earth Science, we've done SDAIE Chemistry…." The staff at Canyon Grove seemed to strategically focus their efforts on closing achievement gaps within their subgroups. They talk about it as if it is an unfair challenge that some of the other district high schools do not have to overcome. Their efforts have had positive results; they had the same 59% proficient and advance rate on the science CST as the two other research sites. Marian, a science teacher from Canyon Grove shared her positive

experience with working with her student population: "I think the nice things about [Canyon Grove] kids they don't come in with a lot of pre-conceived notions, they don't think they're better than you – they're really come in with, "What can I learn?"

Northbrook, on the other hand, had the highest percentage (half) of staff believing all general education students have the ability to access high-level science. The counselor, Maria, was one of the driving forces behind the science/mathematics waiver. She said, "We highly recommend four years and approximately 80% of our students take three or four years of science." It has become the culture at the school that students go beyond the required two years. The master schedule course offerings support the demand for more science courses. Not all of the other schools in the district have this staffing in the sciences and therefore are not able to offer the same variety of science elective course.

The philosophy that all students should take more than the required two years of science is prevalent throughout the district. The principal at Southridge stated:

> I think there has been a lot of discussion, a lot of work done on the teacher credentialing programs with current theory on how students learn, how not all kids learn at the same rate, so the who concept of giving kids more time to demonstrate proficiency and doing retakes, I think is more prevalent now than it has been…

He added that he "think[s] our counselors are doing a good job of pushing students to challenge themselves and do the best they do." He sees a trend of more students being successful in the sciences and the gates opening for more access.

Theme #3: Students are sorted and tracked according to prerequisites that do not necessarily match the needed skill set for the courses. (Research Question:1c)

Students are highly tracked across the research district and much of the tracking is based on the student's mathematics placement at the end of middle school. Philosophically, staff believe all students are capable of learning at high levels, but in practice, tracking takes place.

Ninety three percent of administrators who participated in the questionnaires stated that a teacher's belief that all students could learn science had a great degree of impact on a student's ability to succeed. Maria, a counselor shared that "…all students should be in a full sequence of science classes as long a we are able to provide support for some of the ones that are struggling, which we do." There was evidence in the document review of after-school interventions that are geared specifically for science, held in the science classroom, by science teachers. The problem with these interventions is that they are not mandatory because they are held after school hours. Not all students, however, make it in their science courses. Some fail and are forced to drop. Nicole, at Northbrook High School, shared that she always teaches something different at the semester to the students who had to "drop down" because they didn't make it.

Table 4

Prerequisites for Science

Percentage of participants who answered, "yes" to prerequisites are imposed in cross tab analysis by research school site:

Statement	Southridge	Canyon Grove	Northbrook
Prerequisites are imposed for enrollment in particular sci. courses at my school	63%	56%	71%

Students at Northbrook High School were all placed in the same science course and level (Biology) their freshman year, with the exception of a small percentage of students who enrolled in AP Biology. How they performed in Biology and what their interests were determined their science sequence. If they were successful in Biology, they would go on to Chemistry as a 10th grader. If they were not successful, they would take Earth Science their 10th grade year. Honors and AP students, typically in advanced mathematics courses, had AP science and honors options.

At the other two research sites, Canyon Grove High School and Southridge High School, students were tracked according to the mathematics level they were in when they entered high

school in the 9th grade. The crosstab analysis across school sites however, showed discrepant data; Table 4 shows that 71% of respondents at Northbrook High School agreed that their school imposed prerequisites for enrollment in particular science courses. Beyond 9th grade Biology, many other courses had mathematics requirements. Northbrook's Chemistry teacher shared that students were dropped at the semester if they were not performing at C or above and placed them in a lower tracked course. By contrast, 63% of respondents at Southridge and 56% of participants at Canyon Grove believed that the school enforced prerequisites.

Table 5

Prerequisites for Science

Percentage of participants who answered, "yes" to prerequisites are imposed in cross tab analysis by positions:

Statement	Counselors	Admin.	Sci. Teachers	All other teachers
Prerequisites are imposed for enrollment in particular sci. courses at my school	100%	86%	95%	57%

As shown in Table 5, when the crosstab was run by position at the site, 100% of the counselors answered, "yes" to the question about the enforcement of prerequisites. Their everyday job is scheduling students into courses according to readiness and in this case, a prerequisite. Interestingly enough, only 86% of the site administrators responded "yes" to that question. Although administrators do not schedule students into courses, they approve course syllabi and are ultimately responsible for the curriculum and instruction at a school site. In addition, when asked if they believed only high level students had the ability to take Biology, Chemistry and Physics, only 37% strongly disagreed with the statement at Northbrook, but 52% strongly disagreed at Southridge and 65% at Canyon Grove.

Although the majority of certificated staff surveyed believes all students should enroll in a full sequence of science courses, there is gate keeping and tracking that takes place at the school sites. When asked if prerequisites for enrollment in particular science courses are imposed at their school site, 71% of questionnaire respondents answered, "Yes." Suzanne, a teacher at Canyon Grove stated, "I think that our entire school district has a very profound attitude about who is capable of doing what, and I think it is largely based on income." Northbrook High School, the most socioeconomically advantaged school, however had the highest percentage of staff members (92%) disagreeing somewhat or strongly disagreeing with the statement that science is a rigorous course of study and is only for the top students. On the other hand, Canyon Grove High School, the school with the highest number of disadvantaged students in the district only had 70% disagreeing somewhat or strongly with that statement.

Interviews revealed that there was a disconnect between the mathematics level that the Physics and Chemistry teachers felt the students needed to be successful and the mathematics level that the counselors thought the student needed. In the document review, I examined the Science page that had detail descriptions of each science course offered at Canyon Grove High School. The information included the grade span the course was offered to, whether or not it was UC/CSU [A-G] approved, and how many credits the course was worth and what the prerequisites were. All science courses, with the exception of Earth Science, had listed prerequisites. According to the teachers interviewed, prerequisites were not followed. For example, the prerequisite for Physics A/B stated: Concurrent enrollment in Algebra II/Trig or higher. Adam, a Physics teacher said:

> There are prerequisites for the classes, but usually, at least for me, if students are showing willingness to tackle it and I warn them ahead of time, and then I will let them in. I've actually lowered the requirements for Physics when I did more research on the standards- and even the Next Generation Standards, the textbook we have, the math is much above what the Next Generation's Standards require. So, I've modified the standards for the Next Generation – I think for Physics, now, its Algebra that I require, completion of Algebra to get in (Canyon Grove High School).

On the other hand, a counselor at the same school will place students in the lowest science course, Earth Science if they are a freshman currently in Algebra. Middle school grades drive high school science enrollment in the 9th grade.

> They really do need a have a foundation for math in order to well in the Chemistry and Physics. Our science is based on what class you're in. So students, freshmen coming in, if they're in Algebra, they go into Earth Science. If they're in Geometry of higher, they have the option of taking Chemistry or AP Environmental Science during their freshman year (Barry, Counselor, Canyon Grove High School).

When teachers, counselors and administrators were asked if CST scores and GPAs should dictate what science course a student should take, the majority answered "no." For the most part, the participants overwhelmingly felt the doors should be open to all students willing to put forth effort and work hard. Adam agreed that for Physics and Chemistry, students must be able to do basic algebra. However, the counselor at his teacher's site uses math placement to guide enrollment decisions.

> One of my big concerns about the Next Generation Science Standards (NGSS) was whether or not they would require vectors for Physics – and they don't. They very specifically talk about one-dimensional motion and they're not going to cover two-dimensional motion, which would require vectors. So, that makes a big difference for me, because it means I can leave my prerequisites at Algebra and don't have to bump it up to Geometry or Algebra II. (Adam, Physics teacher, Canyon Grove High School)

Carl, the AP Physics teacher at Southridge, expressed that prerequisites are often too high and too arbitrary, He agreed that there should be a mathematics requirement but that it should be pretty low. He teaches all of the AP Physics classes and says he has no prerequisites. "You can take this class whoever you are, which means that those kids have a chance." Ken, the Physics

teacher at Northbrook shared his views, “For Physics and Chemistry, yes, you have to be able to do basic algebra.” He added, “For my beginning Physics that’s all it is, can you do your power of 10? Can you do the quadratic formula? Sine and cosine?” He shared that he reviews the necessary math steps with his students when he gets to that part in the curriculum.

At Southridge, AP Environmental Science is a course open to freshmen who are up for the challenge. According to the teacher Scott, not all students are “high end.” He explained, “I find it hard to look at junior high grades and know what they actually know, so I’ve opened it up to anybody who wants to take the challenge to take the challenge. My feeling is that everybody has the right to succeed or fail, based on what they do, and they shouldn’t be kept out.” When asked about math and how it affects a student’s ability to get into other science course, Scott replied that at Southridge:

> They have to be in Geometry to be in Biology. If they are not in Geometry yet, they are still in regular Algebra, then they go into Earth Science. They have to have been through Geometry to get into Chemistry. AP Physics, we suggest they be concurrently in Math Analysis for that, but again, exceptions are made.

The counselor at the school site confirmed what Scott shared science enrollment was based on mathematics placement. Exceptions were made when necessary. All freshmen at Northbrook were placed in Biology whether or not they concurrently enrolled in Geometry. There was no consistency between mathematics prerequisites across the research sites with the exception of Calculus-based AP Physics.

> Generally, we look at the math they’re coming in with, so we know whether they should be taking Earth Science. You know, when we sit, for example, with [middle school] students, when we sit with them and do their pre-registration, we’re looking at their math and science grades at that time to see what they’re capable of (Ann, Counselor, Southridge High School).

The information about various science sequences available online present the choices at Canyon Grove High School as if they were based on a student’s plans after high school, but

according to the staff, the enrollment decisions are largely based on the math level the student was at when they entered high school in the 9th grade.

Although almost all of the study participants saw a correlation between mathematics and science instruction, the level of mathematics that counselors and administrators perceived students needed to access the science curriculum was higher than the level the science teachers perceived students needed to be successful in the science course they taught.

Theme #4: There is a desire for more direction, support and higher expectations from the district office. (Research Question: 2)

As a solution to the barriers that exist and gets in the way of students accessing a full science education, staff members talked about wanting more district involvement and direction. High schools often work independently and are given a lot of autonomy as long as they work within the guidelines. The interview data revealed they would like more uniformity and equity in science. It was made clear when triangulating the data, especially during the interview process that a sense of inequity exists. Some of the perceptions are deeply rooted due to cultural expectations and the demographic, ethnic, and socioeconomic boundaries that exist for each school site. For example, when asked about barriers that prevent students from taking a full sequence of science courses on the questionnaire, 60% of respondents at Canyon Grove High School (the highest socioeconomically disadvantaged (SED) school) perceived funding as barrier that prevented students from taking a full sequence of science courses to a great extent. By contrast, only 23% of the staff at Northbrook High School (the lowest SED school) considered funding a huge barrier for students. During the interviews, teachers explained that their science departments ask for donations from the students; they went on to discuss that students from more advantaged backgrounds bring in more donations.

The perceived lack of equity across the district, along with the perceived lack of district direction was a recurring theme when participants were asked about barriers. Northbrook High School offered numerous science electives whereas the other high schools stated they were unable to do so due to staffing limitations. Elizabeth, a site administrator at Canyon Grove, reported, "I think in this district we want everything to be equal, but equal isn't equitable because, for instance, Northbrook gets to offer Honors Nano Chemistry, or whatever it is called and why can't we offer that?" Scott, a science teacher at Southridge High School, offered the following solution to balancing the science teachers at the district's high schools:

> …we are going to take our chess pieces and move you where we need you, then they could balance it…I think we need district direction. I think the district needs to say, "This is what we're going to do and we're not going to put up barriers to kids," and they need to have enough backbone to back it up, and to have an honest discussion about what's in the best interest of kids.

Balancing the staff was a solution Scott offered as a way to create equity among the science programs at the school sites.

One thing everyone did agree on is that students should take more than district/state required two years of science. This sediment received unanimous support; respondents agreed that students should complete more than the two years of required science courses was recommended. During the interview process staff mentioned a desire for higher graduation requirements imposed on students from the Board of Education along with an outlined science sequence recommendation from the district office. According to the questionnaire data, only 3.1% of the respondents (6 out of 196) thought that students should only complete the two years required to earn a high school diploma: 26% answered three year and 63% felt that high school students should take science all four years. John, a site administrator from Northbrook High School stated,

> I think our biggest barrier is board policy that requires two years of math and two years of science. People look at that and say they've completed their two years, they don't need any more to graduate, and they're right, they don't. But they're not putting themselves in a good place. I would love to see the [Research] District go to at least three years in each area.

One way that John chose to address the issue at his own site was to initiate the parent waiver policy, requiring parents sign to opt their son/daughter out of a third or forth year of mathematics or science. The administrative and counseling staff advise parents and students against opting out and the school reports a high success rate with their system and their science and mathematics course completion rate. Michael, another administrator from Southridge High School added,

> I think that our staff – I don't know this to be a fact, but my guess would be that our staff ratio for schools is based on our graduation requirements. So, if our graduation requirements are two years of science, then that is kind of an instant barrier to adding more science classes. So, what we're forced to do as principals is really make decisions about who we're hiring, what subject we're hiring for …..So, we're not staffed by the district to have four years, maybe five years of science for all students, so that becomes an instant barrier, yeah.

He shared that he would love to be able to offer more academic courses like science, if he were staffed to do so. He is hopeful that changing that graduation requirements may also increase staffing ratio allow for more hiring opportunities.

Currently, the schools are autonomous in the way they sequence science and set prerequisites for the courses. This creates issues when students transfer from school to school within the same district. One principal stated,

> I have said for many years that the lack of a science sequence has been problematic. I wish that we had some kind of guidelines from the district office or from the state of California that says, 'This is the sequence,' and 'This is the order in which you should take your science classes,' but really, it's kind of wide open (Michael, Principal, Southridge).

Teachers, counselors and administrators often discussed what other schools in the district were able to offer and they were not. Northbrook high school, the largest high school in the study

and the one with the least amount of students (percentage wise) classified as socioeconomically disadvantaged had the widest variety of science elective in their master schedule. Northbrook is also the high school with the highest API in the district. Due to staffing, they were able to offer unique courses such as Nano Chemistry, Microbiology, Genetics and Marine Biology. Northbrook was also the only site out of the three that started all students off on the same track their freshman year in Biology, with the exception of the small percentage of students who took AP Biology. On the other hand, this was the first year that Northbrook High School was offering AP Chemistry, a class already established at Southridge High School and Canyon Grove High School, and they offered one section of AP Physics where Southridge High School offered five sections.

Theme #5: The benefits of students taking science courses are mainly communicated through counseling, peer interactions and in students' current science classroom. (Research Question: 3)

The overall consensus was that schools could do a better job communicating the benefits of taking a full sequence of science courses in high school. The phrase "full sequence" meant different things to different staff members, and the communication was mostly done passively, except for scheduled counseling meeting where counselors went over all courses, not just science, with students. At Northbrook High School, the site with the most science documentation, by far, and the widest variety of science course offerings, 44% of respondents strongly agreed that the school effectively communicates the benefits of taking science courses to their students. The other sites strongly agreed at a much lower rate – Canyon Grove at 6% and Southridge at 18%. Data from the document review, questionnaires and interviews were analyzed and triangulated to gain an understanding of how the benefits of a complete science

education were currently communicated to the students. Science education in general was communicated in various methods and degrees across the research sites.

When the district certificated staff members were asked, "How often students rely on the following resources to gain information about available science courses and the benefits and the benefits of taking those science courses at your school" the respondents perceived the two most frequent communication methods to be through counselors and peers. The data show that 36% of respondents indicated counselors were the most frequent source of information students used to understand the benefits of taking more science courses; by contrast, 28% of respondents believed that students more frequently received this advice from peers.

Table 6

Communication Resources

How often do students rely on the following resources to gain information about available science courses and the benefits of taking them? (Responses from all staff members)

Option	Very often	Frequently	Occasionally	Seldom	Never	Very often/freq.
Counselor	36%	29%	24%	10%	2%	65%
School's TV	2%	7%	25%	38%	28%	11%
Peers	28%	42%	22%	6%	2%	70%
Recruit. from depart.	6%	26%	40%	18%	10%	32%
Course guide	9%	25%	33%	24%	9%	34%
Sci. information nights	2%	4%	14%	36%	44%	6%

Also noted during the interviews, 20 out of 21 participants included the counselors as a main way, if not the primary source, of passing on information regarding science education to students. Some teachers shared concerns about counseling being the main source of information for students with the high school student to counselor ratio, which is contractually set at 430:1 and can sometimes be as high as 500:1, and what they perceive as a lack of professional development for counselors. When the questionnaire was cross tabulated by position, only 19% of the science teachers stated that students relied on the counselors to gain information about

available science courses and the benefits of taking those courses. Counselors responded 69% and administration 64% to the question regarding counselors and their role in providing students with information about science education. The information regarding available science courses was communicated through, "Counselors, science teachers, and there are specific A through G presentations – that's the majority of it," according to Richard, an administrator at Southridge High School. Anthony, a science teacher at Northbrook shared that students get information about science, "…primarily from meetings they have with their counselors." Science teacher Suzanne at Canyon Grove High School confirmed the fact that counselors are the main method that students receive information about science courses; "99% of it [information about available science courses] comes from the counselors."

Word of mouth from peers was another popular method of how science course information was communicated across a campus, which connects to previous research (Rop, 1999). Southridge High School was an example of this; the AP Physics course is one of the most popular courses on campus. The Physics teacher often takes additional students beyond the contract allotment and last year even taught a section during his prep period to meet the demands for the course. The counselor at Southridge, Ann said, Our AP Physics teacher, he is so good. He is crazy, he is good – not crazy like cuckoo crazy, he's crazy good." She went on to discuss that he allows students in the class that do not meet the math prerequisite and she said, "they're successful because he's such a good teacher." A fellow teacher and department member at the site, Scott, shared, "We have an excellent Physics teacher so I think it's easy to draw kids in. We had 240 kids taking AP Physics last year, more than 10% of the student body, which is crazy, but if you take him out of the equation, you take his personality of the equation, then you don't have that."

Across counselors, science teachers and administration, there was consensus that the recruitment efforts from the science department to pass on information about available science courses and the benefits of taking those courses was low, 7% across the board for occurring "very often."

It was clear that staff members in general believe science will benefit students academically, in their postsecondary endeavors and in the their future careers. According to the questionnaire data, 81% (154/189) of respondents agreed with the statement that they, as staff members, take an active role in encouraging students to enroll in additional science courses. The crosstab analysis across school sites revealed that 70% of the staff members at Northbrook stated they strongly agreed that they actively encourage student to take additional science courses whereas 64% strongly agreed with the statement at Canyon Grove High School and 45% strongly agreed at Southridge. The interviewees shared their experiences of using, unplanned, teachable moments to encourage students to continue in the sciences. Melinda, a science teacher from Northbrook, described her science classes: "I try to make my science classes very, very relevant to the kids and I'm always researching stuff that's not in their book that's going to make my class more relevant." She gave the example she used when teaching about the human body:

> I mean I'm doing it today with telling them that their brain still develops until they're 25 and behaviors that you do now, you're building synapses, or you're pruning synapses at this point, and if you're engaging in risky behavior such as drinking, using illegal drugs, having sex with multiple partners, you're training your brain to need more of that, meaning you'll engage in more risky behavior.

At Canyon Grove High School, the Physics teacher, Adam shared that science helps students learn about life. He recalled lessons he learned during one of his first Physics labs:

> The students had flashlights and it really was a defining moment for how I approach labs because half that students couldn't put the batteries in the flashlights and have the flashlights work. I couldn't understand why all of the flashlights were broken then I went and opened them up- they had put the batteries in the wrong way they had reversed the poles so they would cancel each other out; I was just surprised. And that's when I realized that the big benefit of science labs for many of these students is just to see how things work. And that's really what science is about, anyway.

Adam talked about bringing in as many practical things as possible that students could relate to and even talked about using the game Angry Birds to teach students about projectiles in Physics.

Most respondents (91%) believe students would benefit career-wise, from taking a full science sequence of courses. Almost all, 99.5%, recognize that meeting the A-G requirements and having the ability to apply to a four-year college or university as a motivating factor for students to enroll in a complete science education. When those interviewed were asked who on their campus typically completed an entire sequence of science courses, most described a student motivated to attend a four-year university.

Through the interview process, what counselors, science teachers and school administrator perceived were the benefits of taking a full sequence of science courses varied and ranged from allowing the students to gain access to a four-year university by completing their A-G requirements, to being a positive member of society and better, informed citizens to future job opportunity to allowing students to develop a way of thinking and understanding about how things worked. When principals were asked what they thought they benefits were to students taking a full science sequence, they all looked beyond high school and saw benefits that involved college and career. I was given the following responses:

> I just think they're more well-rounded, they're better prepared, they have more options available to them, they have more opportunity to self-reflect, and one of the benefits of doing something, of taking a class, is saying, "Gee, I really like this, I can see myself in a career with this," or frankly, the opposite is very valuable. "This is not at all what I thought it would be and there's no way I could do this as a career. This is not interesting to me." And so, by having the self-discovery, you're helping to fine-tune what you're going to be doing after high school, after college (Michael, Principal, Southridge High School).

Michael admitted that his school could do a better job communicating the benefits of science to students. Pointing out that the counselors are the primary point of contact for students and family and recognizing that communication should be increased in some other way.

> Well, the benefit I think is that for whatever career you're going to pursue – right now, if you look at what's out there and available, those two programs [math and science] are essential for moving on in college for moving towards careers. To take yourself out of that, to take that possibility out is not a good thing. …you do know what the future's going to bring and even if you major in something else, to have that understanding in math and science, just to be a citizen in the world today and make good decisions politically, I think you need to understand the whole concept of science and the environment, how things work together (John, Principal, Northbrook High School).

John feels strongly about the importance of math and science and takes the opportunity, whenever possible, to communicate that to his community. "Whenever I talked with 8th grade parents- we do a presentation twice a year for 8th grade parents- and at both of those, I talk about the importance of math and science. It seems to be the key to careers today." He went on to share that "Usually, in one of my newsletters, which we send out to parents four times a year, in at least one of them, I usually talk about the courses that students need to take to be successful."

The principal at Canyon Grove Grove High School, Joe, felt strongly about the importance of a science education for his students as well. He shared:

> It's getting harder and harder to be a graduate and to get out into college or your career. If you go out into college, great, but some kids want to go out into the career force. I think science is an automatic, is a no-brainer – a lot of very influential, a lot of very in demand jobs are going through that subject area, if you will and I think we just need to think forward like that.

Joe also talked about the shortages that exist in the sciences and in engineering. He discussed the lack of women and minorities in the sciences and how his school could address those needs.

Although no one mentioned the online resources in the interviews, unless I brought it up, I found evidence of science communication on the schools' websites under the science departments' webpage. Northbrook High School had, by far, the most documents communicating school-related, science education on their website. In addition, Northbrook High School had the most STEM-related extracurricular activities; the "Club" tab on the website listed information for the STEMS club, Robotics club, Ecology Club, SAVES club (a club that works to help endangered species), the Green club and the Science Olympiad Club, a club that competes in science events at the regional level. Southridge High School 's site had information on two science clubs: the Astronomy club and the Go Green club. Both Canyon Grove High School and Northbrook High School posted their intervention schedule online, which included Biology and Chemistry intervention at Northbrook and Biology, Chemistry, Physics and Earth Science at Canyon Grove. All three sites had links to science teacher's websites and some had detailed syllabi, homework assignments, and links to resources.

Northbrook High School had a well established career path program outlined online. Information on how students could complete the school's 18 career paths was available under the "School to Career" tab. Several of the career paths were science related: Environmental Studies, Health Science, Engineering, and Sports Medicine. In addition, every senior is required to take the one-semester, Career Exploration Project class. The course requirements involved a 45-hour internship with a mentor. This evidence was supported in the questionnaire data as well when Northbrook High School had the greatest percentage of staff strongly agreeing (69%) with the statement I believe students would benefit, career wise, from taking a full science sequence of

courses. Staff members at both Southridge and Canyon Grove High School discussed working in collaboration with the district on establishing career path programs during the interview process.

Conclusion

The goal of this study was to create positive change and make a difference in the number of students who have access to information about the benefits of taking a full sequence science courses. The ultimate, long range changes goals were that each year more, if not all, capable student would enroll in a full science sequence and increase course taking rates. The plan was to use the data to come up with recommendations that would be presented to the district.

My findings revealed that there was no universal, high school science sequence that existed, each school operated independently in how they organized their science department. The data revealed that although the majority of staff felt that all students should enroll in a complete science sequence, students who actually completed the sequence were perceived as the high achieving, college-going students at the school. The qualitative data also revealed that students were sorted and tracked according to prerequisites that did not necessarily match the mathematical concepts needed for understanding the science standards. In addition the data showed that although the schools operated autonomously, there was a desire for more unity, direction and support from the district office. And finally, the triangulation of the data showed that counselors were the primary source for passing on information to students about science courses.

In chapter five I discuss these themes and how they affect students and their access to science education. I provided recommendations to the research district based on the Next Generation Science Standards; these recommendations are transferable to other districts that include high schools and have chosen to adopt the NGSS. The recommendations all stem from

the data collected from responses from the questionnaire, the semi-structured interviews and the document reviews.

CHAPTER 5
DISCUSSION AND RECOMMENDATIONS

Introduction

This study indicated that there is no universal science sequence that exists in high schools at the research sites; students' course taking paths varied among the schools studied. It was found that there was a disconnect that existed between whom staff members think should complete a complete science sequence and whom they perceive actually completes a full sequence of science courses. The general consensus was that staff believe all students should complete the sequence. However, they perceived those students who do take a full sequence of science courses are the high achieving, motivated, college-bound students. The study also indicated that students were tracked according to prerequisites that did not necessarily match the skills set needed to be successful in the science courses, limiting the access to a population of students. Staff also revealed a desire for more direction, support, and higher student expectations from the district office. Finally, the findings suggested that the counseling department and peer interactions represent the most frequent mechanisms used to communicate the benefits of taking a full science sequence.

In this chapter I discuss the recommendations that are the results of the five themes that emerged from my study. The recommendations address course sequencing and the relationship science courses have with the mathematics standards; tracking and the unintended gatekeeping that is taking place in the sciences; the desire and need to increase the district's graduation requirements from two years to three years of science; and how to improve the communication about the benefits of students taking science in high school. Following the recommendations, I discuss the limitations of the study and the opportunities for future, related studies. Next, I

discuss the possible implications of education policies. The chapter concludes with my reflections on why this study is so important.

Theoretical Framework Connection

Self-efficacy and social/culture capital are both linked to higher academic success. Self-efficacy and academic proficiency are the strongest predictors for future science and engineering careers (Mau, 2003). The more social and cultural capital a student has access to, the greater the likelihood that student will go on to a postsecondary education (Coleman, 1988).

Self-Efficacy. When the findings were examined through the lens of the self-efficacy frame it was apparent that the staff perceived that students were capable of learning science at high levels; in other words, they believed students could develop their self-efficacy if it was not already developed. Bandara defines self-efficacy as a person's perceived capabilities for learning, assuming achievement depends on the interaction between one's behavior, personal factors, and environment (1997). According to Britner, students form self-efficacy beliefs around science from four areas: experiencing mastery in science, observing others perform science tasks, messages about science and their personal state regarding science (2008). Teachers described students who currently enroll in a full science sequence as students who have traits such as self-efficacy. Richard from Southridge said, they, "come from a background of academic confidence and support and experience. Kind of an academic 'have'…"

Social/Cultural Capital. Social capital, as defined by Plagens, is an intangible resource that emerges (or fails to emerge) from social relations (2011). Science teachers and counselors who advise students about what science courses to take act as "institutional agents." According to Stanton-Salazar, "institutional agents" are high-status individuals who hold positions in the system that enable them to provide social capital and institutional support (2010). When the

findings were examined through the lens of social/cultural capital it was revealed that the students who had social/cultural capital were the students already enrolled in courses throughout their high school years. Students who were placed in lower courses and tracked according to perceived ability levels lacked the capital that peers who, according to Suzanne at Canyon Grove, were "upper-middle class with educated parents" held. The communication systems that were in place helped increase the social and cultural capital regarding science education. The findings revealed that counselors, teachers and peers participated in communicating what science courses were available for students to take. The document review indicated that there were resources available online that communicated science courses, science related clubs, and career paths associated with the sciences.

Teachers and counselors often served as institutional agents for their students, educating them about postsecondary option and science opportunities. Counselors at all three research sites met with student during scheduled meetings to go over class offerings and encourage students to challenge themselves. Suzanne served as an institutional agent for her GOALS students at Canyon Grove and provided them with the social and cultural capital they needed to successfully navigate the high school system. Teachers at all three sites shared that they past on information regarding science organically when topics came up during class. Northbrook and Southridge used waivers to increase math and science enrollment for the juniors and seniors, requiring parent signatures and phone calls to opt out of the courses.

Recommendations for Themes

Sequence of Science Courses. The data revealed that there is not a universal science sequence in the District. Not only did each school site have a different science sequences from one another, there were multiple science tracks within each site. With our nation and the State of

California transitioning to the Next Generation Science Standards (NGSS), the time is ideal to adjust and standardize the science sequence at Local Educational Agencies (LEA). Although the California framework for science education is still being developed, the national framework exists and there are numerous recommended science course sequences available for investigation (NGSS, 2013). There are Model Course Maps that have been released for school districts to use, adopt and adapt, if necessary, to fit their needs (NGSS, 2013). These recommended Model Course Maps, or science sequences, will ensure all students graduate from high school having been taught the NGSS. *I recommend the research district's NGSS transition team study the Model Course Map options and make an informed decision regarding which one would serve the district's students best.* One choice, for example, is the three-year Modified Science Domain Model. It is a model that includes Biology, Chemistry, and Physics; the mandatory NGSS Earth Science standards are incorporated into the three domains, Biology, Chemistry and Physics. For example, the natural hazards and history of the Earth standards are placed in Biology, natural resources and climate change standards are included in Chemistry and Earth and the solar system standards are a part of the Physics curriculum.

The research sites, Canyon Grove, Southridge and Northbrook, had very disparate science sequences as illustrated in Appendix D. Some of the differences noted were Northbrook started their entire freshman class off in Biology and the school had a plethora of science elective courses for students to choose from. Southridge had a booming AP Physics program where 10% of the student population enrolled in the course each year. Canyon Grove purposely placed all sophomores in Biology because of the national life science assessment and struggling learners were encouraged to enroll in Chemistry, with support. Adopting a universal, detracked, sequence would help create equity among the school sites as well as for the students who attend.

Whichever model the NGSS transition team chooses, *I recommend that the chosen model be implemented across all of the high schools in the district to create equity, collaboration opportunities and consistency for students, regardless of which school they attend.* Additionally, I recommend future STEM majors continue to have access to the rigors of the science AP programs that currently exits at each of the school sites. The fourth year of science can be a year of exploration for those interested in the sciences and should be encouraged for all students. Students can take the elective science courses that are outside the universal sequence. These classes may be unique to each school site depending on the expertise, demand, career paths, and materials available at a particular school. Michael from Southridge High School eloquently summed up the issue,

> I have said for many years that the lack of a science sequence has been problematic. I wish we had some kind of guidelines from the district office or from the state of California that says, "This is the sequence," and "This is the order in which you should take your science classes," but really, it's kind of wide open.

I am hopeful that the time has come to create a science sequence for all students and a sequence for aspiring STEM major that consists of AP science courses.

The district and its schools also have an opportunity to sequence their AP courses as well. There are experts in the district who are involved in writing AP exams and training AP teachers nation-wide. These experts have access to information that can help guide the district to make data informed decisions about which AP science class is most appropriate for a freshmen, sophomores, juniors and/or seniors. According to CollegeBoard, students who take AP Environmental Science should be able to do basic algebra, making it an accessible freshmen class, whereas some of the other AP science courses require more background knowledge. AP teachers expressed the desire to have their voices heard. *I recommend having a committee of district experts, along with CollegeBoard resources, to pace out a common science AP path to be*

used at each school site, in order to facilitate more and better communication. Students at varying grade levels and maturity require a different teaching style and ranges of independence in an AP course. If the district adopted a common sequence, teachers could collaborate about age appropriate instructional practices as well as content and curriculum. Interdisciplinary connections could be made more easily during collaboration opportunities. Students could also attend inter-district AP study sessions prior to exams.

Who Should Enroll in Science Courses. *My recommendation is that the district's high schools enroll all students in the full science sequence; future STEM major would still have access to AP science courses.* NGSS are "All standards, All Students" with the goal that all students will be college and career ready (NGSS, 2013). According to the questionnaire data, 88% of the respondents strongly or somewhat agreed that all general education students have the ability to access high-level science standards. All students should be placed in the full sequence that the LEA chooses as their Model Course Map. Mark, from Northbrook summed it up nicely, "You have a stronger education in unity when you have your mixed, inclusive classroom. Trying to separate them out, I think what you end up doing is scraping the cream off the top… "

With detracking and heterogeneous courses, there will be a need for professional development on differentiated instruction[11]. Differentiation allows for teachers to respond to the variance of learners in a classroom (Tomlinson & ERIC Clearinghouse on Elementary and Early Childhood Education., 2000). Differentiation is challenging and requires professional development and planning time for teachers to be able to effectively implement differentiated instruction into their curriculum on a regular basis. The NGSS outlines seven subgroups of

[11] Differentiated instruction: Instruction to meet individual needs in the learning environment. Teachers can differentiate content, process, products, or the learning environment. The use of ongoing assessment and flexible grouping makes this a successful approach to instruction.

students that need to be served in science: economically disadvantaged, students from major racial and ethnic groups, students with disabilities, students with limited English proficiency, girls, students with alternative educational programs and gifted and talented students (NGSS, 2013). If we truly are going to serve all students in science, we could very well have a mixture of all seven of the subgroups in the same classroom. The goal of detracking, or heterogeneous grouping, is to take away the prerequisite barriers and increase the quality of education for all students. Allowing all students the ability to enroll in courses such as chemistry [and physics], could unlock and open gates that have traditionally been closed (Watanabe et al., 2007). I recommend our professional development teams include differentiated instruction as one of their focus areas. Each professional development team might consider having science department members who will be trained and will then work with the science teachers at perspective school sites. Science teachers would benefit most from collaborating with the peers who teach the same course and grade level that they do.

The Science Mathematics Relationship and the Tracking of Students. Students are tracked into different sequences according to their mathematics levels typically beginning from their 8th grade year, with the exception of Northbrook High School where all 9th graders are placed in the same level of Biology, and then tracked in the 10th grade. Most students are sorted based on judgments about students' academic abilities (Oakes, 2008). A student's future is often determined at 13 or 14 years old, before they even step foot on the high school campus.

The standards in the science domains, Biology, Chemistry, Earth Science and Physics can be taught to students who understand basic algebra. Our state and the research district are in the process of transitioning to the Common Core State Standards. The Common Core State Standards accommodate and prepare students for Algebra 1 in the 8th grade; if students master

the K-7 math standards, they will take Algebra 1 as 8th graders. If not, they will be enrolled in Algebra 1 in the 9th grade. The research district currently follows a traditional math pathway of Algebra, Geometry, Algebra II/Trig, Pre-Calculus, Statistics and/or Calculus. Like science, although not as extreme, tracking, variation in the sequences and AP options exists amongst the school sites. Staff members who do not teach the courses often place much higher math requirements on science courses, inhibiting access to students. This was confirmed repeatedly during the interviews and is confirmed in the standards. Juan from Canyon Grove, said "I don't see any correlation between Biology and math." He teaches Biology and AP Biology and mentioned that students who are in a higher-level English course have an easier time handling the reading and writing demands of the course. The CollegeBoard, recommends that students who prepare for the AP Biology exam know basic algebra, know how to collect, analyze, and interpret experimental data, be able to apply basic concepts of probability and conduct statistical analysis and have know how to set up axes and plot data (2014). Suzanne who teaches Chemistry and Adam who teaches Physics at Canyon Grove both shared that courses were taught at the algebra level. According to AP Central, at the College Board, the AP Environmental Science course requires students have an understanding of basic algebra; AP Chemistry, recommends student have an understanding of algebra II; AP Biology recommends a students have an understanding of basic algebra concepts along with some understanding of geometry (CollegeBoard, 2014).

Findings from this study suggest an opportunity for the district to remove prerequisites for grade-level science courses. Now that courses will be specifically sequenced and aligned according to Common Core State Standards in Mathematics, students will be developmentally and content-ready to access the curriculum if it is taught within the standards. When asked on the

questionnaire, 100% of counselors responded that their schools impose prerequisites for science courses. Perhaps students who continue to struggle in grade-level courses can be mandated to enroll in intervention courses or parallel support classes to close gaps in executive functioning, literacy or mathematical concepts.

The recommendation would be to have two paths, one college/career readiness path (one of the Model Course Maps) and one AP path for aspiring STEM majors. I recommend that students be permitted to cross paths should they have an interest in a particular course of study and a desire to challenge themselves in a college-level course. All capable students should be encouraged to enroll AP courses, whether or not it is a science AP course, during high school. All students would be given the rigorous classroom experiences they need to prepare to be successful in a postsecondary setting (Robinson, 2003). *I recommend that all students take courses in the three domains of science: Biology, Chemistry and Physics, which would incorporate Earth Science standards.* Students who have taken rigorous high courses such as Physics, in addition to Chemistry and Biology, are much more prepared to successful in postsecondary science (Kelly, 2009).

Direction from the District Office. It was clear from the data that staff believe students should be required to take more than the current, two years of science to meet graduation requirements. Only 3% of the questionnaire participants agreed that two years was a sufficient amount of science for a student to graduate with. Although 63% of the participants responded that students should take four years of science, findings from this study made clear that the district needs to consider increasing the science graduation requirement from two to three years, with the encouragement from the schools that students take a fourth year. *I recommend the district change the graduation requirement from two to three years and support the schools with*

necessary additional staffing allocations. Students often take the minimum and schools are staffed according to the graduation requirements. "We're not staffed by the district to have four years, maybe five years [for the students who want to double up on sciences one year] of science for all students, so that becomes an instant barrier…" (Michael, Southridge High School principal). *Our National Report Card* describes science as the main gatekeeper to accessing and succeeding in a more advanced curricular level, and science often serves as the determining factor in whether or not a student will meet the college entrance requirements (Nord et al., 2011a). Science is the course where students can practice their literacy, mathematical, innovation, creativity, and collaboration skills all in the same classroom. The NGSS Model Course Maps requires students to take at least three years of science to learn all of the high school science standards. Staffing allocations would have to support the need for more science sections in the master sections. *I recommend that the schools that have the ability (have the staffing) to continue to have parents sign waivers to opt out of mathematics or science and to share this method of increasing enrollment with other school sites.*

I also recommend that the district organize more content-like collaboration among science teachers district-wide. When the district has a Physics teacher, such as Carl from Southridge High School, involved in writing the AP exams and training educators nation-wide on how to teach AP Physics, his knowledge and skills should be tapped into at the district level. Carl is able to get 10% of the students in the school (around 200) to enroll in AP Physics and said, "getting Physics teachers together occasionally might be good." He described the district as invisible to him. He said, "We had a Physics teachers' meeting once in the last 17 years and we have another one today at 3:45, which is interesting because we're going to learn about the new AP Physics exam …" He went on to talk about the role he plays at the national level writing the

exam, a role he believes the district has no knowledge of, and certainly does not leverage. With well over 900 teachers, it is impossible for a few Directors and a few Assistant Superintendents to know the knowledge base and skill level of all individual teachers. Systems need to be put in place where the job-like professionals from across the district have an opportunity to share, collaborate and celebrate successes. Teachers voiced a desire for the district to be more involved and knowledgeable about the work they do. Scott from Southridge articulated this point by saying, "I think you need district direction. I think the district needs to say, 'This is what we are going to do and we're not going to put up barrier's to kids, and they need to have enough backbone to back it up, and to have an honest discussion about what's in the best interest of kids." Districts can look at their science program in its totality to see where the gaps are at the individual school departments and shift teachers with needed expertise to equalize the complete science sequence at all sites. If districts direct schools to have a specific science sequence, provide quality professional development and designate time for content-specific teachers to collaborate together district-wide about practice and curriculum, both educators and students will benefit.

Communications about the Benefits of High School Science. The primary resource in America's public High School to assist students with course taking information is the school counselor (Lee & Ekstrom, 1987). With the high student to counselor ratio of one to 430 at the research district, I think it is unrealistic to rely solely on counselors to deliver the bulk of the communication about courses and the benefits of taking science. Students also rely on peers for information, but occasionally this information is more focused on teacher popularity rather than, learning science and securing a future in the STEM workforce. *I recommend that schools and the district make a more overt effort to advertise the great things that are going on at their school*

sites in regards to science education. High schools have incredible students who are looking for leadership positions and honor society hours. These students can be public relations officers who can contact the local papers and share the great science that is happening at the site. Academics need to be celebrated and published like the local sports are. It was President Barack Obama who said, "We need to teach our kids that it's not just the winner of the Super Bowl who deserves to be celebrated, but the winner of the science fair (Obama, 2011)." Science, along with other academic subjects, can be celebrated in the trophy cases for teams that compete in local competitions. Teams, such as the Robotics Team or Science Olympiad Team, much like the school's athletic teams, can be celebrated when they win in the local paper and on the school's broadcasting system. Students from these teams can be highlighted when they get accepted to the college, much like our athletes are, and followed post-college graduation when they secure careers in the STEM fields. Alumni can be invited back to discuss the benefits of taking science courses in high school and share with current students how science courses helped them with their current and future endeavors. Science information nights, that coincide with open house, can be held with hands-on science opportunities for students to explore what they have to look forward to learning about; future students from the middle schools and elementary schools can be invited to the open house. The local colleges and STEM industries can form partnerships with the schools and speak to the students about 21st century skills needed for college and career readiness.

Limitations of the Study

There are several limitations to this study that are worth discussing. First, the study was conducted in one school district. The school district was among the relatively high achieving school districts in California. School districts are unique in their demographic spread and grade-

span make up. High schools and principals in this particular district had a lot of autonomy as far as course offerings, sequencing and prerequisites. Other districts are more consistent across schools and provide more directives when it comes to these decisions. Within the research district, I looked most closely at three out of the six comprehensive high schools. The science programs varied a great deal amongst the three sites; had the study extended out to a greater number of high schools, I think the data would have been more revealing.

The sample size of the study was also a limitation. There were 621 certificated staff members who received the questionnaire via the district's email system, 208 were returned, netting a 35% return rate. Seven staff members were interviewed at each of the three research sites and were asked to share their perceptions about the school's science sequence and communication about the benefits of students enrolling in science in order to gain a deeper understanding. The questionnaire data, being that I had a 35% return rate on the questionnaire, may not be reflective of the feelings of the staff in the entire research district. A higher questionnaire return rate would have provided greater confidence in the representativeness of the data. More qualitative data from additional interviews may have shown divergent themes or may have provided greater support to corroborate the findings I presented.

The interviewees were selected by criteria I set in place. Names of individual participants to be interviewed were provided to me by the school's principal. This selection process could be a limitation due to the participants the principal chose for me to interview and the bias' they may have held. I interviewed one principal, one assistant principal, one counselor (in charge of schedule and/or science) and four science teachers (to include the department chair, a Physics and a Chemistry teacher). The people I interviewed, for the most part, were extremely positive people about their school, science education and their students.

Although I consistently checked my biases as a researcher, my extensive background in science education and longevity in the research district could have presented a limitation to the study. The familiarity with the district and some of the personnel did make conducting the research easier. I felt the people I interviewed were comfortable, relaxed, and were able to provide honest feedback to my protocol questions.

Opportunities for Future Studies

The following problem was presented at the beginning of the study: in order to meet our future economic demands, we need to educate more students in STEM disciples. Students who take more science courses will be more scientifically literate and will be better prepared to pursue a postsecondary STEM career and/or degree (Aud et al., 2012). This study focused on general perceptions of certificated staff members, in depth perceptions of administrators, counselors, science teachers, and evidence about science education from a document review. The study was limited to a handful of principal-suggested teachers, who were interviewed, as well as principals, assistant principals and counselors. My interviews were conducted with department chairs and teachers who were, for the most part, highly regarded in their departments. Interviewing entire departments would perhaps offer a wider perspective. Interviewing middle school science teachers about how they successfully taught science in a detracked setting would make for an interesting study and would offer an insightful perspective as well.

Another potential study could focus solely on the students and their perceptions about the science education they are receiving, the barriers they believe are in place as far as science education goes, the solutions to those barriers and their ideas for increasing communications about science. Students, who are those most affected by what is happening in the classroom and in a department, are very insightful and can offer a great deal of information to a research study.

I have learned that if you really want to know what is going on in a classroom, ask the students. A survey could be given to college students who had completed the full sequence of science courses in high school to examine how the science courses corresponded to their success in college science classes.

Implications for Educational Policy Makers

There are several policy implications that could result from this study. A first step in improving science education would be, to change the School Board graduation requirements to increase the current, two-year science requirement, to the recommended three-years. This would need to be followed and supported with additional staffing allocations from the district's Superintendent and Assistant Superintendent of Personnel. This may also involve shuffling of teachers from one school site to another to balance out classes, especially if the district agreed to a common sequence.

Reflection

"There's nothing I believe in more strongly than getting young people interested in science and engineering, for a better tomorrow, for all humankind." – Bill Nye

Wanting to make a difference in science education, and help more students access a complete science education was my motivation to conduct this research study. Visiting high school campuses and having the privilege of talking face to face with science educators in the environment they teach in, lead me to realize that the science education at the research district was already high in quality. I was pleasantly surprised by the quality of the facilities and by the obvious evolution of teacher beliefs regarding opening the gates to more and more students taking additional science courses. The culture shift has begun; the structural shift needs to come next and hopefully that will be soon.

The advisory committee that has been formed is looking at the future of science education in our district. This research will provide the data needed to make some informed decisions as to where the district goes next and why we are asking for changes in policies such as graduation requirements and science staffing allotments. One of the main tasks of the advisory committee will be to lay out next steps and a plan of action as we transition to the Next Generation Science Standards and provide all of our students will a high quality, equitable science education.

This study provided me with the opportunity to go beyond the individual classroom walls and high school gates and take in a birds-eye view of the science programs in the district. With that opportunity, I was able to draw conclusions and more importantly, make recommendations that I believe will increase the number of students who can complete the full science sequence. Instead of tracking, all students can be provided with an equitable science path; those already committed to a postsecondary STEM major can continue on the AP science pathway. A consistent sequence among the schools will also provide for collaboration opportunities where teachers can work together on pacing their curriculum, creating formative and summative assessment, and sharing lessons and labs.

With the Next Generation Science Standards on the horizon, the science teachers will need the support of others who teach their same content in their districts in order to transition successfully. This study increased my optimism on just how close we are to providing all students with an equitable, full science education. The NGSS requires that we provide all students with the knowledge and skills in the science standards to include the disciplinary core ideas of Biology, Chemistry, Physics, and Earth Science as well as Scientific and Engineering Practices and Crosscutting Concepts (NGSS Lead States., 2013). It requires that we change what

we are doing in science to address the needs of the 21st century – for all students. My study is timely because the recommendations I am proposing will help meet the demands of the NGSS

APPENDICES

APPENDIX A

The following questionnaire will be given on SurveyMonkey to all high school science teachers, counselors and administrators in the research district.

Benefits of Science Education Questionnaire

Thank you for taking the time to assist me in understanding your role in communicating the benefits of taking science at your high school.

THE PURPOSE OF THIS STUDY:
You have been asked to complete this questionnaire as part of my research at the University of California, Los Angeles on Communicating the Benefits of Science Education to High School Students. This study is designed to gather information regarding the science opportunities that currently exist in our district's high schools.

PROCEDURES:
If you volunteer to participate in this study, I ask that you complete the following, short questionnaire. The questionnaire should take ten minutes or less to complete.

POTENTIAL BENEFITS TO SUBJECTS AND/OR SOCIETY:
The information you provide will possibly help guide the science education in our district and potentially allow more students the opportunity to acquire information about the benefits of a science education.

POTENTIAL RISKS:
Your participation in the questionnaire is strictly voluntary. You may choose not to answer any specific question and still remain in the study.

CONFIDENTIALITY:
Please note that your responses will be used for research purposes only, and will be strictly confidential.
Your answers will never be used in any way that would identify you. They will be combined with answers from other respondents to make a statistical report. These reports will be made available to you upon request. The data for this study may be used for future research.

QUESTIONS AND CONCERNS:
If you have questions regarding the study, you may contact the principal investigator of the study, Catherine Nicholas at cnicholas@hartdistrict.org or 661-510-1134. You may also contact my
faculty sponsor, Dr. Eugene Tucker at tucker@geseies.ucla.edu.

RIGHTS OF THE RESEARCH SUBJECTS:
You may withdraw your consent at any time and discontinue participation. If you wish to ask questions about your rights or ask questions about the study, please feel free to contact:

UCLA Office of the Human Research Protection Program
11000 Kinross Ave., Suite 211
Box 951694
Los Angeles, CA 90095
310-825-7122

Continuing on to the questionnaire means you have read your rights as a research subject as they have been presented on this page and consent to participate in this study.

1. At which site do you currently work?

- ○ Southridge
- ○ Canyon Grove
- ○ Oakpath
- ○ Northbrook
- ○ Cedarmont
- ○ Eastbluff
- ○ District Office

2. How often do students rely on the following resources to gain information about available science courses and the benefits of taking those science courses at your school?

	Very Often	Frequently	Occasionally	Seldom	Never
Counselor	○	○	○	○	○
School's TV program advertisement	○	○	○	○	○
Peers	○	○	○	○	○
Recruitment efforts from science department	○	○	○	○	○
Course guide	○	○	○	○	○
Science information nights	○	○	○	○	○

3. How many science courses do you think students should take in high school?

- ○ 1 course
- ○ 2 courses
- ○ 3 courses
- ○ 4 courses
- ○ 5 or more courses

4. To what extent would you consider the following science courses to be an essential component of a complete high school science sequence for students? (PLEASE CHOOSE ONE OPTION FOR EACH COURSE).

	Essential	To a great extent	To some extent	Not at all
(Regular or Honors) Earth Science	○	○	○	○
(Regular, Honors or AP) Biology	○	○	○	○
(Regular, Honors or AP) Chemistry	○	○	○	○
(Regular, Honors, AP) Physics	○	○	○	○
(Regular or Honors) Anatomy and Physiology	○	○	○	○
Astronomy	○	○	○	○
Marine Biology	○	○	○	○
(Honors) Genetics and Molecular Biology	○	○	○	○
(AP) Environmental Science	○	○	○	○
(Regular or Honors) Nano Chemistry	○	○	○	○

Other (please specify)

5. Does your school impose prerequisites for enrollment in particular science courses?

- ○ Yes
- ○ No
- ○ I do not know

6. Who should be able to enroll in the following science courses?

	All students should be REQUIRED to take course	Open to all who WANT to take course	Only for students with ADVANCED SKILLS	Only for students who wish to MAJOR IN SCIENCE
Biology	○	○	○	○
Chemistry	○	○	○	○
Physics	○	○	○	○

7. Rate your agreement with each of the following statements regarding the role you play at your site in communicating science career options to students. (MARK ONE IN EACH ROW).

	Strongly agree	Agree somewhat	Disagree somewhat	Strongly disagree	Not applicable
I actively encourage students to take additional science courses	○	○	○	○	○
I talk about career options that require science knowledge with students on a regular basis	○	○	○	○	○
I believe students would benefit, career wise, from taking a full science sequence of courses	○	○	○	○	○
I believe only high level students have the ability to take the biology, chemistry, physics sequence	○	○	○	○	○
I believe only high level students have the ability to pursue a post-secondary science / engineering degree	○	○	○	○	○

8. At your school, how many science course are required for your students to meet graduation requirements?

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ more than 4

9. This set of items asks you about students learning science in high school. Rate your agreement with each of the following statements.

	Strongly agree	Agree somewhat	Disagree somewhat	Strongly disagree
All students should take a full-sequence of science courses in high school	○	○	○	○
Any student who wishes to enroll in a particular science course should be given access to the course	○	○	○	○
All general education students have the ability to access high level science standards	○	○	○	○
Counselors should encourage students to take more science courses	○	○	○	○
Teachers should encourage students to take more science courses	○	○	○	○
Administrators should encourage students to take more science courses	○	○	○	○
My school effectively communicates the benefits of taking science courses to our students	○	○	○	○

10. To what extent do the following goals motivate students to enroll in a complete science education.

	To a great extent	To some extent	Very little	None at all
To complete high school and get a diploma	○	○	○	○
To meet A-G requirements and have the ability to apply to a 4-year college or university	○	○	○	○
To pursue a post-secondary degree in STEM (science, technology, engineering or mathematics)	○	○	○	○
To pursue a career in STEM	○	○	○	○
To become a more scientifically literate citizen	○	○	○	○

11. What is your role in the district?

- ☐ Science Teacher
- ☐ History/Social Studies Teacher
- ☐ English Teacher
- ☐ Mathematics Teacher
- ☐ Fine Arts Teacher
- ☐ Foreign Language Teacher
- ☐ Physical Education Teacher
- ☐ Practical Arts Teacher
- ☐ Special Education Teacher
- ☐ Counselor
- ☐ Site Administrator
- ☐ District Administrator
- ☐ Other

12. If you are a science teacher, which of the following science courses (regular, honors or AP) do you teach? (MARK ALL THE APPLY)

- ☐ Earth Science
- ☐ Biology
- ☐ Chemistry
- ☐ Physics
- ☐ Anatomy and Physiology
- ☐ Genetics and Molecular Biology
- ☐ Environmental Science
- ☐ Nano Chemistry
- ☐ I am not a science teacher

Other (please specify)

13. To what degree do the following items impact a student's ability to succeed in science.

	To a great degree	To some degree	Not at all
Math skills	○	○	○
Study habits	○	○	○
Literacy skills	○	○	○
Student motivation	○	○	○
Family support	○	○	○
Intelligence	○	○	○
Student's future career aspirations	○	○	○
Teacher's belief that all students can learn science	○	○	○

14. How much do the following factors affect more student succeeding academically in the sciences?

	To a great degree	To some degree	Not at all
Requiring that students take more / higher level mathematics			
Offering targeted interventions specially designed for science			
Including more hands-on laboratory experiences for students			
Alleviating prerequisites required to get into courses			
Working closely with the feeder schools on science knowledge and skills			

15. Rate your agreement with the following statements about science.

	Strongly agree	Agree somewhat	Disagree somewhat	Strongly disagree
Science is a rigorous course of study and is only for the top students.				
Schools do enough to encourage students in the sciences.				
Science is hard and is not for everyone.				

16. To what extent do you perceive the barriers that prevent more students from taking a full science sequence?

	A great extent	To some extent	Not at all
Staffing			
Lab classrooms			
Funding			
Textbooks/curricular resources			
Student interest			
Student ability level			
Room in a student's schedule			
Students taking more science is not a priority at my site			
Sports and extracurricular activities get in the way			

17. What percentage of students do you think graduate from our district having completed biology, chemistry and physics?

- ○ 75% -100% more than 3/4
- ○ 50% - 75% more that 1/2
- ○ 33% - 50% more than 1/3
- ○ 20% - 33% more than 1/5
- ○ 10% - 20% more than 1/10

18. Your opinion matters! Is there anything else I should take into consideration as a solution to more effectively communicate the benefits to students of taking a full sequence of science courses in high school?

APPENDIX B

Interview Protocol:

1. What do you consider to be the full sequence of science courses in high school?
    a. What classes, specifically name the courses, do you consider make up the complete sequence?
    b. What order do you think the sequence should be taught in?
    c. How many years of science do students at your high school take to meet graduation requirements?
    d. How many years of science do students at your high school take to meet A-G requirements?

2. Do you think all students should take the same sequence of courses? Why or why not?
    a. GPA/ CST / homework completion?

3. Describe the students on your campus that you think should be enrolled in a full sequence of science courses?
    a. Possible probes- Are you describing students with higher than average intelligence, advanced math skills, an affinity for science, a desire to have a career in the science, self-efficacy, strong study habits…?
    b. How do think enrollment decisions should be determined?
    c. Ask Physics teachers – what level math is required for your course?

4. Describe the students (academic achievement, persistence, intellectually) on your campus who currently complete a full science sequence?
    a. What do you perceive is necessary for students to be successful in high school science courses?

5. How do students at your school receive information about available science courses?
    a. What course do you advise your students to take next in the sequence?
    b. What electronic and hardcopies of communications exist?
    c. What presentations, if any, does your school put on regarding science education?
    d. What ideas do you have as to how to increase communication as to these benefits?

6. What actions do you personally take to encourage students to pursue advanced science courses?
    a. What obstacles do you encounter in trying to deliver this information to students?
    b. What resources would you find helpful in reaching out to students regarding taking advanced science courses?

7. What do you perceive are the benefits of students taking a full sequence of science courses?

8. How are these benefits currently communicated to students?

9. What district/school barriers do you perceive that are keeping students from taking the full science sequence?
    a. Do you have any recommendations to change policies in order to overcome these barriers?
    b. What role do you personally play in science education reform and in the movement to help more students complete the full science sequence?
    c. What curricular changes do you think need to take place to allow more students access to a full science sequence?

APPENDIX C

The following is the document review recording sheet. Notes regarding artifacts and documents will be recorded on these sheets and then the data will be coded and analyzed.

Date:

Location (where is this document found on campus):

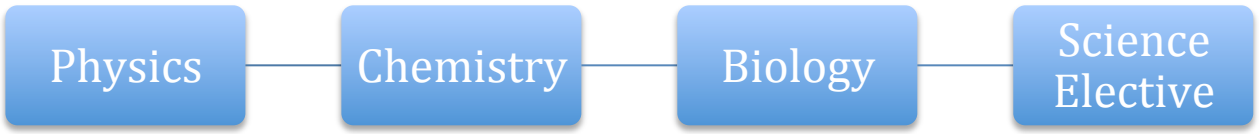
Description:

ONLINE	IN PRINT	ACCESSIBLE TO ALL	SPECIFIC TO SCIENCE	SITE SPECIFIC
☐	☐	☐	☐	☐

Field Notes:

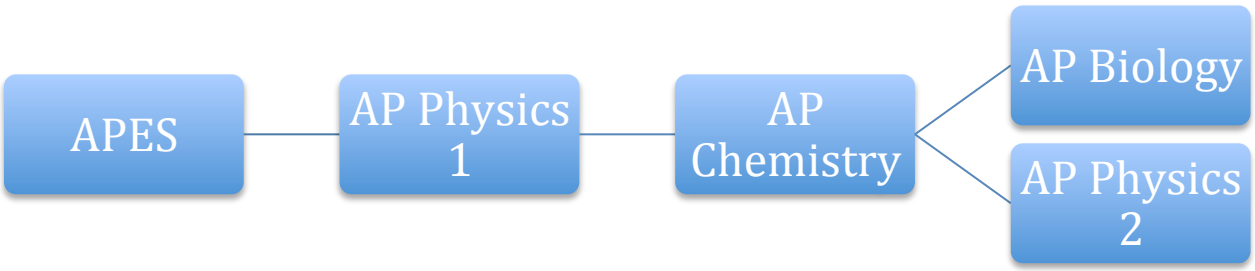
APPENDIX D

Example of a Possible Course Map – For All



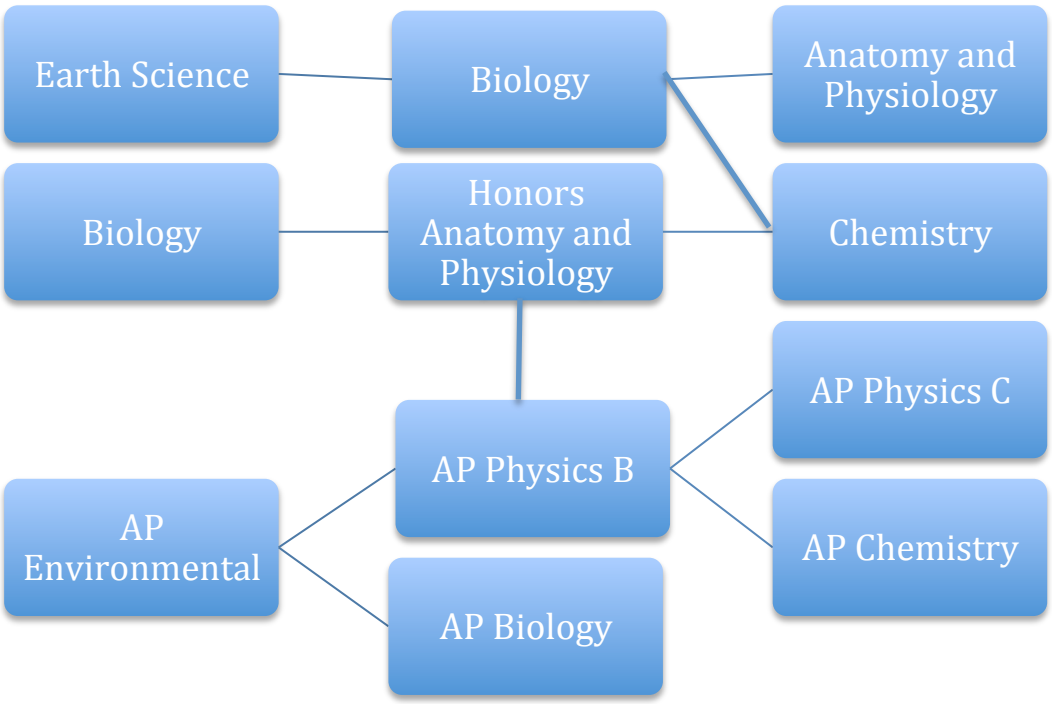
*Earth Science standards would be equally distributed in each domain: Physics, Chemistry and Biology. Course Map would need to be determined by the NGSS transition committee.

Sequence for future STEM Majors (open to all capable students)

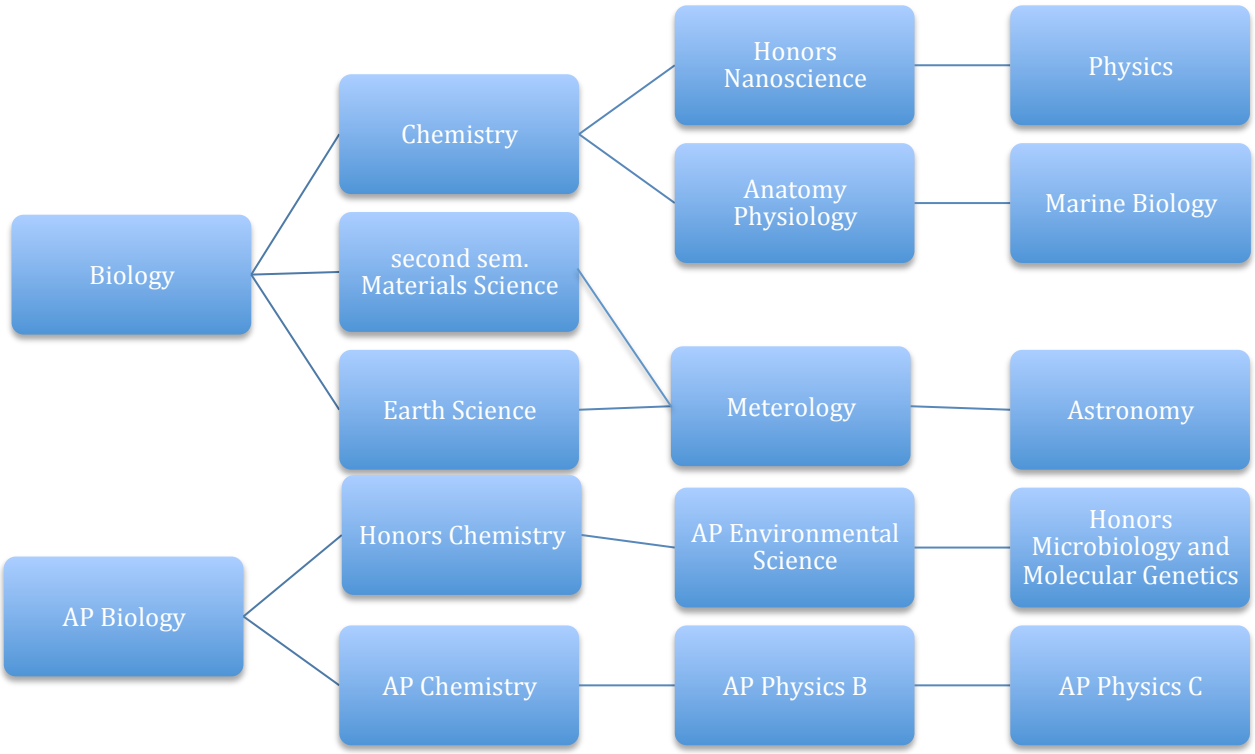


*Sample sequence. Sequence would need to be determined by district experts and information from CollegeBoard.

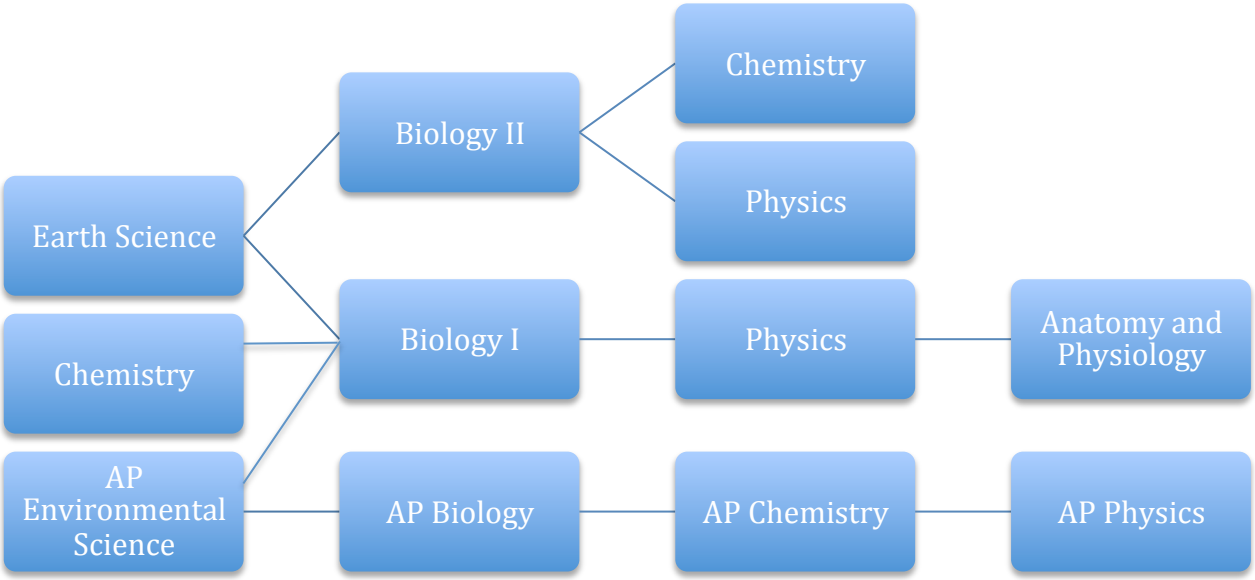
Southridge High School Science Sequence



Northbrook High School Science Sequence



Canyon Grove High School Science Sequence



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