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Perceptions of college/university students on high school science and stem courses

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PERCEPTIONS OF COLLEGE/UNIVERSITY STUDENTS ON HIGH SCHOOL SCIENCE AND STEM COURSES

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DEDICATION

To my parents, Hyun Suk Yoon and Cheong Woon Park, my sister, Min Jung Park, and my brother-in-law, Sun Pil Hwang for their never-ending support.

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VITA

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ABSTRACT

Over the years, the evolution of science along with technology, engineering, and mathematics has been noticeably evident while science education, on the other hand, has shown little development. The research study aimed to investigate future change initiative implementation in secondary science curricula. In addition, the purpose of the research was to learn and examine postsecondary students' perceptions of how well secondary science education prepared them for the postsecondary level plus for schools to utilize the feedback received from students to further improve the quality of science education. The data for the study were collected through semi-structured interviews with 10 college/university students who had experience in both secondary and postsecondary science education. From data analysis, three themes were identified: Insufficient Knowledge, Need Science, Technology, Engineering, and Mathematics (STEM) Guidance, and Improvement in Syllabus and Teaching. The description of each determined theme included the research participants' perceptions of secondary and postsecondary STEM, their interview responses, and the commonalities they shared. Overall, the findings indicated the need for science or STEM curriculum changes, STEM awareness plus guidance, and effective instructional strategies for the enhancement of student preparation for higher education.

Chapter One: Study Purpose

Introduction

The purpose of the research study was to explore and learn postsecondary students' perceptions of how well their secondary science education prepared them for higher education as well as to receive feedback for improvement in secondary science. Taking science courses in high school not only helps students prepare for college/university but also enhances their prospects of securing better-paying jobs later in life (Cooper et al., 2018). This study contributed to the existing body of knowledge on improving high school science experiences, opportunities, and outcomes for students. According to Orishev and Burkhonov (2021), a strong foundation in high school sciences equips students for future success in their careers, continued education, personal lives as citizens, and civic commitments in a democratic society. Generally, secondary students who take science courses are more likely to achieve high school milestones, perform well on standardized exams, complete their secondary education, and be prepared for higher education. However, despite these advantages, many high school graduates lack the valuable skills and abilities necessary for attaining excellent academic results in higher education (Semilarski et al., 2019).

There has been a lack of postsecondary preparation for students in secondary science education, highlighting the need for a change in the science curriculum. According to a report released by Semilarski et al. (2019), teaching children how to solve problems using science is an important aspect of their education. Usak et al. (2020) also asserted that students often graduate from secondary schools without a true understanding of science concepts or flexible reasoning skills, despite the National Council of Teacher Scientist (NCTS) standards advocating for problem-solving and the application of science in real-world contexts. Semilarski et al. (2019)

mentioned that the science curriculum in the United States, as revealed by the Third International Mathematics and Science Study (TIMSS), is confusing and duplicated across different grade levels. For instance, it has been observed that in sixth and seventh grade, little new knowledge is offered due to excessive repetition of scientific topics that students should have already been familiar with. Also, high school teachers often attempt to cover too much content within a limited timeframe, without allowing students to develop a solid conceptual understanding.

When it comes to improving science education, student-centered learning approaches that promote conceptual understanding through challenging tasks have been recommended. Student-centered learning encourages active participation and meaningful classroom conversations, thus enhancing student engagement (Cooper et al., 2018).

Problem of Study

Despite the development of teaching approaches aimed at fostering conceptual understanding in science, there exists a lack of uniformity in science standards and expectations across higher education institutions (Semilarski et al., 2019). This discrepancy indicates a lack of collaboration between colleges/universities and high schools (Cooper et al., 2018). Scott-Parker (2019) also noted a gap between postsecondary and secondary aspirations, highlighting that the problem of students being unprepared for college/university would persist if standards and expectations are not aligned. Phillips et al. (2019) stated that secondary school students are often ill-prepared for postsecondary due to differences in expectations between high school and higher education. Orishev and Burkhonov (2021) suggested that acknowledging the problem is the first step toward resolution and provides a sense of direction for the evidence-collection process. Some students, lacking the motivation and self-confidence to pursue a career in science, perceive scientific knowledge as irrelevant to their daily lives. Therefore, educators must incorporate students' experiences to understand the various factors that could impact their students' performance and competence in postsecondary education. Necessary changes to the high school science curriculum and instruction should be implemented to better prepare students for higher education.

Purpose of Study

The purpose of the study was to explore the perceptions of college/university STEM students on the effectiveness of high school science and STEM curricula with the aim of increasing the level of competency in postsecondary-level science when students continue their education after high school.

Research Questions

- RQ1: What areas of the science and STEM curriculum do college/university students feel were lacking in high school classes?
- RQ2: What amendments do college/university students think should be introduced into the STEM curriculum to acquire the skills needed to readily complete STEM college/university programs and choose STEM as their career choice?

Research Sub-Questions

- Specifically, how do learners talk about their science education in secondary schools (e.g. classes, peer study groups, and teaching)?
- How do students describe their degree of readiness for college/university in light of their extensive preparation?
- What will their first-year or subsequent college/university science coursework experience be like?

- As they prepare for college/university, what do learners wish would have been managed differently at the secondary school level?
- Do students believe that science education in secondary schools adequately prepares them for adult life and the freedom they get when they go to college/university?

Methodology Approach

The researcher used qualitative research methods to gather data on the effectiveness of high school science education in preparing students for higher education. The study utilized one-on-one semi-structured interviews as the primary data collection method. The one-on-one interviews provided an opportunity for the researcher to gather definitive data about the participants' opinions and motivations. Additionally, conducting face-to-face interviews allowed for the observation of students' body language, providing valuable insights to complement their verbal responses (Hamilton & Finley, 2019). In cases where the participants preferred virtual interviews, the video communication program, Zoom was used.

The study included a group of 10 college/university students as participants. Each student was individually interviewed, allowing for comprehensive and uninterrupted responses. The college/university students possessed a high level of knowledge and experience in the subject matter being studied, which facilitated detailed and insightful explanations during the private interviews. Also, studying previous experiences within a defined timeframe helped the researcher gather valuable information on the specific topic (Hitchings & Latham, 2020). This method not only aided in discovering additional information but also helped determine preferred data collection methods for the specific area of study.

Researcher Assumptions

Throughout the study, certain assumptions were made regarding postsecondary students' perceptions of secondary science education. These assumptions include:

- The impact of the COVID-19 pandemic may have resulted in students having more negative experiences than positive ones in their secondary science classes.
- Students may express dissatisfaction with the teaching strategies employed by secondary educators.
- Students may recognize a lack of preparation for postsecondary education during their time in secondary school.
- Students may exhibit a lack of understanding of the purpose of science.
- Students may indicate insufficient practice in scientific inquiry during their secondary education.

These assumptions provide a framework for understanding and analyzing the data collected during the research study.

Limitations of Study

- The research participants were recruited in the southern California region only. Therefore, if the research were conducted in other locations, for instance, states outside of California in the United States, there could be different outcomes. In other words, the results from the research study did not necessarily represent perceptions of STEM students from other locations in the country.
- The COVID-19 pandemic widened preexisting achievement gaps, which had a negative impact on all students and their learning during the pandemic compared to the ones who did not experience it. Therefore, the interview responses from the students participating

in the research could be based on their school experience during the pandemic and not prior to it. In other words, the study could show inconsistent results depending on the specific group of participants in the research, for instance, students who attended school during the pandemic only, students who did not experience the pandemic only, or a mixed group from the two categories.

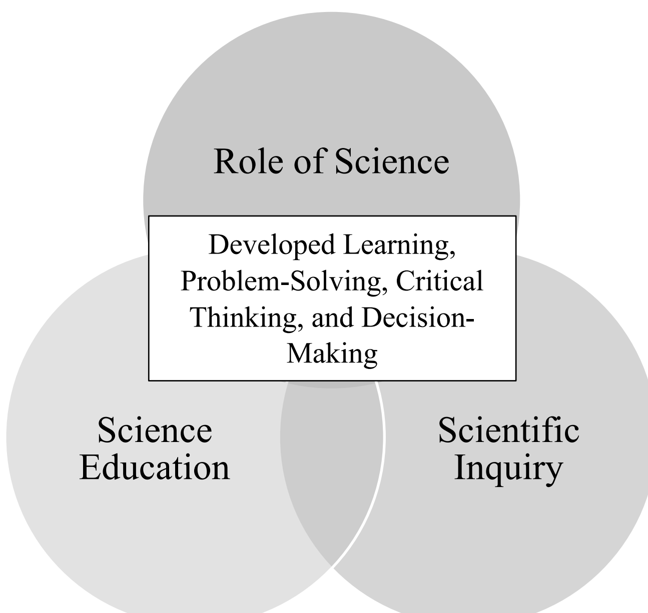
Delimitations of Study

- Students who took STEM courses in both high school and higher education were preferred. However, their criteria for being chosen for the research study were not limited to specific STEM classes they had experience in. Any student with experience in any STEM course in high school and higher education was able to participate.

Theoretical Framework

Figure 1

Three Key Components of Conceptual Framework for Developing Life Skills



Note. Factors contributing to the development of student learning, problem-solving, critical thinking, and decision-making.

The Next Generation Science Standards (NGSS) consists of three dimensions: disciplinary core ideas, scientific and engineering practices, and cross-cutting concepts. These three areas overlap and focus on developing students' understanding and application of content. They also focus on student preparation for college/university and careers (National Research Council, 2013). Just like NGSS, the three components of the theoretical framework overlap. In addition, they support the integration and implementation of NGSS in classrooms. To observe improvement in all three components of the theoretical framework, NGSS must be involved. The framework demonstrates that students understanding the role of science, receiving proper science education, and practicing sufficient scientific inquiry can effectively contribute to the development of their learning, problem-solving, critical thinking, and decision-making.

The Efficiency of Science Education

High school education marks the end of compulsory education in the United States. As students approach graduation, they must contemplate their next steps in life. Some students go straight into the workforce, while others take time off to explore their options. However, most high school graduates choose to continue their education by transitioning into higher education to pursue a degree. Nevertheless, many people find the college/university experience to be challenging due to academic pressure, a lack of structure, and increased independence. It is assumed that high school adequately prepares students for this transition, but there are indications that the system falls short of expectations (Usak et al., 2020).

A survey conducted in 2021 at Grand Canyon University revealed that college/university students think that high school does a satisfactory job of preparing them for higher education (Grand Canyon University, 2021). Approximately 80% of the students expressed that they felt adequately prepared by high school for college/university and adult life. They believed that their secondary education equipped them with the necessary understanding and performance capabilities to succeed in postsecondary-level classes. However, they also felt that high school failed to provide them with essential life skills that could have supported their transition into postsecondary life. Additionally, the students expressed the view that high school should have emphasized the practical application and utilization of the knowledge gained in science classes to improve their life skills (Cooper et al., 2018).

Why Science Education is Necessary

Science is essential in everyday life as people are constantly surrounded by technology and scientific advancements. Governments rely on scientific evidence to make informed decisions regarding public policy. Additionally, the intricacies of the natural world that people encounter daily demonstrate the numerous scientific processes at work. In today's world, children are growing up with advanced technology and science everywhere, therefore, they must be educated on these subjects. They need to learn how to apply scientific knowledge to obtain desired results in real-world contexts (Phillips et al., 2019).

Learning and knowing the scientific method facilitate critical thinking, problem-solving, effective learning, and decision-making skills in students. These skills are essential for all students and should be integrated into the academics and career pathways. Science educators need to ensure they deliver science lessons effectively to ensure their students are equipped with the skills necessary for success in life (Pietarinen et al., 2019).

Role of Science in Students' Daily Lives

Science permeates every aspect of students' daily lives. For instance, when students take school buses to get to school, they encounter multiple elements of science and technology. The school bus is an example of some areas of science and technology including innovation and engineering. Students experience science throughout their bus ride, on the roads, on sidewalks, and when observing lights. These infrastructures are designed and created by planners, scientists, and civil engineers. Students are constantly using their smartphones, yet they may not fully grasp the significance of science behind them. They may have a general understanding but lack a deep comprehension of scientific principles. For instance, while they might be aware that oxygen is needed for survival, they may not realize the role of trees in converting sunlight into stored energy and then producing oxygen, which is crucial for human survival on Earth (Semilarski et al., 2019). Every aspect of a student's life is intertwined with science, whether it is natural phenomena or human-made inventions.

Students instinctively use scientific inquiry to make decisions, whether consciously or subconsciously. The need to solve problems that arises out of necessity is inevitable and can be experienced by anyone. Inquiries involve finding answers to questions posed by problems. In science, experimentalists follow a direct and finite process of inquiry. They formulate a question, develop an explanation based on evidence, connect the explanation to existing information, and share the evidence-based explanation. Similarly, experiments follow a similar process, including formulating a scientific question, developing a hypothesis based on research, conducting experiments to test the hypothesis, analyzing the results, and drawing conclusions (Phillips et al., 2019).

Scientific Inquiry

Scientific inquiry and scientific method are integral components of science education and practice. They underpin every decision-making process in various aspects of life. As humans are naturally curious beings, the scientific inquiry process involves posing questions, developing hypotheses, testing the hypothesis through the use of experiments, evaluating the results to determine if the solution worked, and making sure any future decisions are based on the identified result. This process aligns with problem-solving and critical-thinking skills, which are fundamental in science (Usak et al., 2020). Developing problem-solving and critical thinking abilities is crucial for making informed decisions during and after school.

However, while problem-solving and critical thinking are almost synonymous, high school science educators may not always teach scientific inquiry in a way that effectively promotes these skills. Students need to be able to implement the lessons they learn in science in all aspects of their lives. For example, they should be able to use problem-solving and critical-thinking skills to prove their point whenever necessary. Scientific concepts normally start with an idea and then progress to experimentation, aiming to either prove or refute the idea through the use of scientific techniques and analysis (Semilarski et al., 2019). Science improves critical-thinking skills by providing a logical approach that enables students to connect theoretical and practical work and apply them to their daily lives. Also, it stimulates the intellectual capacity of students, enabling them to perform optimally.

Fosters Understanding of Other Disciplines

As scientific knowledge becomes more intricate, it requires students to develop an understanding of other disciplines to grasp certain concepts. For example, understanding mathematical concepts, such as statistics, can help students in understanding and engaging in qualitative and quantitative analysis. The scientific methodology relies on technical skills, such as conducting controlled experiments and critically studying processes taking place in one's environment (Parno et al., 2020). Presenting scientific findings in reports also serves as a means of teaching students the importance of being thorough and objective in all situations.

Technology plays a pervasive role in all aspects of modern life, including areas such as agriculture, banking, high technology, and medical care. Science education equips students with the understanding necessary to navigate the technology they encounter in their daily routines. This is especially true for future generations whose lives will be influenced even more by technology. Science has the potential to profoundly impact the lives of students in positive ways. For example, smoking rates have significantly decreased because of the science-based interventions presented in schools. Additionally, science can be used to teach students about the health effects of pollutants and excessive drug use, empowering them to make informed decisions and avoid potentially unsafe situations at any time.

Why Has Science Education Not Been Significantly Altered?

When considering why the science curriculum has remained largely unchanged over the past decade, despite the recognized need for change, several factors come to play. Kalogiannakis et al. (2021) stated that a lack of proper teacher education and limited resources are primary reasons for the redundancy within the education system. Despite scientists and educators advocating for the need to change the current system and the development of possible solutions that can be implemented by institutions such as the National Research Council, the government wants to stick with the old, traditional education standards, especially when it comes to science. Most secondary science teachers do not have a background in science and research, highlighting the possibility that the students may not be receiving adequate or sufficient science education (Pietarinen et al., 2019).

Philips et al. (2019) added that the science taught in secondary schools does not effectively guide students to excel in higher education. Students are often taught the basic concepts of science without an understanding of how these concepts were developed or how they may have evolved. Rather than focusing on comprehension and application, students are often taught how to memorize information. They are not taught that science is based on analytic reasoning, logic, argumentation, and experimentation (Philips et al., 2019). Parno et al. (2020) argued that the vast and diverse nature of science makes it so difficult to successfully teach in high school classrooms. Science is related to all entities in this world, meaning that expecting science teachers to provide comprehensive lessons on the subject would be impossible. However, this does not imply that high school students should only be taught lessons that have little relevance to their day-to-day lives. It is essential to provide students with adequate knowledge so that they can learn and thrive in college/university without requiring extra support to learn topics they should have already covered in high school (Semilarski et al., 2019). Postsecondary students have already experienced the rough transition from secondary school to higher education, making them well aware of the gaps that exist between the two levels. Although research has suggested some possible solutions to the issue, it is imperative to engage with those who have experienced the transition from a lower level to a higher level. That way, the changes that need to be made within the secondary science curriculum can be more clearly identified.

Educational Leadership

Educational leadership is based on the principle of developing and applying knowledge through methods that positively impact those involved and the community. It involves collaboration and effective communication with community members to build partnerships and achieve transformative goals. Educational leadership is essential in science as it involves making a connection between theory and the real world to create a comprehensive, evidence-based approach to problem-solving (Connolly et al., 2019). The implementation of educational leadership brings significant benefits to schools, non-profit organizations, and private sector entities. Studies have shown that school principals who implement educational leadership are stronger leaders and have a more positive impact on students and their schools (Connolly et al., 2019). School leaders influence all aspects of their institutions including the curriculum and public perceptions of the campus. Principals with educational leadership create a strong ripple effect throughout the school from the faculty to students plus the community. Educational leadership can be used to change students' perceptions of high school science and STEM for the better by enhancing their academic performance, which can help with their readiness for higher education. Secondary institutions where educational leadership is practiced and advanced science and STEM lessons are implemented have higher rates of student persistence and better student outcomes in these courses (Bush et al., 2019).

Brief Introduction with Key Definitions

Science is part of the daily lives of all students. Some students struggle with the complexities of adult life due to a lack of essential life skills. The gap between secondary and postsecondary-level instruction leaves many students feeling lost when they attend college/university. The high school curriculum fails to provide students with the life skills they need to survive and thrive as adults. Science teachers need to focus on equipping students with real-life skills such as problem-solving and critical thinking. Although not everyone may be interested in pursuing science or STEM, all high school students need to be introduced to STEM classes because they need to be directly addressed with possible real-life challenges and lessons on how to handle these challenges (Kitchen et al., 2018).

Significance of Research Study

The research showed that high school teachers do not have enough information or knowledge regarding college/university course expectations to prepare students for higher education. This study was meant to point out the differences that exist between secondary and postsecondary science education and a possible improvement that can take place in secondary science education for future secondary students. The researcher questioned college/university students about what they found most difficult when transitioning into higher education, the changes they want to be implemented, and the types of information they want high school science teachers to focus on in class. In addition, the research also looked at students' perceptions of:

- Communication and alignment between high school and college/university.
- Building confidence and faith in science and STEM.
- Programs that can help students transition from one level of science and STEM to another.
- High school programming interventions and recommendations for students who want to pursue science and STEM.

With the help of science education, students can gain a deeper understanding of the scientific processes they experience daily and appreciate their significance. Science education enables students to comprehend various scientific topics such as human anatomy and the functioning of intricate systems. This type of information can develop students' understanding of any new ideas presented in college/university, motivate them to make reasonable choices, and ignite their passion in pursuing what they wish to do (Semilarski et al., 2019).

The potential of science to improve the life skills of students and society, in general, is overlooked at schools. Studying science can result in students appreciating the value of disbelief, leading them to question and wanting to learn more about the world. Science allows students to think critically to solve their problems by applying the scientific knowledge they learned in class.

Also, science has the power to transform students' lives, inspiring them to seek more scientific information (Parno et al., 2020). However, it has to be taught well for students to appreciate it. There is a lot of conflicting information on best practices in science teaching, just as there is in other areas of education (Pellas et al., 2019). The research study helped identify topics that appeal more to students and the types of approaches secondary science teachers can use to achieve positive outcomes.

Students have a natural curiosity that drives their desire to learn and seek answers to questions they are interested in. However, natural curiosity is often stifled by the coursework-oriented curriculum in secondary schools. Engaging students in classes and teaching them real-life skills such as how phones work and ways of repairing them when broken can help students connect with the material. Sharing information about topics that students are interested in can foster learning and improve the overall classroom environment (Orishev & Burkhonov, 2021). The researcher in this study specifically investigated the real-life lessons students wished had been incorporated into their high school science classes based on their experiences in higher education.

Chapter Summary

The secondary science education system needs to change to meet the needs of students, as the education system does not effectively teach them how to apply science in a way that improves their lives in college/university. The current science curriculum focuses on going through course materials that take away the joy and passion that can result from learning science. Science needs to be as comprehensive as possible. While it is impossible to teach all scientific topics in high school, students must learn about the items they use in their daily lives, the scientific processes they experience in their environment, and the necessary skills to manifest competence in higher education. The study aimed to establish a standardized approach that can be adopted by both high school and higher education institutions, to ensure students can comfortably transition from secondary to postsecondary with all the academic and real-life skills they need to do so.

Chapter Two: Literature Review

Introduction

Various studies have examined the importance of high school science education and its influence on students pursuing STEM in college/university. Some of the most common themes that emerged within these studies include the importance of previous school science, gender preferences when it comes to certain science subjects, decreased popularity in science subjects, socio-economic factors, and people's perceptions of the importance and relevance of science. Students are influenced by intrinsic and extrinsic factors when determining whether to pursue science or STEM in higher education.

Intrinsic Factors

Intrinsic factors are influences related to students' personal choices and preferences, such as attitudes, interest and engagement, ability, efficiency, self-efficacy, and gender (Ryan & Deci, 2020).

Attitudes

Research has shown the importance of students' attitudes in understanding the decline in students choosing to study science or STEM in higher education (Shin et al., 2017). Extensive research, such as that conducted by O'Hara (2022), reveals that students usually have a positive perception of science when they are young, but their interest begins to fade as they reach adolescence. Many researchers have come to a consensus that high school students' attitudes toward high school science have become increasingly negative (Sáinz & Müller, 2018; Shedlosky-Shoemaker & Fautch, 2015; Sithole et al., 2017). However, York et al. (2019) revealed that the attitudes of Australian students greatly resemble those of Western students from two decades ago, who stated that they enjoyed science subjects. Moreover, a longitudinal study in England revealed that a majority of the 6,500 participating students expressed positive attitudes toward science (Sáinz & Müller, 2018). A quasi-longitudinal study of postsecondary students' experiences in secondary school also showed that students with positive attitudes toward science were more likely to pursue science classes in high school, while those with apathy or negative attitudes opted not to take science courses (Beier et al., 2018).

Perceptions of science and STEM as difficult subjects can influence students' attitudes. Palmer et al. (2017) noted that students perceiving science as difficult, exam-focused, and having a demanding curriculum might lack confidence in their ability to excel in the subject. Furthermore, students believe that an inadequate understanding of science can lead to poor performance on tests, resulting in lower GPAs and a bad attitude toward the subject. High teacher turnover and the frequent absence of teachers perpetuate negative attitudes toward science subjects. Yang et al. (2018) emphasized the need for consistent and reliable science educators in schools to mitigate the negative impact on high school students studying science or STEM. Addressing teacher turnover ensures that students are not adversely affected by teacher shortages and helps maintain a positive learning environment (Sáinz & Müller, 2018).

The high school science curriculum must be carefully planned and executed throughout the academic year to ensure that students have ample opportunity to learn and understand all material. Insufficient preparation of lessons can lead to increased stress for students during examinations. Additionally, the curriculum needs to be structured in a way that aligns with students' comprehension levels. Introducing very complex ideas and concepts prematurely can overwhelm students, leading to a decreased likelihood of choosing elective science classes in the future. Dong et al. (2019) recommended introducing complex scientific concepts only after students have developed a solid understanding of basic concepts. This sequential approach can help alleviate the negative perceptions of the difficulty of science. The attitudes of students toward the subject can also be positively influenced by the creative and enthusiastic delivery of science content by teachers. Teachers can inspire and engage students, nurturing their interest and passion for science (Palmer et al., 2017). Students are impressionable and need to be encouraged and enthused by their teachers, creating an environment that fosters curiosity and an appreciation for the subject.

Interest and Engagement

Roellke et al. (2022) conducted a study that revealed a close correlation between students' enjoyment and interest in science education. The findings highlight the importance of building and maintaining engagement and interest in science and STEM to support students' continued pursuit of science and STEM education at the college/university level. Pew Research conducted an analysis that further emphasizes the significance of fostering engagement and interest in science and STEM among adolescents. A personal interest in a subject is developed through one's understanding and persistence. As students progress through school, they tend to develop special interests in certain subjects, which can ultimately determine their choices of college/university majors and career paths (LaForce et al., 2017). Students tend to discover their interests through activities they excel and anticipate gaining value or fulfillment.

Hsu and Fang (2019) highlighted the significant role of educators in shaping students' interest in science. This means that students' experiences in science classes can help them develop an interest in the subject plus careers in the field. A 2012 study of 116 graduates with science degrees investigated what compelled these individuals to study science in college/university and pursue careers in science (Wyss et al., 2012). The findings revealed that while 45% of the participants had always held a personal interest in science, 40% were influenced by their high school experiences or other education-based activities such as science fairs. Aeschlimann et al. (2016) argued that students’ perception and understanding of their experiences in school and life significantly impact the development of their interest in science. The thoughts, beliefs, and feelings that students associate with high school science help them determine their college/university and career choices.

An interest in a subject, career, life choice, or any other decision is essential in keeping any individual engaged in learning. The importance of interest is clear in many high school science classes in the United States. This holds true for high school science classes, where many students perceive the subject as overwhelming, confusing, and useless information that has little impact on their daily lives or personal goals (Akosah-Twumasi et al., 2018). As students progress through higher grades, their motivation and engagement tend to decline across all disciplines, but this decline is most prominent in STEM classes and further worsens in college/university (McDonald, 2016). A study by Roellke et al. (2022) found that approximately 67% of college/university students in a specific study expressed an interest in STEM. However, only half of these students ended up completing STEM programs. This decline in interest and participation in STEM fields is a major issue, given the ever-growing demand for professionals in these areas that cannot be met by the current number of students pursuing and completing degrees in STEM.

The key to solving the problem of the lack of expertise in STEM fields is to build up and sustain interest. Although raising interest may seem like a simple, straightforward solution, it becomes complicated when considering ways through which educators can assist students with learning high school science, especially when it comes to students who come from certain ethnic groups that are underrepresented in STEM classes (Watt et al., 2017). High school science educators need to support students' interests and increase engagement in their classes constantly. Martin-Hansen (2018) studied the importance of interest in maintaining student engagement in science classes. The study involved more than 200 students from 43 high schools reporting their class experiences in a range of science courses: physics, chemistry, anatomy, biology, and environmental science. Students were required to track their levels of motivation, interest, and engagement during each class for six weeks. The study concluded with students reporting better learning outcomes on days when they were interested in the lessons. On these days, students demonstrated increased effort, paid closer attention in class, and actively contemplated strategies to enhance their learning. They also sought support from their teachers to maintain their motivation (Simon et al., 2015). All the attitudes and behaviors they reported are associated with better learning and academic outcomes. Saturne (2015) illustrated that interest is especially important for students from groups that are underrepresented in STEM. McGee et al. (2016) further emphasized that African-American and Hispanic students, compared to their Asian and Caucasian counterparts, reported that on days when they were interested in the lessons, they were more likely to think about implementing strategies that could enhance their learning in science classes.

If educators fail to assist students in maintaining their interest and motivation, there is a risk of declining interest and disengagement from science classes. Research conducted by Akosah-Twumasi et al. (2018) observed a decline in students' interest over a six-week period. Therefore, teachers need to support and nurture students' motivation to keep them engaged and committed to understanding and implementing the lessons in their daily lives. Chumbley et al. (2022) conducted a study that investigated students' perceptions of teaching strategies and practices used by their teachers. The study examined both traditional strategies and practices aimed at developing students' autonomy. Previous research suggests that when educators create a class environment where students feel encouraged to freely engage with the lessons, they are more likely to feel motivated. The study concluded that students were more engaged and valued the lessons and activities more when their teachers used practices that gave them more freedom (Aeschlimann et al., 2016). These preferred practices were based on activities that incorporated students' preferences and interests and included rationales on the importance, usefulness, and relevance of the class activities.

McDonald (2016) mentioned that when students perceive that their teachers are controlling, they pretend to do their work or do the bare minimum to avoid punishment or any negative emotion that could be triggered in class. Such controlling behaviors can include teachers asserting their opinions as the sole correct viewpoint, limiting students' abilities to express themselves, and implementing activities that students viewed as meaningless (McDonald, 2016). This does not mean that these controlling behaviors are never allowed. They should be allowed when necessary. Martín-Páez et al. (2019) stated that a balance between promoting student independence and implementing necessary control measures could be maintained. Additionally, it is easier for teachers to observe and measure students' increased motivation in autonomy-supported classes compared to control-intensive classes. An interest is related to students' everyday activities including lessons they learn and how they learn them. Educators can use a variety of practices and activities to develop student interest and maintain their motivation in science classrooms.

LaForce et al. (2017) highlight the reciprocal relationship between student interest and teaching practices, emphasizing that student interests can impact the practices used by teachers in subsequent classes. This relationship is especially true for male students who reported increased interest and self-motivation when teachers offered them choices and catered to their interests. This shows that teachers need to study their students and implement more practices that relate to their students' interests in their classes. Martín-Páez et al. (2019 found that positive outcomes were mainly observed among male students, suggesting a potential gender disparity in the motivation and engagement of female students. The lack of attention to female students' interests in science classes may contribute to the underrepresentation of women in STEM fields. It is clear that interest is an essential part of science education and it is an important factor to consider when coming up with solutions to support underrepresented groups in STEM (Isik et al., 2018). Teachers need to support the autonomy and interests of all students, including African-American students, Hispanic students, and female students while developing their interests. That way, a sustainable cycle of student motivation and engagement is created and maintained (Strayhorn, 2015).

Ability, Efficiency, and Self-Efficacy

Students' abilities to perform well in certain subjects are dependent on their attitudes, interests, and self-efficacy. The perceptions of one's ability and capacity to perform or excel in certain subjects influence their academic and life choices. According to Ismail (2018) and Kricorian et al. (2020), students' competence in a subject impacts their achievements and interests. Students who are more likely to excel in science and STEM are those who are encouraged to pay more attention to science in their previous science classes. On the other hand, students who do not take part in post-compulsory science fail to do so because they believe they lack competence in the subject (York et al., 2019). Also, several studies indicate that many students fail to study Physics and Chemistry, especially because they think these subjects are more challenging to receive high grades in. This results in fewer students pursuing STEM in both high school and post-high school.

Self-efficacy, which refers to one's confidence in their ability to produce positive outcomes, also plays a major role in subject selection and student persistence. Students who think that they can complete a science course are more likely to pursue science. Additionally, York et al. (2019) emphasized that students who believe that they can achieve any goals they have in life with a scientific occupation are more likely to pursue science. Widya et al. (2019) further explained that when students perceive that a subject is too difficult for their abilities, they are less likely to pursue the subject. Students' self-efficacy and attitudes toward science influence their decision to continue learning the subject (Wyss et al., 2012).

Gender

Although the trend is changing, traditionally, there have been more men than women studying and pursuing careers in science and STEM. Gender-based preferences are important factors in determining whether students choose science in school. Ismatullina et al. (2022) revealed several factors that contribute to fewer girls studying science and STEM including low self-efficacy, more negative attitudes compared to boys, and viewing science and STEM as "masculine" pursuits. Watt et al. (2013) conducted a comprehensive review of past research on the gender gap in science and STEM, spanning three decades. Watt et al. mention that the issue is complex and yet to be resolved even though several solutions have been proposed. Also, there is a disagreement on genetic differences between men and women being a factor in the lower participation of women in science and STEM. They propose that changes in the teaching strategies used in science classes can increase female participation. The European Commission performed a meta-analysis of the relationship between gender and science, which concluded that the culture in science careers needs to change to encourage more women to participate (Fisher et al., 2020).

González-Pérez et al. (2020) emphasized that male students have a more positive attitude toward science classes compared to female students. Witherspoon et al. (2016) found that female students tend to judge themselves very harshly in male-dominated subjects and occupations, even when they perform equally well or better than male students on standardized exams. Stupurienė et al. (2022) mentioned that female students tend to stay away from occupations such as technicians and engineers even if they have similar interests in science as their male counterparts. When female students decide on whether to pursue a science or STEM career, they are influenced by a combination of perceptions toward the subject, their ability, and qualifications. Women who have a negative attitude toward science may go against studying science (Talley & Martinez Ortiz, 2017). Also, women are greatly impacted by how society perceives them and their abilities, as they are less likely to believe that they can survive science and STEM careers (Watt et al., 2013). Some programs help science and STEM be more appealing to women, however, there is still a disparity between men and women. Therefore, more diversity needs to be introduced to the field (Vennix et al., 2018).

Extrinsic Factors

Extrinsic factors are influences that students do not have direct control over, such as school and home environment. Several themes regarding extrinsic factors include social and economic factors, influential people, curriculum and teaching strategies, career choices and STEM awareness, and the available choice of subject (Ryan & Deci, 2020).

Social and Economic Factors

Both the socioeconomic background and status of students and their schools have an impact on their choice and performance in science. Yerdelen et al. (2016) claimed that students from lower-class socioeconomic families are less likely to choose science compared to those who are from more affluent families. Students from upper-class families interact with many important individuals with science careers including scientists, doctors, and engineers. As a result, they have access to a wide range of options, which can encourage them to pursue and demonstrate competency. They have access to a wide range of options, allowing them to choose from various groups or schools. On the other hand, students from minority groups are adversely affected by social factors, as they are more likely to have less support from their school, family, and community. Disadvantaged students come from minority groups such as African-American and Hispanic communities (Kricorian et al., 2020). Students from such backgrounds get less exposure to all opportunities available to them and are therefore less likely to study non-compulsory science subjects or STEM. Moreover, students from immigrant families that may not be fluent in English are less likely to choose science or STEM compared to native English speakers.

Morgan et al. (2022) suggested that parents' income level and educational background are predictors of the college/university their children commit to, as well as the subjects they choose to study. Roberts et al. (2018) stated that a majority of people who choose to study science, especially physical science, in higher education come from high socioeconomic backgrounds. Studies have shown that socioeconomic background begins to affect student outcomes from very early stages. Wiebe et al. (2018) demonstrated that students' backgrounds greatly affect their performance in science and math starting from the elementary school level.

Pimthong and Williams (2018) argued that schools have certain individual values, behaviors, and attitudes that permeate the school environment and influence how students view learning. Bennett (2005) supported this claim by stating that the ethos implemented in schools, the offered curriculum, school operations, and the career advice and mentorship provided to students all influence their achievements in science classes. Students who attend high schools with a great reputation are more likely to choose science and STEM careers because they are encouraged to do so by their parents and schools. Chumbley et al. (2022) asserted that most decisions students make are predetermined by policies that limit their available choices. Influences play a major role in schools when it comes to choosing science classes and shaping students' experiences in science (Fisher et al., 2020). Additionally, social and economic factors, such as the science curriculum and available teachers in schools, all impact students' decisions.

Influential People

Individuals whom students come into contact with, including teachers, peers, parents, and others from the community, greatly impact student interest and competence in science. Students whose parents are well-educated have a higher likelihood of choosing and excelling in science. Ismatullina et al. (2022) performed a study of more than 5,000 Norwegian students and found that students whose parents had careers in science or STEM were more likely to pursue science or STEM in school. The study also mentions that the way teachers present scientific topics and share their experiences related to the subject influences their students' likelihood of pursuing science. There is no clear picture of how peers impact students' subject choices, however, peers impact other aspects of students' lives, which may indirectly influence their subject choices.

Teachers' Influence. The availability of highly qualified, passionate educators is one of the most important factors influencing students' perceptions of science (Jiang et al., 2022; Kurup et al., 2019; Watt et al., 2013). Numerous studies have examined how teachers influence the interests and academic achievements of students in and out of their classrooms. Aydin-Gunbatar et al. (2018) argue that teachers can help maintain their students' interests and engagement through the methods they use to present the materials or through how they organize their work. This argument is supported by Tekerek and Karakaya (2018), who state that the quality of teaching and the materials being taught are essential determinants of students' experiences and outcomes in science classes and school. Additionally, DeCoito and Myszkal (2018) agreed that the way in which teachers organize and regulate the classroom, the learning approaches, the materials covered as well as maintaining open communication with students all influence students' attitudes toward science (Gardner et al., 2019). Also, students show more interests in learning science through their interactions with their teachers than the content they are presented with in class.

Individual Influence. Individual influences involve factors that shape students' interests, values, and self-efficacy. Although these characteristics are intrinsic, they do not grow in isolation. They are influenced by society and other social constructs such as gender and perceived identity. Moreover, social and cultural influences such as peers and family impact what students perceive as important and determine their attitudes and interests. All these influences are interwoven within students and help guide their decisions consciously and unconsciously. While students ultimately determine which path to follow, their decision-making process is influenced by the individual factors mentioned before. De Loof et al. (2021) state that students' decisions are significantly influenced by their peers, so if peers choose a certain science subject, other students are likely to follow.

Parental and Familial Influence. Students' parents are the first individuals with whom they interact when they are young. Parents teach their children what is important, and their behaviors, occupations, and attitudes toward science impact their children's decision to pursue the subject. Whitehead (2018) illustrated that parents who enroll their children in secondary science classes and provide them with extra support are more likely to encourage their children to pursue postsecondary science compared to parents who do not. Kurup et al. (2019) investigated the importance of parental supervision and interest in students' academic performance and discovered that when parents are more involved in their children's school curriculum and studies, their children perform better and have a more positive attitude toward academics.

Curriculum and Teaching Strategies

While all teachers can influence and advise students on classes and careers they should consider, what influences students' decisions ultimately occurs in the classroom. The quality of teaching and the strategies practiced by educators are important factors in students' subject choices, engagement, and academic achievement. While science is consistently changing, science education has remained relatively unchanged for decades. Science teachers use traditional, transmissive, teaching methods that do not provide modern students with the skills and knowledge they need for their daily lives and future careers (De Loof et al., 2021). Students who perceive science classes as uninteresting or difficult are more likely to develop a negative view of science and STEM, which lowers their interest, self-efficacy, and attitudes toward the subject. Consequently, they are less likely to enroll in science classes and choose science careers.

Scientific experiments and the frequency of students' participation in them are other important factors in science classes. De Loof et al. (2021) stated that students expect to do experiments in their science classes, where they can apply the theoretical concepts they learn. Students' interests in science are likely to go up if they perform experiments and have positive experiences. These findings correspond with Keller et al. (2017), which mentioned that practical lessons lead to increased engagement, although the effect is only short-term. It is important to distinguish between quality experimental work and mediocre experimental work. The purpose of practical experiments is to enhance students' knowledge and help them connect with the content. Therefore, students must be well-supervised to ensure they perform the experiments correctly and maintain proper safety measures to keep them safe both in and out of school.

Makarova et al. (2019) illustrated that students' beliefs in the quality and quantity of scientific experiments decline as they progress through high school. Makarova et al. (2019) also discussed a study where some students reported that the decrease in the quality and quantity of scientific experiments resulted in a decreased interest in science. Many students in the study did not have an opportunity to participate in scientific experiments because they were taught by substitute teachers rather than well-qualified science teachers. In 2015, a study on students' brain activity while observing and performing tasks revealed that students are more engaged and absorb what they are taught when they engage in hands-on experiments (Han et al., 2016). The study showed increased functional activity in areas of the brain associated with better academic outcomes and performance in quizzes and exams. Students' brains retain more information when they are actively involved in lessons, showing the importance of experiments in science.

Beymer et al. (2018) conducted a research study to investigate the aspects of the advanced secondary-level science curriculum that engage and interest students, as well as the aspects that leave them feeling disengaged. The participating students stated that they enjoyed the new and more challenging topics introduced in the advanced science classes, which were lacking in the basic secondary-level science curriculum. The advanced classes provided more detailed explanations and aimed to ensure students clearly understood all the intricacies of the subject matter, rather than focusing solely on the basics. Students who were on a regressive trajectory stated that they disliked certain scientific topics, such as plants and rocks, and argued that these topics were the main reason for their poor performance. Most students agreed that the most interesting and captivating aspect of science classes was the opportunity to conduct experiments, which aligns with the findings of Makarova et al. (2019). Students reported being engaged and motivated during and after participating in scientific experiments.

Another barrier created by the current science curriculum is that it is highly repetitive and test-driven. Some students only study science because they are “decent at taking tests” rather than having any interest in the subject. This overemphasis on exams leads to schools producing uneducated graduates who do not know what to expect in their careers or adult life (Makarova et al., 2019). Makarova et al. (2019) argued that the perception of science being an exclusive field beyond the realm of average individuals is a disservice to the field because it creates a barrier. As science and STEM become more important in the world, there is a shortage of professionals to fill emerging positions. In 2006, England implemented science curriculum reforms that aimed to increase scientific literacy and educate students on socio-scientific issues, creating a more engaging syllabus that connects with students’ lives (Vossen et al., 2020). Students stated that the previous curriculum was disengaging, and they preferred the new curriculum because it was less exam-driven and incorporated both theoretical and practical content.

There is a need to change the current pedagogy in most science classes to meet the needs of the current and future generations. Science plays a major role in students' lives because a large part of their lives is influenced by technology in one way or the other. Siregar et al. (2019) discussed a study focused on the value students place on their phones and computers while doing their schoolwork. According to the study, about 95% of the students felt that they could not complete their work without their electronic devices because they accessed and submitted most of their work through computers. Moreover, students could seek clarification on any questions they had by emailing their teachers. Students need to be scientifically literate because they are growing up in a world that is increasingly technologically advanced.

The science curriculum needs to aim to teach students how to think, learn, and solve problems using scientific methods. This means that science teachers need to be educated on these methods and how to effectively give lessons on them. Science teachers need to know instructional techniques and curriculum designs that are most appropriate for teaching science and improving student learning as a whole. While governmental guidelines are mainly concerned with middle and high school STEM education, educators agree that students' motivation needs to start earlier. Science education provides students with not only problem-solving skills but also a basic understanding of scientific concepts, which engages them with the subject at a younger age. Keller et al. (2017) indicated that children start to form their basic opinion about science immediately when they start going to school. Students who develop a negative opinion from the start find it more difficult to engage with the subject, as they get older. Teachers need to engage younger students with exciting content and experiments to build their interests and motivate them to learn more about science and STEM in the future. Competent science teachers need to be aware of the methods they can use to motivate their students. Science teachers in lower-level science classes need to be extra careful to keep students engaged so that a positive association in students' minds can be created. Science needs to be taught in a way that is relevant to students and can help them learn and apply problem-solving and critical-thinking skills (Wang & Degol, 2017). These skills have the potential to help students in developing ideas, weighing alternatives, making decisions, and determining the credibility of the scientific evidence used to make public policies. The skills developed through science education are relevant not only in school but also outside of school.

A 2019 study mentioned that students are more responsive when their teachers appear to know what they are teaching without having to rely on textbooks, PowerPoints, or videos (Kalender et al., 2019). Teachers need to realize that subject content alone is not the sole important determinant of effective science teaching; the teaching approach also plays a crucial role. Students feel that their science teachers rely too much on information and communications technology (ICT) to deliver their lessons. Students prefer a more student-centered learning approach from their science teachers. They also appreciate science teachers who implement a variety of activities in their lessons, have a sense of humor, and are empathetic about their students' experiences, which lead to a more positive school science experience. Teachers who put in no effort to make science classes fun or engaging, on the other hand, lower students' interest in the subject and motivation in the class (Kalender et al., 2019).

The instructional methods used by teachers directly influence students' interests and learning outcomes. Han et al. (2016) indicated that students become disinterested in science classes when teachers solely rely on copying work from textbooks or videos without relating the lessons to students' real-life experiences. In traditional classes, where teachers are detached from the classroom and have less control, students tend to become disengaged, leading to disruptions as some students resort to inappropriate activities to fill their time. Such types of classes result in limited comprehension of the material and hinder the application of knowledge to real-world contexts, even for students who initially had an interest in the subject. Teachers need to create a classroom environment where all students can concentrate by actively involving students in the lessons and motivating them to keep learning science and STEM in higher education.

Career Choices and STEM Awareness

The subjects that students study during their last year of high school influence their future academics and careers. Mishkin et al. (2016) mentioned that many seniors in high school study science to meet the prerequisites of the college/university they wish to attend and maintain their career choices. Studying science and STEM in high school is an important step if students wish to pursue STEM-related careers. Russell et al. (2018) stated that most students who study physics in high school do so because they recognize the subject's relevance to their future studies or the importance of physics in their career choices. However, Jiang et al. (2022) emphasized that high school science may not be appealing to some students because they lack awareness of the diversity and nature of science careers. Stereotypes associated with science and STEM careers, which are viewed as challenging and isolating, as well as the image represented in the media, can influence students' decisions. Many scientists suggest the need to further broaden students' knowledge of the relevance of a science degree and a better understanding of what science careers entail to positively shape how students perceive careers in the science field (Nawawi et al., 2021).

STEM education provides students with a variety of skills that make them more appealing to future employers and ready to meet the demands of the current labor market. Each aspect of STEM gives learners a different component that contributes to giving them a well-rounded education. Through science, students learn about the world and it helps them understand the different aspects of life. Technology equips students with the technical skills they need to perform efficiently in a high-tech and innovative world. Engineering imparts problem-solving skills and the ability to apply knowledge to develop innovations. Mathematics gives students the ability to analyze information, identify, and eliminate errors and make the most appropriate decisions when designing solutions to issues (Herges et al., 2017). STEM education incorporates all these disciplines, creating a cohesive system that produces professionals capable of driving societal change through sustainable solutions and innovation. However, many students fail to recognize the myriad of benefits they can gain from studying STEM and pursuing STEM careers (Russell et al., 2018). Studying STEM opens up the mind and helps students get acquainted and comfortable with a variety of subjects and fields.

The approach used in STEM increases creativity and fosters divergent thinking while teaching fundamental disciplines. STEM inspires the youth to generate new ideas and technologies. However, STEM classes are not available to anyone as students who learn STEM in high school are more likely to pursue STEM in college/university. Also, some schools are not capable of offering STEM classes because of the lack of funds, lack of STEM teaching professionals, or lack of knowledge about the benefits of STEM (Rottinghaus et al., 2018). Students learn through inquiry-based assignments as STEM education focuses on practice and innovation. STEM education provides students with an understanding of concepts and encourages them to apply that knowledge. The STEM approach mainly involves two major actions; explore and experience. Students are allowed to implement what they learn and put theoretical concepts into practice. When they make mistakes, they are not condemned but encouraged to learn from these mistakes and grow (Nawawi et al., 2021). Problem-solving skills and project-based learning help learners develop a more advanced mindset, preparing them to respond to any challenges they encounter in real life.

The purpose of STEM education is to prepare students for the future. The STEM approach encourages teamwork and professionals from different disciplines to collaborate to develop innovative solutions to problems. STEM students do not need to be experts in every subject. They develop a mindset that allows them to work as part of a very qualified workforce to allow seamless collaboration. Professionals from different fields of expertise all work together and use their different skills to develop cohesive solutions. Teamwork increases the productivity, profitability, and work satisfaction of everyone on the team (Akram et al., 2017). Every member of the team is responsible for a certain aspect of the project such that no one individual gets overwhelmed with extra work. Engaging all experts from diverse fields and ensuring they remain active drives change through society. STEM education introduces students to the proper way to maintain interdisciplinary communication to ensure they can perform efficiently when they enter the workforce. A group of scientists perform research and experiments to explore unknown phenomena and make discoveries together. Technology experts develop gadgets that their teams can use to increase efficiency. Engineers provide answers by designing and implementing possible solutions through developing prototypes. Mathematicians analyze all information presented, identify, and eliminate any mistakes to deliver precise calculations. With STEM, the world is consistently changing (Herges et al., 2017).

The COVID-19 pandemic showed just how fast the world could change as many students quickly transitioned into remote learning. STEM professionals worked to get the world moving through the development of new technologies and measures to protect all individuals. They collaborated to keep everyone safe and ensure students could still learn from their homes. STEM and its approach to teaching and learning must be used to improve collaboration and communication among different fields (Cuomo & Roffi, 2022). STEM students can learn directly from STEM professionals through projects and programs. These collaborative experiences can help broaden the impact of STEM education by showing students exactly what they are working toward and providing them with the skills they need to thrive. Schools can work with local and international experts to promote the reach of STEM programs to improve communities and societies by offering employment and educational opportunities (Vennix et al., 2018). Educators need to further broaden the knowledge they have and work with STEM professionals to provide students access to global experiences and information.

Social Awareness. Skills gained in STEM are in high demand in today's society. STEM allows anyone to decide which subject fits them the best among the four subject areas presented in STEM education. After learning each area of STEM, students can decide which one to pursue based on their interests. Additionally, STEM is an essential tool in any job students wish to pursue in the modern world, as all employment opportunities require the use of science and technology from working at a grocery store to running a company (Rottinghaus et al., 2018). STEM education allows students to enter the work environment as active individuals who can promote progress, take part in STEM discussions with sufficient knowledge, and participate in and offer suggestions and solutions.

STEM awareness raises student interest in a variety of careers. There are currently STEM careers that are understaffed. Schools can produce future competent STEM professionals for these areas by working with professionals who can empower students to venture into the STEM field. Projections show that the U.S. will require more than one million more STEM experts in the near future to meet the demands of the future workforce (Akram et al., 2017). Many STEM initiatives aim to encourage the incorporation of more women and minorities into the STEM workforce. The disparities and developed initiatives to mend the gaps and encourage diversity and equality are identified (Akram et al., 2017). More parents, students, and educators need to participate and engage themselves in school activities to encourage technological and scientific progress.

Available Choice of Subject

High school students are required to choose subjects they want to study from a variety of subjects, which leads to fewer students choosing to learn science. How the classes are scheduled can also impact students' subject choices because of conflicting schedules. Shahali et al. (2016) demonstrated that some students fail to choose science subjects because of the restrictions of the schedule. Moreover, some schools do not offer all science subjects. Fisher et al. (2020) conducted a study of 220 Australian high schools and discovered that 44 of the schools did not offer biology, chemistry, or physics for seniors and approximately 4% failed to offer all three subjects.

Most high schools in the United States are required to offer basic life science classes such as biology and physical science classes such as physics and chemistry. In many cases, these classes include laboratory components that allow students to perform experiments that allow them to apply the concepts they learn. Most states require high schools to offer at least two to three years of science coursework. Schools usually offer Earth or space science, chemistry, physics, and biology classes typically with Advanced Placement (AP) options (Lee et al., 2018). However, some students only meet the minimum science requirements and fail to consider advanced classes or higher education science. It is up to the school and teachers to motivate students to stay engaged and interested in science and STEM through interactive classes and consistent encouragement by building up students' confidence when they perform well (Bolkan, 2015).

The American high school curriculum is designed to focus on science as a major core subject for students to learn. The increasing popularity of STEM classes and careers has raised the number of schools that offer STEM (Lee et al., 2018). As students become more familiar with subjects such as chemistry and physics, students are becoming more enthusiastic about courses that they would not have previously considered. Social awareness of the importance of STEM has led to more students choosing to pursue STEM in high school and college/university. Science and STEM careers are becoming less exclusive to certain social groups and genders as diversity is promoted and encouraged (Kotkas et al., 2017).

Technology

Science gives students basic ideas of exactly how technological devices work. Science teachers can give lessons where students not only learn the theoretical process of creating devices but also where hands-on experience is involved, for example, disassembling a device and then assembling it. This can help students develop new ideas, which can result in new inventions that can help improve society today or in the future—learning how instruments such as microscopes and telescopes work allows students to evaluate equipment and understand their operational differences. Such fundamental knowledge of how technology works can also help students fix minor issues they encounter at home. Most college/university students do not have disposable income to buy new equipment or have broken technological devices such as phones fixed (Semilarski et al., 2019). Learning how to solve some of these problems can lead to major improvements in their lives and adulthood.

High School Science Impacting Students' College/University Course Choices and Careers

High school students with a solid knowledge of STEM are more prepared for work opportunities in the workforce, as they are more likely to choose higher education courses that also focus on these subjects. The U.S. Department of Labor claims that by 2025, most of the fast-growing occupations will require efficiency in STEM, and more than half of them will require a bachelor's degree or higher. The number of students who enroll in STEM at college/university has been steadily rising from 303,000 in 1975 to almost 668,000 in 2015 (Orishev & Burkhonov, 2021). However, of the 668,000 who enrolled in STEM, only 331,000 of them graduated with STEM degrees, which is less than half. Some students do not have the skills they need to complete a STEM program in higher education successfully because they were not well-equipped in high school.

National data from the American College Testing (ACT) showed that only 43% of the 2008 high school graduates who had taken the ACT were ready for college/university-level mathematics, and only 30% were prepared for college/university-level science. Policymakers have expressed concerns about the level of preparedness for postsecondary STEM classes and disparities among students who do participate in STEM (Kitchen et al., 2018). Some students do not have the opportunity to take STEM classes that would allow them to pursue future STEM courses and careers. According to a study conducted in Florida, United States, African-American college/university students are less likely to be ready for postsecondary mathematics compared to other students (Kitchen et al., 2018). Additionally, only 15% of students who finished the three core sciences (chemistry, biology, and physics) in high school met the college/university readiness standard (Dulosa et al., 2019). Individualized procedures are not used in high-stakes science tests required by municipalities, states, and the federal government. Students are required to perform comparable timed exams in the same setting under very strict limits that show little similarity to the personalized learning enabled by Common Core State Standards (CCSS) and Personalized Learning Plans (PLPs). Many higher education institutions demand these standardized examinations for acceptance. While some school boards and administrations have welcomed individualized learning strategies, others are hesitant to abandon standardized test preparation since the results of such exams are used to publicly judge the school. Pellas et al. (2019) revealed that the emphasis on high-stakes testing results in a narrowing of the material taught, with content delivered in isolated chunks that primarily focus on standardized tests. This teaching-to-the-test approach to education runs counter to generating deep and effective learning in science (Dulosa et al., 2019). Pellas et al. (2019) also emphasized the dichotomy of meeting specific requirements versus teaching-to-the-test, stating, "Educators are increasingly being urged by 'experts' that they should be inventive and push our children to study and think critically" (p. 329). Teachers are reminded that their job security depends on their students' exam performance and that the rules made by the government oblige them to manage a curriculum that they did not choose. Traditional schools have been increasing emphasis on STEM; however, some states have established STEM high schools that encourage and support students who wish to take STEM classes. There are two types of STEM high schools, selective and inclusive. Selective STEM schools require students to meet strict standards and motivate them through advanced curricula, advanced laboratory equipment, and more opportunities offered to develop. Inclusive STEM schools are more open to the diversity of students and may choose to focus on offering classes to underserve them with the belief that they can develop skills in STEM if they are given the opportunity to do so (Kitchen et al., 2018).

Multiple educational changes have placed a focus on Common Core State Standards (CCSS) and proficiency-based education. Even though science is one of the three building blocks of education (together with reading and writing), there is still a high need for research on college/university preparation. The skills acquired in higher education courses are more likely to be used in the actual world (Wood & Bhute, 2019). According to Patel et al. (2020), science is important since it applies to many topics and assists individuals in resolving difficulties and critically assessing living conditions. Patel et al. (2020) also highlighted that educators are failing to deliver adequate science education and revealed two major themes, which could be utilized to improve science curriculum and instruction: assuming too early and students' perception and communication. Respectively, the two themes discuss science educators’ proclivity to impetuously believe that their students are prepared for higher education and the lack of information from the perspectives of students. According to Kurniawan et al. (2018), science is a balance between concrete and abstract, inductive and deductive reasoning, and fact and interpretation. Research has shown that students who study higher-level science in high school perform better in college/university and the workplace and that standards in high school and higher education need to be aligned to help bridge the academic gap.

As different types of high schools use various educational approaches to teach their students, it is difficult to evaluate which type of schools produces more STEM-competent students and why this may be the case. However, a recent study disclosed that STEM schools are valuable to students overall as they increase college/university readiness for science and have improved the diversity of students who study STEM in high school and higher education (Scott-Parker, 2019). Research on the role of STEM schools has also revealed that STEM schools and programs that focus on real-world applications and project-based learning such as the pre-engineering Project Lead The Way (PLTW) program equip students with the skills they need in college/university engineering classes and life in general (Scott-Parker, 2019).

Difference Between Traditional and Next Generation Standards

According to National Research Council (2013), there is a significant difference in instructional delivery between educators who follow NGSS and those who use a traditional model of teaching. NGSS utilizes crosscutting concepts, science and engineering practices, and disciplinary core ideas together to make sense of natural phenomena. Also, the purpose of it is for students to understand, build, and apply concepts in a coherent manner. National Research Council (2013) stated that if educators use a traditional model of science instruction, there is a lower probability of creating a highly effective classroom. This is because the traditional method of teaching is outdated. In addition, it does not involve enough developing skills in remembering, understanding, applying, creating, analyzing, and evaluating (National Research Council, 2013). Outdated teaching ultimately results in less engagement; therefore, students' overall views of STEM worsening are inevitable.

According to National Research Council (2013), NGSS focuses on coupling practice with core ideas. Traditionally, the two dimensions, practice and core ideas, were taught separately and sometimes, practice was not taught at all (National Research Council, 2013). This was shown to be neither helpful nor useful since in the real world, STEM is a combination of practice and core ideas. Practice alone is the application of content, and a core idea alone is memorization. Therefore, if practice is coupled with core ideas in classes, science would make more sense to students and allow them to apply the learned material effectively (National Research Council, 2013).

Sustainable Solutions in STEM

STEM disciplines focus on providing solutions to societal and global issues. Natural resources are consistently being exploited to the point of exhaustion. Therefore, the rest of the planet needs to be preserved and the resources that have been overexploited need to be replenished. People's disregard for proper resource utilization stems from a lack of education in environmental science (Beymer et al., 2018). The issues associated with environmental degradation impacted not only the health and future of people but also that of all organisms on the planet. It was essential to implement environmental protection measures. STEM professionals put all their effort into developing sustainable solutions to decrease the impacts of environmental degradation and develop solutions to restore impacted areas through reforestation or other measures (Beymer et al., 2018). During the COVID-19 pandemic, scientists, researchers, technology experts, and medical professionals all worked together to develop measures to protect all people. Multiple telehealth gadgets were invented to decrease pressure on health professionals and protect immune-compromised patients who could not safely leave their homes. Additionally, science allowed the development of at-home testing kits and vaccines. However, due to the lack of proper understanding of vaccines and health protocols, some people refused to get vaccinated for fear of the side effects that may arise. Others refused to wear masks, fearing that they would cause diseases or impair their ability to breathe (Brewster et al., 2020). All students should be given the choice of whether to study STEM to increase scientific awareness in the community.

The impacts of STEM awareness were clear through the increase in climate change awareness among the younger generations. Statistics showed that 70% of people aged between 18 and 34 were concerned about global warming. STEM consistently worked to increase awareness of the steps that individuals can take to decrease their negative impacts on the planet

(Kotkas et al., 2017). STEM education could help answer students' questions and help them make environment-friendly differences in their homes and communities. It could teach them how to find new sustainable solutions for the issues present in their communities. STEM education is essential in producing a STEM-literate community that can work together to develop solutions to problems caused by the lack of information and innovation. STEM has the potential to allow future generations to use practices that cause little to no harm to nature. The environment plays a major role in the economic and social progress of a society. A multidisciplinary approach could help students leverage all the skills from STEM to improve the natural world.

Chapter Summary

Research on science and STEM education showed the importance of developing science and STEM education and how educators go about teaching their science and STEM students. The research explored within the literature review shed light on the manners through which students learn and the ineffectiveness of the traditional method of teaching. The literature discussed teachers needing to personalize the lessons to each of their students' learning styles and avoid relying only on testing (Pellas et al., 2019). Also, it mentioned teachers needing to devise unique methods for each student to show mastery in project-based learning, which allows for several forms of teaching and learning. Students are more responsive to teachers who help them connect with the material and directly engage them in lessons through experiments. Furthermore, science cannot be taught to simply answer questions on quizzes and exams. The primary objective of science and STEM education is to challenge students to interact with the material and apply it when necessary. It is not fully beneficial for students to spend most of their time memorizing information taught in class. Instead, developing and presenting solutions to problems that arise either in classes or outside of academics are the goals. The problems do not need to have "right answers" to allow students to expand their minds and explore solutions and alternatives they may never have thought of (Lamb et al., 2012). Students being encouraged to work in teams and collaborate to make decisions and solve problems is also important.

Science presents a myriad of opportunities and benefits to the lives of students. The literature emphasized science classes needing to promote the application of absorbed knowledge and information. The NGSS model, which is an updated science education model, can be used to give students the confidence and ability to enact change in their neighborhoods or communities (Findley-Van Nostrand & Pollenz, 2017). Developing students' evidence-based critical thinking through the use of scientific methods also increases students' competitiveness and allows them to pay attention to their work. It is important to help students connect with the material by using interactive lessons, involving adult volunteers such as chemists, physicists, or biologists to empower, encourage, and teach students, and incorporate technologies that students use regularly or used during the COVID-19 pandemic to expand their learning outside the classroom.

The literature illustrated that students from disadvantaged groups who may not believe that they can pursue science or STEM also need to learn the importance of these subjects just as much as students from other groups. The purpose of education is to expand the opportunities available to students. However, as different types of students are subjected to different schools and types of learning, the disparity among students increases. Students from lower socioeconomic backgrounds may struggle to put all their effort into school because they lack the confidence to pursue subjects in which they may excel. Also, they are not given equal opportunities as others due to the disparity among students widening. This negatively affects their ability and motivation to pursue STEM.

Chapter Three: Methods

Brief Introduction to Study Purpose

This chapter discusses the research methodology used to study the importance of science education to students' academics after high school based on the experiences and views of college/university students. Phenomenological research is a type of qualitative research approach that aims to comprehend and portray the lived experiences of people. This approach was used to investigate the everyday experiences of people while removing any biases and preconceived assumptions about the world or phenomenon under study (Creswell & Poth, 2016). During the study, the phenomenological approach allowed a deeper understanding of what college/university students believed was beneficial in high school science classes, their thoughts on the existence of gaps between secondary and postsecondary, and their recommendations on the lessons that must be added to the secondary science curriculum to improve higher education preparedness for current or future high school students (Zajda, 2020). The research approach, method, data collection, sample selection, research process, data analysis, and ethical concerns are all discussed in this chapter.

Positionality

The study was conducted by an Asian male with an upper-middle-class status. Therefore, the researcher only had access to perspectives from individuals with the same socioeconomic class, race, and gender were understood. Furthermore, to eliminate biases and explore perceptions of individuals who come from different backgrounds, a diverse group of participants with different social classes, races, and genders was included in the study.

Restatement of Research Questions

The point of the research was to discover any improvement that could be made in the science curriculum such that it could equip high school students with the qualities necessary for competency in their adulthood. The research questions answered by the study were:

- RQ1: What areas of the science and STEM curriculum do college/university students feel were lacking in high school classes?
- RQ2: What amendments do college/university students think should be introduced into the STEM curriculum to acquire the skills needed to readily complete STEM college/university programs and choose STEM as their career choice?

Research Methodological Approach and Study Design

The phenomenological approach is appropriate when the research goal is to provide an explanation for certain phenomena through collecting and analyzing data based on people's experiences of a situation. As stated by Gill (2020), a qualitative approach is necessary when the researcher aims at understanding the correlation between certain variables. Therefore, a phenomenological approach was the most appropriate for the study as the purpose of it was to learn the perceptions or experiences of college/university students on high school science and STEM courses.

Human Subjects' Considerations

Conducting research involving human subjects requires responsible practices to ensure social science development and protect human health and welfare. Compliance with regulations alone is not enough; the researcher must have a deep understanding of the regulations, critically review the available sources on research conduct, and contemplate what constitutes an acceptable study. Before conducting research on human subjects, the researcher completed the human subject-training course via the Collaborative Institutional Training Initiative (CITI) Program, which provides training courses for human subject research to colleges/universities as well as health care organizations and governmental agencies (Appendix A). Some of the factors that were considered before conducting the study included the potential risks and benefits and the most appropriate methods of conducting research involving human subjects and ethical considerations (Linfield & Posavac, 2018). All ethical and regulatory responsibilities were considered and the researcher worked to meet all of them to protect the privacy and welfare of the study participants. In addition, the study was designed to minimize risks to the researcher and the subjects involved and protect the participants' identities (Arifin, 2018).

The researcher had the responsibility of ensuring all participants in the study gave informed consent, freely and with a complete understanding of the risks and benefits of the research. The Belmont principle was followed before collecting any data from the subjects. For example, the Belmont principle of respect for persons states that researchers must take all measures to maintain the participants' privacy, keep all data confidential, and obtain informed consent (Hasan et al., 2021). Federal regulations exist to protect the rights of human subjects, and researchers who fail to meet these requirements face consequences. Therefore, the researcher worked diligently to meet all the regulations, including basic and additional elements, general requirements, and documentation of informed consent. These regulations ensured that subjects had the right to make their own choices with access to all available information (Rasi-Heikkinen, 2022). As evident in Appendix B, all participants were provided with information regarding the type of data to be collected and the methods used to secure their private information. In addition, all participants were informed of the gist of the research study through the recruitment form (Appendix B).

IRB Category of Research

The Institutional Review Board (IRB) must review all research projects that require the involvement of human subjects before any data collection procedures can take place (BrckaLorenz, 2023). The IRB reviewed the content of this study to ensure compliance with the requirements and approve prior to initiating research. The study was conducted only after meeting the specific regulations and requirements set by the IRB (Gautham & Pearlman, 2021). All considerations related to human subjects were incorporated into the study before seeking IRB approval, as indicated in Appendix C.

The research study involved minimal risks to participants. In accordance with the revised Common Rule, which was passed on January 21, 2019 (Wolcott & Lobczowski, 2021):

- The research was conducted in established educational settings where students attended regularly for their academics (Sabati, 2019). The research did not adversely impact the students' learning opportunities or alienate them from educational content in any way.
- The research involved interviews or observations of behaviors whether they were in-person or online as well as the use of audio recordings (Gautham & Pearlman, 2021). All the information was recorded in a manner that the participants could not be identified directly.
- Disclosure of any information given by the respondents did not place them at risk of criminal or civil liability or damage to their financial standing, education, or reputation.
- Information obtained from the data recorded by the researcher was linked to relevant participants using pseudonyms to protect their identities and to ensure adequate provisions were made to protect the subjects' privacy and confidentiality (Johnson et al., 2020).

Data Sources

Primary data sources were used to obtain data for the research study. Primary data was collected from the original source, meaning it was extracted directly from the point it originated from. It was the researcher's responsibility to tailor the primary data source to the particular needs of the specific study, which allowed for a focused approach to a certain phenomenon. This type of data source is depended on the aims and objectives of the population as well as the sampling methods used (Kostrub & Ostradicky, 2019). During the study, primary data was collected using semi-structured interviews, which provided the researcher with an opportunity to gather detailed information about the study participants: their habits, thoughts, and experiences (Zajda, 2020). Quality phenomenological research requires the researcher to immerse themselves in evidence of the phenomenon itself (Gill, 2020). Therefore, no secondary data was necessary and only primary data was utilized for the research.

Selection of the most suitable data source and collection method was a challenging process as there were many options available to the researcher. It is important to understand all the features and characteristics of the research and its methods before deciding what should be used (Wilson et al., 2022). After understanding the types of research, the researcher easily identified the approaches and methods suitable to the aims and objectives of the study.

Population and Sampling Processes

The study aimed to investigate the perceptions of college/university students. A sample size of 10 college/university students was drawn from a population of undergraduate students residing in southern California. They had completed and graduated from high school and were continuing their education in the United States. The selected college/university students were full-time students and the age range was from 18 to 25 years old. All participants were fluent in

English and provided accurate and detailed data for the research. No non-native English speakers were selected. All participants had studied science in high school and transitioned to higher education after graduation. The participants were not limited to the specific college/university courses they studied. However, students enrolled in postsecondary STEM courses were preferred as they could provide more relevant and significant information for the research study.

Two research participants were recruited at AB Church, one was recruited at the University of Southern California, four were recruited at Fullerton College, and three were recruited at California State University-Long Beach. They were each given the researcher's contact information as well as the completed recruitment script, which is presented in Appendix B. When the participants agreed to take part in the research, they contacted the researcher. Then, they were asked to fill out a consent form as presented in Appendix D. The consent forms were sent out electronically via an instant messaging social platform called Discord. All research participants' identities were kept strictly confidential. The college/university students who decided to participate in the research study were asked to respond to semi-structured interview questions as presented in Appendix E. The questions were sent out a week prior to starting the interview, whether it was in-person or virtual. As a result, the students seemed more comfortable and prepared when responding to the questions. The sampling pool of 10 participants was limited to college/university students who fit the definition of the study. Also, demographic diversity within the group of 10 participants was incorporated.

Data Gathering Instruments/Tools

The data-gathering tool used in this research was semi-structured interviews. All interviews took approximately 45 minutes or less and occurred in a private one-on-one meeting.

Both in-person and virtual options were available for all participants who agreed to take part in the research study.

One-on-One Semi-Structured Interviews

Table 1

Semi-Structured Interview Protocol

Interview Questions
1. At what grade in high school did you start taking STEM or science classes?
2. If available, which advanced science classes were offered at your high school (biology, chemistry, physics, environmental science, etc.)? If unavailable, please list the advanced science classes you wish your high school offered.
3. How was your experience in your first college/university STEM course different from what you initially expected?
4. What kind of information, in regards to science classes, did you exchange with your classmates, friends, or teachers at your high school?
5. How well did high school STEM or science classes prepare you for a STEM degree program in higher education?
6. What were some of the advantages, as a result from taking STEM or science classes in high school, you experienced in college/university?
7. In what areas were the STEM or science classes in high school lacking based on your college/university experiences?
8. What is some information or knowledge that you wish you gained in high school science classes before deciding on your major at college/university?
9. In your experience, did your gender significantly impact your choice or opportunity in any way to take additional STEM or science classes in high school?
10. What are some changes that high school administrators should implement in the STEM or science classes to motivate more future college/university students to join the STEM field?
11. What are some changes that high school administrators should implement in the STEM or science classes to persuade high school students to believe that learning STEM can significantly help them succeed post-high school?
12. What are some changes that high school administrators and educators should implement to increase their students' confidence in STEM or science?

Interview Questions
13. If you are aware of any, please list and discuss any programs or resources that helped students prepare for their future STEM or science classes at your high school.
14. Which skills gained from high school science education helped you prepare to be independent in college/university?
15. Please share any recommendations that you might have on the most effective way to implement change in high school STEM or science curricula.

A semi-structured interview takes place in a meeting where the interviewer asks open-ended questions instead of using an approved list of questions (Wolcott & Lobczowski, 2021). This interview format promotes two-way communication. Therefore, it is an effective way for the interviewer to develop their pre-determined questions and probe follow-up questions during the interview process. In other words, it allows the interviewer to stray from the pre-determined questions and ask other questions that are also appropriate for research. Overall, the semi-structured interview led to detailed discussions regarding the research topic and deepened the exploration of the participants' perceptions. Also, the participants were more engaged in the semi-structured interview since the format allowed flexibility and was similar to having a normal conversation (Wolcott & Lobczowski, 2021).

Interviews are designed to gather information as well as the respondents' behavioral traits to ensure they align with the answers they give. One-on-one interviews are most effective when they are issued by the researcher who can work directly with the participants and use strategic questions to gather relevant information. As shown in Appendix E, there was a total of 15 semi-structured interview questions. The in-person format was given as one of the options to the research participants since it is similar to normal communication, which elicits more relevant information and is easier to track (Anzaldúa, 2020). Also, when the interviews were conducted in person, it allowed the researcher to gather not only verbal but also nonverbal communication.

Gill (2020) argued that the importance of observing nonverbal communication is that it allows the researcher to align the responses with the respondents' behavior. The virtual option was also available for the ones who preferred answering the interview questions at the convenience of their home or if for any reason, they could not attend the in-person meeting and had to reschedule. As a result, the individual interviews, both in-person and virtual, helped the researcher gather efficient answers without participants going on tangents or veering away from the questions. The researcher was responsible for keeping time and ensuring the questions were answered appropriately because failure to follow the guidelines could result in decreased efficiency and an inability to gather correct data (Gill, 2020).

Reliability and Validity of Instruments/Tools

The research questions were aligned with each of the interview questions as well as topics discussed in the literature review to certify reliability. Once the interviews were conducted, the researcher confirmed that the interview responses contained data aligned with the research questions plus literature to further safeguard reliability.

Table 2

Relevance of Semi-Structured Interview Questions to Research Questions and Literature Review

Interview Questions	Research Question(s)	Literature
Q1	RQ1, RQ2	Curriculum and Teaching Strategies, Available Choice of Subject
Q2	RQ1, RQ2	Curriculum and Teaching Strategies, Available Choice of Subject

Interview Questions	Research Question(s)	Literature
Q3	RQ1	High School Science Impacting Students' College/University Course Choices and Careers
Q4	RQ2	Influential People
Q5	RQ1, RQ2	High School Science Impacting Students' College/University Course Choices and Careers
Q6	RQ1, RQ2	Career Choices and STEM Awareness
Q7	RQ1	Curriculum and Teaching Strategies
Q8	RQ1, RQ2	Career Choices and STEM Awareness
Q9	RQ1, RQ2	Gender
Q10	RQ2	Interest and Engagement, Curriculum and Teaching Strategies
Q11	RQ2	Interest and Engagement, Curriculum and Teaching Strategies
Q12	RQ2	Ability, Efficiency, and Self-Efficacy, Available Choice of Subject
Q13	RQ1, RQ2	High School Science Impacting

Interview Questions	Research Question(s)	Literature
		Students' College/University Course Choices and Careers, Career Choices and STEM Awareness
Q14	RQ1	Interest and Engagement
Q15	RQ1, RQ2	Interest and Engagement, Curriculum and Teaching Strategies

It is essential to ensure the reliability and validity of all instruments used in research (Kamaruzaman et al., 2022). Reliability refers to the instrument's ability to produce similar or the same results consistently. Validity refers to how accurately the instrument can measure what it is supposed to measure. The reliability and validity of qualitative research are dependent on what the researcher hears and observes. According to Kamaruzaman et al. (2022), establishing the validity of an instrument requires the data gained to be transferable, dependable, and credible and needs to be confirmed. One way to measure the validity of an instrument during the study was ensuring the research participants who were being interviewed had the experience and knowledge necessary to answer the interview questions posed by the researcher.

A method of establishing reliability is to ensure the researcher does not possess any biases. The researcher understood the data in an unbiased manner to ensure reliable and replicable data were delivered. All interviews were audio recorded and transcribed using a software program called Otter.ai. That way, the researcher could refer to the content of the interview for data analysis. As suggested by Parker (2019), a constant comparative analysis was utilized to ensure systematic comparisons could be made and to identify any pattern that exists across extracted codes from the data. Constant comparative analysis helped ensure the credibility of the study and its findings as the data used to make conclusions could be double-checked using the codes (Sürücü & Maslakçi, 2020). Another factor that confirmed the credibility of the conclusions of the study was providing sufficient data. During the study, much data were gathered, recorded, and analyzed to develop a theory and credible solutions to the issue under investigation. Andrade (2018) stated that a research study needs to give adequate data to increase its credibility and validity.

The introduction of bias to the study and its findings was minimized in a number of ways. Kamaruzaman et al. (2022) suggested that clear rules should be set and followed to decrease any bias present in the research. All interviews were audio recorded using an iPhone mobile application called Voice Memos and prevented any addition or exclusion of data provided by the participants (Kutnjak et al., 2019). Also, when coding the interview responses, the interpretation of the data was kept as objective as possible thereby limiting bias. In addition, the use of notes taken during the interviews allowed the researcher to remain accountable and keep track of the findings that emerged from the study.

Means to Ensure Internal Study Validity

Internal validity refers to the accurate measure of answers to the research questions without biases (Li & Frank, 2020). It also helps the researcher rule out any other reasons for achieving certain results. Confounding refers to a condition where a variety of factors interferes with the research outcomes (Kiger & Varpio, 2020). Internal validity and confounding have an opposite correlation such that the higher the internal validity of a study, the lower the chances of confounding (Kiger & Varpio, 2020). Therefore, the researcher ensured internal validity by determining if there were any biases within the findings (Patino & Ferreira, 2018).

Data Gathering Procedures

The study used semi-structured interviews to gather information from college/university students. All of the researcher's thoughts before and after every interview were recorded through notes. All of the interview responses were recorded through an audio recorder (Parker, 2019). In both in-person and virtual interviews, an audio recording application called Voice Memos was used. The interviews began with open-ended questions about the participants' high school curricula and subjects they liked most as well as whether these interests influenced their choice in careers. The more in-depth questions were asked following the open-ended questions. This was to gather comprehensive data on the impact of high school science education. The interviews ended with more open-ended questions. The participants were also asked to discuss any recommendations that could contribute to improving the experiences of future secondary students who will later transition into higher education. None of the interviews was conducted without verbal or written confirmation of the participants' consent. Each one-on-one interview took place at a local cafe, if in-person, and on Zoom, if virtual. Each interview was audio recorded and transcribed by the researcher using Otter.ai.

Data Analysis Methods

A phenomenological qualitative research method was adapted to analyze the data produced by semi-structured interviews with participants. Prior to reviewing all transcripts, the researcher utilized bracketing to set aside any personal biases. From the 10 interview transcripts, a total of eight codes and three themes were determined. The researcher then divided the data by research question, connecting units of meaning to relevant interview questions. This allowed the researcher to detect commonalities and identify themes related to the research questions. Lastly, the researcher engaged in an iterative process of finalizing codes and themes by revisiting the interview transcripts frequently throughout the research process (Creswell & Poth, 2016).

The subcodes were directly and manually created from the raw datasets, which are shown in Appendix F. Then, the existing patterns across all subcodes were studied. The subcodes were organized and classified. All corresponding subcodes were merged to form codes. Upon creating a list of codes, they were then divided, categorized by relevance, and used to identify themes. To check the consistency of the codes, a secondary coder, who is a doctoral student in the Graduate School of Education and Psychology at Pepperdine University, participated in the coding process. Each interview transcript was coded by the researcher and secondary coder separately. The results of the thematic analysis from the secondary coder are displayed in Appendix G.

Breaking up the raw data into manageable codes represented a critical part of the data analysis process. Coding was an essential part of analyzing the participants' experiences in a structured method. Also, coding helped the researcher experience all the important aspects of the study and not overemphasize certain parts of the interview (Miles et al., 2018). Coding the data facilitated the identification of themes that existed within the interview responses.

Chapter Four: Findings

Narrative Content Associated with Graphics

Table 3

Research Participant Demographics

Participant Pseudonym	Age	Sex	Race	Class	Major	Institution Enrollment	Location of Recruitment
A	19	Female	Asian	Middle	Computer Science	Mt. San Antonio College	AB Church
B	22	Male	Asian	Middle	Computer Science	University of Southern California	AB Church
C	20	Male	Hispanic	Low	Chemical Engineering	University of Southern California	University of Southern California
D	19	Female	African-American	Middle	Biology	Fullerton College	Fullerton College
E	21	Female	Hispanic	Middle	Biochemistry	Fullerton College	Fullerton College
F	19	Male	African-American	Low	Biomedical Engineering	California State University-Long Beach	California State University-Long Beach
G	20	Male	Caucasian	Middle	Computer Science	California State University-Long Beach	California State University-Long Beach

Participant Pseudonym	Age	Sex	Race	Class	Major	Institution Enrollment	Location of Recruitment
H	19	Female	Caucasian	High	Mathematics	California State University-Long Beach	California State University-Long Beach
I	18	Male	Asian	Middle	Physics	Fullerton College	Fullerton College
J	25	Male	Asian	Middle	Mechanical Engineering	Fullerton College	Fullerton College

The demographics of the participants are presented in Table 3, which shows the age, sex, race, class, major, institution enrollment, and location of recruitment. There was a total of 10 participants: four female and six male subjects. All of the participants were college/university students who majored in STEM including computer science, chemical engineering, biology, biochemistry, biomedical engineering, mathematics, physics, and mechanical engineering. The participants consisted of multiple different races: four Asians, two Hispanics, two African-Americans, and two Caucasians. The socioeconomic status of the participants ranged from low to high.

Results of Study

During the data analysis process, three themes were identified: Insufficient Knowledge, Need STEM Guidance, and Improvement in Syllabus and Teaching. The codes determined by the secondary coder were mostly consistent with those of the researcher. They also supported and increased the validity of identified themes.

Table 4

Identification of Themes

List of Codes	Grouping of Codes	Themes
High School Preparation	High School Preparation	Theme 1 - Insufficient
Different Pace	Different Pace	Knowledge
Lack of Awareness	Support	
Support		
Gender	Lack of Awareness	Theme 2 – Need STEM
Teaching	Gender	Guidance
Benefits	Benefits	
Needs Improvement		
	Needs Improvement	Theme 3 - Improvement in
	Teaching	Syllabus and Teaching

Table 5

Frequency Table of Themes and Codes for Research Question 1

Theme	Code	Number of Participants/Total	Overall Frequency	A	B	C	D	E	F	G	H	I	J
	High School Preparation	10/10	24	1	4	1	2	2	2	4	2	4	2
Insufficient Knowledge	Different Pace	4/10	7		1		1		4				1
	Support	10/10	38	5	6	3	4	5	5	2	3	1	4
Need STEM Guidance	Lack of Awareness	7/10	12		1	3	3		1		1	2	1

Theme	Code	Number of Participants/Total	Overall Frequency	A	B	C	D	E	F	G	H	I	J
	Gender	6/10	6		1		1	1			1	1	1
	Benefits	3/10	4	2	1			1					

Table 6

Frequency Table of Themes and Codes for Research Question 2

Theme	Code	Number of Participants/Total	Overall Frequency	A	B	C	D	E	F	G	H	I	J
Improvement in Syllabus and Teaching	Needs Improvement	10/10	42	1	1	2	4	7	7	8	4	4	4
	Teaching	10/10	35	4	1	3	3	5	2	7	5	2	3

Theme 1: Insufficient Knowledge

All research participants acknowledged that their postsecondary STEM classes were much more difficult than STEM classes they had taken in high school. The students expressed that these postsecondary classes required a lot of effort to successfully complete. The major issue faced was not being able to keep up with the pace. Participant D explained,

> The first STEM course that I took at my college was extremely difficult. I thought I was prepared before enrolling, but I definitely wasn’t. The pace in college is way faster and the content you learn is way more in depth.

Participant D’s statement highlighted the unexpected disparity in difficulty between high school and postsecondary STEM courses, making the latter even more challenging. This sentiment was echoed by other participants as well. For instance, Participant F remarked, “It was fun, but challenging. College STEM courses are at a different level. I can’t count how many times I went to my professor’s office hours.”

The lack of understanding regarding how different high school and college/university STEM courses are contributes to a lower completion rate of STEM degrees. Wang and Degol (2017) noted that students’ lack of knowledge of higher education coursework increases the likelihood of them losing interest in STEM careers. Participant G also stated,

> In order for students to join STEM, first, they need to be prepared. They could perform well in high school STEM classes, but when they get to college, they could change their minds because college STEM is incomparably more difficult. High school STEM doesn’t deliver enough content for students to do well in college STEM and that needs to change.

Depending on the students’ quality of academic performance in high school, they may feel prepared for college/university STEM classes. However, how they feel does not necessarily equate to them being actually prepared. According to data, students realize that they do not have sufficient knowledge of STEM during their postsecondary years and not prior. Participant E stated,

> My high school science classes were lacking on preparation. Either my school didn’t prepare me well or I underestimated college courses. My high school science teachers definitely could have taught more in detail or more important concepts that I should have known prior to starting my first college science course. I found high school science fun and I thought I’d find college science fun too, but they are very different. I wish my high school science teachers told me about the significant gap between the two levels.

Participant J stated that they felt frustrated and stressed because of how difficult the postsecondary STEM classes were compared to high school classes. This sentiment was shared by Participant F, who emphasized the need to have students mentally prepared for the higher education experience to enable them to fully understand and adequately prepare for postsecondary STEM courses. Orishev and Burkhonov (2021) stated that students in STEM are unlikely to seek mental health support from counselors. Instead, they request it from their peers. Participant F explained,

> High school STEM classes really need to emphasize on the difference in pace between high school and college. The change in pace is something that students can't get used to immediately. The students need to gain all the necessary skills from their STEM classes that they can use to help themselves adjust to the new environment when they enter college.

According to Semilarski et al. (2019), students believe that support from their teachers and peers is essential for building and maintaining STEM-related activity engagement.

Providing Social and Emotional Support for STEM Students. The participants reported that the transition to college/university STEM was extremely stressful because there was a lack of comprehension of classwork and the structure of the courses. For example, Participant B explained,

> I would say, material-wise, it prepared me well as I knew the things I needed to know before taking the class. However, in terms of pacing and general structure of the course, I would say they did not prepare me all that well.

The students were prepared to put their nose to the grindstone in higher education. Their high school STEM classes built their determination to do well in future academics. The primary issue that they faced was the lack of support from the educators and the school. Chumbley et al. (2022) explained the need for high school students learning what is expected of them in school through collaborations with colleges/universities or programs where professionals can be their mentors.

The participants indicated that they felt isolated and were unable to fully enjoy school, primarily due to the lack of social support often resulting in mental stress. The participants mentioned that students always desire and need support due to the challenges they encounter in school. Participant F shared, “There needs to be a program where it helps students with their mental support. Students always need support and whenever they need it, teachers or administrators should be available to help them.” Participant J reiterated, “There should be a counseling program for students and their mental health. Sometimes, they just need someone to talk to. They should be able to relieve stress when they need to at school.”

Mental health is an essential part of students’ academic performance and is viewed as a major factor in quality student learning. Students who are supported and heard by their school have a high likelihood of enhancing their performance (Keller et al., 2017).

Theme 2: Need STEM Guidance

The interview participants made evidently clear statements regarding high school STEM failing to provide them with the necessary skills to make a successful transition from high school STEM to higher education STEM. To provide a clear picture of the areas in which high school STEM is lacking based on the data provided, the theme was further divided into three subthemes: increase awareness of career opportunities in STEM, and learning methods to apply practical skills gained from STEM.

Increase Awareness of Career Opportunities in STEM. Studying STEM subjects requires a lot of effort and dedication, both in high school and even more in college/university. A common practice among all the research participants was to study with their friends before and after exams to fully understand the content. Some of the students also worked with their teachers to ensure they understood the concepts that were taught in class. Despite their commitment to their studies, most of these students lacked awareness regarding the various career paths available to them within the STEM field when choosing their majors for higher education. It is worth noting that both Participants B and C admitted to spending a lot of their time unwisely in college/university because their majors were initially undecided. Participant B stated,

> I wish the classes in high school let me explore my options in STEM more so I had a clearer picture of what I wanted to study in university. I felt like I wasted a lot of time in university because I was initially undecided on my major.

The students were not aware of the careers they could be working toward, which areas to focus on, and what classes to take in higher education. Participant C stated that conducting personal research on the types of jobs available for STEM graduates was necessary prior to deciding on a specific major. In addition, Vossen et al. (2020) stated that students need to be adequately supported in STEM to increase their motivation and the lack of quality resources and confidence decrease students' abilities to achieve their fullest potential in STEM.

High school students may have general knowledge of STEM courses and career paths providing multiple benefits such as getting high-paying jobs. However, they are unaware of what these jobs are or the degrees required to be hired in these fields. Participant C stated, "There needs to be more STEM awareness. I'm sure most of my classmates in high school had no idea what kind of jobs they could have in the future if they earned a STEM degree." Students may have knowledge of STEM; however, they lack information on the types of jobs they can apply for and where to seek these jobs. While Participant C may have performed their own research on the internet, the information available online may not provide a full picture of what STEM careers pertain to. Participant I was of the opinion that:

> STEM needs to be promoted more. Students have no idea what to do with the information they gain from STEM and which careers they can get into. I'm sure they will be more motivated if they were aware of what kind of future they would have if they studied STEM. There needs to be more emphasis on STEM careers. Future jobs and careers are the reasons that they are in school. They need to be taught that learning STEM can lead to them greatly contributing to society in the future.

Working to achieve a specific job could be motivational to students since there is a clear, direct goal that they can aim at. Also, it could be more motivational than completing a degree.

Participant I mentioned the need to increase STEM awareness such as future STEM jobs and careers. The students had minimum knowledge of various career options in the STEM field. They also realized that there was a multitude of STEM jobs that were not promoted as well as others. Participant J added:

> The STEM field is full of high-paying jobs and careers. Money is a significant aspect of success. Students getting jobs that have high salary should be mentioned occasionally so that they can see STEM differently and consider it as their college major and future career.

A clear picture of expectations would allow students to know which classes to take and work on, for instance, gaining experience through internships and working directly with mentors. Participant D stated,

> I believe a lot of students are unaware of the fact that they have a high likelihood of having a successful career if they pursue a STEM degree. School administrators need to promote this type of information to the students. If it's mentioned in STEM classes, it could lead to more students paying more attention.

Participant D recognized that information about the opportunities available for STEM majors could draw in more high school students to take STEM classes in addition to motivating those who are already in STEM to continue studying it.

According to the data gathered, the gender of an individual can be viewed as an important factor in wanting to strive for the STEM profession. Two of the female research subjects, Participant D and E mentioned that their awareness of women being desired in the STEM field played a part in their decision to pursue STEM. Their answers illustrated that if there is an increase in STEM awareness, there is a high chance of more women considering joining the STEM field. When asked if their gender had any impact on their career choices, the participants responded:

> Participant D: "Yes. What I heard was that more women are being wanted in the STEM field, which is why I wanted to pursue STEM."
>
> Participant E: "I heard that there needs to be more women in the STEM field so I took as many STEM courses as I could take in high school to pursue a STEM career in the future."

Theme 3: Improvement in Syllabus and Teaching

The theme is divided into two sub-themes: Syllabus and Teaching. The two sub-themes are related; however, they are discussed separately to highlight the students' overall experience with high school STEM in detail.

Syllabus. All of the students who participated in the research study reported dissatisfaction with their high school STEM classes, for instance, how the classes were taught. All of them stated that multiple AP STEM classes such as chemistry, physics, and biology were offered, however, the organization of these classes left most of them unprepared for postsecondary STEM classes. Participant G stated:

> There was a lack of preparation. High schools in general need to do a better job at preparing their students for college. I wish they informed me of the difference in difficulty level between high school and college STEM. I wasn't even given a heads up. If I did, I would have prepared myself.

Even in cases where the students felt their classes provided them with the necessary content, multiple participants argued that they were not informed of the major pacing differences between secondary and postsecondary. Based on the participants' responses, students who have taken and passed AP classes believe that they are prepared for higher education. This is primarily because they misunderstand AP classes as the equivalent of college/university-level courses. Participant B articulated this perspective, stating:

> I would say, material-wise, it prepared me well as I knew the things I needed to know before taking the class. However, in terms of pacing and general structure of the course, I would say they did not prepare me all that well.

Participant F also shared that they experienced a difficult time deciding their major due to their unpreparedness for higher education. They said, "I wish I knew that pursuing a STEM degree would be more challenging than I initially thought. There was definitely a lack of preparation before deciding on my major."

Two of the research subjects, Participants D and G directly stated that they believed high school STEM prepared them for college/university STEM courses. However, when they started their higher education journey, they realized that their high school curriculum was lacking in a multitude of ways. Participant D claimed:

> My school did an okay job, not too bad, but at the same time, not that good. It would have been better if more important information or lessons were given to the students. I honestly thought my first biology course in college would be a review of AP Biology, but it was pretty much taking a whole new class.

Participant G added:

> High school STEM taught me the basics that I needed to know to continue my STEM education in college. However, my high school STEM teachers didn't mention a lot of the content that I learned in my college STEM courses. In other words, there was barely any preview.

All participants stated that they were startled by the difficulty level of their postsecondary courses. For example, although Participant H was already aware that college/university STEM was going to be more difficult than high school STEM, they were still taken aback by the vast difference in the level of difficulty between secondary and postsecondary. Participant H stated, "It was actually just as I expected. I knew it was going to be very hard for me. There was so much content that I was unaware of."

In terms of content, only two participants stated that their high school STEM classes prepared them for higher education. For example, Participant A reported,

> My high school prepared us well in Calculus classes and just having a lot of advanced classes helped too. It helped me to complete my undergraduate classes faster. In fact, I

> wish I had taken more STEM AP classes in high school because many of them give college credits that I couldn't utilize.

Similarly, Participant B explained, "I would say, material-wise, it prepared me well as I knew the things I needed to know before taking the class." The other eight students reported that high school STEM classes did not prepare them for college/university STEM courses. The students expected college/university STEM to be a review of high school STEM. However, when they started their first academic term of higher education, they realized that the amount of knowledge they had was insufficient. In other words, it was as if they were relearning and utterly new to the material. Participant C summarized their experience by saying,

> I found my first college STEM course difficult because I wasn't prepared for it. There was too much terminology that I wasn't aware of and my high school STEM teachers never taught me. I had to go to my professor's office hours for extra lessons.

Participant D explained that their high school "did an okay job, not too bad, but at the same time, not that good." The participant further explained that the classes did not include clarifying explanations, which could have led to students better comprehending the material without confusion. In addition, Participant H stated that inadequate knowledge was shared in their high school classes. Therefore, due to insufficient learning and a lack of preparation, the challenges experienced in college/university were expected. They shared:

> I knew I was going to struggle in college because I had a feeling that I wasn't learning enough in high school, which is why I expected my first college STEM course to be hard. I guess there was a lack of preparation for students who wanted to continue their education after graduation.

Participant E suggested that high school classes should offer students more useful information to facilitate their adaptation to higher education after graduation. The participant stated that learning STEM in high school was a positive experience while learning STEM in college/university was nearly the opposite. Participant E stated:

> I found high school science fun and I thought I'd find college science fun too, but they are very different. I wish my high school science teachers told me about the significant gap between the two levels. More information about the subject being taught needs to be given. Not enough information is delivered to the students. Also, there needs to be specific assignments or activities given to the students where their knowledge gained in science classes is tested outside of school. The more relatable the subject is, the more the students will be intrigued by it.

It is evident that a lack of preparation can result in students choosing to change their majors from STEM to another area of focus primarily due to overwhelming challenges. Participant J stated, "I did a lot of independent studying in high school. I was always behind in my STEM classes because I didn't understand the material that well. To not fall behind, I had to study alone and catch up."

One of the major shocking experiences that most of the research subjects stated was the quantity of experiments they were required to be involved in for their college/university STEM courses. In high school STEM, mainly concepts and theories were covered during the lessons and there was little application of the material to help students learn and utilize the skills gained from their classes outside of school. STEM includes a myriad of practicable skills that can improve the lives of students plus their abilities to contribute to communities and societies.

However, the STEM curriculum fails to implement these applicable skills due to an overreliance on textbooks (Orishev & Burkhonov, 2021). Participant B stated:

> I found my first university STEM courses hard to adapt to. For classes like Chemistry, there were a lot of labs, which would sometimes require hours of pre-lab work, that high school didn't really prepare me for.

Participant I stated, "Honestly, the lecture part of the class wasn't hard for me to adapt to. However, the labs were difficult. There were many experiments that I had to do in a short period of time, which I wasn't prepared for."

Most of the students wished their high school assigned more experimental work for the purpose of preparing for future laboratory practices. Participant I stated, "I wish there were more labs. If there were, it would have been great practice and preparation for me before transitioning into college." The students mentioned the importance of laboratory assignments at the secondary level as they would not only prepare students for post-high school STEM courses but also increase student engagement in high school STEM classes. Participant A's perspective is particularly relevant to this point:

> Tell the kids that that there are so many options in STEM and every field is good for entering at the career level. I think it would be good to include more labs in STEM classes. Learning more about the subject in real life situations helps the students to enjoy their time more instead of just packing information into their brains.

Some of the participants expressed dissatisfaction with the amount of coursework, outside of STEM; they had to grind through in high school. Based on the responses, the students already decided to pursue STEM prior to attending college/university but were forced to complete all the General Education (GE) requirements to graduate high school. Participant B's perspective on lessening GE requirements for high school students and adding a greater variety of subjects and specialized courses was as follows:

> I believe adding a more variety of subjects and specialized courses could help motivate high school students to pursue these subjects in higher education. In addition, if the administrators could also lessen the GE requirements for high school students, it could give those students more time to explore and find their true interests.

There was an emphasis of GE in the secondary curriculum for the development of well-rounded students and less GE for those who have already decided on their area of focus so that they can explore their options in the chosen field. Participant B added:

> The classes in high school were lacking in specialization/options. I understand high school courses want to give students a general course education but I feel like there is little opportunity to explore one's interests with the current structure of the school system, not just regarding STEM. I wish the classes in high school let me explore my options in STEM more so I had a clearer picture of what I wanted to study in university. I felt like I wasted a lot of time in university because I was initially undecided on my major.

Teaching. In regards to the instances where the students stated that they applied several skills they learned from STEM, these skills were learned coincidentally and were not the primary objective of their STEM classes. Participant B explained, "The lectures and assignments in high school helped build up self-discipline which in turn helped with adapting to the more rigorous university level classes." This statement demonstrates that self-discipline was learned to keep up with the material studied as well as the assignments. The skill was self-taught and not directly instructed by the teachers for the students to implement. Additionally, Participant C stated that their high school teachers were lacking quality instruction such that they had to study independently. Participant C noted that:

> Most of the science teachers I had in high school weren't the best at teaching. From time to time, I had to independently study to not fall behind. Although I didn't have good teachers, my ability to independently study developed over time. Being able to independently study is an essential skill to have especially when attending college.

The students were able to develop the learned skills in spite of their teachers' incompetence. The lessons that were given in class barely had any contribution to the development of the learned skills. The educators clearly did not deliver proper instructions of skill utilization to ensure students excel in STEM classes (Akosah-Twumasi et al., 2018).

The students reported the importance of learning ways to apply the concepts taught in STEM. For example, Participant G explained,

> There needs to be more focus on life skills that students can gain from STEM classes. Instead of spending time on learning concepts that they will eventually forget, more time should be spent on learning how and when to use the life skills that they gain from STEM. Demonstrations and real-life examples should also be used to facilitate their learning and understanding.

Learning to implement the lessons delivered in class can help students appreciate the content significantly more. As Participant C emphasized, "If teachers helped students understand why they are learning what they are learning instead of just what they are learning, I feel like more students would take the classes more seriously." If students familiarize themselves with the correlation between the learned content and the real world, they would be more invested in the lessons and willing to engage with the material.

Several research participants stated that their STEM classes helped them develop life skills that they utilize on a daily basis. For example, the majority of interviewees stated that their STEM classes facilitated the development of their problem-solving skills, which they use when making important decisions. Respectively, Participants C and E explained:

> Problem solving skills and being able to independently study definitely helped me. It helped me make smarter decisions; my problem-solving skills help me a lot. Every time I encounter problems in life, I find ways to solve them. This is something I've been doing since high school.

The students' responses prove that the skills gained in high school can be of long-term use.

The students also explained that their STEM classes developed their memorization skills, which were key factors in their college/university survival. Participant D stated, "My high school biology class helped me develop my memorizing skills. Your ability to memorize any type of information is always useful, especially in biology courses." Participant D added that memorization also helps in navigating through college/university, remembering deadlines, and being aware of the resources available on campus. Participant E also reported, "Chemistry in high school helped me develop my problem-solving skills and biology helped me improve my memorizing skills. Both are useful skills to have when attending college."

However, most of the students stated that the certain skills they gained from STEM were not applicable to the real world and were unclearly mentioned by their teachers in school. Although the students realized the importance of obtaining the skills, most felt that their high school classes did not or did a poor job on putting the skills to the test. In other words, the school did not ensure the students could properly implement the skills in real life. For example, Participant A stated, "I think it would be good to include more labs in STEM classes. Learning more about the subject in real life situations helps the students to enjoy their time more instead of just packing information into their brains." When students get a grasp of the class content, their ability to apply gained knowledge in real life needs to be tested through infield experience. De Loof et al. (2021) illustrated that having activities that help students understand the practical uses of the material they learn in class is important. The activities lead to student engagement and motivate them to constantly learn even in non-school environments such as their home.

The teaching strategies implemented by teachers can greatly impact how students learn and their perceptions of certain subjects. Participant A explained their anecdotal experiences with two types of teachers and how the different strategies used by the two teachers impacted their learning experiences. Participant A's perspective was as follows:

> Being more effective with teaching always helps students. I've had two different kinds of teachers that led me to have vastly different experiences. One had a very organized plan and agenda for what we would do every single day. The other just did whatever he wanted and his plan was very vague. I ended up liking the first subject a lot more. They should offer more of their help like with office hours or give tutoring resources because the difficulty of STEM is what makes it so unappealing to students.

Participant A preferred the type of teacher who had a clear, defined class plan because the students knew exactly what to expect. The other type of teacher, on the other hand, did not have a clear structure, which left the students being unable to follow the lessons. Participant A also argued that their high school purposefully made the AP classes more difficult compared to other high schools. Although the students at their school performed well, they still found the AP classes less appealing.

All of the research participants felt that their teachers did not provide them with implemental lessons such that they needed to consistently study with their classmates or friends after class. Participant C explained that they unwantedly practiced independent studying, which eventually developed over time since their teachers did not effectively prepare them for their schoolwork. Participant C stated:

> Most of the science teachers I had in high school weren't the best at teaching. From time to time, I had to independently study to not fall behind. Although I didn't have good teachers, my ability to independently study developed over time.

In addition, Participant C went on to explain that there was a lack of detailed explanations of concepts and clarifications provided by the teachers, which resulted in the students being confused and struggling during class.

The students also complained among themselves about the classes and teachers that failed to instruct appropriately. Participant B mentioned that their classmates would discuss which classes to take and the ones to stay away from. Participant B's opinion was: "We would complain a lot about certain classes as well and what classes in particular to take or avoid. I did not talk with teachers much in high school." This illustrates that there were students who veered away from certain AP classes that they could have been interested in solely because the teachers who taught those classes were prone to being unskillful.

Additionally, the students explained that high school STEM classes mainly taught them how to memorize the material rather than enhancing their comprehension of it. The high school STEM curriculum encourages the feeling of learning through memorization rather than actual learning and developing students' mental ability to interact with and understand their environment (Herges et al., 2017). Participant D stated, "Your ability to memorize any type of information is always useful, especially in biology courses." Although memorization skills are useful, the students did not have the full experience of STEM, as they did not properly learn how to apply the knowledge they gained. Participant F explained:

> In my high school science classes, there were many students who didn't know how to apply what they learned during exams. They just memorized what they needed to memorize for the exams and forgot about them shortly after. Being able to apply what you learn is an important skill to have and it must be taught properly in STEM since it's mostly about problem-solving. There's no point of learning if you don't know how to apply what you learned.

Interpretation of Results

The study results heavily emphasized the lack of preparation for college/university STEM, the lack of awareness of career opportunities, and improving high school curriculum and teaching strategies.

Lack of Preparation for College/University STEM

The key piece of information that was not mentioned enough in school was the transition from high school to post-high school. Students were rarely informed of the major differences in pacing between the two academic levels. The participants stated that they thought that they were ready for the next chapter of STEM education until they realized that they were unprepared for their classes, to the point where they almost failed.

The students expressed their concern regarding the requirements they need to meet to graduate postsecondary. All of the participants had successfully gone through high school STEM with some stating that they enjoyed it. However, when they transitioned to higher education, they underwent hardships, which they did not experience in high school. The participants stated that the postsecondary coursework was much more demanding than secondary. Although they had excelled in high school, they found it difficult to keep up with the rapid pace and difference in level of content. Multiple participants mentioned that they needed to consistently request academic support from their professors.

The college/university STEM curriculum and its pacing emerged as major challenges, especially when most of the participants realized that their high school underprepared them for future education. They had to tackle new terminology and explore different concepts that they were unaware of. Additionally, even when the students felt their high school had prepared them for post-high school, they were completely ambushed by the unfamiliar pacing of college/university classes. The participants were required to do much more work with less time given while studying for weighted assignments and exams.

Lack of Awareness of Career Opportunities

A notable finding from the study was the students' limited understanding of the careers options available to them upon completing their college/university programs. Some of them entered higher education as undecided majors due to their unawareness of the careers they could venture into and the specific degrees needed to pursue those careers. Most of the participants explained that they knew that obtaining STEM degrees could provide various job opportunities and lucrative careers. However, they were uninformed of the exact types of occupations that could be available to them and the type of educational qualification that they need to attain any available job or the job that they want, if any, in the STEM field.

The participants stated that their high school STEM classes, especially AP classes, provided them with only the subject content that they needed to be aware of to get through their higher education courses. They believed that discussions on potential career paths would have made them feel more motivated to study STEM subjects and enabled them to make informed decisions about their college/university. One of the research participants suggested inviting STEM professionals for students to talk to in regards to the STEM career opportunities awaiting after college/university graduation.

Another significant finding was an individual's gender being a possible important factor in playing a part in their decision to pursue STEM. A few of the female participants stated that their awareness of their gender being desired in the STEM field is what partially encouraged them to consider STEM as their potential career.

Improve High School Curriculum and Teaching Strategies

Learning how STEM classes can be implemented and where certain lessons fit into students' lives can help students engage with the classwork and retain what they learn. STEM education includes many applicable skills, for example, problem-solving and critical thinking, as mentioned by the participants. According to them, it is essential to include lessons on life skills in the STEM curriculum. That way, educators can give thorough instructions on how to apply and implement these skills.

While the students acknowledged acquiring certain skills such as memorization and independence through their high school classes, their explanation revealed that these skills were merely an insensible byproduct of the intense coursework they had to complete. Despite recognizing the usefulness of these skills in their lives, they still believed that the lessons given in their classes lacked practical applicability due to a lack of emphasis and clear instructions on the real-world application.

The participants made several suggestions for improving the high school STEM curriculum. One important recommendation is for administrators to collaborate closely with the teachers to ensure the curriculum allows students to fully absorb the content while also incorporating specific details on how to implement given information. In addition, it is crucial for teachers to have a close relationship with their students. Most of the students stated that they did not have a close relationship with their teachers, which is why they chose to discuss the class content with their peers instead.

The participants stated that their high school curriculum lacked the necessary content to adequately prepare them for the of their future college courses. Most of them discovered the overwhelming dissimilarity in difficulty between secondary and postsecondary when they began their college/university life. When comparing and contrasting the two levels, they realized that their high school educators did not adequately prepare them to be tenacious to complete their future college/university courses. Similarly, the teaching strategies used in high school STEM were lacking student engagement. For instance, the teachers did not include sufficient laboratory assignments in the lessons, resulting in the students being less engaged with the material, which eventually led to them struggling academically in higher education.

Chapter Five: Conclusions, Implications, and Recommendations

Summary

The research summary consists of the description of problem, theoretical framework, methods, key findings, study conclusions, implications, study limitations, recommendations for practice and future research, and closing comments.

Description of Problem

There exists a noticeable disparity between the expectations of high school students regarding college/university and the actual college/university experience they encounter. Postsecondary STEM students often face challenges in adapting to the new academic environment during their first year of higher education, which impacts their studies. Semilarski et al. (2019) noted that although improvements have been made to ensure high school students receive a conceptual understanding of science or STEM, it remains insufficient as the standards for postsecondary institutions are largely varied. This lack of uniformity results in many college/university students being unprepared for their science or STEM courses. It is essential for educators and administrators to consider the experiences of postsecondary to gain a better understanding of the problem and identify necessary changes that can enhance the experiences of future students. Implementing change in the high school science or STEM curriculum can improve students' preparedness for their continuing education after high school and can result in an enhancement of academic outcomes.

Theoretical Framework

The theoretical framework of the research study consists of three major components: the role of science, science education, and scientific inquiry. These components explore the effectiveness of science and the potential for students to develop essential life skills, achieve academic excellence, and succeed beyond the academic realm when there is an improved understanding of the role of science, enhanced quality of science education, and increased exposure to scientific inquiry experiences.

The Efficiency of Science Education

Students must start contemplating their future upon high school graduation. They need to choose between seeking higher education and entering the workforce immediately after high school. Many students who choose to go to college/university find the transition difficult due to the academic differences between high school and higher education. According to a survey conducted in 2021, students reported that while they felt that high school prepared them academically for higher education, they still wished they got more out of their high school classes, for instance, being taught the life skills that could have given them better experiences associated with their postsecondary journey (Grand Canyon University, 2021).

Why Science Education is Necessary

Science plays a crucial role in making informed decisions. For example, government agencies utilize scientific evidence, which they take into account before making decisions regarding public policy. Additionally, with the rapid advancement of technology, children are being raised in a highly technologically advanced world. Therefore, children should be educated on technology, how it works, and practical application in their lives. Being knowledgeable about scientific methods comes with numerous benefits, including critical thinking and problem-solving skills, which are essential for students.

Role of Science in Students' Daily Lives

Students encounter scientific phenomena on a daily basis, from transportation to the technology they use at home or school. These technologies are developed and produced by professionals such as planners, civil engineers, and scientists who have STEM careers that students can aspire to. Also, learning scientific inquiry is an essential skill that all students should be taught as it can result in improving their decision-making and ability to solve complex problems.

Scientific Inquiry

Scientific inquiry and method are essential aspects of both science education and practice, as important decisions are made through these processes. However, high school does not always impact students with the life skills associated with scientific inquiry and method. High school science educators need to ensure that they instruct in a way that their students learn not only the concepts but also the benefits of science.

Fosters Understanding of Other Disciplines

The increasing complexity of science is the reason as to why students need to understand concepts from other areas of study as they help students get a grasp of scientific concepts. For instance, students require a solid comprehension of mathematical concepts in order to excel in statistics and analyze research findings effectively. Additionally, scientific findings can help educate students and change their mindset on certain negative behaviors such as drinking or smoking at a young age (Scott-Parker, 2019).

Why Has Science Education Not Been Significantly Altered?

There is a pressing need to improve and update the way science is taught in high schools, as science education has remained largely unchanged over the past decade. A key factor impacting science education is the lack of proper training for science teachers (Kalogiannakis et al., 2021). Many high school science teachers are not experts in the subject such that they cannot fully convey the importance of science. In many cases, students are taught only the basics of science, resulting in a limited understanding of the development of concepts and their practical application (Philips et al., 2019).

Methods

For this study, a phenomenological approach was utilized, as the research revolved around a single phenomenon: the perceptions of college/university STEM students. Primary data were obtained from postsecondary students through semi-structured interviews, conducted either in-person or virtually. The purpose of the study was to investigate the perceptions of college/university students on high school science and STEM courses. During research, relevant information was gained from a sample size of 10 college/university students residing in southern California. For the purpose of gathering data representing specific groups, the subjects who participated in the research were racially and socioeconomically diverse.

Key Findings

The research data indicated insufficient integration and implementation of NGSS in secondary science classes. Overall, the findings showed a lack of preparedness for postsecondary education, limited STEM awareness, and inadequate high school curriculum and teaching strategies.

Students are Unprepared for College/University STEM Courses

According to the participating students, there is a significant lack of preparation for higher education. Upon enrolling in their first higher education STEM course, they encountered a workload that was more intense than they initially thought. Although all the research subjects had taken AP science classes in high school, they reported that post-high school was a much different experience with more difficult content and varied classes. According to them, secondary and postsecondary seemed disengaged, as they had to start their higher education courses with little information regarding their coursework. Also, they all agreed that they were initially not prepared for their first college/university course. Some students stated that they would have studied harder if they knew how difficult higher education was. The material taught in high school classes, even AP classes, did not adequately prepare the students for academic competence since they were significantly behind when beginning their first college/university STEM course.

Another major problem faced by new college/university STEM students was the unfamiliar pacing of the college/university STEM courses. The students struggled with adjusting to the accelerated pace of postsecondary courses, which proved to be faster than what they were accustomed to in secondary education. These courses were designed to cover a vast amount of content as possible in a limited period, leading to a faster pace compared to what the students were accustomed to in high school. The unusual experience associated with the pacing could have been alleviated if high school science classes were at a similar pace when covering certain topics or units.

Lack of Awareness of Career Opportunities

The research participants expressed a lack of information regarding potential careers they could pursue after completing their postsecondary STEM program. While the students knew that acquiring a STEM degree could provide numerous job opportunities, they were still unsure of exactly what these opportunities meant and the steps they needed to take to utilize these opportunities. Also, a few of the participants expressed their gender being desired in STEM and it played a significant role in their decision to pursue STEM.

Limited High School Curriculum and Teaching Strategies

Most of the participants reported that the high school curriculum was limited. The participants were mentally challenged when beginning higher education since the content they encountered differed from their expectations based on their high school STEM experience. In addition, the teaching strategies used by the students' high school STEM teachers resulted in them not being able to adapt to higher education classes quickly. The participants reported that their high school teachers did not help them engage with the content.

The participants also offered varying information about the skills they gained from high school STEM classes. While most mentioned gaining problem-solving, critical thinking, memorization, and independent learning skills, these skills seemed to be coincidental rather than intentionally developed due to inadequacies in STEM instruction. Additionally, the students reported that they did not learn any practical skills they could implement in real life.

According to the students, there was insufficient laboratory work, which is a crucial part of college/university STEM courses. Also, the lack of laboratory work spells out a major issue with the teaching strategies used in high schools. Roseman and Koppal (2008) explained that although many researchers have stated the importance of providing secondary science teachers proper training to effectively instruct science classes, school administrators have not done much to implement the recommended ideas. Most secondary science teachers have little to no training in the field of science, thus lacking awareness of the importance of the scientific method, implementation of scientific concepts, and the most effective methods of instructing secondary science. The participants in the study explained they constantly relied heavily on studying with classmates due to their limited relationship with teachers and a lack of clear explanation of concepts taught in class. The students made a statement that they were not comfortable enough with their teachers to directly ask for help in areas where they had failed to understand.

Study Conclusions

All three areas of the conceptual framework were lacking in the students' STEM experience; therefore, it resulted in their experiences being overwhelmingly negative.

Based on the participants' responses, a traditional method of teaching could have been used in their classes. Furthermore, the abrupt transition to online learning during the COVID-19 pandemic could have negatively impacted some of the participants' secondary STEM education due to the implementation of updated models such as NGSS being delayed.

The research study revealed the problems within the high school STEM curriculum and highlighted how difficult it is for students to effectively transition to college/university STEM courses. It also disclosed major challenges faced by college/university students due to the deficiencies that exist within the secondary STEM curriculum. Overall, much dissatisfaction from the students was shown in regards to their STEM experience. Also, proper training on effective instructional methods and ways to engage students in science and STEM classes is highly needed.

More importantly, the students discussed the lack of emphasis on life skills development in their secondary STEM classes. Because their life skills were not fully developed and they were never properly taught how to utilize them prior to starting higher education, they lacked versatility and experienced difficulties such as falling behind in classes and not being able to decide on a major in higher education.

Implications

The findings of this study have several important implications for high schools and educators. High school students must be well-informed about the differences between high school and higher education, such that students who plan to continue their education after high school can comfortably transition into higher education. Students, especially ones planning to pursue STEM, take a multitude of AP classes with the understanding that these classes could prepare them for their college/university STEM classes. However, they realize that most of the concepts they learn in their AP classes are not enough for them to perform well in college/university STEM courses. Students may feel disillusioned by the lack of background knowledge, which can directly impact their academic outcomes.

The most significant change for high schools to make is investing in comprehensive training programs for science teachers. Teachers directly impact how students interact with the school material and can help them be interested in learning more about STEM. Training teachers to organize their lessons in such a way that students not only learn the material through text but also learn how to perform experiments and implement the learned concepts is crucial. This can encourage more students to pursue STEM and prepare them for higher education.

Study Limitations

- Self-reported data- The study data were collected directly from college/university students meaning that there was no way to independently verify them. Biases such as selective memory and attribution may have impacted the participants' memory making the data less effective.
- STEM major emphasis- All of the research participants were STEM majors. Therefore, only the perspectives of students majoring in STEM were studied and used as data.

Recommendations for Practice and Future Research

High school educators need to ensure their students are aware of the coursework and the expectations in higher education. Recommendations for change within the high school science curricula and classes include:

- Working with postsecondary institutions and local professionals to create a mentorship program for STEM students, mentors can help them prepare such that they do not get surprised by the intensity and pacing of college/university courses.
- School counselors providing students with information about the career opportunities available for STEM students based on the degrees they wish to pursue when they attend college/university, mentors can guide students based on the counselors' suggestions and recommend other resources.
- Accommodating student needs by providing necessary resources and support.
- Promoting dual enrollment, if available, to high school students for the simultaneous experience of high school and higher education.
- Updating the high school STEM curriculum to allow students to learn the necessary concepts to continue their STEM journey in high school and beyond.
- Including more laboratory experiments and real-life applications of STEM concepts in class, laboratory work helps students fully understand what they learn, giving examples of how scientific concepts are used in real life can increase interest and help students identify with the material.
- Focusing on the development of life skills and ways to use them.
- Increasing the difficulty level of high school AP STEM to the actual college/university-level to prepare students for higher education.

Improvement in High School Students' Knowledge of College/University STEM Courses

The main challenge faced by students was the shift between high school and college/university classes and their inability to adapt to the new environment upon transition. High school students should be encouraged to do research on the institutions they consider committing to after graduation. Also, it is never too late for students to be encouraged to start looking into higher education. It never too early to begin exploring higher education options and it is highly recommended that students begin this research as early as entering high school. Siegel and Ranney (2003) proposed that assigning high school students mentors at the institutions they want to attend. These mentors can act as role models and guide students through their postsecondary courses and experiences. High schools can also work with professionals who have adequate knowledge of higher education. That way, they can volunteer to mentor students on the occupations they are interested in pursuing. In addition, students can learn not only what to expect in higher education but also in the workplace. They can receive information regarding the classes that would best prepare them for their future endeavors. High school administrators can also collaborate with colleges/universities that have service-learning opportunities to encourage higher education students to work with high school students.

Mentors who share similar backgrounds with the students, for instance, professionals in a local community or high school alumni, have the ability to understand the challenges that students face during their academic journey. These mentors can assist students with the college/university entry process by providing them with individual counseling on applications and selection processes for specific courses and degrees. Mentors can read the students' application essays, help them apply for financial aid, or search schools that the students could viably fit into.

Mentors can also monitor their mentees' academic progress by reviewing report cards to ensure they are attaining the grades required for potential acceptance to their desired college/university programs. Mentors can become advocates for students, especially those who may be academically struggling. The participants in the study mentioned a lack of close relationships with their high school teachers, such that they could not approach their teachers when they had trouble understanding certain concepts. Establishing one-on-one connections with mentors allows students to feel more comfortable discussing their problems and be more receptive to advice on how to improve their high school and post-high school experiences. Mentors can also listen to recently admitted postsecondary students about their stress and offer them comfort when needed.

Students Having Access to Guidance in High School and College/University

Students have a general idea about the career they want to go into when attending college/university. When children are asked about what they want to be when they grow up, they rattle on about the careers they observe in the media or the careers they are exposed to through their parents or other relatives. As they grow up, they develop a firm idea of what they want to study in higher education to pursue the careers they want. It is important for high schools to educate their students on the job opportunities available for the career fields they wish to go into as well as the financial earning potential of specific careers (Siegel & Ranney, 2003). These pieces of information will help guide students in the careers they have interests in. For example, several study participants stated that they went into STEM because it was associated with high salaries. However, they were not informed of the types of career opportunities they should be working toward or how their postsecondary degree would help them achieve these careers. Therefore, high school students should be encouraged to conduct research on future career opportunities to increase awareness. This could lead to more students knowing which steps to take with certainty in the future.

School counselors need to advise students in the right direction and the work they need to put in to achieve their potential dream careers. Based on the responses received by the students during the study, it is clear that the students do not have enough information about higher education or careers, especially when continuing their education after high school. High school counselors should guide students to the resources they can utilize to learn more about the careers they want, for instance, My Next Move, which is a website that students can use to explore their future careers. The counselors can also encourage students to look into local companies related to STEM to learn more about careers in STEM. It is important for high school students to investigate their potential career interests by seeking local companies related to STEM and the jobs available because it could motivate them to have a focus and work toward it. If they cannot find companies that provide sufficient information on STEM careers, they can use any online resources that are credible for more research on STEM careers.

In addition, the study results showed that if STEM awareness is increased among female students, there could be a rising number of women joining the STEM field. Therefore, school counselors should encourage more female students, especially the ones who are unsure of their future, to pursue STEM.

Offering mental and social support should also be a priority in high school and higher education for all students because the transition can be jarring resulting in an inability to perform effectively in college/university. High schools should have programs that provide students with recommended resources for addressing mental or social issues they face at their schools. Additionally, these programs should offer students information about college/university to ensure students have as much information as possible in relation to the higher education experience.

Students need to realize how important all aspects of STEM are because of the interconnectivity of concepts in these areas of subjects. For instance, students must have developed math skills to solve chemistry or physics problems. Furthermore, physical science may be challenging for students who do not fully comprehend math (National Research Council, 2006). Encouraging students to practice math for increasing proficiency and building confidence should be considered. Students can also learn how to solve complex problems in and out of the classroom. For example, they can learn different solutions that can be implemented to help in reducing air pollution in certain locations.

Necessary Improvement in High School Curriculum and Teaching Strategies

To address the challenges in high school STEM education, administrators and educators need to make necessary adjustments to the high school STEM curriculum and teaching strategies (National Research Council, 2006). First, the high school STEM curriculum needs to be amended to ensure that students learn the necessary knowledge and skills to prepare for postsecondary education. Although learning basic concepts is essential in understanding more complex ones, students need to learn more than just the texts they read in class. High schools need to provide lessons and curricula that can help students understand postsecondary-level work and what they can expect from it. Also, high schools should urge students, especially those in their final year, to consider taking postsecondary-level classes, which could give them a wide-awake alert. For example, dual enrollment could be a feasible option. It gives high school students opportunities to enroll in college/university courses and earn college/university credit at a local community college (Rodriguez et al., 2021). High schools should recommend dual enrollment to students to allow them to experience the postsecondary level while simultaneously experiencing secondary, that way, they can familiarize themselves with the difference between the two. Such program would allow students to be more comfortable with adapting to colleges/universities in the future when the time comes.

High schools should also set up assessment measures that allow STEM students, as well as other students, gauge their preparedness for higher education. The assessments can help the students identify areas where they are lacking and work to overcome these deficiencies. High school administrators can work with teachers to determine the standards, assessments, and data on college/university readiness. The information on students' performance can then be used to identify their proficiency and post-high school readiness (Roseman & Koppal, 2008). Collecting information about their readiness can help them do what is necessary to be ready for education beyond high school, which could result in their first year of higher education less challenging and overwhelming.

In science classrooms, teachers should actively engage with students by asking questions and encouraging them to attempt to solve problems. For instance, when high school students are in the process of developing their critical-thinking skills, educators should contribute to it by challenging and stimulating them. Pausing to ask if anyone has questions and then clearly answering them, if any, can be very helpful when teaching. Students in science classes should be encouraged to ask questions about the world and be able to connect the learned scientific concepts to complete the full picture, which could help them understand its relevance with the real world. Explaining that students can make real-world differences through concepts they learn can lead to them retaining their interests in science or STEM. High school science teachers should also have lesson plans that can improve their students' perception of them plus the subject. For example, after creating a proper teaching plan, teachers can assign their students pre-class readings or activities, ensuring that instruction during class flows more smoothly for them to better understand the material. This also increases their reliability from students' perspectives (National Research Council, 2006).

High school students interested in STEM need to be provided with opportunities to apply the content they learn. Millar (2002) explained that high school STEM teachers need to provide their students with reference materials and laboratory equipment during experiments to enhance the quality of classroom experience. Also, students who are disinterested in science need to be exposed to scientific concepts that are applicable in numerous areas. The participants of the study reported that they did not have many laboratory experiments in high school, therefore leaving them unprepared for the laboratory aspects of their STEM courses they needed to complete. High school science classes need to include consistent laboratory work to ensure students can participate effectively in their future STEM classes. Also, in AP science classes, students should practice laboratory work at a similar pace as higher education, and be given a similar time period to finish. Laboratory practices are important for preparing students for their postsecondary education and improving their secondary science experience. High school students are often demotivated in class due to excessive emphasis on the textbook material with insufficient experimentation and interaction with content.

Laboratory experiences are essential for not only preparing students for postsecondary but also helping students apply the knowledge gained from classroom lessons. For instance, in a biology class, learning about cells can be a disengaged activity, however, if students become capable of observing cells through a microscope, their confidence is prone to develop as they learn to perform experiments consistently with less errors. Teachers should establish and enforce proper safety protocols for students such that students become confident and comfortable when using scientific equipment. While teachers should always be present for supervision, when students become more comfortable, they should let the students independently perform experiments in small groups. All these changes could be initiated and implemented once teachers receive proper training and are taught appropriate methods of effective instruction specifically for science (Roseman & Koppal, 2008).

Future Research Study

A future research study with a sample size consisting of solely non-STEM majors could be considered to learn different viewpoints and test the accuracy of the data collected and provided. Although the research identified several issues that need to be resolved in high school STEM, further research could help identify other problems in addition to solutions for enhancing the experiences of postsecondary STEM students.

Closing Comments

The findings of this study highlight the concerns expressed by college/university students pursuing STEM degrees regarding the shortcomings of high school STEM education. Issues such as teaching strategies, the curriculum, career awareness, and practical implementation of scientific concepts were identified as areas in need of improvement. The recommendations s provided by the students, such as developing instructional strategies, providing more information about career opportunities, and increasing the amount of laboratory work for more student engagement with the concepts learned in class, can be implemented into the high school STEM curriculum to allow future college/university students to complete the STEM program with minimized challenges.

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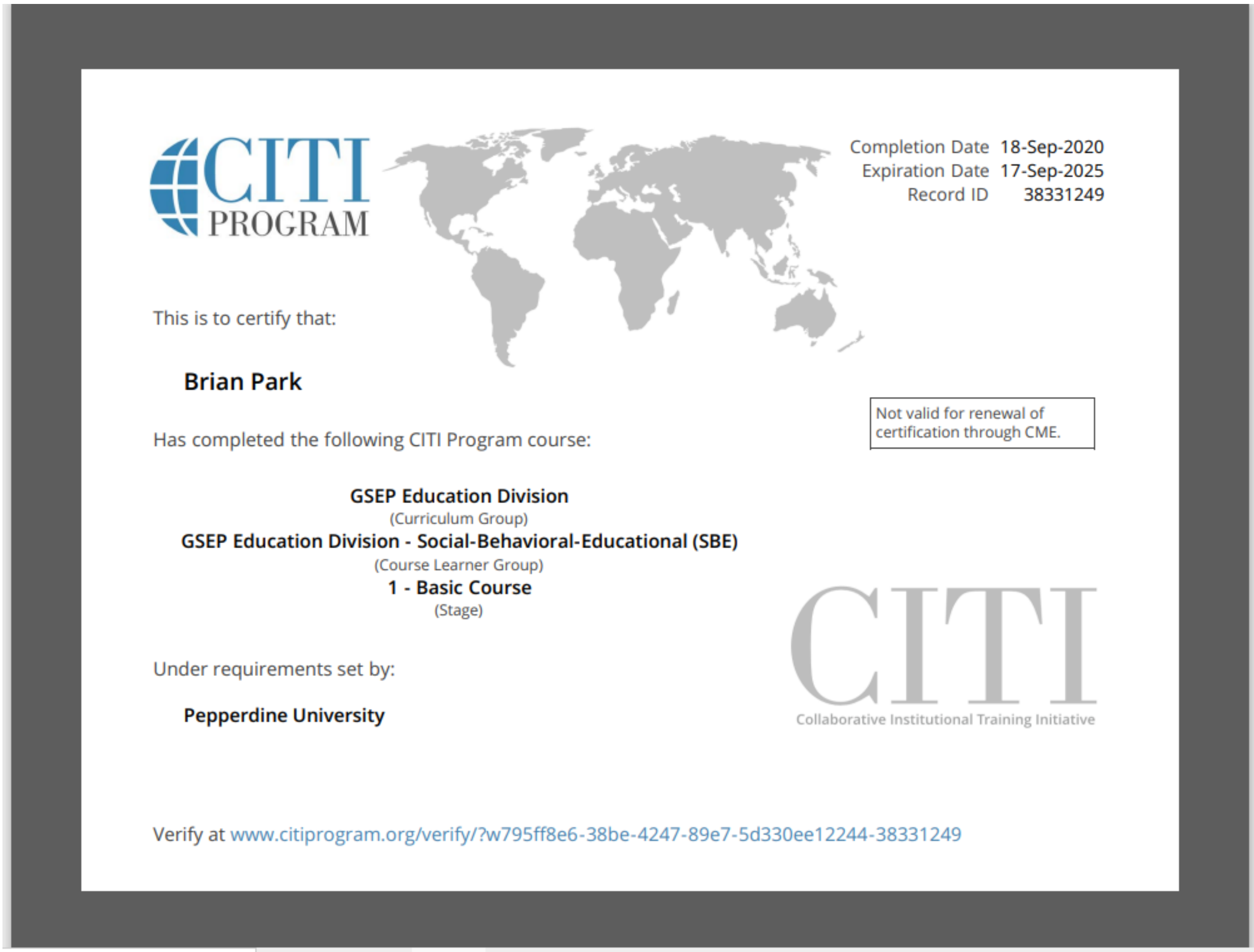
APPENDIX A

Human Subjects Training (CITI Program) Certification



CITI PROGRAM

Completion Date 18-Sep-2020
Expiration Date 17-Sep-2025
Record ID 38331249

This is to certify that:

Brian Park

Not valid for renewal of certification through CME.

Has completed the following CITI Program course:

GSEP Education Division
(Curriculum Group)
GSEP Education Division - Social-Behavioral-Educational (SBE)
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Pepperdine University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w795ff8e6-38be-4247-89e7-5d330ee12244-38331249

APPENDIX B

Recruitment Script

Dear [*name*],

My name is Brian Park, and I am a doctoral student in the Graduate School of Education and Psychology at Pepperdine University. I am conducting a research study in postsecondary students' perceptions of how well secondary science education helped them prepare for higher education, and I need your help! I am seeking volunteer study participants for semi-structured interviews of your choice. Your participation in the study involves an audio recorded in-person or virtual interview and is anticipated to take no more than 45 minutes.

Participation in this study is voluntary, and your identity as a participant will be protected before, during, and after the time that study data is collected. Strict confidentiality procedures will be in place during and after the study. Confidentiality will be maintained using a password protected laptop to store all data collected including informed consent, the recorded interview, and the transcribed data. All data will also be deidentified using a pseudonym, which will be assigned to each individual recording.

If you have any questions or would like to participate in this study, please feel free to contact me at your earliest convenience.

Thank you for your participation,

Brian Park

Pepperdine University

Graduate School of Education and Psychology

Doctoral Student

Email: brian.park2@pepperdine.edu

APPENDIX C

Institutional Review Board (IRB) Protocol Approval Letter

Pepperdine University
24255 Pacific Coast Highway
Malibu, CA 90263
TEL: 310-506-4000

NOTICE OF APPROVAL FOR HUMAN RESEARCH

Date: March 17, 2023

Protocol Investigator Name: Brian Park

Protocol #: 23-02-2082

Project Title: Perceptions of College/University Students on High School Science and STEM Courses

School: Graduate School of Education and Psychology

Dear Brian Park:

Thank you for submitting your application for exempt review to Pepperdine University's Institutional Review Board (IRB). We appreciate the work you have done on your proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. Upon review, the IRB has determined that the above entitled project meets the requirements for exemption under the federal regulations 45 CFR 46.101 that govern the protections of human subjects.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an amendment to the IRB. Since your study falls under exemption, there is no requirement for continuing IRB review of your project. Please be aware that changes to your protocol may prevent the research from qualifying for exemption from 45 CFR 46.101 and require submission of a new IRB application or other materials to the IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite the best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete written explanation of the event and your written response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at community.pepperdine.edu/irb.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval. Should you have additional questions or require clarification of the contents of this letter, please contact the IRB Office. On behalf of the IRB, I wish you success in this scholarly pursuit.

Sincerely,

Judy Ho, Ph.D., IRB Chair

cc: Mrs. Katy Carr, Assistant Provost for Research

APPENDIX D

Sample Informed Consent Form

Formal Study Title: Perceptions of College/University Students on High School Science and STEM Courses

Authorized Study Personnel:

Brian Park (brian.park2@pepperdine.edu)

Key Information:

If you agree to participate in this study, the project will involve:

☒ (Males and Females) between the ages of (18-25)

☒ Procedures will include (Contacting participants using the recruitment script, informed consent, data collection via semi-structured interview, transcription of data, analysis of data, documentation of findings)

☒ One in-person or virtual visit is required

☒ This visit will take 45 minutes total

☒ There is minimal risk associated with this study

☒ You will not be paid any amount of money for your participation

☒ You will be provided a copy of this consent form

Invitation

You are invited to take part in a research study titled "Perceptions of College/University Students on High School Science and STEM Courses". This study is being led by Brian Park, Graduate

School of Education and Psychology at Pepperdine University. The information in this form is meant to help you decide whether or not to participate. If you have any questions, please ask.

Why are you being asked to be in this research study?

You are being asked to be in this study because you are a high school graduate who is continuing his or her education. You must be 18 years of age or older to participate.

What is the reason for doing this research study?

The purpose of this study is to examine college/university students' perceptions of how well science education in secondary school prepared them for postsecondary. It is through the former secondary students' lenses that the research student will look at the secondary science education and identify any improvement that can be made in high school science for future high school students.

What will be done during this research study?

You will be asked to complete a 45 semi-structured in-person or virtual interview. The student will ask you a series of questions aimed at exploring your perceptions of STEM. While the research will take approximately 12-14 weeks, your interview will only take 45 minutes.

How will my data be used?

Your interview responses will be transcribed, analyzed, and aggregated in order to determine the findings to the established research questions.

What are the possible risks of being in this research study?

This research presents risk of loss of confidentiality. The iPhone with the audio recordings collected during the in-person interviews could get lost. To minimize this risk, the iPhone will be password-protected and the “Find My iPhone” service on other electronic devices such as iPad will be turned on.

What are the possible benefits to you?

You are not expected to get any benefit from being in this study.

What are the possible benefits to other people?

The benefits to society may include better understanding of science and its significance. Any secondary school might also benefit from any additional recommendations that are shared by students.

What are the alternatives to being in this research study?

Participation in this study is voluntary. There are no alternatives to participating, other than deciding to not participate.

What will participating in this research study cost you?

There is no cost to you to be in this research study.

Will you be compensated for being in this research study?

There will be no compensation for participating in this study.

What should you do if you have a problem during this research study?

Your welfare is the major concern of the research student. If you have a problem as a direct result of being in this study, you should immediately contact the research student listed at the beginning of this consent form.

How will information about you be protected?

Reasonable steps will be taken to protect your privacy and the confidentiality of your study data. The recordings collected during interviews, whether in-person or virtual, will be deidentified and stored electronically in a password-encrypted file and will only be seen by the research student for transcription during the study. All recordings will permanently be deleted once the transcription process is complete. There will be another password-encrypted file for only transcripts and it will be shared with a secondary coder for analysis. It will be shared through Discord. Once the secondary coder is messaged with the file, it will immediately be deleted/unsent. Upon completion of analysis, the secondary coder will be asked to delete the file. The research student will then request remote access and control and confirm the deletion with TeamViewer.

The only persons who will have access to your research records are the study personnel, the Institutional Review Board (IRB), and any other person, agency, or sponsor as required by law. The information from this study may be published in scientific journals or presented at scientific meetings but the data will be reported as group or summarized data and your identity will be kept strictly confidential.

What are your rights as a research subject?

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study.

For study related questions, please contact the research student listed at the beginning of this form.

For questions concerning your rights or complaints about the research contact the Institutional Review Board (IRB):

Phone: 1(310)568-2305

Email: gpsirb@pepperdine.edu

What will happen if you decide not to be in this research study or decide to stop participating once you start?

You can decide not to be in this research study, or you can stop being in this research study ("withdraw') at any time before, during, or after the research begins for any reason. Deciding not to be in this research study or deciding to withdraw will not affect your relationship with the research student or with Pepperdine University.

You will not lose any benefits to which you are entitled.

Documentation of informed consent

You are voluntarily making a decision whether or not to be in this research study. Signing this form means that (1) you have read and understood this consent form, (2) you have had the consent form explained to you, (3) you have had your questions answered and (4) you have decided to be in the research study. You will be given a copy of this consent form to keep.

Participant

Name:

____

(First, Last: Please Print)

Participant

Signature:

____

Signature Date

APPENDIX E

Semi-Structured Interview Protocol

Q 1. At what grade in high school did you start taking STEM or science classes?

Q 2. If available, which advanced science classes were offered at your high school (biology, chemistry, physics, environmental science, etc.)? If unavailable, please list the advanced science classes you wish your high school offered.

Q 3. How was your experience in your first college/university STEM course different from what you initially expected?

Q 4. What kind of information, in regards to science classes, did you exchange with your classmates, friends, or teachers at your high school?

Q 5. How well did high school STEM or science classes prepare you for a STEM degree program in higher education?

Q 6. What were some of the advantages, as a result from taking STEM or science classes in high school, you experienced in college/university?

Q 7. In what areas were the STEM or science classes in high school lacking based on your college/university experiences?

Q 8. What is some information or knowledge that you wish you gained in high school science classes before deciding on your major at college/university?

Q 9. In your experience, did your gender significantly impact your choice or opportunity in any way to take additional STEM or science classes in high school?

Q 10. What are some changes that high school administrators should implement in the STEM or science classes to motivate more future college/university students to join the STEM field?

Q 11. What are some changes that high school administrators should implement in the STEM or science classes to persuade high school students to believe that learning STEM can significantly help them succeed post-high school?

Q 12. What are some changes that high school administrators and educators should implement to increase their students' confidence in STEM or science?

Q 13. If you are aware of any, please list and discuss any programs or resources that helped students prepare for their future STEM or science classes at your high school.

Q 14. Which skills gained from high school science education helped you prepare to be independent in college/university?

Q 15. Please share any recommendations that you might have on the most effective way to implement change in high school STEM or science curricula.

APPENDIX F

Interview Transcripts

1-Participant A

9th grade.

AP: chemistry, biology, economic science, physics, computer science.

I’ve always done really well in math, both AP Calculus tests were easy for me in high school and I thought I was good at it. At my community college, my first math class was actually pretty difficult so that was surprising and I started to doubt my abilities in math. I also had to take my first physics class and I thought I would hate it initially for being science but the more I understood it, the more I started to like it.

In one biology class I took, information about biology was all we learned. That’s why I hated the class, it was like memorization.

My high school prepared us well in Calculus classes and just having a lot of advanced classes helped too.

It helped me to complete my undergraduate classes faster. In fact, I wish I had taken more STEM AP classes in high school because many of them give college credits that I couldn’t utilize.

The classes didn’t lack much in my high school. The only complaint I have is that they purposefully make it harder than other schools normally would so that it’s easier for us to understand in AP tests and after high school, which made the classes less appealing.

I wish I knew that it’s extremely hard to do well in Computer Science if you’re super invested/interested in it.

No not at all.

Maybe they should start advertising it more and teaching students about the STEM classes and how they be beneficial.

They should also implement how the teachings can benefit them in real life and how taking more STEM classes open up a lot of doors for them post high school.

Being more effective with teaching always helps students. I’ve had two different kinds of teachers that led me to have vastly different experiences. One had a very organized plan and agenda for what we would do every single day. The other just did whatever he wanted and his plan was very vague. I ended up liking the first subject a lot more. They should offer more of their help like with office hours or give tutoring resources because the difficulty of STEM is what makes it so unappealing to students.

There was a free tutoring program for STEM classes.

I barely took any science classes so I wouldn’t say I gained any skills.

Tell the kids that that there are so many options in STEM and every field is good for entering at the career level. I think it would be good to include more labs in STEM classes. Learning more about the subject in real life situations helps the students to enjoy their time more instead of just packing information into their brains.

2-Participant B

9th Grade.

My school offered advanced biology, chemistry, physics, environmental science, and computerscience classes.

I found my first university STEM courses hard to adapt to. For classes like Chemistry, there were a lot of labs, which would sometimes require hours of pre-lab work, that high school didn't reallyprepare me for. The heavily weighted midterms were also difficult to get used to since it meant that there was a lot less room for error. Lectures were also structured very differently and the length of some lectures would make it difficult to keep focused during class.

With classmates and friends, I would generally just talk about concepts and homework problems. We would complain a lot about certain classes as well and what classes in particular to take or avoid. I did not talk with teachers much in high school.

I would say, material-wise, it prepared me well as I knew the things I needed to know beforetaking the class. However, in terms of pacing and general structure of the course, I would saythey did not prepare me all that well.

The lectures and assignments in high school helped build up self-discipline which in turn helpedwith adapting to the more rigorous university level classes. Also, it goes without saying that the material helped prepare me for the more advanced classes I needed to take in university.

The classes in high school were lacking in specialization/options. I understand high school courses want to give students a general course education but I feel like there is little opportunityto explore one's interests with the current structure of the school system, not just regarding STEM.

I wish the classes in high school let me explore my options in STEM more so I had a clearerpicture of what I wanted to study in university. I felt like I wasted a lot of time in university because I was initially undecided on my major.

My gender didn't really impact my choices.

I believe adding a more variety of subjects and specialized courses could help motivate high school students to pursue these subjects in higher education. In addition, if the administrators could also lessen the GE requirements for high school students, it could give those students more time to explore and find their true interests.

To be frank, the main motivation for students taking STEM courses is the money. However, a lotof students taking those classes don't know how and when they will use the things they are learning. If high school teachers/course administrators can find examples of how the material the students are learning can be applied in various STEM-related jobs, it can serve to motivate them even more.

Showing where the material students are learning applies in different careers would be the bestway to increase confidence, as I stated previously.

I am not aware of any resources or programs.

Self-discipline and problem-solving were skills/traits I developed in high school that helpedimmensely when transitioning to university life.

It is basically what I have stated before. Shortening some of the GE requirements would allowstudents to focus more on subjects they enjoy. Also, making summer classes readily available could also help students explore their interests in school more (and in STEM as a result). Adding more STEM classes for students to choose from would be beneficial as well.

3-Participant C

I was in 9th Grade.

My school had AP biology, chemistry, physics, and environmental science.

I found my first college STEM course difficult because I wasn’t prepared for it. There was too much terminology that I wasn’t aware of and my high school STEM teachers never taught me. I had to go to my professor’s office hours for extra lessons.

I would basically discuss homework assignments with my classmates or friends. I wasn’t really close with my science teachers.

Honestly, not that well. I was taught the basics, but that wasn't enough. I never realized the large difference in difficulty level between high school and college until I started my first college course.

Most of the science teachers I had in high school weren't the best at teaching. From time to time, I had to independently study to not fall behind. Although I didn't have good teachers, my ability to independently study developed over time. Being able to independently study is an essential skill to have especially when attending college.

Obviously, compared to college courses, high school classes were too easy. I feel like I didn't learn enough in high school. Most of the concepts I learned were not taught in depth.

I wish I was more aware of STEM careers. Before deciding on my major, I was actually undecided. I had to do my own research on STEM. I looked up myself what kind of jobs or careers I could get into with a STEM degree.

Definitely not.

There needs to be more STEM awareness. I'm sure most of my classmates in high school had no idea what kind of jobs they could have in the future if they earned a STEM degree.

Most of the things we learn in high school classes, not just in STEM, are not applicable in real life. If teachers helped students understand why they are learning what they are learning instead of just what they are learning, I feel like more students would take the classes more seriously. Most students want to apply what they learned in the real world and not just keep them in their heads.

I'd say more positive feedback. There should be a good balance of compliments and criticism. It's never good if one outweighs the other.

I don't remember.

Problem solving skills and being able to independently study definitely helped me. It helped me make smarter decisions.

Only useful things should be taught not just in STEM classes, but all classes. There needs to be more relatable concepts in the classes. If I learn things that I am never going to use in my life, I see no purpose of attending school.

4-Participant D

My freshman year in high school.

AP biology, chemistry, physics, and computer science.

The first STEM course that I took at my college was extremely difficult. I thought I was prepared before enrolling, but I definitely wasn't. The pace in college is way faster and the content you learn is way more in depth.

Nothing really. We just helped each other's homework and talked about what we needed to know for the exams. I didn't talk to my teachers much.

My school did an okay job, not too bad, but at the same time, not that good. It would have been better if more important information or lessons were given to the students. I honestly thought my first biology course in college would be a review of AP Biology, but it was pretty much taking a whole new class.

My high school biology class helped me develop my memorizing skills. Your ability to memorize any type of information is always useful, especially in biology courses.

The biggest area that was lacking was clarification. There were many times when my classmates and I were confused during lectures and the teachers couldn't properly clarify the parts that we were confused about.

I wish I knew that college science was way different, when I say different, I mean difficult, from high school science. That way, I would have prepared myself, even a little bit, before starting college.

Yes. What I heard was that more women are being wanted in the STEM field, which is why I wanted to pursue STEM.

I believe a lot of students are unaware of the fact that they have a high likelihood of having a successful career if they pursue a STEM degree. School administrators need to promote this type of information to the students. If it's mentioned in STEM classes, it could lead to more students paying more attention.

Honestly, most of the things we learn in STEM are not useful in real life. They are not that relatable. I think teachers should educate their students on which concepts and how they can be applied in the real world.

Consistent encouragement helps. Keep telling them that they can do it is effective. It doesn't sound like it has that much of an effect, but these little things can accumulate. Motivation is key.

I am not sure.

I can't think of anything other than memorizing skills. My ability to memorize and recall helps me find classrooms, be aware of my assignment deadline, and be aware of any available resources that I have access to on campus.

Student engagement and motivation are important in STEM classes because the subjects are difficult. If the subjects are difficult, students are more likely to give up. To make them not give up, STEM classes need to be more fun and engaging, maybe there should be more labs in class or activities that students can do on their own outside the classroom for homework.

5-Participant E

9th grade.

AP chemistry, biology, and physics were offered.

I always thought science was the hardest subject to learn. I knew majoring in science in college was going to be tough, but I didn't think it was going to be this tough. I barely passed my first science course. High school science was extremely easy compared to college science.

We just talked about what was on the exams. After the exams, we would discuss our answers just to get a basic idea of how bad or well we did on the exams. I rarely talked to my teachers.

I had great science teachers. They were very passionate. They also made the subject interesting, which made me want to major in science. However, the amount of knowledge I gained from the lessons wasn't nearly close to enough. I wish the content taught was more in detail and beneficial.

Chemistry in high school helped me develop my problem-solving skills and biology helped me improve my memorizing skills. Both are useful skills to have when attending college.

My high school science classes were lacking on preparation. Either my school didn't prepare me well or I underestimated college courses. My high school science teachers definitely could have taught more in detail or more important concepts that I should have known prior to starting my first college science course.

I found high school science fun and I thought I'd find college science fun too, but they are very different. I wish my high school science teachers told me about the significant gap between the two levels.

It actually did. I heard that there needs to be more women in the STEM field so I took as many STEM courses as I could take in high school to pursue a STEM career in the future.

There needs to be guest speakers or role models who are in the STEM field and the students can look up to. Them sharing their experience in the STEM field can motivate the students to want to join it. Teachers alone are not enough.

All the knowledge gained in STEM should be applicable in the real world. There are too many concepts taught that we don't need to learn. I think schools should focus only on the concepts that we need to know to survive and help us become better adults.

Strong encouragement always helps. Positive words can make a difference especially when students show poor performance.

I believe my school had after school STEM tutoring programs.

My problem-solving skills help me a lot. Every time I encounter problems in life, I find ways to solve them. This is something I've been doing since high school.

More information about the subject being taught needs to be given. Not enough information is delivered to the students. Also, there needs to be specific assignments or activities given to the students where their knowledge gained in science classes is tested outside of school. The more relatable the subject is, the more the students will be intrigued by it.

6-Participant F

9th Grade.

My school offered AP biology, chemistry, physics, and environmental science I believe.

It was fun, but challenging. College STEM courses are at a different level. I can't count how many times I went to my professor's office hours.

My friends and I would work on our assignments together. Sometimes, we would study together too.

Not the best, but not the worst either. The pace in college is much faster so it feels like I am always behind. I see College STEM as continuation of high school STEM. The difference in pace between high school and college, however, is way too much. This is something my school didn't prepare me well for.

AP credits. Thanks to them, I was able to skip some courses while earning credit for them at the same time.

There were too many lectures and not that many lab experiments and hands-on activities. The classes were somewhat boring.

I wish I knew that pursuing a STEM degree would be more challenging than I initially thought. There was definitely a lack of preparation before deciding on my major.

It did not.

My school didn't do well on marketing, which is something they or other schools can work on. STEM awareness is needed if you want more students to join the field.

In my high school science classes, there were many students who didn't know how to apply what they learned during exams. They just memorized what they needed to memorize for the exams and forgot about them shortly after. Being able to apply what you learn is an important skill to have and it must be taught properly in STEM since it's mostly about problem-solving. There's no point of learning if you don't know how to apply what you learned.

There needs to be a program where it helps students with their mental support. Students always need support and whenever they need it, teachers or administrators should be available to help them.

There wasn’t any, at least not that I know of.

Being able to solve problems whether they are on exams or in real life. The more your problem-solving skills develop, the more you learn to be independent.

High school STEM classes really need to emphasize on the difference in pace between high school and college. The change in pace is something that students can’t get used to immediately. The students need to gain all the necessary skills from their STEM classes that they can use to help themselves adjust to the new environment when they enter college.

7-Participant G

In 9th Grade.

AP physics, chemistry, biology, environmental science, and computer science were offered.

It was difficult. I almost didn’t pass my class. I received a lot of help from my friends and classmates. Thanks to them, I was able to pass.

Not much information was exchanged. We just discussed the assignments and deadlines.

Mediocre. High school STEM taught me the basics that I needed to know to continue my STEM education in college. However, my high school STEM teachers didn’t mention a lot of the content that I learned in my college STEM courses. In other words, there was barely any preview.

I was able to receive credit for a few STEM courses at my university thanks to AP credits.

There was a lack of preparation. High schools in general need to do a better job at preparing their students for college.

I wish they informed me of the difference in difficulty level between high school and college STEM. I wasn't even given a heads up. If I did, I would have prepared myself.

No, it did not.

In order for students to join STEM, first, they need to be prepared. They could perform well in high school STEM classes, but when they get to college, they could change their minds because college STEM is incomparably more difficult. High school STEM doesn't deliver enough content for students to do well in college STEM and that needs to change.

There needs to be more focus on life skills that students can gain from STEM classes. Instead of spending time on learning concepts that they will eventually forget, more time should be spent on learning how and when to use the life skills that they gain from STEM. Demonstrations and real-life examples should also be used to facilitate their learning and understanding.

Constructive criticism is important. Delivering negative feedback positively to the students can make them want to improve their performance or even themselves. And once there is improvement, they will get more confident.

I don't think my school had any.

Critical thinking and problem-solving skills. If I didn't have these skills, I would be making terrible decisions in life.

I realized what kind of life skills I gained from high school STEM when I started college. I wish I realized it sooner. High school STEM needs to have more emphasis on life skills and help students develop them. This is because the life skills they gain from STEM classes are going to be more useful than most scientific concepts that they learn.

8-Participant H

9th grade.

There were AP chemistry, physics, and biology.

It was actually just as I expected. I knew it was going to be very hard for me. There was so much content that I was unaware of.

My friends and I just discussed assignments, exams, and grades we received in the class.

I really enjoyed my STEM classes. My favorite science class was chemistry because I loved solving problems. I also enjoyed physics. Both classes had a lot of math involved, which I liked. The two classes strengthened my math. I always found math challengingly fun, which is why I decided to major in it.

The problem-solving skills that I gained from high school STEM have been helping me survive college.

They come in handy, especially when I encounter problems, not just in class, but in life overall.

I knew I was going to struggle in college because I had a feeling that I wasn't learning enough in high school, which is why I expected my first college STEM course to be hard. I guess there was a lack of preparation for students who wanted to continue their education after graduation.

I don't have anything in particular. Chemistry and physics helped me confirm my passion for math though.

No, my gender did not impact my choice.

More examples that students can relate to need to be given more often in STEM classes. If they think that the subject that they are learning is not going to be useful in the future, they will pay less attention.

Students learning to use the knowledge and skills gained from their STEM classes in the real world can make a difference in their views of STEM. Instead of constantly giving new information and having students test their knowledge through exams, they should be taught how to use what they learned outside of school.

Positive affirmations are needed sometimes. Discipline is important too, but positive words are what lifts the students up so it's necessary.

There were science and math tutoring programs, which I was part of. I was a math tutor.

My ability to come up with solutions to every problem I face. Chemistry and physics really helped me improve my ability to solve problems. I've been using this skill a lot since I started college.

There needs to be more project-based learning. There aren't that many assignments where students are required to apply what they learned in class outside of school. There should be more of that.

9-Participant I

9th Grade.

AP environmental science, physics, chemistry, and biology.

Honestly, the lecture part of the class wasn't hard for me to adapt to. However, the labs were difficult. There were many experiments that I had to do in a short period of time, which I wasn't prepared for.

My friends and I often worked on our assignments together because they were somewhat hard so we mainly discussed that.

On a scale of 1 to 10, I would say around 4 or 5. I wasn't even prepared that well for my high school STEM classes so I was definitely underprepared for college STEM.

Being able to do research on my own. In my STEM classes, I searched solutions to problems that I couldn't solve on my homework assignments online numerous times. As my experience in research kept piling up, I started learning ways to study on my own.

My high school STEM classes didn't have that many labs. I wish there were more labs. If there were, it would have been great practice and preparation for me before transitioning into college.

It would have been great if my high school let me explore all the career options available in the STEM field. They never told me which specific jobs I could get in the future if I studied STEM.

My gender had no impact.

STEM needs to be promoted more. Students have no idea what to do with the information they gain from STEM and which careers they can get into. I'm sure they will be more motivated if they were aware of what kind of future they would have if they studied STEM.

There needs to be more emphasis on the STEM careers. Future jobs and careers are the reasons that they are in school. They need to be taught that learning STEM can lead to them greatly contributing to society in the future.

Help the students recognize what they are good at and use that to their advantage, if possible.

I am not aware.

Problem-solving. I solved a lot of difficult problems in high school and I still do. It's a useful skill to have in life.

STEM-related jobs and careers need to be mentioned more, especially in STEM classes.

10-Participant J

Freshman year.

My school had AP physics 1, 2, and C, chemistry, biology, and environmental science.

My very first college STEM course was harder than all of the AP science classes that I took in high school combined. It was frustrating and stressful, to be honest.

I rarely talked to my friends or classmates about our science classes. The only times we talked about our science classes were when we had group assignments or projects that required collaboration.

Content-wise, my science classes prepared me well. However, pacing-wise, they did not. The speed at which the material is covered in college STEM courses is way quicker than high school STEM.

I did a lot of independent studying in high school. I was always behind in my STEM classes because I didn't understand the material that well. To not fall behind, I had to study alone and catch up. I am glad I familiarized myself with independent studying in high school because it's a very useful skill to have when you're in college.

A lot of the students struggled in my STEM classes. There wasn't much help or support provided by our teachers or the school, which is mainly why I had to learn to independently study.

I wish the science classes in high school helped me realize my passion sooner. Because I didn't realize it sooner, I changed my major twice.

My gender didn't impact my choice.

I noticed that quite a few high school STEM teachers just give information and don't educate their students on ways to use it. If they teach their students how to utilize the information gained in class, whether in school or in life in general, I'm sure it will attract more students to join the STEM field.

The STEM field is full of high-paying jobs and careers. Money is a significant aspect of success. Students getting jobs that have high salary should be mentioned occasionally so that they can see STEM differently and consider it as their college major and future career.

There should be a counseling program for students and their mental health. Sometimes, they just need someone to talk to. They should be able to relieve stress when they need to at school.

I am not aware of such programs.

Critical-thinking skills. My critical-thinking skills have developed a lot over the years and they help me make better decisions.

There needs to be more focus on why we are learning it than what we are learning. Students are curious about the why part, which most STEM teachers don't usually explain. If the students understand why, I think there would be a major change in how they view the subject.

APPENDIX G

Thematic Analysis Results From Secondary Coder

- **high school preparation**
  - college credit advantage
  - confusion - lack of clarity in HS
  - enjoyment
  - good content prep in HS
  - good HS teachers
  - HS tutoring programs
  - independent study skills advantage
  - lack of challenge in HS
  - lack of labs in HS
  - lack of topic options in HS
  - lack/unaware of HS programs
  - mediocre prep in HS
  - memorization
  - poor content prep in HS
  - poor pacing prep in HS
  - poor teacher support in HS
  - problem solving skills advantage
  - unnecessarily difficult in HS
- **college different from HS**
  - more difficult in college
  - more work faster pace in college
  - stressful
  - unprepared for college
- **social experiences**
  - assessment-related talk
  - assignment-related talk
  - commiserating talk
  - did not talk to teachers
  - help from friends
  - help from instructor
- **recommendations**
  - career/interest exploration
  - need STEM career promotion
  - need STEM role models
  - need to prepare students for difficulty
  - need to show career benefit to society
  - need to show career salary success
  - no recommended improvements
  - show application of knowledge, why important
- **confidence supports**
  - mental health counseling
  - need better teaching
  - need constructive criticism
  - need positive encouragement
  - recognize strengths
- **gender**
  - no gender impact
  - yes gender impact