Lived Experiences of Gifted Professionals in Science

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Abstract

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There is little attention and consensus in science education for gifted learners, leading to insufficient support and understanding of their needs, which hinders their potential development as future scientists and professionals. Utilizing a narrative research design, the study explores the experiences of nine scientists identified as gifted in childhood, through semi-structured interviews, questionnaires, and document reviews. The research addresses three pivotal questions: (1) How do scientists, who were identified as gifted in their childhood, navigate their gifted identity from childhood to adulthood, and how does this affect their social relationships and self-perception? (2) How do scientists, who were identified as gifted in their childhood, perceive and describe the critical elements that contribute to their exceptional performance? (3) How do scientists, who were identified as gifted in their childhood, reflect on the impact of their K-12 science education on their development and career choice? Findings reveal that participants' exceptional performance in science was influenced by various factors such as individual abilities, family background, motivation, support, opportunities, and luck, and education. The impact of K-12 science education varied, with dissatisfaction in early years due to a lack of challenging curriculum, but more satisfaction in high school due to advanced classes and programs. These insights contribute to the development of educational policies and programs that better meet the needs of gifted learners in science, ultimately helping them to realize their full potential as future scientists and professionals.

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Acknowledgments

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Dedication

To my dear sisters

If it were not for you, I would not be here today.

Chapter 1: Introduction

1.1 Statement of the Problem

The imperative to enhance science education for all students, particularly those with diverse educational needs, has steadily increased over the last century. Significant efforts have been dedicated to refining science instruction for those most vulnerable, including individuals with learning or physical disabilities, non-native speakers of English, students from economically disadvantaged backgrounds, and members of cultural minority groups. However, the educational needs of gifted learners in science have not been afforded the same level of attention by comparison.

One of the reasons for the neglect of gifted learners in science might be the lack of consensus on how to define this term and how to identify such learners. There is no universally perfect intelligence test for identifying gifted learners, and not all gifted and talented students show their abilities in a similar way at the same age (Subotnik et al., 2011). Additionally, concerns about educational equity have been raised, suggesting that grouping students by ability and labeling them might exclude non-gifted or unidentified students from specialized programs (Colangelo & Davis, 2003). Moreover, several prevalent but incorrect beliefs might undermine efforts to develop effective science programs for gifted learners. For instance, it is often incorrectly assumed that gifted students require little assistance to realize their full potential, and that they become gifted individuals effortlessly (Sheffield, 2017). In reality, they need substantial support and hard work to excel as professionals such as future scientists (Subotnik et al., 2011). Therefore, it is vital to explore the life stories of prominent individuals in science fields to understand the factors that significantly influence their success. Investigating the elements that hinder or facilitate their learning can help ensure that gifted individuals receive the high-quality

education they deserve, on par with their peers, without losing their motivation to engage in science or pursue a career in the field. Addressing these issues has the potential to significantly impact the future of science education and the development of gifted learners, fostering a more inclusive and effective learning environment.

Science education and gifted education are distinct yet overlapping domains. The intersection of these two fields, especially in the context of science education for gifted children, warrants significant attention. In particular, in the field of gifted education, a profusion of studies has been carried out to define giftedness (e.g., Gardner, 2006; Renzulli, 1978; Tannenbaum, 1983), identify gifted learners (e.g., Gubbins et al., 2021; Peters et al., 2020; Terman & Oden, 1959), explore teachers' views on giftedness (e.g., Russell, 2018), investigate effective teaching methods (e.g., Murphy et al., 2018; Robinson et al., 2014), and determine an appropriate classroom setting for gifted learners (e.g., Moon et al., 1994; Schiever & Maker, 2003; Sitkoff, 1988). Despite these efforts, there remains a lack of consensus among researchers regarding these critical aspects of gifted education.

On the other hand, science is recognized as a crucial discipline that significantly contributes to the wealth of nations (DeBoer, 1991; Hodson, 2003; Jaffe, 2013; Van Eijck & Roth, 2007). Therefore, emphasizing the maximization of gifted students' potential, providing avenues for them to pursue science careers aligned with their abilities, and supporting their growth into distinguished adults, such as eminent scientists who enhance societal well-being, should be among the top priorities of science education (DeBoer, 1991; Van Den Akker, 1998). However, criticisms regarding the perceived privilege associated with giftedness (e.g., Mansfield, 2015; Mazie, 2009)can sometimes lead to the oversight of these students' needs. As a result, they are deprived of exposure to material that corresponds with their interests and

intellectual aptitude. To rectify this situation, it is essential to gain deeper insight and understanding of what is necessary. Consequently, learning from scientists who were gifted children is of great importance in order to grasp the factors that contributed to their development as scientists.

1.2 Purpose of the Study

The purpose of this study was to explore the educational experiences and growth trajectories of gifted professionals in the field of science. Key areas of focus included examining the educational journey of gifted individuals from childhood to adulthood, understanding the impact of the gifted label on their overall development, identifying effective educational strategies for nurturing gifted learners in science, exploring the dynamics of their relationships with educators, peers, and families, and assessing how various factors like curriculum and teaching methods influence their career paths.

1.3 Research Questions

To comprehensively explore the multifaceted experiences of gifted professionals in science, this study was directed by the following critical research questions:

1. How do scientists, who were identified as gifted in their childhood, navigate their gifted identity from childhood to adulthood, and how does this affect their social relationships and self-perception?
2. How do scientists, who were identified as gifted in their childhood, perceive and describe the critical elements that contribute to their exceptional performance?
3. How do scientists, who were identified as gifted in their childhood, reflect on the impact of their K-12 science education on their development and career choice?

1.4 Researcher Perspective

Before beginning my PhD journey at Teachers College, Columbia University in the City of New York, I worked as a middle school science teacher in Turkey. In that role, I encountered a diverse array of students, each shaping my perspective on teaching in their own way. Among them, one student left a lasting impact and inspired me to delve deeper into this field of study —science education for gifted learners. He was a young boy whose vocabulary and thought processes far exceeded his years. His curiosity and passion for science were palpable, leading him to immerse himself in various science projects without any formal assignment. His natural inclination towards scientific exploration stood as a testament to his extraordinary potential.

Despite his exceptional abilities, his grades did not reflect his true potential, leading many educators to overlook him as "gifted". This situation raised concerns about his ability to fulfill his capabilities. He distinguished himself not through academic excellence but through his curiosity and innovative thinking, which left me worried about his future. In my quest to find additional resources and programs to support him, I encountered the challenge of securing a spot for a child who, despite his intellectual gifts, did not possess traditional academic achievements. My greatest fear was that he might lose his interest and motivation in a system that failed to recognize and nurture his unique talents.

The difference observed between gifted achievers and gifted underachievers can be attributed to an array of determinants, among which the attitudes and behaviors of their teachers stand out significantly (McCoach & Siegle, 2003). The interest and value that students attribute to their courses and instructors, coupled with pedagogical approaches that make the classroom environment engaging and assignments stimulating, play a crucial role in enhancing their academic performance and fostering motivation (McCoach & Siegle, 2003; Siegle et al., 2014). Otherwise, students may not be able to reach their full potential.

As a science teacher, I am convinced that our mission extends beyond the confines of the classroom; we must guide every student, irrespective of their background, towards realizing their full potential. A student who aspires to be a scientist and solve global problems should not be ignored but supported. This experience shifted my perspective. Initially, my focus was on offering increased support to those perceived as vulnerable. However, I came to understand that gifted students also possess their own vulnerabilities and require recognition and understanding. For the prosperity of our nation, it is imperative that we furnish these young minds with the opportunities they need to transform their innovative ideas into reality.

As I delved into articles and books on gifted education, I realized that it is a complex concept fraught with disagreements. The process of defining giftedness, identifying gifted students, and determining how to educate them are all intricate but crucial tasks. It is important to acknowledge that a student deemed gifted in one educational setting may not be recognized as such in another. This raises the question of whether giftedness is a transient attribute (Jacobsen, 1999). In reality, what these students need is a deeper understanding. As a science teacher, I have chosen to focus my study on gifted students in science, irrespective of their academic performances. My interest lies in students who show a keen interest in science and possess the ability and skills related to the field.

To this end, it was important to raise concerns about gifted students' education not only in gifted classes but also in regular classrooms. In this study, I made a concerted effort to find nine successful scientists who had been identified as gifted during their childhood. By learning from their experiences, I aimed to inform teachers, policymakers, and future research about ways to nurture these potentials into becoming scientists. It is imperative to acknowledge the presence of students who, despite not being formally identified as gifted, possess substantial potential.

Several critical factors may contribute to the oversight of such students, rendering them absent from gifted programs in which they could otherwise excel and benefit significantly. As educators in the sciences, we must ensure that no individual is precluded from enhancing their potential, irrespective of any labels that may be assigned to them. Emphasizing only those individuals who have been formally identified as gifted may overlook the broader notion that potential cannot solely be determined by labels. Nevertheless, to refine the scope of this research and ensure the precise application of concepts, I have chosen to focus on individuals who have been labeled as gifted at some point in their lives. It is crucial to approach the interpretation of this study with the understanding that potential extends beyond formal identification. Successful scientists who have not been identified as gifted may still be gifted, but they are not the population of this study.

1.5 Definition of Terms

It is important to define the key terms for this study to create a clear understanding of the basic definitions that might be confused with one another. Below are various definitions:

Gifted

Students identified as "gifted" are known to learn faster than their peers, possess strong memories, exhibit high motivation towards learning, absorb new information rapidly, and show a keen interest in academic subjects (Delisle, 2014; Gagne & Deci, 2005; Renzulli, 1978; Subotnik et al., 2011; Tannenbaum, 1983). Students identified as "gifted in science" demonstrate a keen interest in scientific disciplines (Watters, 2004), in addition to the characteristics mentioned in the general definition of "gifted" above. Their curiosity and enthusiasm for science set them apart from other gifted students (Watters, 2004). Yet, establishing this definition alone is insufficient for identifying such students. The identification of gifted students, particularly those gifted in science, remains a complex and nuanced practice widely debated in the academic literature but is beyond the scope of this research.

Gifted professionals in science

The term "gifted professionals in science" refers to individuals who have achieved significant success in their scientific careers and were formally recognized as gifted in their childhood by a credible authority. I identified successful scientists who have stated they were gifted, through an analysis of their educational backgrounds, particularly the institutions they have been associated with, their academic and professional achievements, as well as any awards or honors they have received. While holding or pursuing a Ph.D. may meet the success criterion on its own, I still conducted a comprehensive evaluation using their resumes. This review provided insights into how they shaped their careers, their fields of work, contributions to academic literature, educational background, and participation in a wide array of seminars and workshops—serving as indicators of their expertise and dedication. This methodological approach ensured the meticulous and unbiased selection of these professionals, guaranteeing that individuals meeting the criteria were considered.

Non-gifted individuals

The phrase "non-gifted individuals" in this dissertation refers to those who have neither been identified as gifted nor have ever been ascribed the label of giftedness, regardless of their academic or professional achievements. This study does not specifically focus on students of average ability, students without identified exceptionalities, regular students, or those who are not considered gifted.

1.6 Organization of the Dissertation

In this chapter, I provided a brief introduction to the research study, delineating its significance, objectives, and the research questions it sought to address. The subsequent chapter, Chapter 2, delved into a literature review and discussed the theoretical framework underpinning

the study. Chapter 3 is dedicated to the methodology, elaborating on the qualitative and narrative design of the research, the data collection instruments employed, and the methods used for data analysis. Chapter 4 presents the findings, where I have categorized the research questions under three main themes: “Navigating Gifted Identity from Childhood to Adulthood”, “Critical Elements in Exceptional Performance in Science: Insights from Gifted Professionals in Science”, and “the Impact of Science Education on Gifted Professionals in Science”. Finally, Chapter 5 offers a discussion of the findings, along with the study’s limitations and implications.

Chapter 2: Literature Review

2.1 What does "gifted" mean? Who is gifted in science?

Researchers, educators, school counselors, administrators, parents, or students delving into the study of giftedness often encounter numerous definitions of giftedness and a multitude of debates in the literature. This complexity arises from the continuous discussions over how to accurately identify gifted children, and how to effectively support and serve these children, regardless of whether they have been formally labeled as gifted. While some scholars, like Gardner (2006), argue that all children are inherently gifted, others, such as Coleman et al. (2015), Renzulli (1978), and Tannenbaum (1983), suggest that certain children possess exceptional abilities that set them apart from the rest. Furthermore, some academics, including Borland (2005), even question the very concept of giftedness. This review methodically explores these varied perspectives in chronological sequence, shedding light on the multifaceted nature of understanding giftedness.

The concept of giftedness has evolved significantly over time, beginning with early foundational ideas. Various sources acknowledge Sir Francis Galton as the first to systematically study this topic (Colangelo & Davis, 2003). Galton, in his book *Hereditary Genius* (1892), explained the term *genius* as an inherited attribute by illustrating this with examples from the biographies of eminent individuals. He posited that a high reputation was a marker of giftedness, which could be used to identify exceptionally gifted individuals. Although this perspective has faced criticism from many scholars (e.g., Coleman et al., 2015; Tannenbaum, 2003), Galton's recognition of non-academic areas of giftedness, such as the artistic and musical domains, was ahead of his time.

The early 20th century marked a significant shift in educational focus towards measuring and understanding intelligence. At this time, the notion of intelligence started to capture significant attention in education. Various intelligence tests were developed, continually revised, and used to identify high-ability learners. The first well-known intelligence test, developed by Binet and Simon in France in 1905 (Colangelo & Davis, 2003), laid the groundwork for future assessments. Later, Terman, recognized as the father of gifted education (e.g., Colangelo & Davis, 2003; Warne, 2019), revised this test in 1916 and renamed it the Stanford-Binet Intelligence Scale. This version gained widespread use, becoming the most popular intelligence test of its time. When the test was administered to over 250,000 children, it identified nearly 1500 as gifted (Irvine, 2013). However, this approach of evaluating children's potential solely based on test scores has been subject to criticism by scholars and educators, particularly with the rise of modern and humanistic perspectives in education and assessment.

Since the mid-20th century, a more holistic approach to understanding giftedness has become increasingly important. Renzulli (1978) proposed a novel model, The Three-Ring Conception of Giftedness, suggesting that individuals with a combination of above-average ability, creativity, and task commitment should be considered gifted. Similarly, Tannenbaum emphasized the role of various factors in the development of giftedness with his The Sea Star Model of Giftedness in 1983. This model underscored the significance of elements like chance, described as “the smile of good fortune at critical periods” (Tannenbaum, 2003, p.47), environmental supports such as schooling and parenting, and nonintellective factors including disposition and motivation, alongside general ability and special aptitude. These factors were largely overlooked in traditional IQ-based explanations of intelligence. Tannenbaum’s model thus broadened the discussion, exploring what transforms a gifted child into a gifted adult. The

implication is that if giftedness were merely a matter of above-average ability, there would be less impetus for research aimed at enhancing educational strategies for gifted learners. Consequently, this perspective places greater responsibility on educators and parents to recognize and foster students' talents, aiding them in their self-discovery and personal development.

The Theory of Multiple Intelligences, developed by Howard Gardner (2006), represents one of the most influential and widely recognized approaches to understanding giftedness. This theory proposed a spectrum of seven distinct types of intelligences: musical, bodily-kinesthetic, logical-mathematical, linguistic, spatial, interpersonal, and intrapersonal. According to Gardner, giftedness is not confined to high performance in all these areas; instead, each individual possesses unique abilities that traditional IQ tests might not fully capture. For instance, excelling in an IQ test does not necessarily reflect giftedness in artistic fields. Thus, the Theory of Multiple Intelligences advocated for an educational model tailored to the diverse capabilities of students, urging educators to focus on individual strengths rather than categorizing or labeling students (Gardner, 2006; Karolyi et al., 2003). This approach can be seen as the seed for the development of differentiated instruction, a pedagogical strategy that aims to support the unique talents and learning styles of each student.

Howard Gardner's Theory of Multiple Intelligences (MI) rapidly gained global recognition for its departure from traditional understanding of intelligence (Delisle, 2014). Its inclusive nature appealed to a broad audience, from educators to administrators, leading to its widespread adoption. Teachers began integrating MI into their lesson plans, utilizing a wide array of teaching aids —including visual materials and audio resources—, and incorporating diverse activities, such as drama, role play, painting and singing into subjects like science and mathematics. However, Delisle (1996) criticized the popularity of MI as not necessarily serving

as a valid measure of its effectiveness, asserting that MI is "convenient, simple, and wrong" (p. 12). He argued (2014) that the theory is not as applicable to gifted students as it is thought to be, because having diverse interests does not equate to being gifted in specific areas. For example, it was debatable whether a student with a musical ear could learn multiplication facts faster by turning them into songs due to their musical talent. He contended that the theory led to misguided instructional practices and misuse in gifted education, potentially neglecting gifted students while making other students happy and confident.

Another theory was put forward by Sternberg (1999). According to *The Theory of Successful Intelligence,* there are three facets of intelligence: analytical, creative, and practical. Analytical intelligence is described as the capability to acquire, analyze, and evaluate knowledge. Practical intelligence refers to the ability to apply solutions effectively in real-world scenarios. Creative intelligence, on the other hand, is characterized by the skill to generate original ideas, discover unique solutions, and adopt varied perspectives. Sternberg (2003) claimed that while children may exhibit high academic achievement (analytical intelligence), sustaining success into later life might be challenging if they lack creative intelligence, which involves original thinking. He stated that "an important part of giftedness is being able to coordinate these three aspects of abilities and knowing when to use which" (p. 90), underlining the complexity of intelligences and their application.

Overall, it appears that definitions of giftedness encompass a mix of substantial disagreements and some shared views. Despite this, it remains useful to reiterate that a universally agreed-upon and comprehensive definition of giftedness, one that encompasses all forms of giftedness, has yet to be established, and pursuing such a definition may not be a desirable goal. Gifted talents may reveal themselves in diverse domains, incorporating music, art,

literature, mathematics, and science, or a fusion thereof. This diversity highlights the challenge of defining giftedness in a way that captures its multifaceted nature.

In this study, the aim is to refine the definition of giftedness within the scientific domain to address the ambiguities and the proliferation of definitions found in the literature. I define "scientifically gifted" individuals as those who have quick learning ability, remarkable memory, high motivation for learning, rapid assimilation of new information (Delisle, 2014; Gagne & Deci, 2005; Renzulli, 1978; Subotnik et al., 2011; Tannenbaum, 1983), and a significant interest in science (Watters, 2004). This focused approach helps in recognizing individuals who truly embody the essence of being "gifted in science" and aids in developing educational strategies tailored to their unique needs.

2.2 Gifted Identity

The development of a gifted identity is influenced by how individuals perceive themselves and how they believe their exceptional abilities are perceived by their environment (Davies & O'Neill, 2022). From early childhood, the attitudes of the family, the opportunities to which the child is exposed, and their surroundings play a significant role in shaping this identity. However, as time, place, circle of friends, school, and the difficulty of courses change, alterations in the gifted identity may occur. Although this label is generally perceived positively, due to the fact that it may lead to high expectations, at times, identity confusion may happen when individuals struggle to meet these expectations (Baudson & Ziemes, 2016). For the healthy development of identity, it is essential for schools to foster an environment where gifted science students experience a sense of belonging and feel that their needs are valued. Examples of such services include science laboratories that nurture their curiosity and the presence of various clubs

and communities where they can engage in scientific discussions with their peers (Davies & O'Neill, 2022).

A notable topic concerning gifted individuals is that there is much discussion about gifted children and students, but we find little information about "what giftedness means or looks like during adulthood" (Rinn & Bishop, 2015, p.213). As Jacobson (1999) states, "it is not as though these [gifted] children slough off their giftedness like discarded skin at the age of sixteen or eighteen or twenty-one. Gifted children do grow up, and they become gifted adults" (p. 9). This research aims to illuminate the complex ways in which giftedness unfolds and transforms throughout one's life, highlighting the critical need for support and acknowledgment.

In this research, one of the aims is to shed light on the nuanced ways giftedness manifests and evolves over the course of a lifetime by offering insights into the support and recognition needed. Since children and adolescents spend a significant portion of their time in school, where relationships with peers and teachers, alongside academic achievements, play a crucial role in their identity development (Lannegrand-Willems & Bosma, 2006), it is important to examine the role of educational experiences in not only their academic success but also the formation of their gifted identity. In the following two sections, I will delve into how various educational environments assist these learners, while also examining the potential drawbacks associated with each setting.

2.3 Education of Gifted Students

Identifying effective instructional methods to serve gifted children and creating an appropriate classroom environment, particularly for those who are gifted in science, are as complicated as efforts to define giftedness. Various program types, such as acceleration, pull-out programs, ability grouping, and differentiation have been collaboratively developed and tested by

scholars, teachers, curriculum developers, and leaders. Should gifted students share the same classroom with their same-age peers or with those who have the same level of ability? Are schools responsible for just academic achievement, or are their emotional and social development as important as learners' academic success? In order to fully grasp the impact of these educational strategies on the learning experiences of gifted students, we will now analyze their specific components.

Acceleration is an approach that allows gifted learners to participate in courses based on their academic abilities rather than their chronological age, enabling them to skip grade levels faster than their peers. For instance, a seventh grade scientifically gifted student may have a chance to learn high school physics. Thus, it provides a tremendous advantage in terms of time. However, this accelerated pace may also have some negative impacts on students' social and emotional developments (Gallagher, 2003). Schiever and Maker (2003) argue that younger gifted learners starting school too early may experience frustration due to undeveloped psychomotor skills and they may feel as if they are falling behind their peers. Nevertheless, offering a variety of advanced courses that cater to students' special interests and intellectual abilities, such as advanced physics and chemistry can help mitigate the socialization problems stemming from age differences when these students enter college at an early age. Therefore, while acceleration offers significant academic benefits for gifted learners, it is crucial to balance these advantages with careful consideration of their social and emotional well-being.

Another common method to support gifted learners is ability grouping. Ability grouping is a method that groups students according to their demonstrated skill level and provides them with "instruction at a level and pace as well as conceptual complexity commensurate with their advanced levels of ability and achievement" (Feldhusen & Moon, 1992, p.63). In this approach,

gifted learners maintain their education alongside their gifted peers by being separated from regular students. Scientifically gifted students often grasp content more quickly and have a deeper prior knowledge due to their keen interest in learning about science. However, they may struggle in regular classrooms, where they are required to learn at the same pace as average students, engage in less challenging tasks, and wait for others to catch up (Coleman et al., 2015; Reis et al., 1995; Watters, 2004). Moreover, they may miss out on developing important skills due to the absence of opportunities to engage with more open-ended tasks (Gomez-Arizaga et al., 2020).

The debate around ability grouping in educational settings is often influenced by concerns of elitism, discrimination, and inequality, leading to opposition by some (Colangelo & Davis, 2003). This resistance stems partly from a reluctance to overly celebrate the achievements of highly capable students, to avoid overshadowing or discouraging their peers with average abilities (Subotnik et al., 2011). Conversely, this concept of grouping by ability is not perceived as elitist or discriminatory in other contexts. For instance, achievements in sports, music, and the arts are enthusiastically celebrated in schools, while similar recognition for academic accomplishments is less common (Subotnik et al., 2011). Specifically, students are routinely grouped by skill level in music classes or language courses without any suggestion of elitism or racism. In these cases, students are divided into beginner, intermediate, and advanced groups based on their proficiency, which is generally accepted and does not lead to feelings of superiority or inferiority among students. Feldhusen and Moon (1992) also addressed this in their study. They noted that “motivation suffers when new learning tasks are too easy or too difficult. The level of challenge must be appropriate to students’ level of readiness, and teachers must concentrate their energies on helping all students master the challenges” (p.63). Therefore,

scientifically gifted students can benefit from learning in an environment with peers of similar academic abilities, without necessarily impeding the learning experience of students with average abilities.

Additionally, pull-out programs are also designed by taking gifted learners' unique needs and interests into consideration. As Moon et al. defined, "a pull-out program is one in which identified gifted students leave their classroom for a specified period of time to attend a class designed to meet their special needs" **(**1994, p. 38). Some evident benefits of these programs to students are that teachers specialize in gifted education, the curriculum is differentiated based on students' abilities, and students can spend more time with other gifted learners (Moon et al., 1994). Gifted students who participated in pull-out science and mathematics classrooms stated that the program is "more interesting, challenging, and enjoyable than their regular classes" (Yang et al., 2012, p.280). For example, science centers, which are associated with authentic learning environments, entertainment, and happiness by gifted learners (Epcacan et al., 2020), encourage them to reach their full potential (Sitkoff, 1988). However, as an obvious disadvantage, students may need broader support (Van Tassel-Baska, 1987) because the duration of the program may not allow students to work on challenging long-term projects. Additionally, students may miss some of the classes, which disrupts both teachers' and students' routine and teaching/learning habits (Moon et al. 1994; Van Tassel-Baska, 1987).

On the other hand, work by scholars such as James Borland shifted the focus of attention in gifted education. He challenged the underlying rationale of the conception of giftedness and advocated for an educational program that does not label students. He specifically opposes the view that programs for gifted students are seen as a *raison d'être* for gifted education (Borland, 1996; Borland 2012). Additionally, he supports the idea that providing all students, including

gifted ones, with gifted education is possible without creating ability groups. Reducing inequality instead of reinforcing it must be the ultimate goal of education (Borland, 1996).

Therefore, a differentiated curriculum that addresses the unique needs of every single student seems to be a solution that should be developed and implemented (D'Amico & Gallaway, 2010; Tileston, 2011). In a differentiated classroom, "the teacher proactively plans and carries out varied approaches to content, process, and product in anticipation of and response to student difference in readiness, interest, and learning needs" (Tomlinson, 2001, as cited in Gregory, 2011, p.109). The main goal of differentiated instruction is

> … to provide an appropriate education for all students, covering core curriculum content, goals, and objectives relevant to the specific grade level. Students in this flexible setting will have access to high-quality science instruction and the support they need to be successful, regardless of their learning disabilities, paces, academic levels, behaviors, learning styles, or overall strengths and weaknesses. (p. 21)

D'Amico and Gallaway (2010) illustrate that differentiated science instruction accommodates diverse learning needs, allowing learners with cognitive difficulties to use structured tools and gifted learners to engage in research and collaborative activities.

However, some studies have explored the difficulties that gifted learners experienced in heterogeneous classrooms. For example, Hertberg-Davis (2009) identifies several challenges to effective differentiated instruction for gifted students. These include insufficient training for teachers, a focus on struggling students, regular classrooms failing to provide the necessary challenge for gifted learners, and the need for teachers to have both deep subject knowledge and the willingness to put in significant effort. These factors make it difficult for differentiated instruction to be as successful as specialized programs for gifted students. Chinelo and

Ogochukwu (2014), conducted research to investigate the alignment of differentiated science instruction strategies with the educational needs of gifted science students. The results were interesting; contrary to science teachers who claim to use various instructional strategies for differentiation, gifted students feel these strategies are rarely employed to meet their educational needs. There is a notable discrepancy between the views of gifted students and their science teachers regarding the effectiveness of differentiating content, process, and product in the classroom. Ireland et al. (2020) found similar results, highlighting a persistent gap in the understanding and implementation of differentiated instruction from the perspectives of teachers and gifted science students.

In summary, the debate surrounding the most effective educational strategies for gifted students remains complex and multifaceted. While acceleration, ability grouping, pull-out programs, and differentiated instruction each offer unique benefits, they also present challenges that must be carefully navigated. Ultimately, a holistic approach that considers the academic, social, and emotional well-being of gifted students in science may be the key to unlocking their full potential.

2.4 Science Instruction to Support Gifted Students' Learning

Science has always been considered an important discipline that plays a key role in promoting the welfare of societies and helping societies develop and maintain leadership in the global world (DeBoer, 1991; Van Den Akker, 1998). Societies that are prominent in science and technology are today's giants because the critical structures, such as the military, education, agriculture, industry, and medicine, are all supported and enriched by the knowledge of science. Additionally, science is a tool to understand and deal with uncertainties that modern life has brought. For instance, humanity has faced deadly diseases, natural disasters, and pandemics

throughout history which have had irreversible impacts on human lives. A recent example is the onset of the COVID-19 pandemic, which has prompted scientists, leaders, and economists to tackle previously unforeseen challenges. The pandemic has also sparked a widespread interest in science among the general public, leading to scientific discussions across various professions in an effort to address current issues. Consequently, science, which has always been important, has regained its significance and once again become an integral part of our daily lives, distinguishing itself from other disciplines through its practicality and its capacity to enhance life.

When we recognize individuals who have achieved outstanding success in science-related fields as gifted, the importance of educating gifted children becomes evident. This study focuses on the experiences of scientists during their school years. Some studies in the literature have shown that the middle school period is critical for students' decisions regarding science and their future careers in this field (Bennett & Hogarth, 2009; Van Griethuijsen et al., 2015). These studies indicate that while students exhibit high interest in the sciences during primary school, their positive attitudes toward the subject may decrease after middle school. By examining the impact of students' school experiences on their achievements, this study aims to understand the factors that influence their scientific success, which will help us better support future generations of gifted individuals.

Effective science teaching should allow gifted students to discover their talents, feed their curiosity, and think and behave like a scientist by providing them the flexibility to decide what to learn and how to learn. In this way, science teachers can increase students' curiosity and feed their keen interest in learning more about science. It is well known that "experience is the best teacher." (Donovan & Bransford, 2005, p. 399). Science lessons should provide students with an opportunity to learn by doing, thinking, and exploring. Especially scientifically gifted students

who are more active and curious than other students, may need activities that they can use and show their advanced skills. So, it is a necessity to develop a well-planned and qualified science curriculum and science teaching methods. In the literature, challenging classroom activities such as project-based learning (Karademir, 2016; Mioduser & Betzer, 2007), inquiry-based learning (Eysink et al., 2015), argumentation (Murphy et al., 2018), and STEM activities (Robinson et al., 2014) are found beneficial in supporting gifted learners' academic development and in increasing their motivation.

Inquiry is a common approach that is preferred by science teachers. That term "refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (National Research Council, 1996, p. 23). The level of inquiry can be adjusted based on students' abilities. Both gifted students and other students take advantage of inquiry-based learning, although it can take more time than the direct instruction model. Since gifted students like to take responsibility for their own learning and development and try new ideas, a higher level of inquiry is highly recommended in classrooms with diverse learners including gifted and talented students.

Many studies have affirmed that the aforementioned ways of teaching science effectively support students with diverse needs, including gifted individuals and those with learning differences. However, more research is needed to specifically investigate how different approaches to science instruction have positively impacted gifted individuals and steered them towards careers in science and science-related areas. Therefore, in this study, I aimed to fill this gap by contributing to the knowledge of how successful gifted adults delineate their science learning experiences.

2.5 Theoretical Framework

The talent development model is used as a theoretical framework for understanding the literature and supporting the research problem I aimed to investigate.

Tannenbaum's Talent Development Model

Talent can either grow or diminish, influenced by a mix of external and internal factors. Diverging from the perspective of entity theorists, who assert that an individual's intelligence or talent is fixed, incremental theorists advocate the idea that abilities can be improved through various means (Park & Kim, 2015). This aligns with the Sea Star Model of Giftedness proposed by Tannenbaum, which suggests that while possessing ability is crucial, it is equally important to undertake significant measures for the nurturing and development of talent in order to realize one's gifted potential. Five fundamental elements play a crucial role in the transition of gifted children into gifted adults: general ability, special aptitude, environmental support, chance, and non-intellective requisites (Tannenbaum, 2003). "In addition to *g* [general intelligence] and special abilities, a person needs interpersonal skills, motivation, and perseverance to overcome impediments to their talent-development trajectory" (Subotnik et al., 2011, p.7).

Superior General Ability

Superior general ability, also known as general intellectual ability, general intelligence, or the g-factor, is described as a strong mental capacity that indicates broad cognitive capability influencing performance across a wide range of tasks (Tannenbaum, 2003). Numerous studies in the existing literature debate the inherent versus developmental nature of intelligence (Junkiert-Czarnecka & Haus, 2016; Makharia et al., 2016; Sorjonen et al. 2023; Von Stumm et al., 2022) and address the challenges of incorporating cultural differences in IQ assessments, including discussions on potential cultural biases (Card & Giuliano, 2016; Hemingway, 2022),

the limited skills these tests evaluate, and their relevance to real-world success (Sternberg, 1999, as cited in Tannenbaum, 2003). Nonetheless, this research does not engage with those debates, as they have been extensively researched for many years.

Gottfredson (1997) has synthesized findings from various sources to share the conclusion that "intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience" (p. 13). Supporting this perspective, subsequent research has shown that higher IQ scores in children correlate with more favorable life outcomes in adulthood (Gottfredson, 2004; Lang & Kell, 2020), establishing a clear link between cognitive abilities and academic performance (Breit & Preckel, 2020). However, it is important to acknowledge that, although high intelligence or superior general ability is a critical component, it is not the sole determinant of success (Subotnik et al., 2011; Tannenbaum, 2003). In this study, gifted students in science are defined as those who are academically gifted and have an interest in science, with aspirations to become scientists. Thus, I examine how various factors, including individual abilities, education, and environment, contribute to their development in the science fields.

Special Aptitude

Tannenbaum (2003) emphasizes the existence and importance of special abilities alongside general intellectual capability in gifted children. These special abilities, as he describes, are highly developed competencies in specific domains such as mathematics, arts, music, or science, offering a more nuanced understanding of giftedness beyond the generic measures of intelligence tests. According to Tannenbaum, these abilities manifest as exceptional skills or talents within a person's area of passion and can be identified through precise assessments or observed performances in tasks pertinent to their interests. To illustrate this point,

he uses the example of Einstein's proficiency with the violin, while remarkable, did not mirror the unparalleled contributions he made to physics, illustrating the unique nature of special abilities in comparison to general intelligence. In light of these considerations, this study aims to delve deeper into the development of special aptitudes in science among gifted individuals.

Environmental Support

Being gifted or having high potential per se does not guarantee success in life. As Clasen and Clasen note (2003) "at some time, intervention by an adult or a series of adults is essential to the development of the gift" (p. 255). This also can be explained by the Zone of Proximal Development (ZPD). The ZPD is the difference between what a learner is capable of learning on their own and what a learner can learn with help (Vygotsky, 1978). The person supporting learning can be anybody with more experience, knowledge, or skills in a specific area. Even parents, relatives, older siblings, peers, tutors, or teachers can encourage gifted children to improve themselves. A gifted child can imitate an eminent scientist they admire and see public figures as heroes even though they do not have face-to-face two-way interaction (Pleiss & Feldhusen, 1995). Still, these heroes or idols can support their emotional and moral development (Hunter, 1983). A gifted child can admire an eminent scientist because of their "dedication to work" and "success" and emulate their career development (Pleiss & Feldhusen, 1995, p. 165).

Similarly, Sosniak (2003) urges that **"**no one develops talent on his or her own-without the support, encouragement, advice, insight, guidance, and goodwill of many others. The development of talent is a tribute of many people working for the accomplishments of one" (p. 249). Mentoring is crucial to "nurture potential."(Clasen & Clasen, 2003, p. 254). Clasen and Clasen (2003) also explain that a mentor takes on a number of roles that overlap each other: (1) In the teacher role, the mentor supports the mentee with feedback so that the student learns

self-evaluation. (2) In the expert role, the mentor's skills, experience, and knowledge open up new ways for the mentee to learn about the field. (3) In the guide role, the mentor helps the mentee understand possible challenges they may encounter while they aim to achieve their goals and find effective and unique ways to get rid of any problem that restricts them. (4) In the advisor role, the mentor helps students familiarize themselves with certain standards, practices, and ethics of the field so that students can distinguish valuable and appropriate behaviors from improper ones. (5) In the friend role, the mentor constructs an emotional connection with the mentee and provides them an opportunity to share their feelings. (6) Finally, the mentor becomes a role model for students who try to copy the behaviors and attitudes of their mentor whom they admire (p. 256).

Not every gifted child is that lucky to have a mentor who shows all these different and inspiring roles. Also, mentorship can be pursued unintentionally. An older sibling, a teacher, or a student from the upper grade level may touch the life of a gifted child without being aware of the positive consequences of their behaviors. Various persons can assume different roles and support the child with various dimensions. For example, a successful aunt whom the child admires can be an advisor and a role model, while an older sibling can be a teacher who provides feedback and supports learning. As a result of the combination of different roles, the mentee can realize their abilities and find ways to increase their potential. So, it will be helpful to learn if gifted professionals have had someone in their life who encouraged them to fulfill their dreams or not in terms of understanding the role of helper (supporter, role model, or mentor).

Borland and Wright (1994) brought a new perspective to mentorship by giving adolescents a chance to be mentors of potentially gifted kindergartners. Matching adolescent mentors with mentees from the same racial and ethnic minority groups provided "an invaluable

and otherwise unattainable window into the lives of [gifted] young children" (p. 128). As the bond between mentor and mentee becomes strong, mentees' self-esteem increases. All children, regardless of their socio-economic background, deserve such unique contributions to their development. Mentoring can be considered to be a part of different components of the Talent Development Model, such as environmental support and chance. Therefore, this study will explore how the presence or absence of a helper/role model/mentor impacted gifted individuals' emotional and academic development. It will be significant to explore the ways that some individuals compensate for having little or no support and become as successful as those with more support.

Subotnik et al. (2011) highlight the importance of support and personal efforts in talent development.

> Individual abilities are malleable, need to be deliberately cultivated, and do matter, particularly abilities in specific talent domains; different talent domains have different developmental trajectories, varying as to when they start, peak and end; and opportunities provided by society are crucial at every point in the talent-development process. Furthermore, it is clear from the research knowledge base that psychosocial variables are determining influences in the successful development of talent. And finally, outstanding achievement or eminence—with its attendant benefits to society and to the gifted individual—ought to be the chief goal of gifted education. (p.4)

So, teachers, policy makers, and educators should focus on providing opportunities for children to explore their interests, rather than leaving their talent development to chance or luck (Sosniak, 2003). In other words, the development of children's talents should be intentional and supported by the educational system, rather than being dependent on random or fortunate circumstances.

Schools serve as vital environmental supports, offering gifted children a primary space for learning and development (Gierczyk & Pfeiffer, 2021). The presence of after-school programs, extracurricular activities, and gifted programs are factors that can impact students' engagement. However, it is the teachers who are responsible for utilizing these facilities effectively. Specifically, in science education, when science teachers make effective use of facilities such as science laboratories, computer laboratories, robotic clubs, and libraries, they play a crucial role in enhancing students' learning experiences. A rich and safe learning atmosphere created in the classroom and throughout the school, thanks to the contributions of teachers, is quite important for the development of gifted students (Holešovská, 2012). This can contribute to their ability to use the opportunities presented to them without fear and to embrace their gifted identities without hiding (Casino-García et al., 2021). Their teachers' skill in understanding and identifying the strengths of their students and tailoring teaching materials to higher student levels is key to enabling exceptional performances (Gierczyk & Pfeiffer, 2021).

However, schools are not the only places where children can learn science. Informal learning environments such as museums, planetariums, zoos, and botanical gardens also play a significant role in sparking children's curiosity and enhancing their knowledge (Heydari, 2019). It is important to recognize that informal learning environments extend beyond the confines of traditional four-walled spaces. Family discussions, watching documentaries and scientific TV shows, and even games that encourage exploration of nature all contribute to informal science learning (Fenichel & Schweingruber, 2010). The level of student engagement in these environments often depends on their parents' attitudes toward informal science learning (Lee & Nie, 2014). Additionally, parents with higher socio-economic status are more likely to encourage their children to engage in various extracurricular activities (Badura et al., 2021; Sauerwein &

Rees, 2020) and provide them with an enriched environment filled with books and magazines (He et al., 2023). Research has also shown that parents' causal talk helps their children start to think scientifically and develop an interest in science (Booth et al., 2020; Haden et al., 2014).

Chance

Research indicates that luck and chance is often highlighted as a significant factor in explaining success across various fields (Sobkowicz et al., 2020; Ye & Nylander, 2021). The role of chance is as crucial as intelligence and hard work (Hurwitz, 2011). Austin (2003) dissected the concept of luck into four distinct levels, each influenced by varying degrees of personal behavior and psychological factors. At the foundational level, Chance I represents pure, impersonal luck, occurring without any influence from the individual's actions or traits. Moving to Chance II and III, luck increasingly favors those engaged in exploratory behaviors and those with a prepared mind, respectively. These levels highlight the importance of curiosity, persistence, and a solid foundation of knowledge in turning chance into opportunity. Chance IV, the most personalized form of luck, is influenced by distinctive hobbies and personal lifestyles, suggesting that highly individualized actions can lead to unique and novel outcomes.

As Austin (2003) stated, the transition from Chance I through IV illustrates a shift from randomness to a more deliberate interaction with chance, where personal initiative and uniqueness play critical roles. While Chance I is entirely out of the individual's control, Chances II through IV demonstrate how exploring, knowledge accumulation, and individuality can shape the nature and outcome of luck. This progression not only underscores the potential for personal influence over chance occurrences but also highlights the value of personal traits and behaviors in converting serendipitous moments into meaningful opportunities.

According to Tannenbaum (2003), chance plays a critical yet often overlooked role particularly in the realm of giftedness. It acts as a powerful force that can either facilitate or inhibit success, despite being unpredictable. He explains “luck interacts with inspiration and perspiration in a mutually dependent way. Without high potential, no amount of good fortune can help the mediocre person achieve greatness; conversely, without some good fortune, no amount of potential can be truly realized” (p. 56).

Non-intellective Requisites

Success in life and in performing various tasks goes beyond just intellectual abilities, such as memory and quick learning, which were discussed in previous sections (Duckworth et al., 2019; Magnano et al., 2020). In addition to intellect, a complex tapestry of non-intellective factors plays a pivotal role in talent development. The identification and categorization of these factors, however, vary across studies. For instance, Richardson et al. (2012) identified 42 constructs and organized them into six distinct areas including personality, motivation, self-regulation, learning approaches, and psychosocial factors.

Further broadening our understanding, Subotnik et al. (2023) offer a different lens, grouping these elements into what they describe as non-cognitive or psychosocial factors. They highlight the undeniable importance of these factors in the journey towards excellence. True mastery in any field is not merely a result of refining technical skills. As they say, it also demands the strategic development of psychosocial capabilities that enable individuals to navigate the complexities of their domains and adapt to the inevitable challenges they face. Parents and teachers play a pivotal role, not just by directly teaching these skills, but by creating opportunities for students to practice and apply them in contexts that matter. (Subotnik et al., 2023).

Tannenbaum (2003) posits that nonintellective factors—encompassing creativity, emotional intelligence, motivation, and psychopathology—play a pivotal role in the trajectory of gifted individuals' achievements. He proposes that these elements may serve as catalysts, companions, or outcomes of success, intricately influencing the dimensions of giftedness, achievement, and mental health. This multifaceted relationship underscores the dual potential of these factors to either support or impede the performance and holistic well-being of gifted persons, highlighting the nuanced interplay between nonintellective attributes and intellectual prowess.

A wealth of research underscores the vital role of motivation in achieving high levels of success. Motivation serves as the driving force that initiates behavior, directs actions, maintains engagement and assists individuals in discovering, engaging with, and maximizing opportunities to develop their talents (Graham & Weiner, 2012; Subotnik et al., 2011). Patrick et al. (2021) delve into the intricacies of motivation within the sphere of gifted education, highlighting that mere intellectual prowess does not automatically translate to success or the cultivation of talent. They point out that motivational issues such as "disinterest", "apathy", or "avoidance" can significantly hinder the progress and accomplishments of gifted students, suggesting that overcoming these challenges is crucial for their development (p. 185).

To improve motivation, it is imperative to have an understanding of the sources of motivation and the elements clarify it, such as self-esteem and self regulation. A prevalent perspective on motivation posits that it is derived from either extrinsic or intrinsic factors. Intrinsic motivation is characterized by engagement in an activity primarily for the pleasure and satisfaction derived from learning and personal growth, whereas extrinsic motivation pertains to undertaking tasks motivated by external rewards or the utility of achieving specific outcomes

(Subotnik et al., 2011). Notably, research indicates that gifted students exhibit a higher level of intrinsic motivation compared to their non-gifted peers (Clinkenbeard, 2012), demonstrating the capacity to be motivated by both intrinsic and extrinsic factors (Salem Mubarak Barabwd et al., 2017). Furthermore, empirical evidence suggests that gifted high-achievers display greater motivation than non-gifted high-achievers, and non-gifted high-achievers have higher motivation levels than gifted underachievers (Agaliotis & Kalyva, 2019).

Motivation is widely recognized as a characteristic trait of gifted individuals. Renzulli, however, approaches it with a particular emphasis on what he terms "task commitment". Renzulli and Reis (2018) describe this concept as a specific, "focused form of motivation", encompassing attributes such as "perseverance, endurance, hard work, dedicated practice, self-confidence, and a belief in one's ability to carry out important work" (p188).

Since people are more motivated to take on tasks when they believe they have the necessary skills and expect positive results, gifted students are expected to have higher academic self-efficacy (Clinkenbeard, 2012). Bandura defines self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (1997, p.3). This belief in self-efficacy directly influences self-regulation, wherein highly self-regulated students not only employ strategic metacognitive approaches but also cultivate positive self-efficacy beliefs, enabling them to adapt their strategies to meet their learning objectives effectively (Zimmerman & Labuhn, 2012, p. 309). Furthermore, resilience, which reflects an individual's capacity to cope with adversity, complements self-efficacy and self-regulation by encouraging students to view challenges and setbacks as opportunities for growth, thus fostering a more robust approach to risk-taking and failure (Alexopoulou et al., 2019). This

interconnectedness underscores the dynamic interplay between self-efficacy, self-regulation, and resilience in shaping students' academic journeys and their ability to navigate obstacles.

Overall, "talent development is a complex process involving the individual, the home, the school, and the community" (Robinson et al., 2007, p.55). The personal narratives of gifted professionals in the sciences illuminate the intricate processes behind their talent development, offering invaluable insights into the significant factors that make their journeys distinct or similar. This study investigates how both intellectual and non-intellectual factors contribute to gifted individuals' success in science and identifies ways to enhance science education for them.

Chapter 3: Methodology

3.1 Design

Qualitative research methods allow the researcher to uncover multiple realities, develop an in-depth understanding of the human experience, and create meaning built by individuals (Lichtman, 2010). There are different types of qualitative research depending on the aim of the researchers and the questions they are asking (Merriam, 2007). These five major approaches are: ethnography, phenomenology, grounded theory, case study, and narrative. All these types have certain similarities: "the goal of eliciting understanding and meaning, the researcher as the primary instrument of data collection and analysis, the use of fieldwork, an inductive orientation to analysis, and findings that are richly descriptive" (p. 11).

In this study, I employed a narrative research design for the purpose of exploring and understanding the meaning based on gifted adults' lived experiences and their reflections on their education (Merriam, 2007). As Mishler (1995) claimed that researchers:

> …, too, are storytellers and through our concepts and methods— our research strategies, data samples, transcription procedures, specifications of narrative units and structures, and interpretive perspectives—we construct the story and its meaning. In this sense the story is always coauthored, either directly in the process of an interviewer eliciting an account or indirectly through our representing and thus transforming others' texts and discourses. (pp. 117–118)

The key to a narrative study is the use of stories to analyze how certain factors such as schooling, gender and race impacted individuals' lived experiences (Merriam & Tisdell, 2016). A narrative study is distinguished from other research designs by its focus on the chronological sequence of events and the stories told by participants (Contazzi, 1994, as cited in, Riley, 2022).

This approach not only allows for a rich, contextual analysis of lived experiences but also offers insights into how gifted individuals develop into scientists. By focusing on the sequence of events and the stories told, this study seeks to understand the complex interplay of identity, science, and giftedness through the lens of those who live it.

3.2 Participants of the Study

Determining the ideal sample size in qualitative research is not straightforward, but existing studies provide insights into what might be sufficient. In exploring effective sample sizes for qualitative research, Hennink and Kaiser (2022) conducted a study focused on achieving data saturation: "[…] saturation refers to the point in data collection when no additional issues or insights are identified and data begin to repeat so that further data collection is redundant, signifying that an adequate sample size is reached" (p.2). Their systematic review looked at a total of 23 studies to explore how data saturation was achieved. The results revealed that data saturation could be reached with 9-17 interviews when the group is homogenous. Similarly, Ando et al. (2014) compared the number and structure of codes created by analyzing only 6 interviews with codes formed after 33 interviews. The codes and themes revealed from the first twelve interviews were sufficient to analyze data because additional interviews caused repetitions of codes instead of providing new information. Guest et al. (2020) found that 6 or 7 interviews can help researchers generate most of the codes. So, in the light of current analyses, researchers "can achieve robust results with small sample sizes" (Young & Casey 2019, p. 57).

Merriam noted that "sample selection in qualitative research is usually (but not always) nonrandom, purposeful, and small" (2007, p. 8). I also employed a purposeful sampling method, which means that the study participants were selected purposefully based on the research criteria (Tracy, 2019). The inclusion criterion was that the potential participants must be gifted adults

who have at least a Bachelor's degree in science and hold a current job in the field, including research assistantship. Here, the question arises as to who are gifted adults? Professionals who were either in gifted schools, who wore the gifted label, or who had intelligence test scores (a score of 130 or higher) at some point in their lifetime were determined as gifted adults.

In this study, I utilized multiple strategies to engage with potential participants. Firstly, I created flyers (see Appendix A) and placed them on bulletin boards at some Ivy League colleges to connect with others. Concurrently, I also sent out emails to a wide range of academic individuals, including professors, researchers, and Ph.D. students, using contact details found on prestigious university websites. Additionally, I reached out to scientists through LinkedIn with invitations to participate in the study, selecting them by searching for scientists who have affiliations with Ivy League institutions or work in prestigious companies. Lastly, I got in touch with groups that support women in science and asked them to share my study invitation. This approach aimed to attract a diverse group of participants from the scientific community.

At the conclusion of this recruitment effort, a total of nine individuals responded to express their willingness to volunteer for the study. Each of these respondents met the predetermined selection criteria and were therefore invited to participate. Notably, all selected participants were affiliated with Ivy League universities, rather than being scientists from non-academic institutions. Initially, interviews lasting 50-60 minutes were conducted, followed by a request to share their resumes and fill out an online questionnaire. Some participants were interviewed a second time to enhance the validity of my interpretations from the first interview. These recruitment tactics have proven effective in involving professionals who are aligned with academic standards, as demonstrated by this outcome. However, it also brings attention to a challenge in attracting individuals from a more diverse range of scientific fields.

Table 1

Demographic Information of Participants

Participant / age	Gender	Ethnicity	Department	Job	Father's Job	Mother's Job	Siblings	Identification year
Mike, 40-44	Male	White	Physics	Professor	High School, Machinist	BSN, Nurse	older brother	5th grade
David, 40-44	Male	White	Physics	Professor	Md, Physician	BA, Homemaker	older brother and sister	4 years old
Olivia, 25-29	Female	White Jewish	Pathobiology	Graduate research assistant	JD, Patent attorney	BS, Homemaker	younger sister	1st grade
Emily, under 25	Female	White Asian	Microbiology and immunology	Graduate research assistant	BS, Controls engineer	BS, Financial analyst	only child	2nd grade
Ashley, 25-29	Female	White	Microbiology and immunology	PhD candidate Researcher	BA in the US army	BA, Homemaker	younger sister	Kindergarten
Laura, under 25	Female	White	Physics	PhD student Researcher	PhD, Scientist	Masters, School counselor	younger sister	6th grade
Sarah, under 25	Female	White	Microbiology and immunology	PhD student Researcher	PhD, Professor	Masters, Homemaker	older bro	4th grade
Ryan, 25-29	Male	White	Physics	PhD student Researcher	MPhil, Director of technology at an international school	Doctorate, Senior lecturer	younger sister	Kindergarten, 5th grade
Jack, 30-34	Male	Hispanic	Physics	Postdoctoral Fellow	College dropout Business owner	College dropout Business owner	older sister	4th grade

Table 1 presents general information about the participants. This demographic summary underscores the predominance of White ethnicity within the participant cohort, alongside an equitable distribution of gender, and a participant pool that is notably youthful, with a substantial engagement in academic and research-oriented roles. The educational and professional backgrounds of the participants' parents were predominantly at a higher level. Specifically, the fathers of five participants hold doctoral degrees, one mother possesses a doctoral degree, and two parents have master's degrees. Furthermore, the age at which participants identified as gifted ranges from as early as kindergarten to as late as sixth grade.

3.3 Data Collection

In order to address the research questions posed in this study, I employed multiple data collection methods encompassing semi-structured interviews, online questionnaires, and document reviews. Table 2 provides an overview of the data collection tools and the research questions they target.

Data triangulation, involving the use of these three distinct methods, was employed to enhance the validity of the findings (Merriam & Tisdell, 2016). This approach provides a comprehensive understanding of the factors influencing the development and success of gifted professionals in science. The following sections will detail the rationale and objectives behind the choice of each data collection method.

Table 2

Data Collection Methods Based on Research Questions

Research Questions	Data Collection Procedure
1. How do scientists, who were identified as gifted in their childhood, navigate their gifted identity from childhood to adulthood, and how does this affect their social relationships and self-perception?	Semi-structured interviews, questionnaire
2. How do scientists, who were identified as gifted in their childhood, perceive and describe the critical elements that contribute to their exceptional performance?	Semi-structured interviews, questionnaire
3. How do scientists, who were identified as gifted in their childhood, reflect on the impact of their K-12 science education on their development and career choice?	Semi-structured interviews, questionnaire, resume

Interviews

Tracy describes qualitative interviews as providing "opportunities for mutual discovery, understanding, reflection, and explanation via a path that is organic, adaptive, and oftentimes energizing" (2019, p.156). For this purpose, semi-structured interviews were conducted to delve into the nuanced lived experiences of gifted individuals. The interviews helped me explore participants' perspectives on a range of issues including the notion of giftedness, the importance of specialized science education for gifted individuals in science, recollections of career awareness in their early years, and the factors influencing their career selections and achievements. All interviews were conducted virtually via the Zoom platform, and the questions that guided these semi-structured interviews are provided in Appendix B. The interviews typically lasted between 50 to 60 minutes and were audio-recorded with the consent of the participants. The questions were asked in a sequence that enabled participants to chronologically

narrate their journey from childhood to the present day, specifically focusing on the evolution of their interest and achievements in science over time.

In the development of the interview questions, primary guidance was derived from research questions that aimed to explore how participants navigate their gifted identity and the factors contributing to their exceptional performance. This process was enhanced by a comprehensive review of the literature, which included examining doctoral dissertations (Ballert Potter, 2017; Slaughter-Thierry, 2017) and articles addressing topics similar to the current research. The insights gained from this review were instrumental in adding new questions and refining existing ones. These adjustments were made in accordance with the theoretical framework of the study. The questions were designed to elicit detailed narratives from participants, enabling them to reflect on and articulate their experiences spanning from childhood to adulthood. Given the semi-structured nature of the interviews, the questioning was flexible. For some participants, the conversation naturally progressed to cover the intended areas without the need for extensive prompting. However, for others, additional questions were necessary to clarify certain points or delve deeper into specific aspects of their stories.

Upon the completion of the initial interviews, all interviewees were invited to participate in a second interview, aimed at validating the researcher's interpretations and findings derived from the first session. This approach aligns with the member checking process described by Creswell (2009), which involves verifying the accuracy of qualitative findings by discussing them with participants. For practicality and effectiveness, the first four participants who scheduled these follow-up interviews were selected. These second interviews, lasting approximately 15 minutes, provided an opportunity for participants to reflect on and respond to

my comments, interpretations, and preliminary findings from the initial data analysis, thereby contributing to the validation of the data.

For the preparation of a second interview draft, I took notes and developed initial codes and themes for each participant following each interview. A separate interview question draft was prepared for each of the four participants who expressed a desire for a second interview and arranged it at the earliest opportunity. In the interviews, I aimed to share my own interpretations and inquire about their thoughts.

Questionnaires

An online questionnaire was developed for this study, as detailed in Appendix C. This questionnaire comprised two main sections. The first section gathered demographic and background information, including name, gender, age, ethnicity, educational history, current employment, parental education levels, and the city of upbringing. This data provided context for each participant's unique journey.

The second section of the questionnaire concentrated on the specific educational experiences related to being identified as gifted, asking participants to detail the types of gifted programs they attended. It further explores their engagement with science during their formative years by asking them to rank various science-related activities by enjoyment and impact. This section aims to identify the key experiences and influences that fostered their passion and aptitude for science. This approach provided participants with an opportunity for deeper reflection and a more thoughtful response, a contrast to the interview setting where responses were more immediate and spontaneous.

Initially, all questions in Part 2 were designed as open-ended. However, it was observed that this approach dampened the enthusiasm of the participants. Consequently, I shortened the

questions, removed some that were repetitive, and transformed six questions into Likert scale format. Since any changes to the approved IRB protocol require submission as an IRB modification, these minor modifications were resubmitted and subsequently approved. Following this approval, new invitations were sent to potential participants, resulting in a sufficient number of requests from participants who met all the criteria.

Resumes

A resume or curriculum vitae (CV) provides a detailed account of a scholar's entire career, unlike other data sources (Dietz et al., 2000). Dietz et al. further described it as "not simply a list of credentials, but a historical document that evolves over time capturing changes in interests, jobs, and collaborations" (p. 420). Building on this understanding, participants in this study were asked to provide their resumes. Although I did not engage in direct discussions with the participants specifically about the details on their resumes, the solicitation of these documents was designed to facilitate a comprehensive analysis of their educational backgrounds, professional trajectories, notable achievements, and contributions within their respective scientific disciplines. The incorporation of resumes into the study yielded critical insights into the unique characteristics of these gifted individuals, and it was instrumental in drawing connections between their academic experiences and subsequent career choices.

3.4 Data Analysis

According to Patton (2002), the analysis of qualitative data presents a significant challenge, requiring the meticulous interpretation of extensive datasets. This process includes simplifying complex data to its most essential parts, separating less important details from crucial ones, finding relevant patterns, and creating a method to clearly communicate the key

findings from the data. The complexity of this endeavor is heightened by the absence of standardized guidelines for qualitative data analysis.

In response to the challenges identified by Patton (2002), I utilized the thematic analysis framework described by Braun and Clarke (2006). Their method, renowned for its versatility and robustness, offers a systematic approach to qualitative analysis, directly addressing the issues of standardization and methodological clarity. They outline a comprehensive guideline consisting of six phases for conducting thematic analysis, which includes: (1) familiarizing yourself with your data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. They emphasize that qualitative data analysis should be viewed as a "recursive" process (p. 86), meaning that the researcher must be willing to go back and improve their steps in an iterative manner, rather than adhering to a strict sequential order. By utilizing this iterative method, a comprehensive and critical interaction with the data was aimed to be achieved, improving the depth and rigor of the analysis.

Understanding that data analysis is a demanding and lengthy endeavor (Miles & Huberman, 1994), I recognized the importance of beginning this process as early as possible. Early engagement with the data not only facilitates subsequent steps but also deepens understanding of the current data (Merriam & Grenier, 2019; Miles & Huberman, 1994). Additionally, this approach allowed me to review my research questions, key concepts, and literature review. It enabled me to identify any flaws and make the necessary changes and interventions in a timely manner (Merriam & Grenier, 2019).

After outlining the general framework for thematic qualitative analysis, I incorporated the Talent Development Model into this approach. This integration ensured that the analysis was not only methodologically sound but also closely aligned with the theoretical framework of this

study. I will now delve into each phase in detail, beginning with the initial step of familiarizing myself with the data.

Familiarizing Data

Nine participants provided their consent for the storage of audio recordings and transcriptions generated during the Zoom meetings. Following each interview, I listened to the audio recordings, which were securely stored on my password-protected personal computer and personal Google Drive. I then meticulously edited the initial transcriptions created by the Zoom software to enhance their accuracy and clarity. This process involved a careful and slow re-listening of the audio recordings to ensure precision in every detail. I took detailed notes and wrote a short summary for each participant. This approach aligns with the insights provided by Miles and Huberman (1994) in their book, Qualitative Data Analysis, which underscores the importance of ongoing data analysis rather than postponing it until all data are collected.

For the second interviews with four participants, I thoroughly prepared by reviewing their initial sessions and consulting my notes. These interviews were specifically conducted as part of the member checking process, where participants were invited to review and validate the accuracy of the interpretations (Creswell, 2009). I listened to and transcribed the audio recordings, then edited them for validation purposes. Necessary additions were made to the relevant sections of their first interviews, which were then incorporated into the data analysis process.

Generating Initial Codes

Miles and Huberman (1994) advocate for an intertwined process of data collection and analysis to optimize learning from ongoing data and improve research management. By adhering to this, I regularly evaluated the need for adjustments in the research process and interview

questions. Furthermore, as they caution, "trying to do the coding all at one time tempts the researcher to get sloppy, resentful, tired and partial. This attitude damages the robustness of the data and the quality of analysis" (p. 65). Adopting a more staggered approach to coding helped me avoid burnout and effectively prepare for upcoming interviews. This was also beneficial in equipping me with the skills to formulate and address follow-up questions more effectively.

It was advantageous to develop a preliminary list of codes, understanding that they would likely be reevaluated, reshaped, and redefined during the coding process (Miles & Huberman, 1994). The initial list of codes, which is presented in Table 3, was constructed based on the theoretical framework and research questions, and was formulated by drawing inspiration from the example provided by the referenced authors. Incorporating the Talent Development Model into the coding process was instrumental in shaping and facilitating the coding process. The model's dimensions—general ability, specific ability, environmental support, non-intellectual factors, and chance—offered a structured lens through which to view and categorize the data.

After each interview, I aimed to rigorously review and refine the initial code list to enhance its precision and applicability. Initially, this process proved invaluable, providing a structured approach to navigate the complex data. However, as the analysis progressed, I realized the decreasing necessity for such a list, especially since each participant's data generated a substantial number of codes, varying between 140 and 180. During the coding phase, I deeply engaged with the data, striving for a thorough understanding and nuanced interpretation.

Table 3

Provisional Start List

Provisional Codes	Research questions	Theoretical framework and key concepts
Gifted identity	1	Talent development The "gifted" label
Labeling	1	The "gifted" label
Parenting	2	Talent development
Schooling	2, 3	Talent development
Effort and hardwork	1, 2	Talent development
Out of school activities	2	Science education for gifted learners
Career awareness	3	Science education for gifted learners
Engagement with science	3	Science education for gifted learners
Science career interests	3	Talent development

Searching for Themes

In the study, I implemented a color-coding system for each participant to enhance the organization and analysis of data, allowing for easy tracking of each participant's data. This method enabled me to efficiently gather and categorize all relevant codes into potential themes identified during the analysis. Importantly, the process of grouping codes into themes was deeply informed by Tannenbaum's Talent Development Model, which facilitated a more streamlined approach to distinguishing and correlating themes across the diverse responses of participants. This enabled me to effectively compile a set of themes for further analysis.

Table 4

Searching for Themes: An Example

Codes	Merged codes	Themes
ahead of their peers, rapid conceptual understanding, eager learner, self-learner, perseverance, quicker task completion, being more knowledgeable, recognized by teachers, school was effortless, being the top of their class, more intelligent than most, being different	Advanced learning capabilities Personal traits Educational achievement	Gifted identity
school was boring, participation in science fairs, no mentorship in middle school, hands-on activities, various teaching methods, unique instructional strategies, insufficient science education in early grades, earth science less interesting compared to other sciences, excited to go home and do homework	Educational environment and resources Extracurricular science opportunities Academic preferences and inspirations in science	The quality of science education

Reflecting on the phase of analysis described by Braun and Clarke, where the initial coding transitions into a thematic focus, I engaged in a rigorous process of sorting and collating codes into potential sub-themes and themes. This was evident in Table 4, where codes sharing similar attributes—such as “being ahead of peers”, “being the top in the class”, and “being more intelligent”—were synthesized into comprehensive sub-themes like “advanced learning capabilities” and “personal traits and educational achievement”. These synthesized codes laid the groundwork for the development of a significant theme: “gifted identity”. Similarly, as detailed

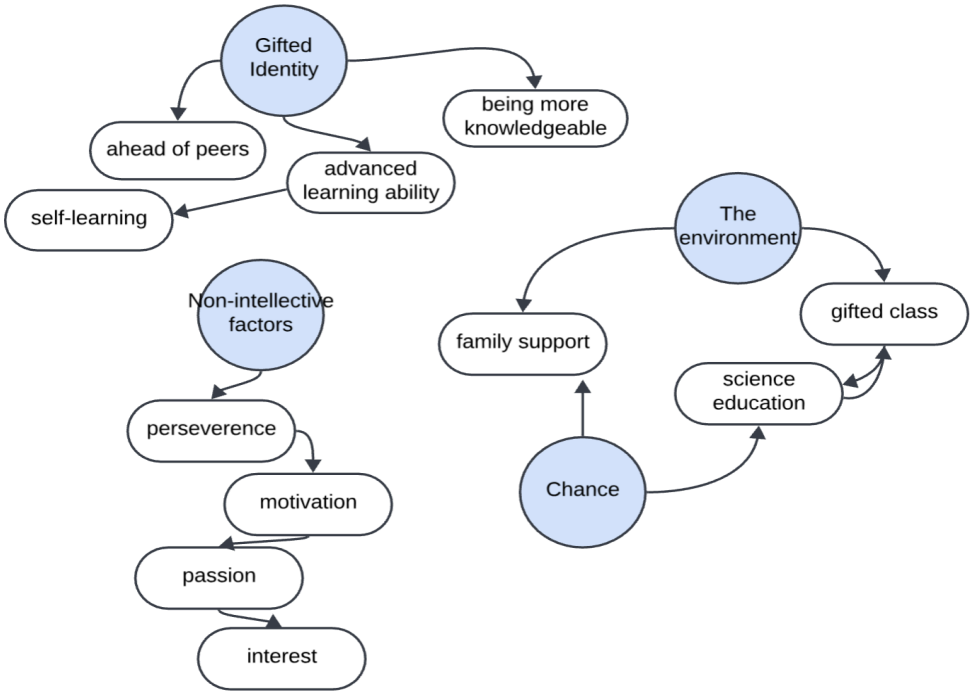
in Table 4, codes related to educational experiences were combined into sub-themes like "educational environment and resources", leading to the creation of the theme "the quality of science education". This theme highlights the role of educational settings and activities in shaping the scientific engagement and development of gifted individuals.

Reviewing Themes

In this phase, I carefully reviewed the candidate themes and assessed the codes under each to ensure they accurately reflected their respective themes. My aim was to verify the internal coherence of data within each theme, ensuring that each theme was distinct and clearly defined. As shown in Figure 1, I developed an initial thematic map as suggested by Braun and Clarke to demonstrate the preliminary organization of themes.

Figure 1

Initial Thematic Map



Defining and Naming Themes

Following my review and refinement of the themes, along with a thorough re-examination of the codes and themes in relation to the research questions, I developed a more satisfactory thematic map, as depicted in Figure 2. Ultimately, I established three main themes, each addressing one of the research questions and identified a total of ten sub-themes. To ensure clarity and relevance, I briefly described each sub-theme to assess its scope and content. Then, I finalized the names of the themes, ensuring they were concise, impactful, and accurately reflected the essence of each theme's content (Braun and Clarke, 2006).

Below is a detailed description of each sub-theme:

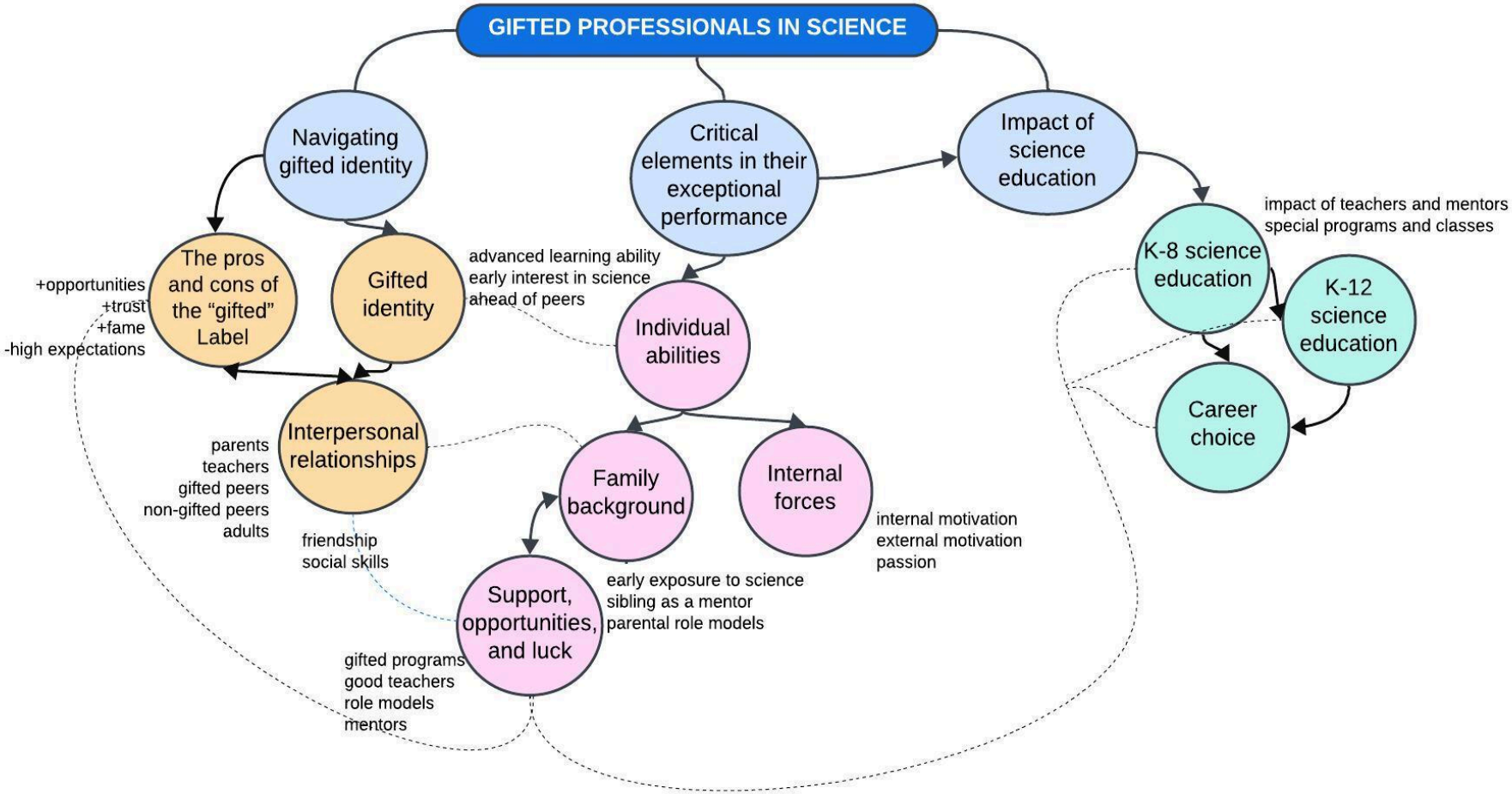
Perception of Giftedness and Gifted Identity. This theme delved into how individuals recognized and interpreted their giftedness across different life stages. It examined their self-awareness and evolving self-concept as a gifted person, tracking the transition from childhood to adulthood. The exploration highlighted the complexities and nuances in how gifted individuals view themselves and their abilities over time.

The Pros and Cons of the Gifted Label. This theme investigated the advantages and disadvantages of being labeled as gifted, including impacts on personal development, opportunities, and challenges.

Interpersonal Relationships. This theme focused on how being identified as gifted affected relationships with peers, family, and teachers, examining social interactions and connections.

Figure 2

Developed Thematic Map



Individual Abilities. This theme redefined giftedness in the realm of science, placing a strong emphasis on the significance of individual abilities. It incorporated insights from the sub-theme of perception of giftedness and gifted identity, centering on individuals' remarkable capacity for rapidly comprehending complex concepts and intricate ideas. This exploration underscored the qualities that distinguished gifted individuals in science, highlighting their special abilities for navigating and mastering complex scientific theories and principles with ease.

Family Background and Childhood Experiences. This theme explored how factors such as an individual's family environment, parental education, parenting styles, and childhood experiences collectively contributed to their success in the field of science.

Internal Forces: Motivation and Passion. This theme looked at internal drivers such as personal motivation and passion for science, and how these factors fueled exceptional performance.

Support, Opportunities, and Luck. This theme analyzed the influence of external support, opportunities provided, and the role of luck in achieving exceptional performance in science. This analysis also highlighted the indispensable roles played by mentors and role models—including family members, educators, and fellow scientists—in steering individuals towards their scientific careers. These figures not only motivated and guided the participants but also offered essential support, shaping their paths to success in science.

The Impact of K-8 Science Education. This theme explored the influence of formal science education during the K-8 years on participants' achievements in science. It examined the

types of schools attended and the gifted education provided to them, assessing which science teaching methods contributed to or did not contribute to students' development in the field.

The Impact of High School Science Education. Focusing on the later years of formal education, this theme delved into the critical role that high school science education plays in honing the abilities and interests of budding scientists. Additionally, it explores how out-of-school activities solidified students' career aspirations in science, preparing them for higher education and beyond.

Career Choice in Science. By examining the journey from initial interest to the commitment to a scientific career, this theme sought to understand what drove individuals to dedicate themselves to the pursuit of scientific knowledge and innovation.

Producing the Report

The sixth and final phase of the thematic analysis was "producing the report". In this phase, I presented the insights gathered from the data in the designated section for findings. While writing this section, I strengthened my arguments by directly quoting from the statements of the participants. In the findings, I created separate headings for themes that addressed the research questions. This organization was crucial for clarity, coherence, and engagement, ensuring the narrative presented by the data was effectively conveyed both within individual themes and across them (Braun & Clarke, 2006). Ultimately, I summarized all findings, ensuring a clear and academic presentation of the data that directly connected participant insights with the overarching research questions.

3.5 Resume

The infrequent use of resumes or curriculum vitae (CVs) as qualitative data tools in research may stem from the typically smaller participant pools in qualitative studies and the

challenge of maintaining confidentiality due to the personal information contained in CVs. Despite these challenges, research has successfully utilized CVs. These works span a range of objectives, from analyzing scientists' career trajectories (Dietz et al., 2000) and documenting the professional life stories of senior women in academia (Bawazeer & Gunter, 2016), to evaluating the influence of center affiliations on scholarly productivity (Gaughan & Ponomariov, 2008) and examining gender disparities in academic promotions (Sabatier et al., 2006). While these studies primarily emphasize quantitative measures such as analyzing the correlation between promotion duration and variables like gender or educational quality, my research utilized a CV analysis for qualitative insights. This approach dove into narrative elements, capturing personal experiences and significant accomplishments to enrich our understanding of professional development.

Resumes, which contain highly personal information, were examined only in terms of similarities and differences in participants' life trajectories. For instance, I investigated whether scientists in similar age groups engaged in comparable jobs or had similar numbers of publications. Initially, I developed a table to record specific details, including the universities where participants obtained their bachelor's, master's, and doctoral degrees, the occurrence of double majors, the prestige of their institutions, their years of work and productivity, as well as any awards and fellowships received. Additional information such as presentations, and national and international studies, was also noted. The data extracted from the resumes was instrumental in understanding their outstanding success within their respective fields. This analysis included factors like career progression, recognition within the scientific community, and their contributions to their fields of expertise.

3.6 Questionnaire

The data from the initial nine questions, aligned with information gathered from the resume analysis, were used to construct Table 1. This table provides an overview of the participants' backgrounds and helps to validate the information in their resumes. Inspired by Horgan's qualitative study (2021), which innovatively employed Likert-scale questionnaires—a method not typically seen in qualitative research—for the development of interview questions and data triangulation, this study similarly adopted questionnaires for the purpose of data triangulation. In this study, questions 10–16, originally open-ended, were converted to Likert-scale format. This adaptation was strategically implemented to increase participation rates, particularly considering the demanding schedules of the participants who are successful scientists. For these individuals, even dedicating one hour for an interview was significant. The primary aim of this adaptation was to reduce the workload for participants, thereby enhancing their participation and ensuring the collection of sufficient data for in-depth analysis. The responses to these Likert-scale items, when analyzed in conjunction with their verbal responses, were instrumental in facilitating the identification of themes. Questions 17 and 18 were coded according to the methodology outlined in the data analysis section, with their responses integrated into the overall interview data for comprehensive analysis.

3.7 Validity

There are several techniques to avoid personal biases and increase validity in qualitative research. In this study, I attempted to use triangulation, member checking, and thick description.

Triangulation

Triangulation, as defined in the literature (Litchman, 2010; Merriam & Grenier 2019), involves synthesizing data from diverse sources like interviews, questionnaires, and artifacts to

construct a comprehensive understanding. To realize this in my study, I employed a multifaceted data collection approach, integrating interviews, questionnaires, and resumes as primary tools. This methodology enabled me to cross-examine and corroborate the findings from different sources, ensuring consistency in the interpretations (Merriam & Tisdell, 2016). The insights gained from semi-structured interviews were evaluated against the responses from online questionnaires and the detailed professional profiles presented in the participants' resumes. Such comparative analysis, as suggested by Merriam and Tisdell (2016), was vital in validating the interpretations and ensuring that they were reflective of the participants' lived experiences and perceptions, thereby reinforcing the credibility of the research findings.

Member Checking

Member checking is a method used to "determine the accuracy of the qualitative findings through taking the final report or specific descriptions or themes back to participants and determining whether these participants feel that they are accurate" (Creswell, 2009, p.191). According to Birt et al. (2016), member checking can be conducted in several ways: by sending "the interview transcripts back to participants, [holding] a member check interview using the interview transcript data or interpreted data, [organizing] a member check focus group, or returning analyzed synthesized data" (p. 1803).

In this study, I utilized a member check interview approach in which I analyzed data from individual participants rather than directly sharing the transcripts of audio recordings. This decision was motivated by concerns over participant discomfort with reviewing their own spoken language, including grammatical mistakes, pauses, or hesitations, which might lead to reluctance or discomfort, as suggested by Forbat and Henderson (2005). To avoid such issues and encourage a more engaging review process, I chose to share my analyses of the data with

participants. This strategy allowed for a secondary interview where participants were presented with my interpretations of their initial responses, offering them an opportunity to confirm, modify, or clarify these insights (Birt et al., 2016), thereby promoting a collaborative and comfortable atmosphere for discussion (Forbat & Henderson, 2005) and improved time efficiency.

Following the completion of the initial interviews, I initiated contact with all participants to schedule a second interview. The intent behind these follow-up interviews was to gather their feedback on my initial analyses and interpretations, as per the guidelines suggested by Merriam and Tisdell (2016). Of those invited, three participants, who had previously indicated their willingness to engage in a second interview, attended. This step was crucial to verify whether my detailed analysis of their self-perception of giftedness, along with significant factors like education, parenting, and support that might have influenced their development in their scientific careers, truly reflected their own views. For instance, below is a simplified excerpt from the second interview with Olivia:

Researcher: You mentioned the impact of being labeled as gifted on your confidence. I am curious to explore this further. Could you discuss whether it was the actual success in an environment or the "gifted" label itself that had a more significant influence on your confidence?

Olivia: Before college, it was definitely the label. This label set me apart from the general population and made me confident in my abilities, but within gifted programs, I often felt less accomplished than my peers.

Another excerpt from Laura's second interview:

Researcher: Let us talk about what you believe were the key contributors to your exceptional performance in science, considering our discussion on the influence of early access to advanced classes and a supportive family environment.

Laura: Yes, I was quite privileged and lucky to just have a stable home life. And I had every opportunity to do what I wanted to do, to pursue my interests. It was indeed a significant advantage.

Upon presenting my analysis to Jack, he confirmed that my interpretations were accurate. Below is a selected passage from the last interview conducted:

Researcher: A significant transition occurred in high school when your interests shifted from art to science. This change was influenced by exposure to advanced science classes, participation in extracurricular activities like robotics, and encouragement from influential teachers and friends. Your participation in robotics and science clubs, your close friendship group, and your discussions with your father, were critical in solidifying your interest in pursuing a science-based career. Does this accurately reflect your experiences?

Jack: Yeah, that pretty much sums it up.

After analyzing these follow-up interviews, I reassessed my overall understanding and incorporated additional relevant information into the data analysis section. This procedure reinforced my assurance in the accuracy of my interpretations for all participants, guiding me to ascertain that the data interpretation was as precise as could be achieved. As a result, it became

apparent that repeating this procedure with all nine participants was unnecessary. Adopting this efficient method preserved the study's thoroughness and analytical depth, enabling me to concentrate on deriving significant conclusions from the collected insights.

Thick Description

In this research, the method of "thick description" was employed to enhance the study's validity. Creswell (2009) highlights the importance of this approach, stating, "when qualitative researchers provide detailed descriptions of the setting or offer various perspectives on a theme, the results become more realistic and richer" (p. 192). To implement this, the research began with a comprehensive portrayal of each participant, including their backgrounds, motivations, and experiences—particularly those influencing their perspectives on science—thereby providing a rich context for interpreting their responses. The findings section was carefully structured to present these detailed participant descriptions before delving into the thematic analysis. This approach facilitated a seamless transition from individual stories to overarching themes. To further enrich the study, direct quotations from the interview transcripts were included, offering a vivid and genuine representation of the participants' experiences and viewpoints (Ponterotto, 2006).

3.8 Ethical Concerns

In her book "Qualitative Research Methods", Tracy (2019) highlights three approaches to ethics: procedural, situational, and relational. Practicing procedural ethics involved adhering to Institutional Review Board (IRB) requirements, which include principles such as "not harming", "avoiding deception", obtaining "informed consent", and protecting the "privacy and confidentiality" of participants (Tracy, 2019, pp. 283–284).Initially, I submitted an IRB application for review. After receiving approval, I began participant recruitment. Due to

challenges in finding enough participants, I revised the questionnaire and subsequently secured renewed IRB approval for my study. Consent forms, detailing a brief description of the study, were distributed to participants. In order to minimize the risk of harm, participants were informed that they could skip any question or withdraw from the study at any time without providing an explanation. It is important to note that participants' private information was kept confidential, with pseudonyms used in place of real names.

Situational ethics involve tailoring ethical decisions to the specific context of the research, thereby encouraging researchers to evaluate whether the overall benefits of their research justify the costs involved. In this particular context, the application of situational ethics was uncomplicated, primarily because there was no necessity for deceit, considering that the involvement of adult participants and their understanding of the research had little to no effect on the results.

According to Ellis (2007), "relational ethics recognizes and values mutual respect, dignity, and connectedness between researcher and researched" (p. 4). Reflecting this approach in my study, I emphasized building a relationship of respect and trust with the participants. When participants shared sensitive and impactful life events, I constantly reminded participants that they could skip any topics that made them uncomfortable and could withdraw from the study at any moment. Besides informing them of these options, I set aside my researcher identity and approached them with empathy, acknowledging the delicacy of their experiences. Finally, it is noteworthy that while participants did not receive direct benefits, their contribution is invaluable to advancing science education. Their involvement provides deeper insights into the unique needs and experiences of gifted students in the science learning environment, thereby enriching the field.

Chapter 4: Findings

The primary aim of this narrative study is to explore the educational journeys and personal experiences of gifted adults who have chosen careers in science. By retrospectively examining their lived experiences, this research aims to illuminate the intricate interplay between gifted identity and educational paths, from childhood to professional life. The study was structured around three primary research questions:

1. How do scientists, who were identified as gifted in their childhood, navigate their gifted identity from childhood to adulthood, and how does this affect their social relationships and self-perception?
2. How do scientists, who were identified as gifted in their childhood, perceive and describe the critical elements that contribute to their exceptional performance?
3. How do scientists, who were identified as gifted in their childhood, reflect on the impact of their K-12 science education on their development and career choice?

These questions probe deeply into how these gifted individuals navigate their unique identity across different life stages, the impact of this identity on their social relationships and self-perception, and the critical elements contributing to their exceptional performance in science. Additionally, the study investigates how gifted professionals retrospectively assess their K-12 science education on their personal development and career choices. Through a narrative analysis of the data guided by the theoretical framework and aligned with the research questions, three overarching themes and ten sub-themes were identified. The first set of themes encompass perception of giftedness and gifted identity, the pros and cons of the “gifted” label, and interpersonal relationships. For the second, themes include individual abilities, family background and childhood experiences, internal forces, and support, opportunities and luck. The

third set of themes focus on K-8 science education, high school science education and career choice in science.

4.1 Narratives of Participants

In this section, through a critical analysis of interview transcripts, questionnaires, and resumes, I endeavored to narrate the life stories of the participants with respect to their experiences and identity as gifted in science, tracing their journeys from childhood to the present day. This presentation of qualitative research findings brings forth the most recent insights as of September 2023.

Mike

Mike, a physics professor, grew up in a small town, where his childhood was filled with exploration and curiosity. His family played a significant role in nurturing his interests in science through engaging in early computing activities with his brother, drawing inspiration from science-focused TV shows, and receiving robust support from his father's active encouragement and his mother's unwavering dedication. His father, a passionate reader and skilled machinist, exposed Mike to the practical side of building and creating things, and introduced him to literature beyond his age, thereby fostering an advanced understanding and appreciation for complex ideas from a young age.

Despite being identified as gifted in the fifth grade, Mike's education did not include any specialized gifted education. His mother's decision about schooling was based on the importance of establishing a stable social environment over pursuing advanced academic opportunities. His advanced academic skills allowed him to learn new material and complete assignments faster than his peers, often leading him to wait for others before the class could proceed to new material.

Mike was socially adept and well-integrated; he did not experience isolation or bullying during his school years. His identification as gifted did not significantly alter his self-perception or social relationships. He viewed giftedness as one of many individual variations, not as a superiority marker. He emphasizes the importance of passion, attitude, and the ability to learn from failures. Although Mike had always been interested in science since childhood, the turning point in Mike's decision to pursue physics came during his high school years. He was particularly drawn to the logic and predictability of physics, which resonated with his methodical way of thinking. His passion for the subject led him to major in physics at university, despite initial uncertainties about his career path.

The recognition that success in science and life is as much about passion and dedication as it is about intellectual capabilities shaped his approach to both his professional work and mentoring. Looking ahead, he aspires to contribute to his field while fostering an environment that encourages the next generation of scientists to pursue their curiosities, embrace challenges, and appreciate the value of lifelong learning and personal development.

David

A professor in physics, David, exhibited extraordinary talents from a very young age. His father introduced him to chess at the age of three and a half, a game through which David's analytical and strategic thinking skills quickly blossomed. His mother significantly influenced his critical thinking skills and intellectual curiosity. David and his mother engaged in deep discussions about politics, philosophy, and similar topics. When he was around eight years old, his older sister taught him about atoms and the periodic table. This knowledge ignited his interest in science and motivated him to learn more.

David, in third grade, achieved success in national chess championships and served as the chess team captain. He also developed a strong interest in computers and programming. He started learning computer programming in fifth grade and quickly grew to love it. He began with playing computer games and then started making his own. One of his big projects was creating a Jeopardy game for education, showing his skill in using programming in a creative way.

David was identified as gifted when he was about four years old, after he performed exceptionally well on a set of standardized tests. During his elementary and middle school years, David frequently experienced feelings of intellectual frustration and boredom. This was predominantly due to the fact that, despite attending a private school renowned for its academic rigor, there were not any specialized programs to support gifted students like himself. His frustration sometimes manifested in behavioral issues, highlighting the disconnect between his intellectual needs and the available educational support. However, his high school period was transformative, shaping his academic focus and steering him towards a career in science.

In high school, he was immersed in an environment filled with intellectual challenges and surrounded by like-minded peers, thanks to his participation in the Science Honors Program and his experiences at a Natural History Museum. The advanced physics courses he took on weekends outside of school, particularly in his junior and senior years, profoundly deepened his interest in and understanding of complex scientific concepts. Concurrently, his time at the Museum, starting around his junior year, allowed him to engage with real scientists and apply his skills in a professional setting, further nurturing his scientific curiosity and solidifying his ambition to pursue a career in the field.

Olivia

Olivia, a graduate research assistant in pathobiology, grew up in the suburbs of a city with her parents and a younger sister. She was a secure and playful child, engaged in sports like soccer, softball, and tennis, and interested in reading, watching TV, and playing computer games. Her mother was a stay-at-home mom, providing her with ample attention and supervision. Her father, a patent attorney with a STEM background, was keen to engage her in science-related discussions.

Olivia was identified as gifted at age 6 during the first grade. Throughout her schooling, she was part of the gifted programs. In elementary school, this meant going to a separate classroom several times a week. Middle school offered specific gifted electives like architecture. In high school, she had a particular curriculum for gifted students in language arts and social studies until the tenth grade, followed by no specific classes but meetings with the gifted program director.

Olivia showed a strong interest in science, particularly biology, from a young age. Her father's interest in chemistry and her mother's preference for medical shows on TV influenced her. In school, she enjoyed biology, languages, and literature. She preferred concrete problem-solving tasks in math and science but found assignments based on open interpretation, like in English, frustrating.

Olivia's interest in science solidified in high school and was further reinforced during her undergraduate studies. She chose a STEM major in college, eventually gravitating towards biology over chemistry and physics. She is currently pursuing a PhD in biomedicine, leaning towards a career in industry rather than academia. She values a good work-life balance and intellectual satisfaction in her future job.

Olivia credited her parents, especially her father, her friends, and her teachers for their support and influence on her journey. She also acknowledges the impact of being labeled as gifted, which set high expectations and confidence in her abilities. She felt fortunate for the resources and opportunities she had and valued hard work in addition to her giftedness.

Emily

Emily, a graduate assistant in microbiology, grew up in a developed urban area in the United States. Her mother is originally from Vietnam, her father is from the US and she has no siblings. She attended local public schools from elementary through high school. During her childhood, Emily engaged in a diverse range of activities, including physical pursuits like taekwondo, scientific explorations such as self-discovery in nature, and creative endeavors like reading, painting, and writing poetry. She described herself as more introverted and independent, with a small, close-knit group of friends. Despite being quieter among peers, she was comfortable conversing with adults and authority figures from a young age.

Emily was identified as gifted in second grade, primarily due to her advanced writing skills. She was nominated by her teacher to join a literacy challenge program, which started in third grade. Later, she also joined a math challenge program, which involved complex tasks and real-world problem-solving. Emily acknowledged the positive impact of being identified as gifted, especially the confidence it instilled in her. However, she also recognized the heightened expectations and pressures that came with the label.

Emily's passion for science was fostered through engaging activities with her father and grandfather. Her father often took her to work on "Bring Your Child to Work" days, where she participated in various experiments. Similarly, her grandfather engaged her in science projects like creating an electromagnet. At home, her parents supported her curiosity with scientific toys

and discussions. Emily's childhood memories with a microscope involved exploring nature close to her home. She collected leaves and other natural specimens to examine under her microscope, sparking her interest in biology. However, her deep interest in science, particularly molecular biology, did not develop until high school. Her academic journey reflected a shift from an initial interest in chemistry during middle school to a stronger inclination towards biology in high school.

Emily had a close and supportive relationship with her parents and grandparents. She valued open dialogue with them and received encouragement for her interests. She also had a strong connection with her teachers, whom she saw as role models and sources of inspiration.

Ashley

Ashley, a PhD candidate and researcher in microbiology, moved across various states and countries during her childhood because of her father's career in the army. From a young age, Ashley was serious and self-disciplined. She was an easy child and had a good relationship with her parents and her sister, although her sister felt overshadowed by her academic success. She made friends easily despite frequent relocations, showing adaptability. She enjoyed reading, playing soccer, and horseback riding in Germany. She also developed an interest in art, particularly pottery, in her older years.

Ashley was identified as gifted in kindergarten and participated in talented and gifted programs, which varied with each move. She excelled easily in schools and was always in top. From kindergarten to second grade, she was part of a gifted program where she engaged in more challenging coursework, often with a small group of students. In her third grade, Ashley and another student received specialized instruction in puzzles and math-based activities, enhancing her analytical and problem-solving skills. In a small school setting, Ashley was placed in a

mixed fourth and fifth-grade class, which was designed for top-performing fourth graders. This experience allowed her to engage with older students and more complex material. Ashley viewed her giftedness as a source of confidence, particularly during challenging periods. However, it also brought pressure and expectations from her parents regarding her career choices.

Ashley's educational experiences in middle school were less focused on gifted programs compared to her earlier years. She maintained high academic performance and began to develop a strong interest in science. This interest was not initially intense due to the simplicity of the science curriculum at that stage, but it laid the groundwork for her future pursuits. In high school, Ashley's academic interests became more pronounced. Her fondness for biology, which later guided her career choice, emerged during this time. Ashley was part of the International Baccalaureate (IB) program, which offered a more challenging curriculum. Ashley was bilingual in German and English from a young age. She also studied Spanish and undertook a Spanish major alongside her molecular biology degree.

Laura

Laura, a PhD student and researcher in physics, has parents who are Polish immigrants, so she grew up in a bilingual environment, speaking both English and Polish. Her parents had science and mathematics-related backgrounds and her younger sister was also identified as gifted. As a child, Laura described herself as initially noisy and friendly, but then became quiet and bookish. She had a strong interest in reading. She enjoyed playing imaginary games, board games and video games. Throughout her education, Laura faced challenges in socializing, partly due to her introverted nature. She expressed a wish that she had developed better communication skills earlier in life.

Laura was identified as a gifted student during her elementary school years. She participated in an enrichment program where a select group of students would engage in advanced and distinct lessons compared to the rest of the class. One of the pivotal elements of Laura's gifted education was her involvement in an advanced math program starting from the fourth grade. This program was distinct from the standard curriculum and was conducted at a local state university. In middle school, Laura's science skills were particularly nurtured through hands-on experiences. She mentioned enjoying science labs where they conducted practical experiments, such as studying erosion or demonstrating laws of physics. These labs provided a tangible and engaging way to understand scientific concepts.

In high school, Laura continued to excel and seek out advanced learning opportunities. She pursued advanced math classes and expressed interest in science-related subjects. She initially enrolled in an electrical engineering program in college but soon realized that her true passion lay in physics. This realization led her to switch her major and fully immerse herself in the study of physics.

Laura believed that being labeled as gifted played a significant role in her educational and career choices, especially in pursuing physics. She received significant emotional and academic support from her parents throughout her education.

Sarah

Sarah, a PhD student and researcher in microbiology, grew up in the western part of the US with her parents and her older brother. Her family was supportive, providing both emotional and financial support during her education. Her father, a scientist, played a significant role in nurturing her interest in science and math through storytelling and informal learning experiences. She was confident and competitive from a young age, often emulating her older brother's

activities. She was involved in athletic activities and was described as shy before starting elementary school.

Sarah was identified as a gifted child around the 4th grade. She recalled attending meetings and solving puzzles as part of the gifted program, which gave her a sense of being special and more capable than her peers. In high school, she took AP (Advanced Placement) Biology, Computer Science, and Physics, as well as Honors classes in science subjects. She studied Physics at an Ivy League University.

She had positive relationships with certain teachers who believed in her abilities, particularly her math teachers in elementary and high school, who were challenging yet supportive. While she did not face significant academic obstacles, she did feel a disconnect with her non-academic friends.

Ryan

Ryan is a PhD student and researcher in physics, both of whose parents had doctoral degrees, significantly influencing his early development. They played educational games and provided him with resources like animal magazines, fostering his interest in learning. He has a younger sister who is quite different from himself.

Ryan was identified as reading at a fifth-grade level in kindergarten and showed advanced academic abilities from a very young age. He attended a Montessori preschool and was involved in gifted programs. Due to financial considerations, he could not attend more advanced classes. Throughout his elementary and middle school years, he was often bored due to the lack of challenge in standard curriculums. He was aware of his giftedness from a young age and initially felt a sense of pride and arrogance, which mellowed over time. He had a good social life and maintained friendships from various stages of his life.

Ryan had a broad range of interests, including science, music, and the arts. He played instruments like the cello and engaged in various extracurricular activities, including advanced science programs at a university during high school years.

His interest in science started very young, particularly in biology and genetics, influenced by his childhood fascination with animals. However, his career aspirations fluctuated over time, and he ended up pursuing physics in his bachelor's degree. Ryan reflects on the impact of being identified as gifted, including the opportunities and challenges it brought. He emphasizes the importance of hard work alongside natural talent and the value of a supportive educational and family environment.

Jack

Jack, a postdoctoral fellow in physics, grew up in another country until the age of 8, then moved to the United States. He overcame the language barrier within two years. His parents had an engineering background but did not complete their college education. They were always supportive of his interests. His father played a significant role in nurturing his interest in science.

He was identified as gifted in the fourth grade after being tested by his school, leading to his placement in special classes. These classes offered more material and optional projects, especially in math, where he excelled. Despite this identification, Jack did not perceive himself as gifted until later in high school.

From an early age, his inclination towards hands-on activities and technical hobbies was evident. This interest was further nurtured by his father's business in security cameras, exposing him to electronics at a young age. He participated in math teams in middle school and joined a robotics team and science clubs in high school, where he developed a strong interest in science. He had a dedicated teacher and a critical friend in high school who greatly influenced his

direction towards science. Jack emphasizes the importance of finding mentors and like-minded peers in developing scientific interests.

He pursued two degrees in chemistry and physics in college, reflecting his broad interests in science. Despite his gifted label, Jack believes his success is more attributable to his experiences and interests developed in high school, rather than his early educational experiences.

4.2 Navigating Gifted Identity from Childhood to Adulthood

To address the first research question, the analysis focuses on the perception of giftedness and identity, examining the effects of the "gifted" label. The key themes include the perception of giftedness and gifted identity, exploring both the advantages and challenges associated with being designated as gifted, alongside the dynamics of interpersonal relationships.

Perception of Giftedness and Gifted Identity

The data, derived from interviews with nine participants, consistently highlighted a shared perspective on giftedness. Among the interviewees, a prevailing characteristic identified was their accelerated learning pace compared to their same-age peers. They uniformly described an individual ability to grasp and master subjects with ease, often outperforming the majority in academic settings. Sarah and Ryan reflected on their academic experiences, respectively stating, "I was above average. …I always got the best scores," and "I was always in the highest level of the classes". Olivia also commented that she perpetually finished the school work more quickly than others. As all of the participants agreed, "school was always very easy" (e.g., Ashley). Mike noted "[my teacher] thought that I was operating at a higher level than the average student in the class," and he observed his classmates also seemed to hold this perception: "My peers somewhat gave me the impression that they thought I was smart."

This sense of academic superiority, however, was accompanied by feelings of alienation. Five participants shared how they "felt different among [their] classmates" (Emily), and how it was hard to "fit in with peers" (David). Even prior to wearing the label of "gifted", all of them were aware of their heightened intellectual capacities and possessed a keen interest in scientific subjects. David further highlighted this early divergence in interests, recalling, "in about third grade, I became very interested in various scientific topics, and most of the other kids were not interested."

Reflecting on the points noted earlier, all participants reached high academic achievement with minimal effort during their elementary and middle school years, emphasizing their natural talents and the lack of sufficiently challenging school programs for such learners especially in the sciences. This frequently led to them being the top students in their classes until high school years where they met other gifted students (Ashley, Laura, Sarah). For example, it was during this period, particularly in an advanced course, that Laura faced her first substantial academic hurdles. This experience was the first time she found herself needing to study extensively and complete homework to fully grasp the class material, as she noted, "It was essentially the first time I had to actually study." Mike also elaborated on this situation, emphasizing the change upon entering college. He found it challenging to adjust to the reality that, despite his continued passion and enjoyment for his field, the amount of work required for success was significantly higher compared to some of his peers who seemed more intellectually capable. This realization was "disheartening" but also led him to understand that success is not solely determined by raw ability. He reflected that part of what limits a person's success at any given moment is how well they are prepared, suggesting that prior education and the ability to integrate information quickly are crucial factors in academic performance.

The participants' perception of being gifted as an identity exhibited a significant evolution from childhood to adulthood. During their childhood, this identity was linked with their academic superiority and advanced learning abilities. Their early recognition occasionally led to a sense of arrogance for some (e.g., Jack, Ryan, Sarah); for instance, one participant, Laura, confessed to holding a belief of being "better than everybody" during this phase. Sarah also reflected on her early awareness of being gifted, recognizing the distinctiveness of the label and feeling a sense of pride and exclusivity as a child. She knew that "there was something special about [the gifted label] because not everyone had that title," which contributed to her strong self-identification with giftedness in her formative years.

In contrast, adulthood brought about a more refined comprehension of individual differences, particularly during key transitional periods, such as high school and college years, as mentioned earlier. The evolution of their identity, once primarily based on giftedness, was influenced by several factors. Firstly, encountering other highly gifted individuals in advanced classes altered their perceptions of themselves as the consistently top performers. For example, Laura's experiences in such environments prompted her to acknowledge her limitations and recognize peers with equal or superior talents, thereby reshaping her understanding of giftedness. Similarly, Emily suggested that the label of "gifted" was more relevant in her younger years and did not strongly align with it as part of her current self-perception. Another factor involves a growing skepticism about the "gifted" label as subjective and potentially arbitrary. This viewpoint is exemplified by Mike, who described giftedness as "an arbitrary concept." Mike's reflections indicate that his identification as gifted could have been influenced by the teaching methods employed. He concedes that the standards for identifying giftedness are subjective and

may differ with each assessment approach. Nonetheless, he remains conscious of his distinctive talents.

Finally, with maturity, the emphasis on possessing a gifted identity began to diminish. While recognizing their exceptional abilities, individuals also acknowledged the importance of individual differences and additional talents. David underscored the value of kindness and respect towards others with varied talents, emphasizing that human decency and meaningful relationships are as vital as academic achievements, and that success is rarely achieved in isolation.

The Pros and Cons of the "Gifted" Label

The analysis of the data revealed a nuanced spectrum of perspectives on the impact of the "gifted" label on participants' personal and professional journeys. Starting with the benefits, many participants (Ashley, Emily, Laura, Olivia, Ryan, Sarah) highlighted how being recognized as gifted served as a catalyst for enhanced educational opportunities and personal development. For example, Emily's experiences corroborated the benefits of receiving more support and growth opportunities due to the gifted label. She acknowledged that this may have given her an advantage over peers not identified as gifted, saying, "I thought it was exciting that it felt like you were getting singled out, but in a positive way. … I was excited to get more challenges."

Furthermore, six out of nine participants reported that the gifted label also contributed significantly to their self-confidence and resilience. The label served as a source of confidence, especially during periods of doubt, allowing individuals to remind themselves of their capabilities. This psychological benefit of the gifted label underscores its role not just in educational advancement but also in shaping a positive self-esteem and resilience in the face of adversity. The following statements were shared by Emily and Ashley, respectively:

> …I think once that label was applied, I felt a little bit like, 'Oh, I can do it', even if I do not think I can. You know, you are more sure of yourself, that something that poses a challenge, you can still handle it. So, I think that gave me that mentality, which I still have today, that I can solve difficult things and still face problems, even if they seem a little bit daunting to me at first.
>
> Something that, when I was at lower confidence periods in my life, I would look back on to give me confidence. Like, if I ever felt, I do not know, bad, I could always tell myself, 'You know, at least I am smart.' So, it gave me a source of confidence.

On the other hand, it is also intriguing to explore the influence of the gifted label on social dynamics within the classroom. Olivia and Mike's experiences reveal how being labeled as gifted fostered trust from classmates, translating into positive social recognition and opportunities for leadership and collaboration. This trust, derived from their gifted identification, not only established them as reliable contributors but also enhanced their social interactions, enabling them to assume leadership roles in group projects and gain extra trust in their abilities. In Olivia's words:

> I feel like I frequently took on a leadership role in group projects to get things done. And maybe there was a wait for my approval on some of the work because students had extra trust in me because of the [gifted] label.

Echoing this sentiment, Mike observed that this trust often translated into a form of popularity, signifying positive social recognition among peers.

The findings suggest that although the "gifted" label can yield considerable benefits, it is also important to consider less favorable experiences it may entail. Jack identified the social stigma attached to the gifted label as a significant drawback, particularly impacting younger

children. He explained, “I think people think that we want [the gifted label] to be special. Or, it is for the other kids who think that liking school is nor cool. That is the only negative thing I can see.” His insight underscores how the gifted label can lead to misconceptions among peers, framing gifted children as seeking to be seen as special or alienating them for their academic interests. Jack succinctly described this challenge as “just a social obstacle to overcome”, emphasizing the complexities gifted individuals face in social settings due to their label.

Another disadvantage of the gifted label, as illuminated through the personal narratives of Emily and Ashley, is the heightened expectations and pressure from their families. Emily shared, “When I was younger, my family often said, ‘Now that you are in this program, you should definitely be achieving this or that’”. Ashley discussed the challenge of meeting these family expectations, which did not diminish even when pursuing academically demanding careers, such as a PhD, because her family viewed medical degrees as more prestigious and struggled to understand her career choices. This constant pressure to achieve and meet family expectations resulted in a lack of relaxation and personal freedom. Consequently, while the gifted label provides numerous opportunities, it also carries the significant burden of living up to elevated expectations and navigating the pressures of success as defined by family standards.

Interpersonal Relationships

In terms of interpersonal relationships, the participants in this study reported a diverse array of experiences influenced by multiple factors, including their giftedness, personality traits (such as introversion or shyness), age, the educational level of their school, and the surrounding environment. Some participants (e.g., Mike, Olivia, Ryan) recounted positive peer interactions and friendships extending from childhood to adulthood. They were not only socially skilled but also held leadership roles, gaining respect and admiration from their peers. Mike reported a

memorable incident from his 4th grade mathematics class. When his teacher challenged him with a 20-digit long division problem, Mike decided not to go to recess and instead worked on it. Upon successfully solving the problem, his achievement was celebrated by his classmates, turning his triumph into a collective victory. This experience was not only a testament to Mike's exceptional academic abilities, which stood out from the norm, but also an early recognition of the support and admiration he received from his peers. In line with these experiences, Ryan reflected on his own school days, noting, "I was pretty well respected and liked by [classmates]. People valued doing well in classes at my school." Similarly, Olivia indicated that her advanced skills were recognized by her classmates, which caused her to be seen as a leader mostly in group projects and harder tasks.

However, two participants encountered negative attitudes from their peers, a phenomenon more prevalent in high school than in middle school. Sarah mentioned how her friends' perceptions of her success led to unrealistic expectations, making it difficult for her to share her struggles and connect with them on a deeper level. Her friends assumed that her achievements meant she had no grievances and led an ideal, perfect life. She shared:

> I think that left a bit of a disconnect with my friends because they were not taking the APs (advanced placement courses). And I think they felt a bit different from me. I think it probably did impact my friendships a little bit. … There might have been a little bit of resentment or jealousy.

Adding to these complexities, Laura shared how being viewed as a "teacher's pet" was hurtful. She clarified that her timely completion of assignments stemmed from a strong sense of responsibility and a genuine enjoyment of diligence, rather than favoritism. Furthermore, Laura, along with two other participants, mentioned that having an introverted nature posed difficulties

in social interactions. Emily, for example, described herself as somewhat reserved, preferring to engage with teachers and authority figures over peers her own age. These stories convey the complex social dynamics that gifted students navigate, where their outstanding performance or determination can sometimes create misunderstandings among their peers, leading to barriers in forming relatable and empathetic connections.

On the other hand, some participants (David, Jack, and Olivia) expressed a natural inclination to connect with other gifted students, finding that their similar interests and mutual understanding facilitated easier and more meaningful interactions within the group. This synergy, rooted in their shared intellectual and emotional experiences, played a crucial role in strengthening their social bonds and highlighted the significance of common ground in nurturing relationships among gifted individuals. Jack shared an engaging story about how he and his friends, united by similar interests and skills, collaborated on various projects and conducted experiments in the laboratory during their free time. He noted, “this was really the thing that set my soul on fire.” emphasizing the deep value of shared passions in friendships.

In a similar vein, David’s academic advancement—moving directly from 6th to 8th grade after being granted permission to skip 7th grade—offered him a unique perspective. He reflected:

> I found that I got along much better with kids who were a little bit older. I found a group of kids who were very interested in computers, science, politics, and all kinds of stuff, and I found a friend group. I think, for the first time, I had a real group of friends. We did a lot of interesting extracurricular activities together, one of them was called future problem solvers, and we met once a week.

These findings are consistent with the answers obtained from the questionnaire. Indeed, in the questionnaire, David, along with the other three participants—Olivia, Emily, and Laura—,

expressed a preference for collaborating with gifted peers over non-gifted ones, indicating a stronger inclination towards working with individuals who share similar levels of ability and interests.

Seven participants also noted that they formed better relationships with older individuals, authority figures, and teachers. For David, one of the particularly special people was his childhood chess teacher, with whom he maintained a lifelong friendship. He appreciated the teacher's adult-like treatment towards him, similar to Emily's and Sarah's experience, making him feel valued. David described his relationship with his teacher: "[My chess instructor] was strict, but he was also very caring, and he treated me like an adult. He talked to me. He did not talk down to me. He was wonderful and had a huge impact on me." This underscores the positive effect of teachers adapting their approach according to the mental and emotional maturity of their students.

The special treatment gifted students received from their teachers was often evident to others, leading to feelings of hostility and jealousy among peers who were not gifted. Yet, when teachers managed to discreetly provide this attention, ensuring that each student's needs were met appropriately, they effectively mitigated potential conflicts between gifted individuals and their peers. This approach also made students feel a sense of belonging and fostered greater respect and affection towards their teachers. Laura, for example, mentioned her teachers with admiration, noting that "they treated me implicitly differently" because "they knew I cared [about learning]. Ashley provided insight into this dynamic, sharing her personal experiences. She mentioned:

> My relationship with elementary school teachers was positive; they always liked me, and I was a model student. In high school, it was similar, but probably less [pronounced]

because you were not with a single teacher all day. I was respected, but I felt more favoritism in the younger grades, where you are with one teacher for an entire day. In high school, with multiple teachers, the sense of favoritism was less evident.

Three gifted professionals (Mike, David, Jack) acknowledged that they could have been challenging for their teachers from time to time. This was often attributed to the lack of adequately stimulating and suitable materials in heterogeneous classroom settings, which failed to meet their specific needs and contribute to their intellectual development. David reflected on his elementary school years, acknowledging that his behavior was problematic. He said "I was getting into trouble very frequently, and I was a real problem for the teachers. I did not know how to handle my frustration and boredom, and also my sense that the people around me were incompetent." This statement underscores the importance of providing appropriate intellectual challenges to gifted students to prevent behavioral issues and ensure their engagement and growth.

4.3 Critical Elements in Exceptional Performance in Science: Insights from Gifted Professionals in Science

In addressing the second research question, the analysis identified several central themes: individual abilities, family background and childhood experiences, internal forces, support, opportunities, and luck, as well as the influence of role models and mentors.

Individual abilities

In the section addressing the perception of giftedness, I presented the participants' collective perceptions and experiences related to their giftedness. It is important to remember that all participants acknowledged their superior intellectual capabilities from a young age, characterized by a quicker learning pace relative to their peers. Furthermore, they reported

achieving significant academic success with minimal effort up until high school. To illustrate these points, here are direct quotes from three participants:

David: I started to notice that I was stronger at mathematics than most of the other students, also around the age of 9, when I was in third grade.

Olivia: I remember [that] a handful of other [gifted] students and I were finishing our work more quickly in kindergarten, first grade, second grade. So we had to be given additional tasks because we were running through things quickly.

Ryan: I think natural talent has carried me pretty far.

Further analysis, incorporating data from the questionnaire, revealed responses that were consistent and supportive of the interview findings. The questionnaire included two distinct questions related to participants' perception of their abilities. In one question, participants were asked about the influence of their rapid learning ability on their grasp of complex scientific concepts. There was unanimous agreement on its vital role. This agreement was clear, with six participants strongly agreeing and three agreeing, underscoring the recognition of rapid learning ability as a fundamental component of their scientific understanding and achievements. Similarly, another question probed the essential factors contributing to their scientific accomplishments. While five participants emphasized their special ability as one of the key factors, three participants (Emily, Mike, and Olivia)—echoing sentiments shared in their interviews—pointed out that while special abilities helped facilitate the process, support from teachers and parents and opportunities were deemed more crucial than any other factor. Mike also underscored the value of personal interest and ambition, suggesting these factors propel individuals to greater accomplishments.

Family Background and Childhood Experiences

The majority of the participants came from families with high levels of education. Specifically, five participants have fathers with doctoral degrees, two with bachelor's degrees, one whose father was a college dropout, and another with a father who had only a high school degree. On the maternal side, one mother holds a doctoral degree, two had master's degrees, five had bachelor's degrees and one is a college dropout. This high level of parental education, combined with an attentive parenting style, contributed to providing a rich environment full of learning opportunities from an early age, even before attending kindergarten. All participants spoke of the quality time they spent with their families and the strong bonds they shared with their parents.

The role of family members, whether it is a father, a mother, an older brother, or a sister, in encouraging an interest in science among gifted children is clear from the stories shared by the participants. For example, Olivia's passion for science was significantly fed by the influence of her father who had a background in chemistry. As Olivia said, "[My father] was eager to talk to me about science." One of her earlier memories was, "he would wear a periodic table of elements t-shirt for all the time, so I would endlessly ask him questions about the elements and feel excited when he wore that shirt". She also mentioned the benefits of having a stay-at-home mom who provided her with constant supervision and attention. The choice of games and toys made by her parents was tailored to her intellectual interests. Tools like doctor kits and microscopes allowed her to engage in activities akin to a junior scientist, conducting her own experiments or simple research.

The combination of parental involvement and carefully selected activities done with family members played a crucial role in the development of a gifted child's early interest in science, a trend not unique to Olivia's case. Talking about this issue, David said,

> My dad got me very interested in science and chess, and he did talk about math with me when I was little. My mom and I had a lot of philosophical and political discussions. When I was very young, they got me very interested in thinking and talking and arguing. Those were huge influences. My older sister was the first person who taught me what atoms were, and how the periodic table works.

Mike also mentioned the significant influence his family had on his talent development. His father, an avid reader, instilled in him a strong reading habit and a deep passion for books. As part of their nighttime routine, his father would choose a novel from adult literature, and they would take turns reading it aloud. Reading books beyond his age led to an improvement both in his vocabulary and imagination. He expressed admiration for his father, describing him as a "very clever" individual. Weekends spent in his father's machine shop, observing the construction of various items, significantly contributed to his understanding of the experimental process. He learned about "the process of conception to realizing a physical thing, how you could build things that you just sort of conceived and how you can make them do things", gaining valuable insights into the practical application of ideas. Additionally, he credited his mother's dedication and hard work for helping him overcome challenges and doubts about his abilities. His brother played a key role as well, motivating him to explore nature like a young scientist. Through time spent with his brother, Mike developed skills in computing, collaboration, and research. Watching science-focused children's television series like "3-2-1", immersed him in science and fueled his curiosity.

Emily and Jack had similar experiences like Mike, spending their spare time delving into scientific investigation at their fathers' workplaces. When Emily had the opportunity to visit her father's office, she was captivated by "a full room of experiments and different things". Bringing home the various products she created ignited her interest in science. Likewise, Jack recounted his earliest memory of being fascinated by the electronics in his father's business. One of his first encounters with science involved playing with wires and electronic components. He described his excitement and curiosity while exploring these items and added, "all of the science that I learned growing up came from talking to my father." This exposure and interaction were instrumental in his early scientific education.

Sarah's father, a scientist, played a pivotal role in her early scientific curiosity. She reflected, "my interest in science began when I was super little because my dad was a scientist. He always told us about cool things going on and about the universe." In the case of Ryan, the high academic achievements of his parents, both holding doctoral degrees, significantly shaped his aspirations. He humorously remarked that he "assumed everyone had doctoral degrees" and that he too was going to earn one. His family nurtured his interests from a very young age. When he was four, they bought him a book related to his fascination with animals. Additionally, mathematical video games and family conversations about science were key factors that fostered his inclination towards scientific fields.

Turning to focus from parents to siblings, it is clear that older siblings often served as another key factor contributing to their exposure to scientific activities and academic pursuits for these participants. Sarah shared, "I always wanted to do the things my brother was doing, and he was a lot older than me." Her eagerness extended to doing homework even before her school years began, driven by her innate curiosity and a persistent "drive to do things and to learn about

things." Mike also highlighted the significant impact his brother had on him, inspiring him to explore the world, engage in projects, and conduct research during their childhood.

In summary, the findings highlighted the significant influence of family environments on the development of gifted individuals. From early childhood, all participants expressed a natural interest in science, which was nurtured and supported by their families. The intellectual background of parents, as well as their purposeful choice of games, toys, leisure activities, and access to books and computers, were instrumental in sparking and sustaining the participants' scientific curiosity. Educational television programs, opportunities for scientific conversations with parents, visits to their workplaces, and following in the footsteps of older siblings, all provided practical and enriching experiences. They expressed their appreciation for their families who always supported their inherent drive for reading, learning, and exploration and allowed them to ask questions. Collectively, these elements contributed to gifted children's talent development.

Internal Forces: Motivation and Passion

Gifted scientists shared a common characteristic: a high degree of motivation and passion propelled them towards scientific excellence. However, the source of this motivation varied across individuals. Seven participants expressed that their motivation was intrinsic. For instance, Mike noted, "I always was really driven to succeed academically. It was something that I always just felt really motivated to do." This internal drive was not unique to Mike; Emily, too, shared a similar enthusiasm, "I was excited to get more challenges," highlighting a thirst for academic rigor. Another interviewee said (Laura) "I was somebody who was both willing and capable of taking these harder classes at harder levels than most other people could be bothered to do."

Similarly, David stated: “I could not wait to get home and do them [science homework]. There was nothing more I wanted to do.”

On the other hand, Ashley was motivated by the urge to fulfill or surpass the expectations placed on her following her identification as gifted. While her friends could even take a gap year, she was continually motivated, and perhaps even pressured, to learn more. She recounted this with a tinge of sadness but ultimately with a sense of gratitude. Her parents, recognizing her exceptional intelligence, expected her to work hard and achieve success, and they even sought to guide her career choices. She navigated the expectations set upon her due to her giftedness, highlighting the complex interplay between internal desires and external influences.

Interestingly, Olivia expressed uncertainty about the roots of her drive for learning and success, pondering whether is stemmed from internal motivation or external expectations set in early childhood:

> I will never know if my motivation and the caliber of the work I do is because I am intrinsically motivated to do it, or because I am meeting an expectation that was set for me when I was six years old.

The responses of gifted scientists regarding motivation in the questionnaires were consistent with those expressed during the interviews. The participants articulated that a passion for science holds equal importance to possessing advanced intellectual capabilities. All participants concurred with this statement, with none expressing disagreement or neutrality.

In this study, participants pointed out their persistent hard work as a unique quality setting them apart from others. Many of them pointed out that their unbridled passion for learning led them to spend more time at the forefront of books. As Ryan stated, “passion helps

people work harder." They mentioned that they have been eager to learn since their childhood and have exerted effort to learn more than what was presented to them.

David demonstrated remarkable determination and self-motivation from a young age. He had a strong inclination for independent learning, immersing himself in a variety of activities. A prime example of this was his self-taught programming skills, which he skillfully used to create programs and games. Moreover, he mentioned mastering mathematics and physics on his own, demonstrating his commitment to achieving his personal goals. This self-directed learning was due to the lack of instruction in these complex subjects in his previous educational setting. He added: "I learned a tremendous amount on my own during summers. I taught myself quantum mechanics by the time summer arrived." Instead of resorting to excuses, he assumed personal responsibility and proactively addressed these challenges.

David's narrative, which resonated with the experiences of other gifted individuals such as Laura, illuminated a pattern of intrinsic academic motivation evident from a young age. Laura reflected, "[my parents] never needed to tell me to do my homework, to read or to study," —a statement that underscores her natural inclination towards learning and self-discipline. This theme of self-driven learning is further reinforced by Sarah, who asserted, "I had some drive to do things and to learn about things. I was always pretty curious." These accounts collectively underscore a recurring motif in the lives of gifted individuals: a deep-rooted, self-sustained motivation for academic and intellectual pursuits.

Support, Opportunities and Luck

Another theme revealed from the data was "Support, Opportunities, and Luck", which at times overlaps with themes of family background and science education. All participants spoke of the significance of opportunities they encountered at certain points in their lives, the support

they received from their families and other individuals, and the mentors or role models who guided them in their academic journeys. Additionally, they viewed their participation in certain programs, contingent upon their location or the schools they attended, as a stroke of luck. Generally, encountering a good teacher, making friends with similar interests, or simply becoming aware of a program that could open new paths for them were all considered matters of fortune.

Predominantly, participants identified their parents and older siblings as pivotal examples, guiding them towards realizing their goals and cultivating successful adult careers. Gifted scientists frequently attribute their early interest in science to their family members. As detailed in both the methodology and family background sections of this study, with the sole exception of Jack, all participants' parents possessed at least a bachelor's degree. Furthermore, all parents, whether mothers or fathers, displayed a certain degree of interest in science. In instances where the participants found their formal science education lacking, they often received supplemental learning from their parents. This early exposure to science through informal learning at home laid the foundational stones for their subsequent achievements and interests in the field.

Sarah, for example, discussed the profound professional inspiration she received from her father, a dedicated and successful scientist. She described his influence, stating, "he was a really hard worker and he was doing really cool things in science... he thought I could do something like he could do." This expression of belief and support from her father was instrumental in fostering her confidence and shaping her aspirations to follow a similar career path in science. Similarly, Jack explicitly recognized his father not only as his biggest supporter but also as a pivotal intellectual role model. His father's role extended beyond mere encouragement, actively

nurturing Jack's curiosity in scientific domains. Olivia, on the other hand, expressed her admiration for her father, referring to him as "the smartest person in my family." Laura acknowledged her father's intelligence and determination although they had distinct differences in personality and approach. She identified her father as a significant influence in her life, particularly due to his scientific background, which seemingly paralleled the trajectory she herself pursued.

Participants such as Mike and David shared that they consider both of their parents as role models, each in distinct ways. David stated:

> Both my parents were huge role models for me. Intellectually. My dad got me very interested in science and chess, and he did talk about math with me when I was little, although not a lot. My mom and I had a lot of philosophical and political discussions. When I was very young, that was very interesting, and got me very interested in thinking and talking and arguing.

This highlights how both parents contributed uniquely to their intellectual development and interests. Mike, on the other hand, admired his mother for her sheer dedication and hard work, as she balanced raising children, working, and studying to become a nurse. This profound commitment greatly influenced Mike's own work ethic and perseverance. Additionally, he saw a role model in his father, a clever machinist, whose hands-on approach to building motorcycles inspired Mike's experimental mindset in science. He also indicated that following his brother's lead in various activities played an influential role in shaping his early experiences, and perhaps his approach to exploration and discovery.

The influence of teachers and mentors is a critical aspect in shaping the intellectual development of individuals from an early age. Reflecting on their educational journey, many

recalled teachers who left a lasting impact on their growth. David, for example, fondly remembered his chess instructor who skillfully blended strictness with a nurturing and mature approach. He also mentioned the significant roles of his fifth-grade math and science teachers, as well as his high school physics teacher, in his academic development. The admiration for these educators often stemmed not only from their intellectual prowess but also from their ability to inspire and guide students towards their passions.

Ashley's experience further emphasized the profound influence of such educators. She recalled her fourth grade teacher who was a well-organized and qualified teacher. Her admiration was particularly strong for this teacher who held a PhD and managed to engage every student actively. She, even at a young age, found herself deeply inspired by this teacher's professional demeanor and qualifications, viewing her as a role model in both academic and professional realms. She said "She held a PhD. I really looked up to her as a professional even at a very young age." Similarly, Emily mentioned "I looked up to teachers, I definitely wanted to be like them and especially the science ones, who I thought were really cool."

In addition to the support received from family and teachers, as well as mentors, some students also spoke about the significant impact their friends had on their lives. Olivia, for instance, described herself as being lucky to have a group of friends who are incredibly smart and hardworking. She was identified as gifted in the first grade and participated in a gifted program from first grade until the end of high school. Gifted programs involved being taken out of regular classes for a few hours each week for specialized instruction, which included a range of activities from playing board games to engaging in more advanced learning tasks. Her close friends were also part of the gifted programs. This shared educational experience with her peers created a strong bond and a sense of shared identity among them. Her friends, whom she admired

for their work ethic and intelligence, served as role models and sources of motivation. Reflecting on this unique blend of academic challenge and peer support, she added, “I was in a really unique situation with my program and at my school”. Similarly, Sarah mentioned a gifted program where she played board games and did puzzles. This made her feel special, as she stated, “I felt like I was doing something a little bit more special than everyone else”, but she still preferred more challenging activities to those games.

The importance of finding like-minded friends who share similar interests was also highlighted by Jack. In his narrative, he identified his best friend as a significant role model, particularly during his high school years. Jack described meeting this friend as one of the “huge critical point(s)” in his life. The reasons this friend stood out as a role model for Jack include their shared passion for science, the motivation to delve deeper into scientific pursuits, and their collaboration on significant science projects both in their leisure and academic endeavors.

David’s experience as an intern at a natural history museum marked a turning point in his development, offering him a unique exposure to real scientists that broadened his educational journey. Guided by his best friend’s advice in eleventh grade, he began this role with an initial focus on natural science tasks. However, he quickly realized his disinterest in this area, prompting him to proactively reach out to the astrophysics department. His initiative and the presentation of his astronomy website impressed the department, leading to a pivotal shift in his internship. This adjustment not only aligned more closely with his interests but also significantly improved his computer programming skills. This experience was exhilarating and eye-opening for him, offering a glimpse into the world of professional science and shaping his understanding of what a career in science could entail.

On the other hand, none of the participants mentioned any historical or contemporary scientific figure as a role model. Emily attributed this lack of role models from the history of science to the idealization of renowned scientists like Rosalind Franklin, suggesting that such idealization inadvertently fosters a sense of unattainability among students. Nevertheless, the fact that they did not struggle to find role models, whether among friends, family members, or teachers, indicates that they were not alone in their educational journeys. This reflects that they were able to find various forms of support throughout their academic lives.

In summary, the narratives shared by the participants underscore the profound influence of support, opportunities, and luck in shaping their paths as gifted scientists. From the pivotal role of family members, who not only provided foundational support but also sparked initial interests in science, to the significant impact of mentors, teachers, and role models who guided and inspired their academic and professional journeys. Programs contingent on location or school played a serendipitous role, offering unique educational experiences that further honed their talents and interests. David's transformative internship at a natural history museum or Olivia's enriched experience in a gifted program, illustrates the intricate web of factors contributing to the development of successful scientists.

4.4 The Impact of Science Education on Gifted Professionals in Science

A common critique shared by all participants was the absence of a challenging science curriculum during elementary and middle school years. However, many had a positive view of their high school science education, attributing this to the opportunity to take advanced classes that challenged them and aligned with their areas of interest. According to the information obtained from interviews and surveys, various gifted programs in which participants are involved at different stages of their education are detailed in Appendix D.

K-8 Science Education: Exploring Elementary and Middle School

The interviews and questionnaires revealed variations in participants' science learning experiences, which depended on factors such as the state they resided in, the age at which they were identified as gifted, their access to gifted and talented programs, the content of those programs, compatibility with their teachers, and differences in the science curriculum.

To begin with, all participants uniformly expressed their dissatisfaction with the absence of challenging material in science classes. Many participants (Ashley, David, Jack, Olivia, Ryan, and Sarah) reflected on their boredom and frustration with these classes. They criticized the science curriculum for not sufficiently challenging and found the science classes unengaging. For example, Sarah found the middle school curriculum, especially in science, to be slow and not challenging enough for her as a gifted student. She felt that she was ahead in math and science, and the pace of the curriculum did not match her abilities. Ashley reflected, "I don't remember any school being hard where I actually really had to study until maybe high school chemistry. So maybe my junior year of high school was the first time I was really challenged." However, she also appreciated the progressive structure of the middle school curriculum, which shifted from topics that seemed obvious to her to more complex subjects. Particularly towards the end, subjects such as atoms were found to be stimulating and "mind-opening".

Moreover, Jack expressed dissatisfaction with the limited instructional time dedicated to science, alongside the inadequacy of the curriculum's content in elementary and middle schools. He noted that, while gifted programs offered richer and more challenging content in mathematics, similar opportunities were not available for science education. He viewed this discrepancy as unfair. Surprisingly, five participants had ample opportunities to be challenged with more advanced mathematics content during their K-8 years depending on their teachers'

personal efforts. Mike also mentioned how his mathematics teacher posed harder questions to him upon recognizing his academic abilities. Jack shared: "In the math[ematics] classes that we took, we were able to get far enough ahead [to be] a couple of years ahead of the rest of the kids." David's story highlighted the challenges faced by gifted students seeking appropriate educational enrichment due to other parents' concerns about privileges being granted to certain children over their own. Despite his teacher's willingness to provide additional resources, the situation brings to light the limitations and sensitivities involved in catering to gifted students within a traditional school setting. David shared:

> I remember very distinctly talking to my math teacher, and she took me aside into a private room, and said, 'Look, I know you really want additional enrichment, and I will provide you with some more advanced work, but you cannot tell anybody…It could make other families upset that their children are not getting special treatment.' So, she gave me some enrichment work. But, it was very meager, and things did not get any better.

Additionally, three participants critiqued the middle school science curriculum's focus. Emily, Laura, and Jack all found the focus on geology within the science courses to be boring. They shared a preference for subjects like chemistry or biology. Emily remarked, "my interest was more inclined towards biology, and in younger classes, the emphasis often seems to be on geology." Laura offered her view: "You could do Earth science [as a gifted elective], but personally, I would have been super okay if they did offer more advanced [science] classes." Olivia shared her uninspiring eighth-grade experience in Earth science: "I remember talking about volcanoes and stuff which were cool, but not super exciting to me. …It did not strike me at all in the same way that the content in the biology class did."

Participants' complaints about science classes were a general issue regardless of their state of residence and whether they were enrolled in gifted programs. For instance, Olivia, who completed her entire K-8 education within a gifted program, articulated general satisfaction with being educated among gifted peers and felt fortunate to have access to such programs. However, she also highlighted the absence of an intriguing and advanced science curriculum during her middle school years. The elective courses offered to her as a gifted student, such as architecture and financial planning, did not align with her interest in science. Similarly, Emily pointed out that, despite being part of gifted programs, advanced classes were predominantly offered in mathematics and English, not science. This scenario was mirrored in the experiences of Ashley and Jack.

On the other hand, David, who was identified as gifted at an early age but did not participate in a gifted program due to school limitations, vividly remembered the positive impact of his fifth-grade teacher compared to his struggle in sixth grade. He shared:

> In fifth grade, I had very generous [two]teachers. They taught two classes [between them]: one teacher taught English writing and science, [while] the other taught history, social studies, and mathematics. The classrooms were physically connected. Both of my teachers seemed very comfortable talking to me about me being unusual, and having these very strong intellectual interests. Both of them were very amenable to giving me enrichment work without making me feel bad at all. Those two were probably the best teachers I ever had in that year.

Conversely, David's sixth-grade year was markedly different, described by him as "a terrible year" due to the lack of support and understanding from his teachers. This experience finds a parallel in Jack's story, another gifted student who generally had positive interactions with his

teachers. Yet, Jack encountered a teacher whose negative reaction to his potential move to a special class left him feeling isolated and misunderstood. Upon learning of Jack's potential move to a special class, this teacher openly made dismissive remarks such as, "this child is in his special classes, we don't need to talk about him anymore," and "you want to go to the special class so you answer the question now." The needs of gifted students are not always well received by educators, as shown by these examples. Despite these challenges, both David and Jack observed an improvement in their educational experiences in subsequent grades, highlighting the pivotal role individual teachers play in the lives of gifted students. David's reflection, "any additional enrichment I received was only out of the generosity of my teachers [in middle school]," emphasizes the significant, albeit sometimes inconsistent, influence teachers have on gifted students' academic journeys.

When I asked them about their most memorable science activities from their K-8 years, many participants initially struggled to recall specific examples, except for the science fair David and Emily joined. They both reminisced about these events as the pinnacle of their middle school science experiences. David specifically mentioned, "I do not think there was anything else I did that was scientifically interesting in middle school." He won first prize at the Tri-County Science Fair, which he still remembers with honor. Emily similarly shared her success and enthusiasm in participating in the science fair. She invented an original and mechanical device to help her elderly grandparents with putting on socks, a project in which she leveraged her skills in observation and problem-solving. The sense of pride was clear on their faces when they recalled how they had created projects addressing specific real-world issues. These opportunities not only enhanced their creative thinking skills but also promoted autonomy in their learning and fostered flexibility in their approach. These experiences were invaluable in developing a diverse range of

skills, from designing to project development, effectively immersing them in the role of a researcher.

Additionally, the analysis of questionnaire data and interview transcriptions revealed that the most commonly enjoyed activities were hands-on experiments, field trips, and projects, suggesting the need for diverse and personalized educational strategies due to the unique characteristics of gifted individuals. Mike shared an enlightening experiment from his school years, which played a significant role in shaping his approach to science. He described a homework assignment where he was asked to measure the boiling time of water based on its quantity. Mike conducted this experiment with enthusiasm, measuring different amounts of water and recording the time taken to boil each. He was captivated by the process of plotting the data and observing a trend, even though he later realized that his approach was more intricate than the assignment necessitated. His mother even questioned whether such an extensive experiment was necessary to conduct at home. This experience was important for Mike; he found every part of the experimental process engaging and intuitive. It resonated with him deeply, reinforcing his passion for systematic investigation and data analysis. He stated:

> …I remember very clearly what I was doing when every part of the process just clicked for me: it all made sense and was a lot of fun. That is kind of how I approach things. It is the reason why I became an experimentalist. Obviously, the basic set of rules that I discovered in that early experiment has more or less guided how I have approached everything I have done since then.

He reflected on how the fundamental principles he learned from this early experiment—formulating a clear question, systematically exploring it, and analyzing data for

quantitative answers—have guided his approach to all his subsequent work in experimental science.

When asked about memorable classroom activities, Ryan also recalled hands-on experiments and investigations. He described one particular experiment where they filled a balloon with hydrogen, set it on fire, and observed water formation due to the chemical reaction between hydrogen and oxygen. “That one was really cool. … It was pretty fun” he remarked. Ryan further recounted performing dissections, like that of a lamb, which he found to be quite engaging. Laura echoed this sentiment, “I loved the labs that we did in middle school so much. I think they really encouraged you to think about science concepts in a hands-on way. …It was about actively doing science and it was so much fun.” These experiences, combining fun with educational value, clearly left a lasting impression on gifted children.

Sarah, in her role as a scientist, greatly appreciated an educational approach in science that gave students a voice in their learning and the freedom to explore their personal interests. This was particularly impactful during her middle school years, where she had the opportunity to undertake a project on black holes and the principles of general and special relativity. This project was a significant experience for her, as it allowed for deep engagement with a subject she was passionate about and the ability to express her creativity. She emphasized the importance of such educational opportunities, stating, “when they allowed creativity, I liked that...I like to think about my interests and be able to show my interests in a different way.” Sarah advocated for the integration of creativity in science education, seeing it as essential for enabling students to explore and present their interests in unique and innovative manners.

High School Science Education

Turning our attention to their high school years, the memories of the participants became more vivid and impactful. During this crucial stage, high school provided a platform for self-discovery and guided them towards future career decisions. The availability of Advanced Placement (AP) courses and weekend programs offered by various universities, which aligned with their interests, also played a vital role in their educational and personal growth.

Two participants of different ages joined the same private university's Science Honors Program in a big city during high school on weekends, as per the recommendation of their schools. For both, this program was a significant milestone in their lives. David, who recalled his K-8 school years as boring and frustrating due to unchallenging learning materials, mentioned that the program he began in the 11th grade "definitely now holds a very special place in [his] heart." The earliest a student could take the placement test was in ninth grade, which would allow them to start the program in tenth grade. However, David, with a somewhat reproachful tone, pointed out that he was unaware of the program in ninth grade and only took the test in tenth grade, which qualified him to participate during his eleventh and twelfth grades. He found the test very difficult but managed to score well enough to gain admission to the program. He was deeply intrigued and delighted by the challenging and complex topics of the classes, especially in subjects like special and general relativity, quantum mechanics, and particle physics. He said:

> These courses were taught in the physics building, so I would go to the university and go to the Physics building to take these classes. This class was completely relevant, revelatory to me and it was the most amazing thing I had ever seen.

Ryan explained that being exposed to advanced material at a young age thanks to this weekend program, particularly in physics, significantly benefited him. By the time he entered undergraduate studies, he already possessed an advanced understanding of physics, which directly relates to the work he does now in his physics PhD. He recounted attempts to conduct research with professors during his undergraduate years, where some initially hesitated, noting the necessity of understanding complex subjects like general relativity and quantum mechanics, typically taught at the junior level in college. However, Ryan's background in these subjects from high school opened doors for him to engage in research and experiences that would have otherwise been inaccessible to him during that phase.

Jack expressed great admiration for his high school physics teacher, who significantly encouraged him to participate in after-school programs such as Robotics and the Science Trivia. He said; "I think he really tried to get kids that were interested in science into programs that they otherwise would not have known about." Along with a friend, Jack joined a robotics team at another high school, where they competed with a prominent sponsor and gained insights from experienced engineers. These mentors taught them practical skills such as working with certain tools and building large robots for complex tasks. Furthermore, Jack engaged in science trivia competitions, which required rapid responses to science-related questions from teams representing various high schools. These endeavors in robotics and science trivia not only played a crucial role in enhancing his college applications but also greatly enriched his scientific knowledge and skills.

On the other hand, Emily highlighted the importance of hands-on activities in her preference for physics over biology during high school. She pointed out that at that stage, physics seemed more interactive and creative compared to upper-level biology classes, which

often required more expensive equipment and specific reagents that were less accessible in a high school setting. In contrast, as opposed to other fields, physics allowed for a more practical engagement through the use of common objects like balls or toy cars in simple experiments to explore fundamental principles like velocity and acceleration. This hands-on approach in physics made the subject more appealing to Emily. She found it easier and more enjoyable to learn through direct experimentation, where she could measure and observe physical phenomena firsthand. Emily criticized the lack of any experimentation in middle school science classes and mentioned that, as a result, she had difficulty in recalling memorable activities from those science lessons. As previously mentioned, she noted that the science fair was the only memorable event in her middle school science education, with no other notable activities.

It is worth noting that there were also some students who reported they enjoyed even traditional teaching methods when intellectually engaged. For example, Ashley's favorite teacher used a simple, traditional way of teaching in biology, like writing on the board and having students take notes from the book. She was very good at explaining things by turning them into stories and narrowing down the content making it simple so that students found the lessons interesting and exciting. "Without a lot of bells and whistles, … she made everything really interesting somehow." as Ashley observed. This approach effectively transformed her into an eager learner, who "wanted to know more about biology".

Career Choice in Science

Despite all participants emphasizing that their interest in science began in childhood, career decisions were predominantly influenced during high school and even college years. Their decision to pursue a career in science was not straightforward or predetermined. Through their personal accounts, it became evident that the routes to becoming a scientist are both diverse and

parallel, stressing the value of exploration, mentorship, and family impact in shaping their professional lives.

A common thread among these professionals is their intrinsic love for science (e.g., physics, chemistry) which served as a critical determinant in their career choices. For instance, Laura recounted her journey, illustrating a transition from electrical engineering to physics, driven by her core interest: “I have always liked physics in my heart...I did not want to use physics; I wanted to do physics”. Similarly, Sarah’s discovery of quantum mechanics in a high school chemistry class sparked a profound interest in physics, leading her to declare, “this is something I want to do!”.

The role of mentorship and encouragement from educators and family members is equally pivotal. Mike’s decision to apply to a physics program was directly influenced by his high school physics teacher’s advice, reflecting the impact of mentorship: “His response, I remember, was, ‘you should apply to physics that is what you should do’”. This guidance is not only about affirming the students’ abilities but also about recognizing and nurturing their potential in science. Similarly, Ashley’s high school biology teacher played pivotal roles in guiding their academic focus and career choices Ryan’s narrative further underscores the influence of a supportive environment, mentioning both the encouragement from his high school and the unwavering support from his parents, despite facing challenges in his undergraduate physics department.

On the other hand, participants faced various challenges such as familial pressures and educational disparities among other gifted students. Ashley’s experience was illustrative: her parents believed professions such as medicine were more suitable for diligent and successful individuals and undervalued academic research. This perspective made it difficult for her to see a

career in biology as a feasible option until her immersive lab experience during her undergraduate studies. She stated, “I did not think I would be a scientist. It never crossed my mind until I worked in a lab, and I did not even think about people working in labs. I did not know it was a career.” David’s concern when he started university was feeling significantly underprepared and “inferior” compared to his peers in mathematics and physics. He doubted his mathematical capabilities and felt “very behind”. However, his interest in the subjects and a growing fascination with physics and calculus eventually fueled his determination to overcome these initial setbacks. He added,

> I had no real exposure to that in high school, and so I did not do super well at the beginning. …I remember learning these things [on my own]. …Pretty soon, all I wanted to do, all day, all night, was physics and calculus. And basically, that hasn’t changed since [then].

Mike had the same problem at college, he doubted his abilities and felt inferior because of lack of enough prior knowledge. Then he understood,

> Part of what limits people’s success at a given moment is how well-prepared they are. What is your prior training? I had this other thought that I did not come from the most elite schools. I did not go through gifted training programs. That was not my background. And so, that may have been a part of the disadvantage I faced.

Both Mike and David’s experiences demonstrate that even gifted individuals may doubt their abilities when first encountering other gifted individuals. However, with strong passion and dedication, they manage to overcome the problems caused by insufficient prior knowledge, a problem they attributed to the absence of rigorous programs for gifted individuals.

4.5 Summary of Findings

The first research question aimed to delve into how participants navigated their gifted identities from childhood through adulthood and the subsequent impact on their social relationships and self-perception. Initially, all participants acknowledged their aptitude for comprehending ideas at a faster rate than their peers, a quality that allowed them to excel in their K-12 education without requiring significant studying. From a young age, they recognized that this distinction was not only apparent to themselves but also to their peers and teachers. As they matured, their perception of their gifted identity evolved. The emphasis on individual talents diminished over time, giving way to a growing appreciation for diverse abilities and a more humble demeanor. While the "gifted" label provided benefits such as enhanced self-confidence and access to advanced learning opportunities, it also introduced challenges, including social stigmatization and the pressure of high expectations. The nature of their interpersonal relationships varied, influenced by their personality traits, educational environments, and the intellectual levels of their classmates. A commonality among them was the ease of connecting with adults. While some established meaningful relationships within peer groups that shared similar talents, thereby nurturing lasting friendships through mutual interests and understanding, others exhibited advanced social skills independently of these factors.

The second research question aimed to uncover the critical elements contributing to the exceptional performance of gifted scientists. The findings highlighted the importance of factors such as individual abilities, the impact of family background and childhood experiences, internal motivation and passion, support, opportunities, luck, and the role of mentors. The significant role of family was underscored, with many participants coming from backgrounds of highly educated parents who nurtured their interest in science through exposure to intellectual activities and

encouragement of curiosity. Internal forces such as motivation and passion were also crucial; individuals were driven by a deep-seated desire to learn and succeed. Support from parents, teachers, and mentors, as well as opportunities like advanced programs and internships, facilitated their development. Role models, spanning from family members to educators and peers, deeply influenced their aspirations and attitudes towards science. Collectively, these factors emphasize the multifaceted nature of achieving excellence in science and highlight the importance of a supportive and enriching environment in fostering the talents and passions of gifted individuals.

To explore the third research question regarding the impact of early science education on their successful development as scientists, participants unanimously criticized the lack of challenging curricula. They reported feeling "bored" and unengaged, although some noted that exceptional efforts by individual teachers occasionally mitigated these issues. However, high school years brought more satisfaction due to the availability of advanced classes and programs that aligned with their interests, such as AP courses and university-led weekend programs. These opportunities allowed for deeper exploration and engagement in subjects like physics, chemistry, and biology, significantly influencing their career paths. The narrative underscores the importance of challenging and engaging educational experiences for gifted students, noting that hands-on experiments, field trips, and special programs play a crucial role in their academic and personal development, fostering a love for science that carries into their professional lives.

Participants' science careers began with childhood curiosity but were decisively shaped in high school and college years. Their profound passion for science was pivotal in navigating career paths, despite facing challenges like familial expectations and academic disparities. Encountering feelings of unpreparedness in new academic settings was common; however, they

overcame these through dedication, underscoring that initial educational shortcomings could be surpassed with a deep commitment to science. This narrative reveals that the route to a science career is complex, influenced by various factors including mentorship, family support, and self-discovery.

Chapter 5: Discussion

In this study, I aimed to explore lived experiences of gifted scientists, with a specific focus on discerning the pivotal factors that have shaped their remarkable achievements in the field of science. This inquiry centered on understanding how these individuals navigate their gifted identities throughout various stages of their lives and how science education had an impact on their development as a scientist. This comprehensive approach aimed to provide a deeper insight into the interplay between inherent talents and educational experiences in shaping the trajectories of these gifted professionals in the field of science.

5.1 Perception of Giftedness and Gifted Identity

Participants in this study perceived themselves as "different", attributing this distinction to their heightened interest in science and their accelerated ability to grasp new ideas. Interestingly, during the interviews, they attempted to primarily emphasize their curiosity about science rather than their intellect per se, which could be interpreted as an act of humility or a way to avoid seeming boastful about their abilities. This tendency may stem from societal biases against gifted individuals or an attempt to downplay their advantages, as noted in existing research. A case in point is when David was in fifth grade; he was advised by his teacher to conceal his request for advanced work to avoid offending other parents, making him feel as if his needs were something he had to hide, which he found disappointing.

This "gifted identity" of the participants evolved from childhood to adulthood, maturing alongside their social and academic experiences. It is common for gifted students to have a more positive self-concept during the K-8 years, often due to the lack of a challenging curriculum and the absence of opportunities to meet other highly gifted students. This change in self-concept can be explained by the Big Fish Little Pond Effect (BFLPE), which posits that academic

self-concept of gifted students tends to decrease when they are exposed to other gifted individuals (Marsh, 1987; Tokmak et al., 2021; Zhang, 2021). Preckel et al. (2010) conducted research to observe changes over time in the academic self-concepts of two groups of gifted high school students: one in a gifted ability group and the other in a regular classroom. The results of the study suggest that increased comparison and competition might diminish gifted students' views of their own academic abilities. However, it was found that students in gifted classes were happier in terms of educational level and did not experience boredom, unlike their peers in regular classes. Similarly, Tokmak et al. (2021), found that fifth and sixth graders in gifted programs experienced a decrease in their science and mathematics academic self-perception over time, although their self-concept remained relatively high compared to the average-level students. The gifted students were noted for their impressive ability to adapt, with the conclusion drawn that "the big fish is aware of both the big pond and the little pond and swims accordingly" (p.103).

However, participants in my study navigated the complexities of their gifted identities, facing challenges that sometimes led to self-doubt and career reconsideration. Despite these struggles, they managed to overcome the difficulties associated with identity crises (Suri & Ishala, 2018; Zuo & Cramond, 2001), as their narratives reveal a journey of independent self-discovery and adaptation. Moreover, my study is distinguished by its retrospective perspective on this phenomenon. Various life stages lead to changes in gifted identity. These changes during the process do not imply a loss of belief in their abilities; rather, individuals come to recognize their giftedness as just one facet of their broader self. Importantly, recognizing their talents and achievements did not automatically result in overlooking the qualities of others or developing a sense of superiority especially after high school years. As stated, "those who are

able to resolve this crisis develop a strong sense of self" and respect differences (Zuo & Cramond, 2001, p. 252).

As highlighted by Cross (2016), excelling academically can enhance a child's reputation during their formative years, yet the enthusiasm for learning often becomes stigmatized by peers in the high school environment. However, this positive perception often shifts in the high school environment, where a passion for learning might be stigmatized by peers. This was the case for Jack and Laura, with Laura being derogatorily called a "teacher's pet" for her studious nature, and Jack criticized for his eagerness to learn. As Davies and O'Neill (2022) also mentioned in their studies, a sense of belonging and achievement contributed to their ownership of their identities and their self-confidence. On the other hand, the lack of "support, encouragement, or celebration", not setting and maintaining personal goals, led to these students' unhappiness (p. 33).

This study revealed that participants predominantly recognized the benefits of having a gifted label. This included not only access to advanced programs, but also a notable boost in their self-confidence. Emily and Ashley, for example, specifically pointed out how being labeled as gifted fostered a sense of capability and resilience. This aligns with the insights from Klimacka's research (2022), which underscored the label's role in elevating self-confidence and unlocking a wide range of educational opportunities. Similarly, Berlin's (2009) research demonstrated that students with a gifted label often enjoyed school more and showed greater engagement, largely attributed to their exposure to differentiated curricula and superior teaching. While Berlin's study also noted that these students valued the pride their families felt in their achievements, this aspect was not articulated by the participants of my study.

As seen in the experiences of Emily, Olivia, and Mike, the gifted label bolstered social trust and respect among peers, leading to enriched opportunities for leadership and collaboration. These outcomes align with Klimacka's (2022) findings, highlighting the comprehensive impact of the gifted label. For many students, being labeled as gifted led to increased popularity among their peers and teachers. This popularity raises the debate of whether it comes directly from the gifted label or could have been achieved through their outstanding performances, even without the label. However, the notion that the "gifted" label always negatively affects social interactions with non-gifted peers does not entirely reflect the truth.

On the other hand, there were participants who struggled with effective communication with peers during their school years or felt isolated. For example, a participant named Laura attributed her social challenges not to the label she carried, but to her introverted nature. This suggests that it is not accurate to generalize that labels are the cause of social problems experienced by students.

In conclusion, my study contributes a fresh perspective to the existing body of research on the gifted label within academic contexts. While various studies (Berlin, 2009; Klimecka, 2023; Kosir et al., 2015; Thomson, 2012) have explored both the advantages and disadvantages of being labeled as gifted, my findings emphasize the generally positive impact of the label on self-esteem and their access to advanced opportunities for talent development. This challenges the predominant focus in the literature on its negative effects, such as increased expectations, pressure to excel, and an increased amount of schoolwork. Interestingly, this study found that although two students sometimes viewed high expectations as a disadvantage, a significant number, including these two, expressed concerns about the lack of challenging work. They indicated that the cognitive demands of their assignments were not sufficiently stimulating.

Furthermore, it is crucial to consider the experiences of students who, despite not receiving the gifted label, are academically high achievers, as their perspectives may offer additional insights into the broader impact of such labeling within educational settings. Finally, it is important to note that although this study focused on the experiences of scientifically gifted students, these individuals were primarily identified as academically gifted. While it is possible to infer that this is a general situation for gifted students across academic domains, such an inference cannot be made for gifted students in creative and practical areas.

5.2 Critical Elements in Exceptional Performance in Science: Insights from Gifted Professionals in Science

The findings of this study resonate with the Tannenbaum's Talent Development Model that emphasizes the dynamic interplay of individual abilities, environmental support, and non-intellective requisites in the development of gifted professionals in science. These findings align with Subotnik et al. (2011) and Tannenbaum (2003), highlighting the multifaceted nature of giftedness and the significance of nurturing talent through various stages of an individual's life.

The pivotal role of mentors and role models in the lives of gifted individuals in science, as highlighted in the findings of this study, aligns closely with established theories and research in the field of gifted education. Clasen and Clasen (2003) emphasize the necessity of adult intervention in developing the potential of gifted individuals, a view that is reflected by the participants of this study who acknowledged the significant influence of their parents, siblings, and teachers. This is consistent with Vygotsky's (1978) concept of the Zone of Proximal Development (ZPD), which illustrates that the gap between what gifted individuals can achieve independently and what they can accomplish with guidance is often bridged by these influential figures. For example, consider David's experience in a natural history museum, where the

guidance and support from experienced scientists helped him advance his skills and knowledge beyond what he could have achieved on his own. Similarly, in Mike's case, his older brother played the role of the more knowledgeable other. Despite being only two years older, his brother's interest and knowledge in computers and programming were significantly greater than Mike's at that time, creating a learning opportunity within Mike's ZPD. These narratives underscore the impact of diverse figures in the participants' lives, ranging from family members to professional scientists. As Sosniak (2003) asserted, this recurring motif in the participants' stories illuminates the varied sources of inspiration and guidance they encountered throughout their lives.

Conversely, the study also revealed challenges, as seen in the experiences of participants like Laura and Emily, who reported a lack of role models. Despite this deficiency, the significance of available mentors—whether they are teachers, classmates, or family members—was profoundly acknowledged. This dichotomy highlights the need for accessible and diverse role models in science education. Emily's criticism of the idealized portrayal of renowned scientists in educational narratives brings to light the potential negative impact of such idealizations on students' perceptions of attainability in science. Supporting this viewpoint, Milne (1998) argues that storytelling in science education not only educates but also shapes students' beliefs about the nature and attainability of scientific success. Therefore, introducing relatable and diverse role models becomes essential, emphasizing that science is an inclusive field, attainable and enriched by a variety of perspectives and experiences. This approach helps in demystifying the scientific journey, making it more accessible and inspiring for future generations of scientists.

In the world of science, the achievements of gifted professionals are deeply rooted in their motivation and passion. This aligns with previous research underscoring that gifted individuals often exhibit a higher degree of motivation compared to their non-gifted peers (Baruch & Hazema, 2023) and there is a direct correlation between elevated motivation and enhanced scientific achievements (Leong et al., 2018). Consistently, participants in this study reported a deep-seated motivation and fervor for learning and progressing in science. For example, David shared, "I could not wait to get home and do them [science homework]... I learned a tremendous amount on my own during summers." This statement reflects a motivation extending beyond formal education's structured demands. Similarly, Laura's comment, "[my parents] never needed to tell me to do my homework, to read or to study," highlights her drive for academic engagement. Coleman et al. (2015) suggest that such a passion significantly differentiates the experiences of gifted children from those of their non-gifted counterparts, because they possess an inexhaustible thirst for learning and are always eager to expand their knowledge. Collectively, this strong motivation appears to act as a catalyst, fostering self-regulation and an eagerness to undertake activities like homework and independent research, thereby deepening their scientific knowledge and expertise.

All participants agreed on the pivotal role of high motivation in their achievements, yet they differed in opinions about its origins. This lack of consensus reflects the complexity outlined by Tannenbaum (2003) in discerning the sources of such intrinsic drives. He describes the interplay between personality traits and developed competencies as a "chicken-and-egg" dilemma, highlighting the challenge in pinpointing the root of their motivation (p. 53).

It may not be coincidental that many participants have parents who possess bachelor's, master's, and doctoral degrees (see Table 1). As an exception, although Jack's parents were both

college dropouts, they had a keen interest in science and supported his development. Research consistently shows a positive correlation between children's academic achievements and their parents' attitudes, particularly when parents actively support and value their educational endeavors (Benner et al., 2016; Fuligni, 1997; Kim & Hill; 2015). Furthermore, as parental education and household income levels increase, there tends to be a corresponding improvement in students' academic achievements (Davis-Kean, 2005; Chung, 2015) in science (Betancur et al., 2018). Families play a crucial role in nurturing giftedness in children by providing experiences beyond the school environment and investing in extracurricular activities and holiday programs (Vialle, 2017). In line with this, participants in this study frequently highlighted the importance of their parents' influence. Olivia and David reminisced about engaging in scientific discussions with their fathers, Emily and Jack were inspired by their fathers' workspaces, Sarah's early interest in science was kindled by her scientist father, and Ryan's ambitions were influenced by his parents' academic successes. These accounts underscore the significant impact of parental encouragement in developing a passion for science from a young age.

The factors contributing to the participants' becoming scientists were sometimes intertwined. For example, family can be considered both a matter of luck and as environmental support and role models. Similarly, many participants felt fortunate to have access to gifted education programs, which can be related to both opportunities and luck. It is important to ensure that gifted individuals interested in science have similar chances. Recognizing and compensating for disadvantages in school environments is extremely important. Although they can be examined under the general categories of controllable and uncontrollable factors, why not

maximize controllable environments such as school atmosphere, teacher support, and extracurricular activities to benefit the gifted children in science to the fullest?

5.3 Science Education for Gifted Learners

Participants' mixed experiences in science education, from middle school to advanced high school courses, echo the debates around effective instructional methods for gifted learners (e.g., Gregory, 2011; Plunkett & Kronborg, 2007; Watters & Diezmann, 2003). As Coleman et al. (2015) indicated, highly able students often endure long periods of waiting hours in classes due to their ability to grasp new material more swiftly than their peers. Similarly, in my study, all participants expressed dissatisfaction with the slow pace of classes and the insufficiently challenging nature of the course material encountered during their middle school years. Olivia's remark, "we, [along with other gifted students] were running through things quickly and then started distracting other students because we did the work more quickly" exemplifies the frustration experienced by these students in a learning environment that fails to adequately challenge them.

Interestingly, the participants expressed greater dissatisfaction with science classes compared to mathematics. Although this study did not aim to compare gifted programs across different subjects, such a situation emerged based on the students' explanations. This discrepancy may stem from the nature of the subjects; mathematics teachers can offer varied problem sets or increase question difficulty to meet gifted students' needs, an approach less readily applied in science classes. Mike's experience offers a noteworthy example. He recounted, "my teacher challenged me, (saying), 'If you really understand it, then try this 20-digit number in long division.'" This highlights the potential for individualized challenges in subjects like

mathematics. This finding underscores the need for more research on differentiated instruction strategies tailored to each subject area, particularly in science education.

The findings from the interviews with David and Emily align with the insights presented in Höffler et al. (2017), underscoring the significant role that science competitions, like science fairs, play in fostering interest and engagement in science among gifted students. These students' experiences reveal that conventional science curricula often fail to sufficiently challenge gifted students, leading to a lack of engagement. As David reflected, "I do not think there was anything else I did that was scientifically interesting in middle school (except the science fair)." These events provided them with an opportunity to engage in more challenging, creative, and autonomous scientific endeavors, which were not only intellectually stimulating but also personally rewarding. This is particularly relevant in the context of fostering future scientists, as the study identifies a strong correlation between participation in science competitions and increased interest in science-related activities. In a similar vein, these experiences echo Zelenda's observations on Science Olympiads (2014). Zelenda notes that Olympiads are found to be engaging and enjoyable for students, providing them with opportunities to apply their knowledge in an exciting and competitive environment. This further illustrates the positive impact such competitive platforms have in stimulating a deeper interest and active participation in scientific fields among gifted students.

The findings from interviews and questionnaires with gifted students, showing a preference for hands-on experiments, field trips, and projects, align with the research of Kanevsky and Keighley's (2003) and Karademir (2016). These studies emphasize the benefits of challenging and project-based learning for such learners. In addition, Singh's (2014) study indicates that a form of teaching, which focuses on active participation and inquiry, demonstrates

a significant shift towards a more engaged and personalized educational experience for gifted students. Teachers reported that this approach not only plays to the students' capabilities in abstract thinking but also acknowledges their preconceptions, enriching their learning experience.

The participants of my study particularly appreciated teachers who inspired them to think critically. Their science teachers' ability to pose high-level, thought-provoking questions and understand their unique perspectives was found to be as effective, if not more so, than hands-on experiments in fostering an interest in science. Importantly, achieving this level of intellectual stimulation and empathy in teaching does not necessarily require extensive or elaborate teaching materials. This highlights the significant impact that intellectually stimulating and empathetic teaching can have on the engagement and development of gifted students in the scientific field.

The participants' dissatisfaction with science programs was not influenced by their participation in gifted programs. Students in gifted programs, regardless of the program type (e.g., gifted classes, pull-out programs, or enrichment), also indicated that science was not challenging enough. This situation may suggest that the middle school science curriculum was not designed with gifted students in mind. Alternatively, as stated in the works of some researchers (Chinelo & Ogochukwu, 2014; Ireland et al., 2020), there may be a mismatch between science teachers' and students' perspectives on advanced learning materials. While teachers believe they are addressing all students' individual needs, gifted students in science suffer from the unchallenging content of the classes.

The discrepancy between how teachers and students perceive the level of challenge in science may stem from the abstract nature of the concept of "challenge" (Scager et al., 2014). While teachers are advised to challenge students according to their levels, finding concrete

examples of how to do so can be difficult. Scager et al. (2014) state that challenging gifted learners effectively requires offering them autonomy to work independently on subjects that interest them, and establishing a safe learning environment. In this environment, gifted learners should be encouraged to engage in frequent and open communication with teachers, facilitating a more personalized and engaging educational experience. The level of challenge (McComas, 2022; Taber, 2010) and the freedom students receive during the activity are also important for enhancing their interest in science, ensuring that students enjoy activities without feeling "lost" (Scager et al., 2014, p. 676).

5.4 Implications for Science Education for Gifted Individuals

In the evolving field of science education, particularly in the education of gifted individuals, there are critical aspects that require attention. Teachers must exert maximum effort to ensure that students labeled as gifted do not suffer from the negative consequences of such labeling. Activities suited to the levels of identified students should be provided. This label can enhance the necessary self-esteem and motivation for gifted students to realize their potential and develop gifted identity.

Gifted programs should be tailored to students' academic achievements, future aspirations, and areas of interest, rather than being generic or focused solely on activities like puzzles and board games without academic relevance. Students, particularly those with a keen interest in science, require more specialized support. Opportunities to meet scientists, observe laboratory work environments, and explore career paths in the scientific field should be provided for these scientifically gifted students. Many participants of this study mentioned that such experiences were a critical spark in their pursuit of a science career. In their study, Kompella et al. (2020) indicate that interactive youth science workshops, where graduate students present

their research to middle and high school students, not only promote effective science communication but also provide unique experiences that boost young learners' interest and preparedness for future careers. Similar workshops should be expanded within gifted programs and should also be inclusive of other students interested in science. Additionally, Clough (2011) highlights that science stories can be used to enhance students' understanding of fundamental scientific concepts and the challenges faced by scientists in their pursuit of knowledge, thereby attracting young students to science careers. As an alternative to board games and puzzles, these stories can be customized to suit the intellectual level of the students and introduced at an early age to help gifted learners engage with science earlier.

The science curriculum, both in mainstream education and in programs designed for gifted and talented students, needs significant improvement. Specifically, the middle school science curriculum should be tailored to meet the needs of gifted students in science as well. Gifted students often express disappointment in the lack of stimulating science activities and specialized science programs, compared to the abundance of these opportunities in mathematics. Having to wait until high school to access opportunities that truly challenge them in science, and relying solely on outside-of-school support from families during their K-8 years, may seem unfair to these students. This situation underscores the necessity for a curriculum that genuinely caters to and nurtures the abilities and interests of gifted students in science from an early stage. Given their role in curriculum delivery, it is essential for teachers to possess a comprehensive understanding of the characteristics and interests of gifted students. This knowledge enables them to effectively identify and accommodate these students' unique educational needs (Biber et al., 2021; Knopik & Oszwa, 2022). Additionally, expanding access to advanced programs, typically available in high school or university, to younger students is crucial. Early exposure to

such enriched educational opportunities, as stated by some participants of this study, can significantly benefit cognitive and academic development. These programs, encountered by students like David and Ryan during their later educational years, should be introduced at an earlier stage to maximize their potential impact.

Based on the experiences of the participants and supported by literature studies (Bintz et al., 2005; Sherrod et al., 2009), the integration of mathematical thinking into the middle school science curriculum could be another way to make science learning more engaging and enriching for gifted students. By incorporating mathematical reasoning into scientific investigations, educators can tap into the analytical reasoning abilities of these students (Pang & Good, 2000), challenging them at a more sophisticated level earlier in their academic journey. This approach not only makes the subject matter more captivating but also allows gifted learners to delve deeper into scientific concepts, applying the mathematical skills they acquire in their math courses to real-world scientific problems. Furthermore, the integration of mathematics and science can serve as an effective differentiation tool for science teachers, particularly in mixed-ability classes. It enables a tailored learning experience where some students can focus on the quantitative aspects of science, while others explore the conceptual or qualitative dimensions. The ability of teachers to quickly elevate the level of instruction and introduce a variety of mathematical challenges may ensure that all students, including gifted ones, are adequately engaged and challenged (e.g., Mike's 20-digit problem). This balanced approach may ensure that gifted students are provided with opportunities to excel and develop a comprehensive understanding of the interconnectedness of math and science, along with the appropriate challenges they need.

The integration of various disciplines into science education has consistently been a focal point of interest. The interdisciplinary approach, as noted by Shen & Wang (2020), fosters a holistic understanding and prolonged efficiency in learning by empowering students to integrate and apply knowledge from diverse disciplines. Beyond traditional subjects, incorporating literacy, art, and music into science education can further enhance gifted students' engagement and present more challenging content (Crowther et al., 2023; Green et al., 2018; Zhbanova, 2018). Therefore, science teachers should be versatile and willing to incorporate different subjects into their lessons. Providing teachers with science lesson plans and materials that integrate various subjects can facilitate their work while ensuring that gifted students have access to education tailored to their needs.

As an interesting point, participants in this study expressed a clear preference for biology, physics, and chemistry over earth science, finding the latter less engaging and not in line with their expectations of science in middle school. This preference may be attributed to their particular interest in these subjects. Yet, their feedback highlights the need for educators and curriculum developers to reevaluate and improve the appeal of earth science, making it more engaging and interesting, especially for students gifted in science. Although the sample size of nine participants limits the ability to generalize, this feedback suggests that further studies could be valuable in exploring ways to enhance the attractiveness of earth science to students.

Both the personal narratives of the participants and the empirical findings from the literature (e.g., Byko, 2004; Esteves & Costa, 2010; Höffler et al., 2017) highlight the value of science competitions in nurturing the scientific curiosity and talents of gifted individuals, suggesting a need for educational systems to integrate more of such enriching experiences into the science curriculum for gifted students. Moreover, research shows that students without the

gifted label also benefit from participating in science fairs. For example, Ong et al. (2019) found that science fairs not only spark students' interest in science through engaging and enjoyable activities but also significantly enhance their inclination towards pursuing science-related careers.

The role of mentors and role models in the lives of gifted students is undeniable. By implementing mentorship programs, gifted students can engage in meaningful interactions with a diverse group of professionals, educators, and older students, thereby fostering substantial developmental growth. According to Clevey (2018), the distinction between a mentor and a role model primarily resides in their interaction with students: mentors offer active support for both academic and psychosocial development, such as resilience, through their engagement in students' lives (Subotnik et al., 2021). Conversely, a role model is someone a student perceives as somewhat similar to themselves and aspires to become more like by emulating their qualities (Gibson, 2004). As Emily pointed out (see p. 87), students may encounter difficulties in forming connections with role models due to the idealization of renowned scientists. While such scientists often inspire admiration, it is the tangible connections and guidance from teachers that profoundly influence students' selection of role models (Clevey, 2018). For this reason, exposing students to a wide array of relatable role models, especially in the scientific community, can demystify the journey to scientific accomplishment and encourage broader participation in science.

Finally, integrating gifted education into science teacher training is essential for helping these teachers create an inclusive learning environment that accommodates the diverse needs of all students. Science teachers must be adept at recognizing the unique characteristics, talents, strengths, and weaknesses of their students to effectively support their learning journeys.

Acknowledging the challenges in education, it is stated that "teachers need to be armed with the means necessary to address student diversity within their classrooms" (Lucas & Frazier, 2014 as cited in Rowan & Townend, 2016, p. 2). This capability stems from rigorous teacher training programs for pre-service teachers and ongoing professional development for in-service teachers, which are crucial for enhancing teachers' content-specific knowledge, general pedagogical skills, and specialized skills for educating gifted students (Rowan & Townend, 2016; Siegle et al., 2014). According to Siegle et al. (2014), employing pedagogical practices that encompass high expectations, creativity, and enthusiasm not only boosts student performance but is also pivotal in fostering autonomy in the classroom. Moreover, they highlighted the importance of aligning educational strategies with students' personal interests to further engage and motivate them. Additionally, a science teacher's content-specific expertise is vital for presenting challenging material and satisfying the curiosity of gifted students with insightful answers to their questions (Siegle et al., 2014). They bear the responsibility of providing differentiated instruction and incorporating a variety of subjects into the science curriculum to cater to the varied interests and abilities within the classroom, including the needs of gifted students.

5.5 Diversity Challenges in Gifted Education

This study's participant pool, predominantly white and originating from educated families, underscores the persistent issue of underrepresentation of African Americans and other minority groups in gifted education programs. The prevailing literature, including works by Flynn (2023) and Hemingway (2022), critiques gifted education as a reflection of white privilege, pointing out that the criteria for identifying giftedness often lack cultural inclusivity. Specifically, Flynn's (2023) research shows that White students are more prevalent in gifted programs than Black students. This discrepancy persists despite widespread discussions on the

underrepresentation of minorities and concerted efforts to address educational disparities. Historical data spanning 2011 to 2018 further confirms that White students have been the primary beneficiaries of gifted programs. In a parallel finding, Blanchett's research (2016) draws attention to the disproportionate placement of African American students in special education for those with learning disabilities or behavioral issues, highlighting another facet of white privilege. This pattern not only manifests segregation but also deprives Black students of opportunities for enriched learning, underscoring the need for more equitable and inclusive identification practices in gifted education.

The underrepresentation of people of color in gifted programs can be attributed to several factors. Primarily, white and affluent families are more likely to provide their children with an enriched learning environment (Hemingway, 2022). They "... spend dozens of hours familiarizing their children with learning tasks that are often similar to IQ test items" (Rimm et al., 2018 as cited in Hemingway, 2022, p. 210), thereby engendering a pronounced advantage for their children over peers who lack such a sophisticated learning environment at home. Additionally, there is sometimes a conscious decision by students of color to avoid participation in these programs to not appear as "acting white", due to peer pressure (Ford & Whiting, 2011). Furthermore, the learning and demonstration styles of students of color may not align with the intelligence tests used, contributing to their underrepresentation (Hemingway, 2022; Sternberg, 2007).

The narratives from this study's participants reveal that being identified as gifted afforded them access to more advanced learning opportunities. These individuals often received understanding and support from parents with a keen interest in science, who nurtured their children's curiosity through various informal learning activities. While the recruitment of

predominantly white participants was not intentional, their involvement underscores the urgent need for culturally responsive identification practices and the creation of learning environments that celebrate and nurture diverse talents and intelligences (Hemingway, 2022; Sternberg, 2007). Including individuals of color identified as gifted could yield different insights, highlighting the importance of understanding the barriers faced by underrepresented groups.

5.6 Limitations

This study, while providing in-depth insights into lived experiences of gifted scientists, is subject to several limitations that merit consideration. Primarily, the study's reliance on a small group of nine scientist volunteers restricts the diversity of perspectives. Additionally, the fact that all participants, with the exception of one, are white, may further limit the generalizability of the findings to other racial and ethnic groups. While this cohort size is deemed sufficient for achieving data saturation in qualitative research, as noted by Young and Casey (2019), a broader range of participants could have provided a more comprehensive view of the varied experiences of gifted individuals.

Another limitation arises from the method of data collection, which relies on participants recalling their past experiences. As noted by Merriam and Tisdell (2016), current emotions and feelings can influence how past experiences are perceived and recounted. Consequently, the narratives provided by the participants may not solely represent historical accuracy but are likely influenced by their present perceptions, potentially leading to a reconstructed reality rather than an objective recounting of past events. To mitigate this, the use of questionnaires and resumes was employed to help participants focus on more factual aspects of their experiences.

The study's participant pool is exclusively from academic circles, with no representation from the industry. Additionally, all participants are associated with Ivy League universities,

holding qualifications such as a bachelor's or doctoral degree, or occupying research positions. This homogeneity may limit the diversity of experiences and viewpoints, potentially confining the findings to an academic context. Consequently, these factors might hinder the study's capacity to accurately reflect the experiences of the broader population of gifted individuals in varied educational settings.

Furthermore, the significant cultural and educational background differences between the researcher and the participants might have led to potential misunderstandings or interpretive biases. To address this, a meticulous approach was taken in data analysis to ensure that these differences did not unduly influence the interpretation of the findings. Additional measures, including follow-up interviews and questionnaires, were implemented to further minimize this issue in the study.

It is crucial to emphasize that this study does not aim to generalize its findings but rather to explore the specific experiences of the participants. Still, some insights could benefit a broader educational context. For example, recognizing and nurturing individual potential at various educational stages can significantly enhance science teaching approaches in general education settings. Notably, students who were not part of gifted science programs expressed dissatisfaction with the delivery of science education in regular classrooms. Therefore, it is important to tailor science instruction based on the varied needs of students from different ability levels. Additionally, exploring the experiences of gifted individuals identified at around the same age could have offered a more focused understanding of age-specific impacts on educational experiences. All participants in this study have been identified as gifted at various stages of their educational journey, from as early as age 4 to the 6th grade.

In conclusion, while these limitations frame the context in which the findings should be interpreted, they also highlight the depth and specificity of the research, contributing to a nuanced understanding of the lived experiences of gifted individuals in science. I attempted to uncover how participants navigate their gifted identities from childhood to adulthood and the factors that contribute to the development of their interests and knowledge in the field of science. It offers valuable insights for educational policies and program development in science, emphasizing the educational and professional growth of gifted individuals, while also contributing strategies to better meet their needs and fully realize their potential.

5.7 Direction for Future Research

This study aimed to explore the lived experiences of gifted scientists, seeking to understand their perceptions of giftedness, the presence of a gifted identity, and the factors contributing to their exceptional achievements in science. Conducted with nine gifted scientists, predominantly from white families with the exception of one Hispanic participant, the research illuminated various facets of the gifted experience in science. However, future research could benefit significantly from including those underrepresented groups in gifted education, particularly focusing on comparative studies involving students of color to uncover factors influencing their scientific achievements and interests.

Most participants in this study come from families with a high level of education (e.g., Bachelor's, Master's, or Doctoral degrees), which likely facilitated nurturing their curiosity during childhood. Consequently, future research should focus on gifted professionals from lower socioeconomic backgrounds who have achieved success in science. Such studies could reveal how different backgrounds and resources influence the development and realization of scientific

giftedness, providing a more comprehensive understanding of the diverse pathways to success in the scientific field.

Repeating this study with participants from different age groups could yield valuable insights. Particularly, reaching out to high school students who are gifted in science could offer a deeper understanding of their experiences in elementary and middle school science education. Additionally, conducting a longitudinal study that tracks gifted students from childhood into their professional lives or at least through their elementary and middle school years could shed light on how these early experiences influence their future paths in science.

For future research, it would be advantageous to conduct a comparative study between successful scientists who were not labeled as gifted in their childhood and those who were identified as such. This comparison could provide valuable insights into how the "gifted" label affects individuals' psychological development, social interactions, and educational paths. Exploring these impacts could enhance our understanding of both the necessity and effectiveness of specialized education for gifted students in science and reveal the advantages of science education in diverse classrooms. Additionally, including individuals who were recognized as gifted but did not pursue successful careers in science or chose different paths would provide a broader perspective on the long-term impacts of early academic labeling and educational strategies on career development.

Current literature includes studies that parallel this research, notably Ballert Potter's (2017) analysis of high-achieving adults and Slaughter-Thierry's (2017) investigation into the educational experiences of talented professionals in the arts. The former explores the middle and high school years, concentrating on social support, academic opportunities, and self-perceptions. The latter examines the educational paths of successful individuals in the creative and

performing arts, emphasizing the role of family, mentorship, and environmental influences. My study, on the other hand, differs from these two in its specific focus on gifted professionals in science, the exploration of their perceptions of giftedness and factors leading to their success in science, and the use of a narrative research design. This represents a unique contribution to the field, particularly with its emphasis on the progression of giftedness from childhood to adulthood within a specific professional context, namely science.

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Appendix A

The Volunteer Recruitment Flyer

RECRUITING VOLUNTEERS FOR A STUDY ON

GIFTED PROFESSIONALS IN SCIENCE

Teachers College, Columbia University

IRB Protocol Number: 23-193

Qualifications:

You are invited to participate in this study if you fit into the following criteria:

- If you are currently working in science and science-related fields.
- If you were a *gifted child**

*What does it mean to be a gifted child?
You were a gifted child if you fit into one of the following criteria:

- If you have attended gifted and talented schools or programs
- if you have been labeled/identified as gifted by a school or a center/organization for gifted students
- if you have had intelligence test scores (a score of 130 or higher) at any point in your life

Commitment:

Participants will be asked to participate in an individual 60-minute virtual **interview**, share their professional **resumes**, fill out an online **questionnaire**.

Contact:

Feyza Dumanoglu, Ph.D. Candidate, Teachers College, Columbia University

email: fd2423@tc.columbia.edu

Appendix B

Semi-Structured Interview Protocol

Dear Participant,

Thank you for agreeing to participate in this interview.

You do not have to answer every question; you can skip any question you do not feel comfortable answering or withdraw from the study at any time without penalty or the need to provide an explanation. However, I would like to inform you that your contribution is extremely important for addressing issues related to science education for gifted students.

Needless to say, your private information will be kept confidential. I will use pseudonyms instead of your real names and remove any information that could potentially identify you to others.

May I have your permission to begin the audio recording? Please answer "yes" to indicate your verbal consent.

1. Could you please tell me about your childhood? How would you describe yourself as a child?
2. Do you consider yourself gifted? Can you describe what being gifted feels like? How was this experience for you during your elementary and middle school years?
    a. Is being recognized as gifted a significant aspect of your identity? How do you interpret this identity, especially within the scientific community?
    b. How do you perceive yourself in relation to your colleagues, family, or peers from your elementary and/or middle school days?

3. What were the advantages and disadvantages of having a gifted label throughout your elementary, middle, and high school years, and why?
4. What was your favorite subject in elementary school, middle school, and high school? Why?
5. Reflecting on your time as a student, what did you like most about the science classes you took?
6. Who was your favorite teacher during your elementary, middle, or high school years, and what distinguished them?
7. How did you spend your leisure time when you were an elementary and/or middle school student?
8. "When did your interest in this field begin?" (Slaughter-Thierry, 2017) Why? How?
9. At what point and why did you decide to pursue a career in science?
10. Did you receive support from individuals or institutions in your journey? Who played a pivotal role in supporting you? (This could include parents, peers, teachers, etc.)
11. Can you describe the challenges and support you encountered both as a gifted learner and within your professional scientific career?
12. As a gifted student, were your educational needs adequately met? Were there specific resources or forms of support that would have benefited you as a gifted learner, and how might these differ from the support provided to non-labeled learners?
13. Is there anything else you would like to add?

Thank you very much for your participation. I really appreciate it.

Appendix C

Questionnaire

Part I

1. Please indicate your name (The data will remain confidential)

   _____

2. Please indicate your gender:

   Female

   Male

   Other ———

   Prefer not to say

3. Please select the category that includes your age

   under 25 25-29 30-34 34-39 40-44 45-49 50 or above

4. Please specify your ethnicity

   White Asian Hispanic/Latino Black

   Other, please specify ———————— Prefer not to say

5. Please indicate your graduation years

   High school ————————————

   College ————————————

   Masters degree (if applicable) ————————————

PhD degree (if applicable) ———————————

6. What is your current job? Please describe your job.

_____

7. Thinking back to your childhood, what was your father's level of education at that time? What was his job during your childhood?

_____

8. Thinking back to your childhood, what was your mother's level of education at that time? What was her job during your childhood?

_____

9. Where did you grow up?

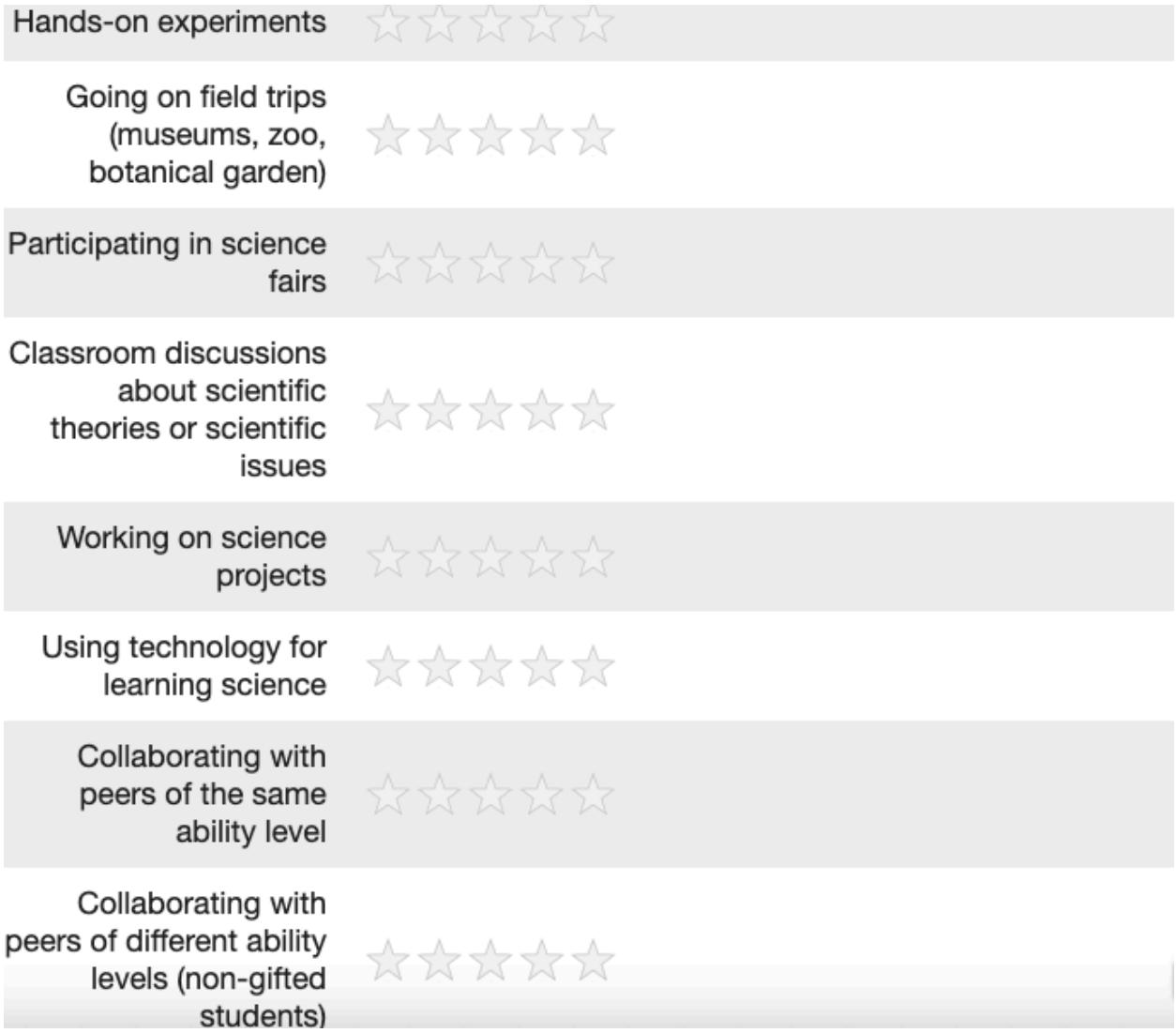
_____

Part II

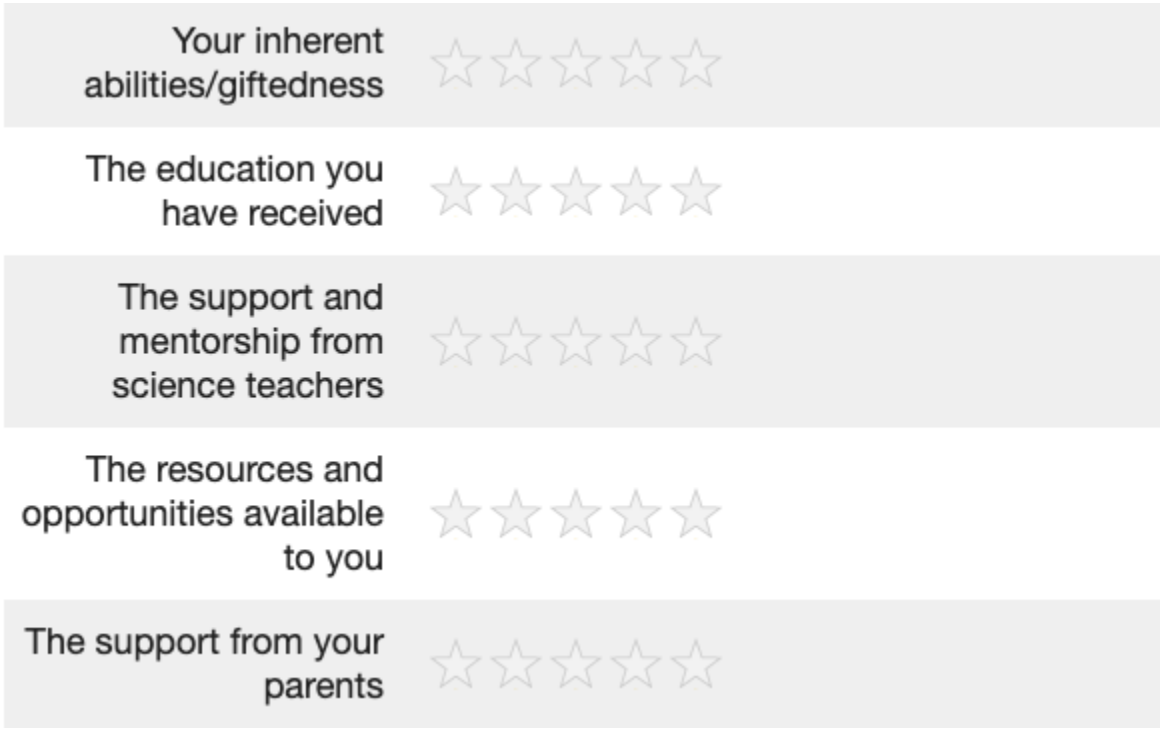
10. What type of gifted programs have you ever attended?

	Elementary and/or Middle School	High School	Both
Differentiated instruction- Your teacher(s) tailored learning activities and content to fit your advanced needs and abilities.	☐	☐	☐
Acceleration- You moved through school faster, for instance by skipping grades or taking advanced classes early.	☐	☐	☐
More homework- You were given extra homework assignments.	☐	☐	☐
Gifted school- You attended a school specially designed for highly intelligent or talented students.	☐	☐	☐
Gifted classroom- You were in a specific class within a regular school that was designed for highly intelligent students.	☐	☐	☐
Out-of-school programs- You attended educational programs outside of regular school hours designed for highly intelligent students.	☐	☐	☐
Summer schools for high achievers or gifted students- You attended special summer school programs designed to challenge and enhance learning for top-performing students.	☐	☐	☐

11. Please rank the following science activities based on how much you enjoyed them in elementary and middle school.



12. Please rank the following factors based on their contribution to your achievements in science.



13. You believe your rapid learning ability has been a key factor in your understanding of complex scientific concepts.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

14. Your passion for your field is as important for your success as your giftedness.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

15. If you had not been identified as gifted, you would have been as successful in your career as you are now.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

16. Access to advanced scientific resources during your education significantly contributed to your professional achievements.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

17. What would you suggest to young gifted people who have an interest in science?

_____

_____

18. Is there anything else you would like to add?

_____

_____

Appendix D

Scientists and Their Participation in Gifted Programs During K-12 Education

Name	K-8	High school	Notes
Mike	Advanced tasks by teachers depending on their initiatives		Middle school: Gifted programs were not pursued due to personal and family considerations.
David	Acceleration (skipped 7th grade) Summer school for gifted students	Differentiated instruction Summer school for gifted students	Preschool: Participated in chess. Attended a private school (K-8) without a gifted program. 4th grade: Received enrichment in mathematics. 5th grade: Received enrichment in science, English, mathematics and social studies, feeling adequately challenged. 6th grade: Did not participate in any specialized program. 7th grade: Skipped the grade. 8th grade: Attended honors classes in science and mathematics. High school: Engaged in a university's honors program on weekends. Participated in advanced classes in science and mathematics.
Olivia	Differentiated instruction Gifted classroom	Differentiated instruction Gifted classroom	Elementary school: The gifted program involved going to a separate classroom a few times a week for various non-traditional educational activities. Middle school: The gifted program offered the option to choose specialized electives like architecture or financial planning instead of standard electives. 9th and 10th grade: Teachers condensed classes for three days, with enrichment projects on the remaining days. After 10th grade: Met with the director of the program, without attending class.

Name	K-8	High school	Notes
Emily	Differentiated instruction More homework Gifted classroom		3rd grade: Met once or twice a week during normal English class hours for specialized activities, including creating a book of selected writings and engaging in thinking challenges. 4th grade: Joined a math challenge program focusing on the stock market, where activities included building company profiles, tracking growth predictions, and tackling complex math problems with creative approaches. High school: Enrolled in advanced placement courses.
Ashley	Differentiated instruction Acceleration Gifted classroom	Differentiated instruction Acceleration Gifted classroom	Kindergarten-2nd grade: Participated part-day in a talented and gifted program with challenging coursework. 3rd grade: Engaged in a talented and gifted program with one other student, focusing on puzzles and math-based activities. 4th grade: Placed in a mixed fourth/fifth-grade class for top-performing/talented fourth graders. Middle school: Undertook harder course work. High school: Enrolled in advanced classes.
Laura	Differentiated instruction More homework Gifted school Gifted classroom Out-of-school programs Summer school for gifted students	Differentiated instruction Out-of-school programs Summer school for high achievers or gifted students	Elementary school: Was taken out of class and put into a special class. 4th grade: Participated in advanced mathematics. Middle school: Took advanced science classes. Gifted Math Program: Attended a local state university twice a week for accelerated and enriched math lessons. High school: Continued participation in the Gifted Math Program throughout high school.

Name	K-8	High school	Notes
Sarah	Differentiated instruction Gifted classroom Out-of-school programs	Differentiated instruction Gifted classroom Out-of-school programs	4th grade: Participated in meetings and activities specifically designed for gifted students. Middle school: Enrolled in an honors system, placed in higher-level classes. High school: Took Advanced Placement (AP) courses: AP Biology, AP Computer Science, and AP Physics: also participated in honors classes in biology, chemistry, and physics before taking AP courses.
Ryan	Differentiated instruction More homework	Differentiated instruction More homework Out-of-school programs Summer school for high achievers or gifted students	Kindergarten: Read at 5th level; was taken out of the regular class for individualized reading activities. Middle school: Did not pursue gifted education due to cost constraints; participated in science clubs. High school: Enrolled in the International Baccalaureate (IB) program, taking higher-level courses. Attended a physics summer program. Participated in a university's honors program on weekends
Jack	Differentiated instruction Gifted classroom	Differentiated instruction Gifted classroom	4th grade through middle school: Taken out of class and put into a special class, High school: Enrolled in advanced classes (11th-12th grade)