education sciences

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Empowering Female High School Students for STEM Futures: Career Exploration and Leadership Development at Scientella

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Abstract: Women remain underrepresented in STEM fields, with a major STEM pipeline leakage occurring between high school and post-secondary education. Past research suggests that providing female high school students with opportunities for problem-solving, prosocial behaviors and working towards authentic communal goals can improve their perceptions of STEM and the attractiveness of STEM careers. Building on this prior research, we investigate Scientella, a US-based, student-run organization that provides out-of-school consulting projects, mentorships and webinars to female high school students. Drawing on the direct experiences of Scientella's co-founders and analyzing program survey data, we explore how Scientella provides these opportunities, the benefits realized by students, and the challenges faced by the organization. Survey data show that involvement in Scientella's activities provides students with benefits related to STEM career exploration and counter-stereotypical STEM skill development, including career discovery, industry engagement and practical experience, and the development of collaboration, communication and social research skills. The admissions of Scientella student leaders to STEM majors in selective US colleges indicates the promise of Scientella's approach, and that providing students with opportunities to engage in STEM-themed career exploration and leadership development could be an effective strategy to increase female STEM participation in post-secondary education and the pursuit of subsequent career opportunities.

Keywords: career exploration; college readiness; counter-stereotypical skills; female student; gender gap; high school; leadership development; prosocial behavior; STEM; student chapter

Citation: Ford, S.J.; dos Santos, R.; dos Santos, R. Empowering Female High School Students for STEM Futures: Career Exploration and Leadership Development at Scientella. *Educ. Sci.* **2024**, *14*, 955. https://doi.org/10.3390/educsci14090955

Academic Editors: Patricia Caratozzolo, Angeles Dominguez and Claudia Camacho-Zuñiga

Received: 16 July 2024
Revised: 21 August 2024
Accepted: 28 August 2024
Published: 29 August 2024

1. Introduction

Despite efforts to reduce their barriers to participation, women continue to be underrepresented in science, technology, engineering, and mathematics (STEM), with a persistent gender gap observable in enrollment in undergraduate university degrees, pursuit of careers, and achievement of senior leadership positions [1,2]. In the traditional conception of a STEM pipeline, major leakages can be observed in the educational system between high school and post-secondary education [3,4], and when students graduate from post-secondary institutions and enter the workforce [1,2]. However, despite successes in terms of increasing female STEM participation and achievement in high schools, "*filling the seats of high school science and math classrooms with equal representation does not necessarily translate into greater representation in STEM disciplines at the postsecondary level or promote pursuit of STEM careers*" [5].

A variety of approaches have been taken to increase the perception among female high school students that STEM is an attainable and attractive career choice, including activities that promote engagement and interest in STEM outside the classroom. While many out-of-school programs focus directly on the development of STEM skills, other US-based initiatives such as GAINS—Girls Advancing in STEM [6], STEMblazers [7], and

STEM for Her [8] focus on career exploration opportunities and networking with STEM professionals to help female high school students make informed college and career choices.

While these organizations are run professionally by adults for students, in this article we focus on a student-run, adult-guided organization, Scientella [9]. Its mission involves "*empowering the next generation of women STEM innovators*" and it seeks to reduce the pipeline leakage between high school (secondary) and college (post-secondary). Through activities such as student consulting projects, mentoring, and webinars, Scientella provides its members with opportunities for career exploration and leadership development, and for them to engage in prosocial behaviors and develop counter-stereotypical STEM skills. In this article, we investigate Scientella through the following three questions:

- RQ1. How does Scientella help female high school students prepare for future post-secondary education and careers in STEM?
- RQ2. What benefits do stakeholders receive from their participation in Scientella's out-of-school programming?
- RQ3. How has Scientella addressed the challenges it faces when delivering its out-of-school programming?

Through answering these questions, we gain insights into how Scientella helps female high school students gain the types of beneficial and demonstrable experiences that improve their chances of success when applying for STEM majors in college, and the ongoing challenges Scientella faces as a student-run organization.

2. Literature Review

2.1. The STEM Gender Gap

The underrepresentation of women in STEM is a persistent global challenge. In the United States (US), women make up 51% of the population aged 18–74, and 48% of the workforce. However, they comprise only 35% of the STEM workforce [2]. This is significant because STEM occupations have higher earning power than non-STEM occupations, with a median STEM salary in the US being USD 63,000 in 2021 versus USD 40,000 for non-STEM occupations. Furthermore, while a gender gap persists in both STEM and non-STEM occupations, the differences are smaller in STEM (USD 65,000 vs. USD 60,000) than in non-STEM occupations (USD 48,000 vs. USD 36,000) [2].

While the traditional conception of the "leaky pipeline" in STEM has been expanded to take a more comprehensive pathways approach [10], the transition between high school and post-secondary education remains one of the major leaks where potential female STEM students are lost [3,4]. However, as can be seen among recent US high school completers who enrolled in college, the problem is not one of progression from high school into post-secondary education. Since 1987, in all but one year, a higher percentage of young women than men have completed high school and gone on to enroll in college that same year. In 2022, these figures were 66% female versus 57% male [11]. Instead, young women are choosing not to pursue STEM majors in college. Specifically, they are choosing not to pursue physical and earth sciences (including chemistry and physics), mathematical and computer sciences, and engineering. In 2020, the percentages of women gaining bachelor's degrees in these disciplines stood at 43%, 26% and 24%, respectively. In comparison, gender parity has been exceeded in agricultural and biological sciences, with women forming 64% of all bachelor's degree recipients [2]. Similar figures are observable at an international level, with little change in the percentage of women pursuing these disciplines during the last two decades [12].

2.2. STEM Identities

A variety of perspectives have been put forward to explain the academic and career choices of young women. Among the reasons for the pipeline leakages and the gender gap are the STEM identities of female high school students and how these are shaped by STEM stereotypes and signals from their social environment [13]. The formation of such identities starts early in the education system. During middle school, boys already show

greater interest in science and engineering-related occupations than girls [14]. Meanwhile, participation in robotics competitions shows how attitudes towards computer science change during the education system; girls are more likely than boys to be involved in programming during elementary school and entry-level competitions, with the situation reversing in high school and more advanced competitions [15].

Prevailing STEM stereotypes include perceptions about the difficulty of STEM subjects and a requirement of brilliance or giftedness for success, and the cultural and social stereotypes of scientists and the work they do [16]. These STEM stereotypes are perpetuated in media portrayals of STEM participants, leading to the underrepresentation of positive female role models [17,18].

The local STEM social environments of young women are shaped by their family [19,20], peers [21], teachers [22], and counselors [23,24]. The signals young women receive from these sources can make it challenging for them to identify with STEM, with disconnections felt in terms of belonging and failure to embody STEM stereotypes [5]. Taken together with STEM stereotypes, these factors combine so that both men and women acquire implicit biases that sciences are associated with males, while arts are associated with females [3].

2.3. Academic and Career Aspirations in STEM

Understanding how high school students develop their career interests is an important step for understanding post-secondary STEM outcomes [22,25]. For female students, the challenges of belonging can be amplified due to intersectionality with ethnicity, race, socioeconomic status, and first-generation college status. Due to their STEM identities, different interventions and support may be required for their successful transition into post-secondary education and STEM majors [26].

As high school students consider their next academic steps and potential future careers in STEM, counselors can play an important role in equipping students with the necessary knowledge, skills and experiences to make informed choices, particularly so for underrepresented groups facing barriers [19,23]. Counselors can help improve the STEM readiness of students by guiding them towards academic courses that are aligned with their career aspirations. Unfortunately, there is a lack of trained counselors who can provide this support, and counselors may not be able to provide such guidance if they lack STEM disciplinary knowledge [24]. Furthermore, the personal biases of counselors may influence their recommendations, with biases arising from their own inexperience with STEM, or their own preconceived notions of the characteristics required of students to pursue STEM degrees [24].

Exposure to successful female role models can inspire female high school students and offset some of the effects of negative STEM stereotypes [27–29]. By learning about and interacting with such role models, students can begin to recognize similarities between themselves and the STEM professionals and understand how such career paths could be achievable for them [5]. Such benefits are amplified when entering mentoring relationships with such role models, with mentors providing deeper knowledge of STEM professions, advice and encouragement to counteract negative stereotyping [30–32]. STEM attitudes and career intentions among female students can also be positively affected by other changes to their STEM environment, such as through out-of-school programs [33,34], summer camps [35,36], and career development programs [23]. However, the absence of longitudinal evaluations of such interventions means that there remains uncertainty over their long-term effectiveness [37,38].

There is emerging evidence that the development of counter-stereotypical STEM skills and interpersonal competences such as teamwork, leadership, and communication in relation to STEM can change STEM attitudes among females and have positive effects on STEM interest, belonging and career intentions [29,39,40]. Such benefits can occur when female STEM students engage in problem-solving and prosocial behaviors (e.g., altruism, cooperation, helping) and work towards authentic communal goals [34,41,42]. Women prefer careers in which they can engage in prosocial behaviors [25], and the perception

of STEM as a masculine subject in which they cannot engage in such behaviors shapes young women's STEM career aspirations [43]. Within STEM, this preference for prosocial behaviors provides an explanation why more women gravitate towards life sciences as opposed to computer sciences, engineering, mathematics, and physics [44].

2.4. Admissions into Post-Secondary Education

Barriers to progress into STEM majors and careers can arise during admissions processes into post-secondary education. During these processes, applicants to post-secondary education institutions gain exposure to the potential STEM environment of those institutions and build an anticipatory sense of whether they belong or not. Early in that process, potential applicants may review admission viewbooks and be influenced by the language and imagery used with them. Such viewbooks have been found to perpetuate myths of white men as scientific "*superheroes*", while women are typically depicted as "*brainy babes*" or as "*sidekicks*" in subordinate roles to men [45]. In the US, colleges use in-person campus tours to persuade applicants to attend their institution. Escorting applicants on a "*golden walk*" through the campus is a crucial part of the recruitment process, with the campus tour guide playing an important role in generating positive feelings within the applicants towards the college [46]. The ability of potential applicants to meet with a STEM professor during these tours, either one-on-one or in small groups with peers, has been found to have a positive effect on STEM career interest. However, the size of this effect has not been explored for specific demographic groups [47].

Within engineering, there has been some recognition that college admission processes and standardized tests can be a structural barrier to the underrepresentation of women and people of color [48,49]. However, there has been little research into this issue in undergraduate engineering degrees [50,51] or during the admission processes for other STEM subjects in post-secondary education [52]. Looking more broadly at admissions into post-secondary education, approximately 95% of U.S. colleges with selective admission processes use a merit-based holistic review to assess a student's ability beyond just their exams or test scores. Alongside their academic transcripts, grades and standardized test results, applicants are typically asked to submit additional personal and demographic information, extracurricular activities, essays, and letters of recommendation [53]. Nonacademic factors play a significant role during holistic review. Within the Educational Testing Service (ETS) framework [54], the nonacademic factors most commonly used by admissions officers at private colleges to inform decisions relate to performance and attitudinal factors. This highlights the importance for applicants to demonstrate performance capabilities such as their engagement, leadership, management, professionalism, and teamwork, along with attitudinal constructs such as their adaptability, ethics, interests, self-concept, self-efficacy, and social values [55].

While one intent of holistic review is to enable applicants from marginalized backgrounds the opportunity to be considered alongside those from more privileged backgrounds, the inclusion of elements such as diversity essays has been criticized for being "*a meter of privilege* [that] *creates a hierarchy of stories and experiences that are more accessible to some young people than others*" [56]. Similar concerns have been expressed in the UK, where personal statements are required for university admissions [57]. These provide opportunities for applicants to convey their suitability for their chosen field of study, along with demonstrating their commitment, enthusiasm, and why they "*stand out from the crowd*" [57,58]. However, applicants from deprived backgrounds face barriers to university education as they cannot provide as many or as varied examples of life and work experiences in their personal statements as compared to applicants from more affluent backgrounds [59]. Comparing the ratios of high-skill, high-prestige, generally unpaid work experiences to low-skill, low-prestige, paid jobs, it has been observed that applicants from fee-paying private schools have ratios more than twice as high as those of applicants from sixth form colleges and comprehensive school applicants [57].

3. Methods

This paper focuses on Scientella, a student-run, adult-guided fiscally sponsored nonprofit organization that aims to empower the next generation of women STEM innovators. Scientella was co-founded in August 2020 in San Diego, California, by the daughter–father team of Raquel dos Santos and Ricardo dos Santos. Women's underrepresentation in STEM was apparent from statistics on women's participation in the STEM workforce and their enrollment in STEM college majors. The co-founders knew that these issues had roots much earlier in life, in middle and high school, where girls suffer from gender stereotypes, male-dominated cultures, fewer role models, and math anxiety. They also saw first-hand how challenging it was for teenagers to search for opportunities to develop their career interests, with many having trouble finding them due to gender bias, socioeconomic means, no prior experience, or a lack of connections. While such problems can be addressed by corporations, most do not offer internships for high school students and lack career discovery and leadership development programs for girls.

Their solution was to create Scientella and provide female high school students who have an existing interest in STEM with access to innovative experiential learning programs, impact-leadership responsibilities, and interactions with role models. Scientella calls these career exploration opportunities "matches". By providing these matches, Scientella aims to help young women gain the skills, confidence and resume to thrive in the careers of their choice and thereby narrow the STEM gender gap. Along with encouraging participants to develop their own STEM career passions, Scientella also aims to foster an impact-minded leadership mentality within its participants, encouraging them to think beyond their personal aspirations, and provide similar learning opportunities to their peers.

Past research has indicated that initiatives focusing on the development of counter-stereotypical STEM skills and prosocial behaviors could lead to greater interest in and pursuit of STEM majors and careers among high school students [29,34,39–42]. As Scientella is a novel program in which these skills and behaviors are practiced, it provides an opportunity to explore how its combination of activities helps address the gender gap in STEM. Three questions are investigated in this article:

- RQ1. How does Scientella help female high school students prepare for future post-secondary education and careers in STEM?
- RQ2. What benefits do stakeholders receive from their participation in Scientella's out-of-school programming?
- RQ3. How has Scientella addressed the challenges it faces when delivering its out-of-school programming?

The primary data and analysis presented in this paper come from the direct experiences and personal reflections of Raquel dos Santos and Ricardo dos Santos, along with surveys of Scientella's participants and student leaders. Raquel dos Santos is the first and current General Manager of Scientella and a Biological Sciences Major at the University of Chicago. Ricardo dos Santos is the Board Director of Scientella and continues to serve as one of its industry advisors.

The survey data were collected as part of Scientella's normal program operations and have been used to support its continued development and growth. They include responses from three separate online surveys of consulting project participants (28 respondents), mentorship participants (8 respondents), and Scientella student leaders (5 respondents). The use of this anonymized data was approved by the Office of Research Ethics at Simon Fraser University and these data are available at https://doi.org/10.17605/OSF.IO/DTM73 (accessed on 19 January 2024).

The consulting project survey data were collected between December 2020 and February 2024, with responses collected at the conclusion of six consulting projects. The mentorship survey data were collected between December 2020 and December 2022 after students completed their formal mentorship engagement. Finally, the student leader survey data were collected between February and May 2024. The lead author followed a thematic

coding process on the survey data to identify and categorize emergent themes and the benefits participants received from their involvement in Scientella's activities.

4. Results and Discussion

The first research question to investigate is "*How does Scientella help female high school students prepare for future post-secondary education and careers in STEM?*" The following subsections provide an overview of Scientella, including its organizational structure and the activities it offers its participants.

4.1. Organizational Structure

Scientella prides itself on being student-run and adult-guided. A combined headquarters (HQ) team called the "Steministas" consists of volunteer student leaders and adult role models (both female and male allies) that work together to manage the organization and jointly fulfill Scientella's mission. The HQ team focuses on overall organizational management, including career exploration matchmaking, student and professional engagement, communications, partnership initiatives, and fundraising.

The HQ is the hub in a hub-and-spoke model, with the spokes being the high school chapters across the US and its first international chapter in India. Scientella high school chapters are formed as school clubs to reliably recruit new Scientella members and offer an additional layer of student career exploration and leadership opportunities. At the end of 2023, Scientella had 16 active high school chapters spanning five states (California, Florida, Massachusetts, North Carolina and Texas) and two countries (USA, India). Thirteen chapters are at public schools, with three at private schools. These chapters are listed in Table 1.

Table 1. The high school student chapters in Scientella.

Chapter Name	Location	School Type	Year Founded
Canyon Crest Academy	San Diego, CA, USA	Public	2021
Del Norte High School	San Diego, CA, USA	Public	2021
Valencia High School	Placentia, CA, USA	Public	2021
The Rivers School	Weston, MA, USA	Private	2021
Heritage High School	Frisco, TX, USA	Public	2021
The Bishop's School	San Diego, CA, USA	Private	2022
Portola High School	Irvine, CA, USA	Public	2023
Canyon Hills High School	San Diego, CA, USA	Public	2023
Westview High School	San Diego, CA, USA	Public	2023
Troy High School	Fullerton, CA, USA	Public	2023
Pacific Ridge School	Carlsbad, CA, USA	Private	2023
Allen High School	Allen, TX, USA	Public	2023
Doral Academy Preparatory High School	Doral, FL, USA	Public	2023
Ardrey Kell High School	Charlotte, NC, USA	Public	2023
Millenium National School	Pune, India	Public	2023
Independence High School	Frisco, TX, USA	Public	2023

Scientella recognizes that the teenage years are pivotal to career discovery and adopts a "*be good, be hopeful*" impact-leadership mindset. While young girls start as beneficiaries for career matches as general Scientella members, they can enhance their leadership within

the organization as chapter leaders, and later as HQ leaders. This encourages members to pay it forward to other youth, promoting a "*kids for kids*" service-minded mentality.

On the adult-guided side, industry professionals begin as match givers in which they volunteer their time and give back to their community by sponsoring one or more of Scientella's three career exploration match types. Professionals can have longer-term engagement with the organization by holding an Ambassador position, becoming a point of contact when Scientella seeks match assistance, partnership, and/or fundraising opportunities from that professional's company. Lastly, a professional may be invited to hold a position on Scientella's advisory board. There are currently 10 advisors representing companies such as Illumina, Microsoft, Qualcomm, and ResMed. Advisors act as points of contact for their company and provide oversight of Scientella's activities.

4.2. Activities

Since being founded, Scientella has provided female high school students with access to consulting projects, mentorships, webinars, and scholarships. The first three aim to help female high school students prepare for future post-secondary education and careers in STEM, while scholarships provide rewards to student leaders who give back to the organization. Furthermore, Scientella school chapters also organize initiatives that enable members to have positive impacts within their local communities.

4.2.1. Student Consulting Projects

Scientella has organized 14 consulting projects since being founded, involving the participation of 316 students and 12 project sponsors. Table A1 in Appendix A provides details of these consulting projects, while Table 2 summarizes the phases and activities of a typical Scientella consulting project.

Table 2. The phases and activities of a Scientella consulting project.

Project Phase	Activity	Description
Project initiation	Kick-off webinar	The project sponsor introduces themselves, their organization, and the consulting project challenge during a webinar.
	Student registration	Interested high school students register for the consulting project.
	Team formation	Student teams are formed, with a preference for teams within the same high school chapter to allow for in-person communication.
Project execution (6–8 weeks)	Problem analysis	Teams begin exploring the challenge to understand the problem, its causes, and consequences.
	Data collection and analysis	Teams collect and analyze appropriate primary and secondary data to expand their understanding of the problem.
	Solution development	Informed by the data collected and analyzed, teams identify potential solutions.
	Team support	Throughout the project, teams receive support from a combination of the General Manager, up to two student project managers, and the project sponsor.
	Project deliverables	Teams produce a final report that summarizes their understanding of the problem, their recommended solutions, and potential implications.

The consulting projects are designed to enable students to participate in a real-world STEM innovation and research challenge and gain the type of professional experience that is difficult to obtain during high school. During the consulting project, students sample a specific STEM field and learn about the company hosting the project, all while building relevant technical and human-centric skills to assist their future academic and professional careers. For example, during the ResMed "Sleepless in High School" projects, teams investigated habits, awareness, and attitudes towards sleep amongst high school students. Teams conducted surveys and interviews with teenage peers, kept sleep diaries, and analyzed existing reports, thereby building their social research skills. Their final reports included written and visual summaries of their research, including affinity diagrams, journey maps, and sleep-student personas, and provided participants with an opportunity to practice their written and visual communication.

For the project sponsors, the consulting projects provide an impactful mechanism for them to give back to the next generation of women STEM innovators, while simultaneously gaining invaluable data and insights on their respective business or corporate social responsibility challenges from the perspective of students.

4.2.2. Mentorships

Scientella's one-on-one mentorships provide students with an opportunity to interact first-hand with a STEM role model. It has provided 43 mentorship matches between female high schoolers and industry professionals (Table 3). Scientella's mentorships typically involve students learning about their mentor's journey, sharing their thinking on college and career prospects, and receiving enriching advice that promotes self-discovery and helps them navigate their future path. Students gain experience interacting in a professional manner and expanding their networking skills. While only two meetings are formally scheduled as part of the mentorship, students are encouraged to maintain the relationship outside of Scientella at the conclusion of the mentorship.

Table 3. Mentorship matches by Scientella.

Fiscal Year	Number of Mentorship Matches
2020–2021	16
2021–2022	9
2022–2023	7
2023–2024	11

4.2.3. Webinars

In partnership with industry professionals, Scientella runs webinars to help female high school students with their career exploration and preparation. It has run 18 webinars on a variety of STEM-related topics (Table A2 in Appendix A), enabling attendees to learn about the work experiences of professionals and discover what companies do in relation to particular STEM fields. In addition, several career preparation webinars have focused on professional skill development such as resume building, networking, and interviewing.

4.2.4. Scholarships

Whereas other non-profits may offer need-based or merit-based scholarships, Scientella offers unique "Impact Scholarships" to its student leaders. They are designed as incentive-based scholarships that reward students for their contributions to the organization and its beneficiaries in pursuit of Scientella's mission. The scholarships are awarded by a funding committee, which makes decisions based on a student's impact within Scientella, including how the student led and supported their peers, demonstrated their "*kids for kids*" mentality, and led initiatives to give back to their community. Recipients of the USD 1000 scholarships can use them towards any education-related expenses. Among the expenses the scholarships have helped cover, recipients have put them towards the costs of college applications, pre-college programs, college travel, dorm rents, and tuition fees. To date,

sixteen scholarships have been awarded, with six, six and four scholarships awarded in the 2021–2022, 2022–2023 and 2023–2024 fiscal years, respectively.

4.2.5. Chapter Activities

Independent of HQ, Scientella chapters provide an additional layer of career exploration and leadership development opportunities for their local student members through chapter meetings and special outreach initiatives. Chapters are encouraged to pursue STEM-related outreach initiatives inside and outside of their school to have a direct impact on their peers and local communities. Since the end of the COVID-19 pandemic, 12 such initiatives have been organized by six student chapters (Table A3 in Appendix A).

While chapter leaders are the local enablers of Scientella's main activities, the role also provides these students with an opportunity to take initiative and arrange activities that are of interest to their local peers and beneficial to their local community. Given the limited leadership opportunities during high school, it can be many students' first experience leading an organization. The role offers a level of responsibility that is not overly demanding, but which provides the type of experiences that can improve their leadership, communication, and teamwork skills, and enhance their college applications.

4.3. Benefits

In this section, the second research question is investigated: "*What benefits do stakeholders receive from their participation in Scientella's out-of-school programming?*" The benefits arising from Scientella's main activities are described in the next sections and include wider discussions on leadership development and college readiness.

4.3.1. Student Consulting Projects

From analysis of participant responses, five main characteristics of the consulting projects were recognized, with participants describing the projects as interdisciplinary, relevant, collaborative, prosocial, and fun.

The consulting projects brought aspects of business and innovation together in a STEM context and participants recognized the value of this interdisciplinarity. One participant commented that "*Working with [the company] was a really great experience as to how we could develop our understanding of the intersectionality of business and science*", while another described how "*This project gave me an opportunity to explore STEM through a more business-oriented lens. I feel much more confident and excited to pursue an interdisciplinary field in the future*". Furthermore, students appreciated seeing how the STEM subjects they were studying could be applied in relevant, real-world settings. Students stated that "*The opportunity to work on a project about a prevalent topic in our world currently was like never before*", and that "*It was super interesting to collaborate with other highly capable girls on this project and create something that would be very useful to companies*".

Students appreciated the opportunity to collaborate with other high school females. Some expressed how it allowed them "*to work with an amazing team and resourceful leaders*" and "*collaborate with like-minded girls*". Similarly, the prosocial nature of the consulting projects was commented upon positively by students, with recognition of how working with peers on the projects allowed them to help others. One participant commented that "*I learned immensely valuable experiences that really helped cement my passion for design and benefiting other people with my creations*". A second student noted that "*Being able to interview counselors and work with a team to come up with solutions for a real-world need was a new experience and very interesting*". Such perspectives were expected based on past research into communal goal fulfillment among young women [41,42], and the result was that participants found the consulting projects to be fun, enjoyable and exciting, as seen in comments such as "*I had lots of fun and learned lots of interesting things about genomics and cardiovascular disease*".

While the consulting projects were each different in terms of their focus and scope, when participants were prompted to provide information on their project experiences and

what they gained, six benefits grouped within the two categories of career exploration and skill development were most prevalently reported (Table 4).

Table 4. Benefits of Scientella's consulting projects.

Category	Theme	Example Student Quotes
Career exploration	Career discovery	"*I also enjoyed how this project tied in STEM, business, and technology and it gave me an opportunity to learn about possible career paths*". "*I was exposed to the field of pediatric genetic counseling and the intersection of counseling and technology*".
	Industry engagement	"[I] *received guidance from an experienced industry professional*". "*It was a really cool experience to be able to work with a company as famous as* [the company]".
	Practical experience	"*It was great gaining insight on the business world and gaining real world experience!*" "*Scientella provided me with an extremely rare opportunity to gain hands-on experience in the business world of the STEM field*".
Skill development	Collaboration	"*I learned a lot about* [. . .] *how to work with teammates*". "*Throughout this process I learned* [. . .] *the pros/cons of working in a fully digital team*".
	Communication	"*It was very fun interacting with the team and I gained a lot of exposure not only related to the topic but also important skills of communication*". "*I learned* [. . .] *how to create a real presentation to present to real world leaders. I enjoyed this*".
	Social research	"*I learned useful information about conducting interviews* [. . .] *and qualitative data analysis*". "*I came into the project with minimal knowledge of market research, and I was surprised by how much I learned over the course of a few months*".

In the career exploration category, students found that working on the projects helped them gain an improved awareness of the types of STEM occupations and careers they could pursue. One former HQ leader, who is now enrolled in a STEM major in college, commented, "*The consulting projects helped me navigate through deciding on a major and career choice. They were also a great opportunity to ease me into working in a professional manner in a low-stake environment*". Engaging with industry provided them with opportunities to network with professionals and work with high-profile, reputable companies as clients. Furthermore, the projects allowed participants to gain the types of practical experiences that are usually inaccessible to high school students. As participants commented, "*I was able to acquire some experiences that would have been difficult to find elsewhere*". As is discussed further in Section 4.3.5, these experiences are valuable for college preparation, as they enable students to incorporate higher-prestige examples in their personal essays that highlight qualities such as their leadership, professionalism, self-efficacy, and social values [55,57].

While the team-based nature of the consulting projects means that they are inherently collaborative, participants recognized they needed to develop their interpersonal skills to

collaborate successfully. Communication skills were a core aspect of these interpersonal skills but were just one type of communication skill that participants practiced as they also needed to write final reports and deliver presentations to the clients. The social research skills that participants developed depended on the nature of the consulting project but contrasted with traditional STEM research by involving qualitative rather than quantitative data collection and analysis, and included applying needs analyses, market research, conducting interviews and analyzing interview data, and creating customer and user personas. These interpersonal skills are not traditionally viewed as STEM skills. Consequently, practicing them in the context of the consulting projects helps to counter prevalent stereotypes that STEM predominantly involves 'masculine' skills [44].

4.3.2. Mentorships

Previous research has demonstrated the benefits of mentorship with STEM role models as it can provide female students with deeper knowledge of STEM careers, career advice, and perspectives that help counteract negative STEM stereotypes [30–32]. Analysis of Scientella's mentorship survey data reveals that mentees gained STEM career-related benefits in three main themes: STEM college preparation; STEM career awareness; and STEM career journey.

In the first of these three themes, STEM college preparation, students shared how the mentorships helped them prepare for the college admission process and college life. Regarding their college admission preparation, one student stated, "*I gained highly interesting and relevant insights into the college process and what might work well for me as a girl interested in STEM*". Meanwhile, another student's comment exemplifies how the mentorship helped them prepare for college life: "*I received very informative advice and the first-hand experience from* [mentor] *which now prepares me for the do's and don'ts of university life*".

In the second theme, STEM career awareness, students learned about what working in a STEM occupation involved. As seen in student comments, such as "*It was very valuable to be able to gain more insight about the field and what her job looks like on a day-to-day basis*", meeting with their mentor enabled students to gain an informed perspective of what their own futures could look like as a professional working within that STEM field. Through gaining a more informed perspective, the mentorships also helped students improve their career decision-making, as demonstrated in another student's comment that the discussion with their mentor "[. . .] *allowed me to look into the lives of STEM related professionals and help me decide if I want to go a similar path as they went*".

In the final theme, STEM career journey, students were able to gain a wider lens of the mentor's STEM progression from college and into their professional occupation. This learning is illustrated in student comments such as "*[. . .] it was very helpful listening to college and professional advice on how to move forward in my career, like scholarships, internships, and just the daily college lifestyle*" and "*The way she connected her career and her experience together made it easier to understand what I was getting into*".

4.3.3. Webinars

Although Scientella has yet to survey participants on the benefits they gain from webinars, the organization offers them because the co-founders see them as a valuable complement to the mentorships and consulting projects. They are a minimal-time-commitment opportunity for students to receive exposure to substantive STEM topics, hear from role models, and learn about useful professional tools and skills. Benefits are also experienced by the corporate sponsors as they gain a platform to expose their company's mission, increase recognition of their STEM field, and provide valuable insights and skills to younger generations. An example of how these benefits were experienced comes from the project sponsor, ResMed:

> "*As a sponsor of the 'Sleepless in High School' consulting project, we ran several webinars aimed at educating students about sleep science, disorders, treatments, and digital solutions. These sessions offered a platform for female STEM professionals like myself*

to share our career journeys. The webinars were aligned with ResMed's mission to raise awareness about sleep health and the importance of effective treatments for sleep disorders. Introducing others early to sleep health ensures people place the right amount of attention to their sleep, improves their quality of life and ability to recognize when there is an issue to seek diagnosis and treatment.

Through these webinars, ResMed employees had the opportunity to present their diverse backgrounds in various STEM fields, including clinical, technological, and research disciplines. It was such a rewarding experience to connect with and introduce the younger generation to the wide range of STEM career paths available to them. I wish I had similar opportunities at their age to help guide me on my path!"

4.3.4. Leadership Development

While other career discovery-focused out-of-school programs in the US are adult-run (e.g., GAINS, STEMblazers and STEM for Her), Scientella is run by college and high school students. As chapter leaders and HQ leaders, they take on additional responsibilities compared to regular Scientella members. These leadership roles provide additional learning opportunities to practice their interpersonal, teamwork and organizational management skills. Former HQ leaders who are now enrolled in STEM majors in college commented that these leadership benefits were part of what made their Scientella experience so useful. As one such HQ leader described,

"*I gained a lot of benefits from my Scientella experience, especially with leadership skills. It was a new experience to manage a group of students across counties, and sometimes states, while also working with industry professionals. It presented a new set of challenges and required me to develop a different set of skills which have proven to be immensely useful. Determining how to structure a project and delegate work in a manner that played to everyone's strengths, while pushing people to develop their own skills was an interesting and challenging task*".

This view was echoed by two other former HQ leaders. One described the overall benefits of being involved with Scientella as being the "*Interaction from industry mentors, experience with new/growing fields, teamwork building, leadership skills, responsibility, personal fulfillment*". Another found that their experiences "*[. . .] provided valuable experience in leadership and communication, especially as I am applying to club leadership and research positions now*".

While calls have been made for female students to gain more opportunities to act communally in STEM contexts [41,42] and be exposed to more counter-stereotypes [29], leadership is not a skill that has particularly been emphasized in past interventions to improve STEM interest, belonging, and career interest. By providing opportunities for leadership development and related counter-stereotypical STEM skills such as teamwork and interpersonal communications, there are indications that Scientella is helping its leaders develop valuable skills, retain their STEM interest, and develop a stronger sense of STEM belonging that many young women often do not feel due to prevailing 'masculine' STEM stereotypes [44].

4.3.5. College Readiness

Scientella aims to enhance the college prospects of female high school students and help translate their existing STEM interest into the pursuit of STEM majors in college. As a relatively new organization that is run by student volunteers and is still establishing its practices, Scientella does not currently collect data on the planned or actual college enrollment of all its participants. However, it has data on the 12 Scientella student leaders who have graduated high school. Of these, all 12 student leaders have gone on to enroll in college and 11 of these are pursuing STEM majors (Table 5).

Table 5. Colleges and majors of Scientella's student leaders (N.B. the University of Texas at Austin, Computer Science entries relate to two different students).

College	College Major
Carnegie Mellon University	Chemistry and Mathematics
Emory University	Biology and Mathematics
Massachusetts Institute of Technology	Mathematics
University of California Irvine	Dance and Psychology
University of California Los Angeles	Bioengineering
University of California Los Angeles	Neuroscience, Pre-Med
University of California Santa Barbara	Data Science
University of Chicago	Biological Sciences, Pre-Med
University of Maryland	Mathematics and Computer Science
University of Texas at Austin	Computer Science
University of Texas at Austin	Computer Science
Washington University in St Louis	Biology

These current STEM majors have described how their Scientella experiences helped them improve their chances of college admissions success.

> "*I definitely think it played a significant role in my college applications, as I was able to write about the specific impact I had on individuals in my community, both on a personal level and a larger scale*".

> "*Really nice resume boost & research experience. I love providing solutions for big companies, and I later am able to understand the company's mission when I talk about them. The activities/work are great talking point for group projects experience, and nice to mention during interviews*".

For those from non-privileged backgrounds, the Scientella experiences were transformative. As one current college student described, involvement in Scientella provided them with significant professional networking benefits that extend to their current applications for internships and intended post-graduation career in STEM.

> "*I learned the importance of networking. As a first-generation immigrant, I have no relatives, let alone connections in the country to help me professionally or personally. All of Scientella's professional events and advising network opened my eyes to how valuable it is to know people coming from all walks of life. Now in college, as I am applying to internships, I still benefit from the rich network Scientella offers, being able to reach out to professionals and connect with them*".

Although the sample size is small, the experiences of these former Scientella student leaders indicate the collective benefits of their involvement in Scientella's activities and the leadership positions they held. While it is unknown if they would have been admitted to their current colleges without their Scientella experiences on their resume or in their personal essays, their comments show that they believe they helped them. As one current STEM major stated, "*My Scientella experience has helped a lot in getting me to where I am today*".

4.4. Challenges

As a voluntary, student-led organization, Scientella has encountered numerous challenges since its inception, each presenting a unique opportunity for growth, expansion, and improved impact. In this section, the third research question is explored: "*How has Scientella addressed the challenges it faces when delivering its out-of-school programming?*" The most prominent challenges discussed are related to scale-up, operational, and resourcing challenges. We share and reflect on these challenges so that others may learn from them when creating similar organizations to Scientella.

4.4.1. Scale-Up Challenges

Following an initial period in which it focused on local engagements, Scientella has since sought to develop a scalable model to enable the expansion of its support for female high school STEM students. As demand from students grew, the organization faced challenges in providing enough career exploration opportunities. Despite increased visibility and networking, scaling the number of professionals involved in consulting projects and mentoring proved difficult. Scientella addressed this by revising its consulting project model, allowing multiple student teams to work with a single sponsor, thereby expanding opportunities without increasing organizational effort. Additionally, Scientella restructured by introducing high school chapters, empowering local leadership and increasing engagement.

Student-led organizations, particularly those led by high school students with less experience, can find it difficult to engage with industry professionals. Unless parents or close family already work in STEM professions, high school students may not know of or be able to identify and engage such professionals for the student organization's activities. In Scientella's case, the creation of the industry advisory board has been essential to its successful scale-up. Building on the professional network of Ricardo dos Santos, the industry advisors have helped recruit professionals from STEM-oriented organizations to be consulting project sponsors, mentors, and webinar presenters. Having established this advisory board and its credibility, Scientella has been able to build on these initial networks to create strategic partnerships with organizations such as Athena, a well-established global advocacy organization that supports female STEM leadership [60]. Connecting to Athena's professional community should allow Scientella to involve a greater diversity of STEM professionals in its career exploration activities and go beyond its geographic origins in Southern California.

4.4.2. Operational Challenges

As a volunteer-based student organization, Scientella faced significant operational challenges, including short-term, opportunistic planning, lack of role training, and poor coordination between HQ and local chapters. This led to unpredictability in the quality and quantity of student–professional matches and missed opportunities for deeper connections. To address several of these issues, Raquel dos Santos was appointed to a paid, part-time role as General Manager in June 2023. Her appointment led to the adoption of a year-long planning forecast, more clearly defined student leadership roles, and improved accountability from its voluntary leaders.

Student turnover is a common challenge in student organizations due to factors such as student graduation, the competition between curricular and extracurricular demands, and conflicts with other goals [61,62]. While Scientella created the high school chapters to increase the number of high school students it could positively impact, their creation introduced several additional operational challenges around chapter engagement and member retention. One challenge arose from the absence of a motivated and initiative-taking chapter leader, which led to some high school chapters lacking direction, support, and ideas for local chapter activities such as those in Table A3. To address this issue, Scientella created a Chapter Management HQ Leader position so an experienced Scientella student leader could guide these chapters.

For high-school-based student organizations, the annual high school graduation of chapter leaders is unavoidable and brings with it the risk that high school chapters become disengaged after these students graduate. Scientella has attempted to mitigate this risk by encouraging chapter leaders to involve members of all grades, thereby maintaining Scientella's presence at that high school and helping improve the chances of student leader succession. This student turnover can also lead to a loss of organizational knowledge and good practices, with student organizations repeating the mistakes of the past. Scientella has sought to address this issue by appointing several graduating student leaders who are pursuing STEM majors into HQ leadership positions. The retention of these student

leaders not only helps with organizational continuity, but as STEM role models and future mentors, they provide inspiration for high school students who are considering following similar STEM pathways.

4.4.3. Resourcing Challenges

As a non-profit organization, Scientella faces the challenge of establishing a consistent and reliable source of funds. Scientella raises money through website donations, in-person fundraiser events, online campaigns, corporate sponsorship, advisor hour matching, and high-net-worth individuals. These funds primarily go towards the Impact Scholarships, the salary for the part-time General Manager position, and fees to its fiscal sponsor, Mission Edge [63].

In the coming years, Scientella aims to increase its financial income so that the benefits of its activities can be received by more students, and so it can award more Impact Scholarships. However, its leaders are high-school- and college-aged students who are primarily interested in STEM, and none are experienced fundraising professionals. While one strategy could be for Scientella to recruit voluntary professionals with fundraising experience, it intends to remain a student-led organization rather than becoming adult-run. At present, its General Manager serves as the head of fundraising and has the responsibility of developing appropriate fundraising strategies, despite not having years of fundraising experience. This appointment illustrates the tension and trade-off between Scientella's objectives of student learning and organizational growth. By being run by students for students rather than being run by adults, Scientella provides its student leaders with additional learning opportunities for counter-stereotypical STEM skills development. These benefits are considered to outweigh any mistakes that may be made or opportunities that may be missed and is aimed at building an organizational culture in which student leaders take ownership and responsibility for the organization's sustainability and social impact.

Moving forward, Scientella plans to maintain its student-led, adult-guided approach by appointing an HQ leader to focus on grant investigation and funding applications and will assign a dedicated advisor to support them.

5. Conclusions

This article has explored how Scientella provides career exploration and impact-minded leadership opportunities for female high school students who are interested in STEM, the benefits of student involvement, and the challenges of running such an organization. Scientella was created to help such students improve their awareness of potential STEM careers and their readiness for pursuing STEM majors in US colleges. In doing so, the organization helps to address one of the persistent leaks in the STEM pipeline between secondary and post-secondary education.

Past research has suggested that reframing high school STEM initiatives to include problem-solving, prosocial behaviors, and authentic communal goals may be effective in changing girls' STEM identities and their perceptions of STEM as a viable college and career path [34,41,42]. In this regard, Scientella's approach shows promising indications of helping female high school students go on to study STEM majors. Participants reported benefits from involvement in Scientella's consulting projects and mentorships, and that their involvement in these activities and leadership roles within Scientella helped improve their college readiness. Among these benefits, the consulting projects provided valuable career exploration (career discovery; industry engagement; practical experience) and skill development (collaboration; communication; social research) opportunities that are difficult to obtain elsewhere, while the mentorships helped students with their STEM college readiness, STEM career awareness, and STEM career journeys. That participants developed these counter-stereotypical skills during the consulting projects adds to the emerging literature on how their development in a STEM context can help increase STEM major and career intentions among female high school students [29,39,40].

In the absence of family members who work in STEM careers, interactions with STEM role models can be rare for female high school students. During Scientella's initiatives, participants can meet and build connections with female STEM professionals. By engaging with these role models, female students gain opportunities to learn how STEM careers could be attainable for them and not just for their male peers, gain greater belief in the attainability of such careers, and become inspired to follow similar STEM career pathways. Furthermore, in the absence of effective high school career counseling [24], we believe that mentorship from STEM professionals can provide a valuable opportunity to complement, or even correct, the guidance and encouragement provided by high school career counselors on potential STEM careers.

As a student-led organization, Scientella provides leadership opportunities within its HQ leadership team and high school chapters. Among the early cohorts of high school students who have taken on these leadership roles and participated in Scientella's initiatives, participants have gained experiences that improved their college readiness. Consequently, they have been able to describe these experiences in the personal essays they included in their college applications. Through doing so, Scientella members have been able to demonstrate some of the highly rated nonacademic factors, including performance and attitudinal capabilities, that admission officers use to evaluate candidates [55], and gain admission into STEM majors at prestigious US colleges (Table 5).

As has been seen from past studies [56,57,59], applicants from less affluent and marginalized backgrounds are less likely to be able to gain access to the types of work experience that enable them to showcase their capabilities in college applications. By creating new student chapters and allowing any female high school student to be part of a consulting project, Scientella provides equitable opportunities to gain the types of work and life experiences that are valued by college admission officers and help them stand out during the college admission process. The majority of Scientella's student chapters are located at public schools, enabling access to those who may have greater need for these experiences.

Limitations and Future Research

Due to our methodological approach involving the analysis of data previously collected by Scientella, combined with the relatively small number of students who have been involved in Scientella during its start-up phase, the findings presented here are tentative and require further investigation. Dedicated data collection is required to enable our initial findings to be tested and substantiated. Quasi-experimental designs involving pre–post surveys and control groups would help establish causal relationships [32,38]. Such surveys could focus on one of Scientella's initiatives (e.g., consulting projects, mentorships, webinars) to further understand what knowledge, skills and attitudinal changes occur among participants. Alternatively, surveys could be used to consider the whole Scientella experience of participants and how their involvement in Scientella reshapes their local STEM environment and, in turn, their STEM career intentions and college readiness for STEM majors. What happens after a student's involvement in Scientella could also be explored. While Scientella's mentorships involve two meetings between mentor and mentee, investigating which pairings persist beyond these meetings and understanding why they endure could help improve future matchmaking and increase the impact of mentorships.

Scientella's main objective is to increase the number of female high school students who pursue STEM majors in college. As there have so far been few high school graduates who have been involved in Scientella, longitudinal research is also necessary to identify if the current progression of Scientella student leaders to college persists, in which a high percentage of these college students pursue STEM majors (Table 5). Although HQ leadership positions are limited, Scientella provides STEM career exploration opportunities to all its members. As such, in combination with the pre–post surveys, the longitudinal data collection needs to be expanded to track the post-high-school outcomes and college enrollments of all its participants and the progression to STEM majors in college. As

Scientella's membership within the high school chapters consists primarily of Juniors (Grade 11) and Seniors (Grade 12) with an existing interest in STEM, their participation introduces self-selection biases that need to be accounted for when comparing outcomes against wider high school populations. Through doing so, a clearer picture will emerge of how effectively Scientella's career exploration matches and leadership opportunities address the STEM pipeline leakage between high school and college.

Author Contributions: Conceptualization, S.J.F., R.d.S. (Raquel dos Santos) and R.d.S. (Ricardo dos Santos); Data curation, S.J.F.; Formal analysis, S.J.F.; Investigation, R.d.S. (Raquel dos Santos); Methodology, S.J.F.; Visualization, S.J.F. and R.d.S. (Raquel dos Santos); Writing—original draft, S.J.F., R.d.S. (Raquel dos Santos) and R.d.S. (Ricardo dos Santos); Writing—review & editing, S.J.F., R.d.S. (Raquel dos Santos) and R.d.S. (Ricardo dos Santos). All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Office of Research Ethics at Simon Fraser University (#30002139, 19 January 2024).

Informed Consent Statement: Not applicable as the research involved secondary use of anonymized survey data, as approved by the Office of Research Ethics at Simon Fraser University (#30002139, 19 January 2024).

Data Availability Statement: The original data presented in the study are openly available in the Open Science Framework at https://doi.org/10.17605/OSF.IO/DTM73 (accessed on 19 January 2024).

Conflicts of Interest: Raquel dos Santos is the General Manager of Scientella and receives a part-time salary for the role. Ricardo dos Santos is the unpaid Board Director of Scientella and one of its industry advisors.

Appendix A

Table A1. Consulting projects completed by Scientella.

Date	Project Sponsor	Project Title	Participants	Description
2020	ResMed + GSK + Catalia Health	Social Robots for Pediatric Asthma	A team of 3 students	The team assessed the utility of social robots in the management of pediatric asthma. For primary research, the students interviewed asthma patients, a respiratory care/pharmaceutical expert, a pediatric asthma physician, and a social robotics expert. For secondary research, the students explored pediatric asthma, treatment, and existing digital technologies. The final report included summaries of research, a day in the life of an asthma patient with and without a social robot, and solution ideas specific to sponsor companies.
2021	Embodied	Expansion of Social Learning Robot Content	A team of 8 students	The team explored how Embodied could expand their social learning robot content beyond just children to also involve other family members, both inside and outside the home.

Table A1. *Cont.*

Date	Project Sponsor	Project Title	Participants	Description
2021	BrainLeap Technologies	Sales Strategy for Attention-Training Video Games	A team of 6 students	The team investigated the parent decision-making process pertaining to the purchase of solutions for children's attention deficit challenges. For primary research, the students interviewed parents of children with attention issues and the BrainLeap Chief Science Officer to learn about the scientific basis of the Attention Arcade (BrainLeap's product). The final report included a summary of parent interviews, buyer personas, a customer journey map, and insights on solutioning for BrainLeap's sales strategy.
2021	HP	Printing Behaviors and Attitudes Amongst High Schoolers	A team of 6 students	The team explored technology trends amongst high schoolers and solutioning for today's major digital issues. For primary research, the students surveyed and interviewed other high schoolers. For secondary research, the students investigated current teenage technology trends and problems. The final report included a summary of survey results, identification of technology problems, and explanations of solutions for each.
2021	Quanterix	Demand Projections for COVID-19 Testing in Schools	A team of 7 students	The team assessed the demand for high-level COVID-19 testing in high school and college settings for the 2021–22 school year. For primary research, the students conducted surveys and interviews with high school students, college students, and school administrators. For secondary research, the students investigated COVID-19 testing situations across the country. The final report included summaries of research, major insights, customer personas, future scenario possibilities, and solution ideas for Quanterix.
2021	Illumina	Digital Trends in Pediatric Genetic Counseling	A team of 8 students	The team set out to investigate the future of Pediatric Genetic Counseling via the use of digital health technologies such as telemedicine, patient self-guided apps and AR/VR. For primary research, the students conducted interviews with genetic counselors at leading children's hospitals. For secondary research, the students researched the proliferation of genetic testing and how it poses challenges and opportunities. The final report included summaries of research as well as the top problems and solutions that Illumina could look to address.

Table A1. *Cont.*

Date	Project Sponsor	Project Title	Participants	Description
2021	ResMed	Sleepless in High School	A team of 7 students	The team sought to understand habits, awareness, and attitudes towards sleep amongst high school students. For primary research, the students conducted surveys and interviews with teenage peers, and kept their own daily sleep diary. For secondary research, the students researched sleep science and sleep performance facts and trends. The final reports included summaries of research, an affinity diagram, journey map, sleep-student personas, and solution ideas ResMed can consider.
2022	Qualcomm	The Future of NFTs	A team of 7 students	The team explored the future of Non-Fungible Tokens (NFTs) including minting and selling their own. Through their research and a hands-on in-person experience at Qualcomm in San Diego, the students uncovered the technical aspects of NFTs, their role in society, how they are shaping digital media and what it would take for teenagers to embrace the concept fully beyond what could be a passing fad.
2022	Microsoft	The Future of the Metaverse	A team of 6 students	The team explored the future of the metaverse from the perspective of their generation. The students identified future possibilities, but also the associated challenges to ushering in the era of a mixed reality. Digging deeper, the students surveyed and interviewed their peers to find out which applications best resonated with teenagers and which concerns must be addressed to realize the potential of the metaverse in improving the human condition.
2022	ResMed	Sleepless in High School	9 teams, 53 students	Teams sought to understand habits, awareness, and attitudes towards sleep amongst high school students. For primary research, the students conducted surveys and interviews with teenage peers, and kept their own daily sleep diary. For secondary research, the students researched sleep science and sleep performance facts and trends. The final reports included summaries of research, an affinity diagram, journey map, sleep-student personas, and solution ideas ResMed can consider.
2023	Microsoft	ChatGPT and The Future of Education	7 teams, 26 students	Teams researched ChatGPT online, experienced ChatGPT directly for essay writing assistance, and conducted surveys with students and teachers. They drafted final reports on the pros and cons of ChatGPT and presented them to Microsoft and their respective schools.

Table A1. *Cont.*

Date	Project Sponsor	Project Title	Participants	Description
2023	Illumina	Genomics of Cardiovascular Disease	8 teams, 38 students	Teams created and presented a final report based on primary and secondary research to investigate cardiovascular disease, its intersection with genomics, awareness/interest amongst high schoolers, any problems with current screening methods, solution proposals including ways Illumina can be involved, and prediction of future trends.
2023	ResMed	Sleepless in High School	13 teams, 87 students	Teams sought to understand habits, awareness, and attitudes towards sleep amongst high school students. For primary research, the students conducted surveys and interviews with teenage peers, and kept their own daily sleep diary. For secondary research, the students researched sleep science and sleep performance facts and trends. The final reports included summaries of research, an affinity diagram, journey map, sleep-student personas, and solution ideas ResMed can consider.
2024	aTyr Pharmaceuticals	Pharma Companion Apps: Therapeutic Benefits and Scientific Dissemination	9 teams, 54 students	Teams sought to understand the pulmonary sarcoidosis (PS) patient journey including common symptoms, needs, and challenges. Through primary and secondary research methods, they assessed whether aTyr should develop their own companion app to accompany their drug Efzofitimod for the personalized treatment of pulmonary sarcoidosis (PS). They provided scientific dissemination examples on how aTyr should understandably explain Efzofitimod, basic tRNA synthetase biology, and the basic science of PS to general users.

Table A2. Webinars run by Scientella.

Year	Sponsor's Company	Webinar Name	Description
2020	Exagen	College and Career Success	Students learned how to self-brand to secure opportunities, write their resume, craft a cover letter, and succeed in interviews.
2021	ResMed	Innovator's Journey	Students learned about qualitative and quantitative user research methods, empathy in innovation, interviewing, and reflection through visualization techniques.
2021	ResMed	Sleep Science and Obstructive Sleep Apnea	Students learned about sleep science and Obstructive Sleep Apnea, including diagnostics and therapeutics.
2021	Embodied	Moxie: The Social Robot	Students learned the basics of making a social robot, including the robotics, artificial intelligence, and sensor technologies, and software rules required to enable social, emotional, and cognitive development for kids.
2021	Illumina	Genomics, Microarrays, and Next-Generation Sequencing	Students learned about the career journey of an Illumina R&D veteran, as well as explored the basics of genomics and DNA sequencing platforms.

Table A2. *Cont.*

Year	Sponsor's Company	Webinar Name	Description
2021	Microsoft	The Metaverse	Students learned about Microsoft, the basics of the metaverse, and how Microsoft engages with this field through AR/VR technologies.
2021	Slalom	Careers in STEM Consulting	Students learned about what it means to be a STEM consultant, including why companies seek consultants, education requirements, and the panelists' experiences as women consultants in STEM.
2021	ResMed	ResMed, Sleep, and Career Advice	Students learned about the career backgrounds of ResMed professionals, received valuable career advice, learned about ResMed's medical devices for chronic respiratory conditions, and were introduced to the upcoming Student Consulting Project titled "Sleepless in High School" to investigate sleep challenges/attitudes/behaviors amongst high school students.
2022	Qualcomm	The Future of NFTs	Students learned about the basics of Non-Fungible Tokens (NFTs), including key enabling technologies, common applications, and challenges.
2022	LinkedIn	LinkedIn Profile Building and Personal Branding	Students learned from a LinkedIn employee on how to strategically build their LinkedIn profile, create a strong professional online presence, and leverage the platform's networking and job search benefits to bolster their career journey. Tips included turning one's LinkedIn profile into a story, reaching out to recruiters at target companies, and posting engaging content.
2022	Appia Bio	Careers in Cell Therapy	Students learned the career trajectories of Appia Bio scientists and operations managers. They received tips on how to discover the possibilities of college degrees and jobs in biotechnology fields. Students also received advice on how to succeed in their first job, including ensuring a good fit between the company and their personal strengths/aspirations.
2022	ResMed	ResMed, Sleep, and Career Advice	Students learned about the career backgrounds of ResMed professionals, received valuable career advice, learned about ResMed's medical devices for chronic respiratory conditions, and were introduced to the upcoming Student Consulting Project titled "Sleepless in High School" to investigate sleep challenges/attitudes/behaviors amongst high school students.
2023	Microsoft	ChatGPT and The Future of Education	Students learned the basic technology premises behind artificial intelligence and new foundational models. They explored ChatGPT, ethical considerations, and what it could do to revolutionize schooling. Students were introduced to the upcoming Student Consulting Project on this topic.
2023	Illumina	Illumina, Genomics, and Cardiovascular Disease	Students learned about Alexa Tralla's career background, experience with the American Heart Association, and Illumina's involvement in cardiac disease genomic testing, and were introduced to the upcoming "Genomics of Cardiovascular Disease" Student Consulting Project.
2023	LinkedIn	LinkedIn Profile Building and Personal Branding	Students learned from a LinkedIn employee on how to strategically build their LinkedIn profile, create a strong professional online presence, and leverage the platform's networking and job search benefits to bolster their career journey. Tips included turning one's LinkedIn profile into a story, reaching out to recruiters at target companies, and posting engaging content.

Table A2. *Cont.*

Year	Sponsor's Company	Webinar Name	Description
2023	ResMed	ResMed, Sleep, and Career Advice	Students learned about the career backgrounds of ResMed professionals, received valuable career advice, learned about ResMed's medical devices for chronic respiratory conditions, and were introduced to the upcoming Student Consulting Project titled "Sleepless in High School" to investigate sleep challenges/attitudes/behaviors amongst high school students.
2023	5 physicians	Women in Medicine	Students heard from a panel of five physicians (working psychiatry, neurology, emergency medicine, and pathology) on their academic and career journeys, experiences as women in medicine, day-to-day life, biggest pieces of advice, and a Q&A.
2024	aTyr Pharmaceuticals	Pharma Companion Apps: Therapeutic Benefits and Scientific Dissemination	Attendees heard from an aTyr employee about aTyr as a pharmaceutical company and their use of innovative tRNA synthetase biology for new fibrosis and inflammation therapies. Students were introduced to Scientella's upcoming aTyr Student Consulting Project called "Pharma Companion Apps: Therapeutic Benefits and Scientific Dissemination" set to investigate the pulmonary sarcoidosis patient journey, explore how companion apps accompany a drug to improve the therapeutic experience, and the importance of proper scientific dissemination.

Table A3. Initiatives run by Scientella's high school chapters.

Year	Chapter	Initiative	Description
2022	Heritage High School	Battery Drive	Organized a battery drive and donated over 425 batteries to the City of Frisco Environmental Services.
2022	Valencia High School	"Down to a Science" Camp	Ran a free 4-week science camp at their local elementary school for students in 4th and 5th Grade. By providing lessons across a variety of unique STEM fields, Valencia members acted as positive role models and sparked fascination for STEM in younger students.
2022	Valencia High School	Beach Clean Up	Hosted a beach clean-up at their local Huntington Beach.
2023	Del Norte High School	Blood Drive	Organized a blood drive in partnership with the San Diego Sikh Foundation and American Red Cross.
2023	Del Norte High School	Webinar with a Pharmaceutical Professional	Recruited a pharmaceutical professional to give a virtual talk on their educational and career journey, job responsibilities, and advice.
2023	Doral Academy Preparatory High School	Family Expo with The Children's Trust	Shared free school resources and information about resources and opportunities for children in their community, such as after-school enrichment programs, nutrition education, injury prevention, and programs for children with special needs.
2023	Doral Academy Preparatory High School	Clothing Drive	Hosted a clothing drive and donated 2300 pieces of clothing, shoes, bedsheets, and bags, worth an estimated USD 10,000+, to Goodwill South Florida for children and families in need.
2023	Doral Academy Preparatory High School	Holiday School Supply Drive	Gathered hundreds of school supplies, assembled 36 bags tailored for elementary students, and distributed bags to families facing financial challenges for support during the holiday season.
2024	Canyon Hills High School	Visit to La Jolla Institute of Immunology	Organized a visit to the La Jolla Institute of Immunology. They went on a tour and spoke to 5 female scientists about their careers, how it is to be in STEM as a woman, and various possible career paths.

Table A3. *Cont.*

Year	Chapter	Initiative	Description
2024	Canyon Hills High School	Visit to UC San Diego Women Who Inspire Conference	Attended the 'Women Who Inspire' Conference at UC San Diego on International Women's Day. They gained industry exposure and heard from women professionals on a variety of STEAM topics.
2024	Canyon Crest Academy	STEM Showcase	Created a large poster and shared information on Scientella to fellow students at their local STEM Showcase.
2024	Canyon Crest Academy	Raffle Fundraiser	Hosted an online raffle fundraiser to raise money for Scientella through chapter member ticket sales and prizes.

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