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METEOR v HS

Broadening the STEM and Health Pipelines

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Executive Summary

"Mentored Experience to Expand Opportunities in Research version High School" (hereafter METEOR) was a six-year NIH-funded project (Award 5R25HD090722-05) designed to provide high school students and teachers with short-term training opportunities in biomedical research. Initiated by the Children's Research Institute (CRI) at the Children's National Medical Center, the project was carried out from 2017 to 2022, during which time CRI staff collaborated with partners at George Washington University's Schools of Education, Medicine and Health Sciences, and the DC Public and Public Charter High School (DC/PCS) system to create a series of six-week summer programs that offered high school students and teachers throughout the Washington, DC metropolitan area an opportunity to familiarize themselves with the inner workings of the world of biomedical research.

METEOR's overall aims were to enhance science literacy, and to promote greater diversity in the biomedical research pipeline. Specific goals were to:

- Attract young students to careers in science;
- Provide opportunities for college students to gain valuable research experience to help prepare them for graduate school; and
- Enhance the skills of science teachers and enable them to more effectively communicate the nature of the scientific process to their students.

Accomplishments & Impacts

Knology served as METEOR's external evaluator. Our assessment showed that METEOR succeeded in each of the aforementioned goals. In particular, the project:

- Deepened students' interests in science and medicine;
- Deepened students' knowledge of scientific and biomedical careers, and made them more confident in their ability to succeed as scientific and biomedical professionals;
- Advanced students' knowledge of science and medicine, and helped them acquire some of the skills required for success in STEM and health-related fields;
- Taught teachers new kinds of methodologies and practices, and how to incorporate these into their teaching;
- Showed teachers how to build more inclusive STEM learning environments; and
- Deepened teachers' commitment to promoting students' pursuit of scientific and biomedical careers.

These accomplishments clearly show that METEOR has the potential to support student and teacher advancement in the STEM and health pipelines. While documenting evidence of these positive impacts, this report also sheds light on a number of persistent challenges METEOR encountered throughout its six-year history, and concludes with a series of recommendations aimed at strengthening future iterations of the project.

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Introduction

A growing body of scholarship indicates that the United States is failing to produce a sufficient number of qualified scientific and medical professionals (Hunt et al., 2021). Solving the problem that is the "STEM pipeline crisis" will require widespread reforms throughout the US educational system, but existing research indicates that one key weakness in this system is the transitionary phase between high school and postsecondary education (Constan & Spicer, 2015). Due to a lack of role models, professional connections, and a host of other factors, many high school students with strong STEM aptitudes and interests struggle to pursue advanced training in science and medicine after graduating. This problem is particularly acute for racial minorities, who face considerable obstacles to entering the STEM and health pipelines, and who are thus severely underrepresented in scientific and biomedical occupations (Alfred et al., 2019).

What can be done to promote persistence in STEM and health-related career aspirations across the secondary-postsecondary divide? What kinds of policies, programs, and interventions are needed to help high school students with interested in STEM and health-related occupations gain advanced training and employment in these fields? A number of researchers (Kitchen et al., 2018; Linnenbrink-Garcia et al., 2018) have argued that precollege outreach programs offer a promising means of combating the problem of pipeline attrition, and the available evidence indicates that these programs can help students with STEM and health-related career ambitions remain within these fields as they transition from high school to postsecondary education (Kemp et al., 2021).

To help underrepresented students with interests in science and medicine gain access to the STEM and health pipelines, in 2017, the Children's Research Institute (CRI) at Children's National Medical Center secured NIH funding (Award 1R25HD090722-01) for a project called "Mentored Experience to Expand Opportunities in Research version High School" (METEOR). Pursued through partnership with George Washington University's Schools of Education and Medicine and Health Sciences and the DC Public and Public Charter High School (DC/PCS) system, METEOR was a six-year program designed to provide high school students and teachers throughout the Washington, DC metropolitan area with short-term training opportunities in biomedical research. Structured as a series of six-week summer programs, METEOR exposed students and teachers to real-world research practices within a children's medical center.

METEOR consisted of two separate, parallel programs: one for students, and one for teachers. By attending seminars, conducting rounds, participating in laboratory-based experiments, and interacting with practicing scientists on a day-to-day basis, METEOR students gained access to the inner workings of the world of biomedical research, and were able to familiarize themselves with the kinds of knowledge and skills required for success in a variety of STEM and biomedical occupations. METEOR teachers worked with basic, translational, or clinical research teams to develop methods and processes for bringing the knowledge and skills they acquired through the program back to the classroom. METEOR

teachers also pursued professional development activities leading to a STEM certificate, and obtained credits that could be put toward the earning of a master's degree in education through George Washington University. Both students and teachers received a stipend for their participation.

METEOR's overall aims were to enhance science literacy, and to promote greater diversity in the biomedical research pipeline. It did this by mentoring high school teachers and students from the DC metropolitan area, an area that serves mostly low-income minority students, and that employs fewer teachers specializing in STEM fields than do neighboring school districts (Klawe, 2015). The program sought to help students take the required steps toward careers in STEM and biomedical research, and to help teachers improve their abilities as STEM educators in the classroom. Specific goals were to:

- Attract young students to careers in science;
- Provide opportunities for college students to gain valuable research experience to help prepare them for graduate school; and
- Enhance the skills of science teachers and enable them to more effectively communicate the nature of the scientific process to their students.

Throughout the project's six-year duration, Knology served as METEOR's external evaluator. Using a combination of qualitative and quantitative research instruments (including surveys, interviews, and self-reflective journaling inquiries), we have measured progress toward the above goals by assessing the effects of METEOR programming on students, teachers, and mentors. During each of the project's first five years, we issued an annual report that documented yearly outcomes and provided suggestions geared toward strengthening those aspects of METEOR in need of improvement. In this final summative report, we provide a holistic assessment of the project and ascertain the extent to which METEOR met its goals.

Our evaluation focuses on outcomes for METEOR's two primary participant groups: students and teachers. With regard to students, we asked what effect METEOR had on their interests in science and medicine, whether training programs broadened their understanding of the range of scientific and biomedical careers open to them, and about the different kinds of knowledge and skills the project helped them acquire. For teachers, we asked about METEOR's impact on their knowledge of different research methodologies and practices, about the extent to which they were able to incorporate METEOR content into lesson plans, discussions, and other classroom activities, and if the project improved their ability to facilitate students' STEM and health-related career aspirations. In addition to these questions, for both students and teachers, we asked about their reasons for participating in the project, and their overall impressions of METEOR. Taken together, the data we acquired through these inquiries has enabled us to provide a comprehensive evaluation of the project, and to determine how successful METEOR was in contributing to the goal of creating a more diverse biomedical research workforce.

This Report

This report is organized into six chapters. Chapter 1 discusses the inception and development of METEOR programming from 2017 through 2022. Chapter 2 outlines the instruments, protocols, and methodological approaches we utilized to evaluate the program. In chapters 3 and 4, we focus on outcomes for students and teachers, highlighting the experiences of these participant groups across the project's six-year duration. These two chapters comprise the bulk of the report, and highlight examples, anecdotes, and other forms of evidence that substantiate our general conclusions as to the project's effectiveness. Chapter 5 summarizes our key findings and offers recommendations for future programming. Chapter 6 offers some concluding remarks and contextualizes the project in order to understand its broader significance.

Throughout this report, we refer to the project's goals and outcomes in broad, inclusive terms, using the language of "STEM and health" when discussing careers, interests, skills, and forms of scientific and/or biomedical knowledge.

Project History

Origins

The high school version of METEOR emerged out of a similar program established in 2011 for incoming first-year medical school students. Prior to matriculating, these students participated in a summer research internship that included special educational programming, social activities, and the opportunity to work with a translational or clinical researcher who served as their mentor. After completing their first year of medical school, these students participated in a second summer research internship. As of 2017, there were 14 medical students enrolled in this program. In addition to presenting their work at George Washington University's "Research Day," many of these students published the results of their research in scholarly journals.

METEOR version High School aimed to expand on this initial outreach program by shifting the focus to high school students and teachers, who were recruited into unique mentorship opportunities designed to generate excitement about STEM and health-related careers. The initial plan was to provide an 8-week summer research experience to nine high school students and two teachers every year. Students would be immersed in basic, translational, clinical, and community research, and would complete a research project linked to a topic of personal interest and community importance. Teachers would be exposed to the inner workings of CRI's research laboratories and would participate in professional development training designed to help them translate the knowledge, skills, and techniques they mastered into curricular content for high school STEM courses.

General Overview

Program Participants

The number of students and teachers who participated in METEOR changed each year of the project. Table 1 below indicates the number of students and teachers invited to participate in METEOR each year.

Table 1. Program participants in METEOR

Participant Group	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Teachers	0	2	2	2	1	1
Students	4	7	8	*	*	11

Note *Student portion of the program was not funded by NIH.

METEOR for Students

Upon entering the program, students first selected the track that best reflected their interests and needs. There were three of these in total: a research track, a clinical track, and a behavioral track. Mentorship was at the core of the program. Project leaders envisioned an internship where students worked in a laboratory under the direct supervision of a faculty scientist or physician investigator. These mentors were to guide students through all phases of the biomedical research process—from the formulation of hypotheses, through data collection and analysis, to the presentation of final results during a summer "Research Day." Students were also to work with a larger mentorship team, whose members would help them develop their critical thinking skills, become familiar with a body of scientific literature connected to their interests, and design a research question, hypothesis, and methodology for their study. In addition to learning from their mentor and mentorship team, students were to participate in a variety of specially designed enrichment activities, which provided additional opportunities to learn about the biomedical, clinical, and behavioral sciences. Examples of these activities included:

- Safety Training: a workshop that introduced students to health and safety requirements for research laboratories, and to the broader regulatory environment that governs the design and implementation of laboratory experiments;
- Lecture Series: a didactic series of lectures that covered various topics of importance, including medical statistics, robotics, molecular medicine, mobile health apps, innovation, and clinical competency in clinical trials;
- College and Career Preparation Program: a series of bi-weekly two-hour programs that helped students identify the colleges and undergraduate programs best aligned with their interests and goals, and that also provided advice on test-taking, finding appropriate scholarships, college interviewing, and other aspects of the application process;
- "Lunch and Learn": a program that brought students and their mentorship team together for a 60-minute session led by mentors, who assembled a multidisciplinary team to explore the concepts of team science and care delivery;
- Research Discussions: a series of weekly one-hour meetings in which program participants came together to discuss their research and receive feedback from peers;
- Special Interest Groups (SIGS): a series of weekly meetings aimed at fostering interdisciplinary team science;
- Simulation Center Experiences: a series of eight sessions that introduced students to pediatric physiology, disease processes, and pediatric procedures in a simulated clinical environment designed to teach students how healthcare teams work together to care for patients;
- Field Trips: a series of events in which students broadened their understanding of careers in human and animal research through trips to the NIH, FDA, and Smithsonian laboratories; and
- Student Research Day: an event held on the last day of the program, at which students delivered a poster presentation on their research to peers, mentors, hospital leadership, and CRI staff, along with students' school STEM leadership, families, and friends.

METEOR for Teachers

For teachers, there were two core elements of the program. First and foremost, METEOR sought to familiarize teachers with the workings of interdisciplinary laboratory research. After being assigned a laboratory mentor, teachers were immersed in laboratories specializing in research on one of six topics: genomics, proteomics, metabolomics, molecular pathophysiology, nanotechnology, and/or robotics. By participating in and contributing to laboratory experiments, METEOR sought to impart knowledge, skills, and techniques that teachers could apply to their work with high school students.

The second element was coursework. Through collaboration with math and science faculty at George Washington University's School of Education and Human Development (GSEHD), project leaders created a 12-credit graduate certificate program in STEM teaching. The program, which could be counted toward an MSEd degree, had two main goals: (1) to help teachers develop disciplinary practices aligned with the Next Generation Science Standards (NGSS) and Common Core Math Standards (CCMS); and (2) to help them develop classroom content that reflected real-world STEM experiences and practices, which took into account innovations in methods, tools, and techniques across a wide variety of STEM fields (including biomedical systems, space exploration, sustainable environments, big data analytics, and health services).

Teachers began the program with an instructional seminar, in which GSEHD faculty familiarized them with a pedagogical model aimed at helping them transform METEOR content into active classroom learning experiences. In addition to teaching them this model (which emphasized disciplinary practices that center student ideas and the "doing" of math and science), throughout the program, GSEHD faculty conducted site visits and classroom implementation support visits, which would allow them to tailor their instruction to the specific needs and circumstances of METEOR teachers. The faculty mentor worked with teachers throughout the academic year, assisting with curricular development, providing feedback on lesson plans and classroom activities, and ensuring that STEM pedagogies reflected the project's goals. Teachers continued coursework throughout the year and earned their STEM Master Teacher certificates in their second summer.

Program Modifications

METEOR began in the summer of 2017. Over the course of the next six years, the project evolved considerably. Some of these changes were intentional, and were made as a result of regular program monitoring and in response to recommendations issued via Knology's annual reports. Other changes were prompted by unforeseen developments—most notably, the COVID-19 pandemic. In what follows, we discuss some of the more important developments in METEOR's trajectory across the project's six-year history.

During Year 1, no teachers participated in the program, as a delayed Notice of Grant award prevented CRI and GWU staff from recruiting in time to start the Fall 2017 semester. Furthermore, although the grant proposal called for nine students to be admitted to each summer program, in Year 1, only four high school students participated in what turned out

to be a shorter, six-week summer immersion experience. This was considered a pilot year for the program.

Year 2 began the first full year of METEOR. Small modifications made on the basis of observations from the pilot program allowed project leaders to build a more complete cohort—one consisting of seven students and two teachers. With this, more mentors entered the program, and in Year 2, GWU professors joined METEOR in earnest. At the end of Year 2, recommendations from Knology helped build more interest in METEOR among the project's targeted audiences.

To increase interest and attract more applications from both students and teachers, prior to Year 3, CRI staff lengthened the application period and began the recruitment process earlier. As a result, participation was much higher: in Year 3, eight students and two teachers participated in METEOR. To help mentors and students more effectively manage expectations for the program, CRI staff also began offering a student orientation event, while also emailing mentors their students' schedules in advance.

During Year 3, project leaders also initiated several changes designed to expand enrichment opportunities for participating teachers and students. In response to a suggestion from Knology, CRI staff developed a series of extracurricular activities for students, including field trips to the FDA and George Washington University's School of Medicine. They also shared information about a competitive NIH opportunity. Perhaps more notably, for the first time, students gained the ability to return to METEOR year after year. In Year 3, one student from the previous year's cohort took advantage of this opportunity. Lastly, four students who completed the program indicated that they would continue to work with their METEOR teams as they returned to school and began their senior thesis projects.

Teachers also benefited from changes made to the program during Year 3. In response to a recommendation that METEOR engage teachers more fully, and that they be given more opportunities to make connections between their coursework and the laboratory research they participated in, during Year 3, CRI staff introduced a new "Curriculum Building Friday" program, which gave teachers the opportunity to attend lectures given at the hospital. Along with this, teachers were encouraged to both attend students' poster presentations and to make presentations of their own.

Year 4 of the project coincided with the onset of COVID-19. The pandemic necessitated a rapid transition to virtual programming, which project leaders implemented for both students and teachers. To adapt the student portion of METEOR for use in remote settings, CRI staff initially reached out to the NIH in the hopes of developing a COVID-specific plan for Year 4. Unfortunately, the NIH was unwilling to support this portion of the project, as it represented too much of a departure from the original grant. However, through private philanthropic financial support, CRI staff was able to run the student version of METEOR, creating a mix of synchronous and asynchronous online learning opportunities that combined independent coursework on COVID-19 with regularly scheduled, individual mentor meetings. While Knology did not evaluate any of these activities, CRI staff conducted an internal assessment of student learning during Year 4. For teachers, the pandemic prompted changes as well, but these were less dramatic, and the NIH approved them for funding. Other than the substitution of virtual learning for in-person learning, the teacher

experience of METEOR unfolded much as it had in previous years. On account of this, during Year 4, Knology was only able to evaluate METEOR teachers.

During Year 5, COVID-19 continued to present challenges to the project's implementation. Students who enrolled in METEOR were once again provided with a virtual learning experience. In the summer of 2021, however, COVID-19 restrictions eased, and with this came the resumption of in-person learning experiences for teachers at George Washington University (GWU). On account of the same funding constraints experienced in the previous year, Knology was only able to evaluate METEOR teachers in Year 5 as well.

Though initially intended as a five-year project, setbacks caused by COVID-19 encouraged project leaders to apply for a no-cost extension. This was obtained, allowing METEOR activities to continue into a sixth year during the summer of 2022.

Evaluation Process Overview

As METEOR's external evaluator, Knology developed a series of instruments to measure progress toward grant goals. All student and teacher participants (see Table 1 above) were asked to participate in the evaluation, as well as student mentors and GWU staff who organized the certificate program. Created to capture the experiences of these diverse audiences, our instruments were designed not only to assess program outcomes, but also, to inform program implementation and thus contribute to METEOR's long-term goal of diversifying the STEM pipeline. Toward that end, we structured our data collection efforts within a framework of cultural competence, devising tools that recognized race, ethnicity, and culture as central components of program participants' experiences. This allowed us to assess METEOR through a culturally sensitive lens, and to assess the project's primary aims in a comprehensive, holistic fashion. The data we gathered was analyzed by Knology researchers, and quotes were edited for grammatical clarity while retaining the intended meaning.

To identify project outcomes for teachers, students, CRI mentors, and GWU professors, we used the following tools:

Journal Entries

When possible, throughout the initial four years of the project, we asked students, teachers, and mentors to generate accounts of their experiences as they moved through and reflected on different METEOR activities. As a self-reflective instrument, journaling allowed these program participants to talk about themselves and their "*presuppositions, choices, experiences, and actions*" (Mruck & Breuer, 2003, p. 3). As such, this data helped us understand not only what participants were experiencing, but also, how they were perceiving those experiences.

To facilitate completion of this task, students were provided with a series of prompts aimed at helping them discuss their engagement and interaction with others, their thoughts and behaviors, their learning processes, and their key outcomes. For teachers, we provided three journal prompts over the course of the program, asking them to document ideas about curriculum modification and the incorporation of new content into the classroom. After completing the summer program, teachers were given a second set of prompts that opened a space for discussing changes made to their teaching, along with the impacts of those changes on students. Mentors also provided input through journaling. These participants were asked to discuss student engagement, to reflect on how their own background and experiences might be influencing their interactions with students, and to provide general feedback on the program.

For an example of specific prompts that we gave program participants, see Table 2 below, which lists several questions posed to teachers during Year 4 of the project.

Table 2. Journal Prompts for METEOR Teachers, Year 4

Journal number	Date sent	Journal prompts
1	July 1, 2020	1. Tell us about you. Please tell us how this program will align with your own culture and your values and then also the cultural context and values of the school where you teach. Describe your role, experience, and feelings about how it feels to be a teacher in this partnership. 2. What are your goals for working with METEOR? What are your strengths in this role? What would you like to change?
2	July 16, 2020	1. Thinking about your classroom students in general, how will you include their voices in the planning and implementing of the experience that you have had with this program? Pay attention to how race, power, inclusion, politics, and privilege may be affecting this context and discuss their relevance to the program in this journal entry.
3	July 30, 2020	1. Now that you're winding down your summer experience, please discuss the ways that it has prepared you to support STEM learning with your students. What worked? How could we improve this training? In what ways do you still need support? What work did you do here that is most in line with your long-term goals?

Surveys

Throughout the course of the project, students, teachers, and mentors were asked to fill out a series of online surveys that asked questions about STEM identity and their experiences with the program. These included:

- A ***Biomedical Science Identity Assessment***, which asked students to rate their interest in STEM and biomedical careers, the recognition they received from others, and their perception of biomedical scientists;
- An ***Alumni Follow-Up Survey***, which asked students to assess METEOR's strengths and weaknesses, and to share information about their current interest in STEM activities, fields, and careers;
- A ***Teacher Follow-Up Survey***, which asked teachers to discuss changes in their awareness and understanding of biomedical career opportunities for youth, and to document how METEOR content was being infused into their STEM curricula; and
- A ***Mentor Post-Experience Survey***, which asked mentors to provide feedback geared toward improving METEOR, especially in terms of mentor preparation requirements and personal outcomes.

Interviews

Throughout the project, we regularly conducted ***exit interviews*** with teachers, who were provided an opportunity to discuss their experiences, learning outcomes, and expected impacts on their teaching. During Year 5, when only one teacher enrolled in the program, we

recorded an hour-long interview with this participant, combining our existing journal and interview instruments. At the conclusion of Year 5, we also conducted ***retrospective interviews*** with two GWU professors, asking them to reflect on their experiences across the entirety of the project.

During the no-cost extension year, we also conducted ***summative interviews*** with student and teacher alumni who participated in METEOR at various points in the project's six-year history. These individuals were asked to reflect back on the time that had passed since their METEOR experience, and how their views may have changed over time. Some of these conversations were conducted on an individual basis, while others took the shape of group interviews.

Responses

Table 3 below provides year-by-year data on the number of students, teachers, mentors, and GWU professors whose feedback we acquired through use of the above evaluation tools.

Table 3. METEOR Assessment Respondents by Year

Evaluation activity	Participants	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Journals	Students	3	6	8			
	Teachers		2	2	2		
	Mentors	4					
Surveys	Students & alumni		8	16			
	Teachers		2	2	2		
	Mentors		7	10			
Interviews / debrief conversations	Students & alumni						11
	Teachers & alumni		2	1	1	1	5
	Mentors		5	4			
	GWU professors*					2	

Note. Knology spoke with GWU professors each year in an unstructured manner to hear about the program. In Year 5, this conversation was done as data collection via a semi-structured summative interview.

Thematic Findings: Student Outcomes

Students' Motivations

METEOR students were recruited from STEM-focused high schools, and all of those who participated did so on account of strong preexisting interests in science and medicine. Many had parents or other relatives employed in hospitals, laboratories, or other biomedical institutions, and most planned to seek employment in a STEM or health field themselves. When asked about their reasons for participating in METEOR, many indicated a desire to learn about the day-to-day occupational realities of life in different scientific or medical professions, and to use the insights gleaned from their observations of, and interactions with, working scientists to discover the specific careers that best matched their interests and aptitudes. One student considering a career in nursing indicated that they *"would like to learn more about nursing education and how a nurse does their everyday task[s]."* Similarly, a student with an interest in surgery explained how *"being in the operating room and being able to witness multiple surgeries"* would help them decide whether this was the best career path for them to embark upon.

By witnessing the practical aspects of scientific and biomedical work, students hoped to not only acquire technical knowledge and skills, but to also familiarize themselves with patterns of work within contemporary biomedical settings, to embed themselves in existing professional networks, and to develop the personal and social skills required for success within contemporary scientific and biomedical institutions. Speaking to this last goal, one student listed *"accountability, responsibility, and independence"* as skills they hoped METEOR would help them cultivate. Along similar lines, another student simply remarked that *"my expectation for my program mentors is for them to show me what they do each day so I can learn and absorb their tasks which can later help me in my career path*."

In addition to these motivations, many students explained how they were drawn to METEOR on account of its emphasis on local health concerns and the medical needs of under-served communities. One student applied to METEOR because they wanted a career where *"I'm doing medicine and helping my community in any way possible."* After completing the program, they pursued coursework in translational science and community-based medicine, and began conducting research on HIV. Explaining their career trajectory, they reflected on how *"African Americans make up the majority [of the community] and minorities period make up the majority of patients treated at [the hospital for HIV]*."

Like this student, most of those who participated in METEOR did so because they wanted to pursue an academic and/or professional future in a STEM or health field. Nearly every student we spoke with is now either attending or applying to a university, where they are planning to major in, or are already majoring in, the STEM and health fields. Still others are pursuing scholarship opportunities, fellowships at hospitals, or healthcare internships.

Students' Impressions

Our evaluation showed that students were wholeheartedly appreciative of the opportunities METEOR afforded them. Filled with statements such as *"the best opportunity," "one of the peaks of my high school career*," and *"I loved every part of the internship,"* their assessments of the project were overwhelmingly positive, and reflected a near universal belief that METEOR had made a significant contribution to their pursuit of scientific and biomedical livelihoods. Even those who initially suspected that spending six hours every day at a hospital would become *"very tiring"* reported that their experiences were *"very rewarding*." Articulating a widespread view, one student exclaimed that they were *"excited to be there every day*."

Among other things, students appreciated the *"immersive"* nature of the program, and drew attention to how shadowing scientists, doctors, and nurses in their day-to-day professional lives allowed them to see *"all aspects of the health field*." This was an incredibly meaningful activity for students, who were grateful for the opportunity to learn about real-world laboratory environments and operations, and to observe the kinds of values and behaviors required for success in different scientific fields. One student reported that interacting with doctors, nurses, and interns *"opened up a lot of opportunities*." Another student noted how *"I gained new knowledge that I will probably be using in 5 years*."

More than anything else, what students valued were the relationships they developed with their mentors and the larger teams they worked with. Students felt supported by their mentors and the other professionals on their research teams, and were grateful for the way they were respected, valued, and treated as equals throughout the six-week program. *"Even though I was just a high school student,"* one participant noted, *"I was still treated as an equal. This helped my get out my shell and network without inhibitions*." Echoing this, another student explained: *"I was able to come to my mentor and not feel judged. I like the honesty in the relationship. If I didn't know something, I wasn't scared to speak up and ask*." Another student found the relationship they developed with their mentor was *"informative yet fun,"* and explained that *"there isn't anything I didn't like*." Speaking to how they loved working *"with my research team,"* one student explained how in this environment, *"it wasn't just me talking to a group of people… it was me talking to a group of people willing to teach me the ropes and teach me what I needed to succeed*."

Mentors were equally impressed by the students they worked with. Comparing them favorably with other trainees, one mentor described METEOR students as *"very self-directed*," and went on to note how they *"tend to come in with a good foundation of scientific and technical skills that interns from other programs don't tend to have*." Mentors also praised students for their creativity, motivation, enthusiasm, and eagerness to learn. Admitting to some surprise here, one mentor remarked that *"I did not predict the level of commitment and dedication that some [students] showed*."

Many students also appreciated the social aspect of METEOR. *"The highlight of my experience was definitely the cohort,"* one student observed, echoing the views of those who similarly appreciated the way METEOR created opportunities for peer learning and networking. As another student put, the most enjoyable part of the program was *"being*

surrounded by a bunch of other people my age who wanted to pursue the same path as me." Also valuable was the opportunity to observe graduate students in medical school, whose presentations many METEOR students attended. *"I think that was very important*," one student observed, *"especially being high schoolers and not knowing where we wanted to go at that point in time, but getting to sit in on their presentations and see how they do things*."

Because of how much they enjoyed the program, many students told us that they have gone on to recommend it to their friends and peers. One student explained that when they went through METEOR their senior year in high school, they *"decided to mention it to a few of the underclassmen*." They did this to stimulate the younger students' interests in STEM and *"to get them interested in research."*

Finding #1: Students deepened their interests in science and medicine

As previously noted, the vast majority of students who participated in METEOR did so because of long-standing interests in science and medicine. But some had no particular attachment to these subjects, and others were unsure if employment as a STEM or healthcare professional was the correct career path for them. As one student explained:

> *I am unsure of what I will be in the future, and I thought I should give the medical field a chance. I do genuinely find certain aspects of medicine interesting, but I am unsure if I would pursue a stereotypical medical career.*

As a consequence of their participation in METEOR, students in both of these groups developed more positive associations with science and medicine and began to understand what some STEM-related forms of employment could look like. For many, it was the opportunity to talk and interact with a variety of biomedical professionals that deepened their interest in STEM and health careers. Underscoring this, one student explained that while traditional classroom STEM learning was uninspiring because it felt *"forced into a curriculum*," METEOR made science and medicine come alive for them. This student explained how experiencing science and medicine in real-world settings convinced them to take AP Biology in the upcoming school year. Registering similar observations, another student wrote that *"my view of myself has changed in that now I feel I could be a scientist and [it] is more enjoyable than I imagined*."

Like these students, most of those who completed the program reported an increased desire to succeed in science classes, and to pursue STEM-related extracurricular activities. *"Now that I have been part of METEOR,"* one student stated, *"I hope to apply myself more at school*," adding that they planned to *"engage more in STEM by following my science course more clearly, as well as possibly joining robotics*." Another student discussed plans to start a science club, *"so that everyone will have the opportunity to get exposure to science and the medical world*." As this indicates, for many students, participating in METEOR generated a desire to serve as STEM ambassadors, and to promote broader engagement with scientific and medical pursuits within their communities. A student who described METEOR as *"some*

of the coolest things I've ever done" explained how they now talk to their peers, friends, and family about science on a regular basis.

Even students with strong preexisting attachments to science found that METEOR deepened their interest in STEM-related activities. For many, learning about the research side of medicine brought more profound feelings of enjoyment and fulfillment. As they became aware of the fact that hospitals contain not just doctors and nurses, but also researchers and laboratory workers, students became more excited about STEM careers. Speaking to this, one student explained how METEOR *"helped solidify my interest in medicine, because I really like the science aspect and I was able to see how you can incorporate research while also being a doctor, and I didn't know you could do that."*

Finding #2: Students deepened their knowledge of different scientific and biomedical careers, and became more confident in their ability to succeed as STEM and health professionals.

One of METEOR's signature achievements was the knowledge it imparted to students about the inner workings of scientific and biomedical workplaces, and about the daily lives of STEM professionals. While in-school experiences helped them develop the scientific literacy that is a prerequisite for entry into a STEM or health-related career, METEOR's value lay in the way it showed students what it actually means to be a research scientist, a doctor, or a nurse. Mentors repeatedly drew attention to this aspect of the training program, and highlighted how effectively METEOR helped students become *"well-rounded STEM professional[s]"*—that is, individuals possessed not only of advanced technical abilities, but also of the many other forms of knowledge and expertise required for success in contemporary biomedicine. Noting that many students lack a *"full understanding"* of what it takes to be a biomedical professional, one mentor explained how they worked to help strengthen mentees' public speaking and literature review skills. Other mentors focused their efforts on communication skills, working with partners, or building relationships through networking.

Regardless of the shape they took, students gained much from these professionalization exercises. They expanded their understanding of different STEM and health-related career fields, and learned about aspects of employment in scientific and biomedical occupations they had not previously considered. One student was surprised to learn that in order to do research in a biomedical laboratory, it is essential to acquire grant funding. Another student learned that being a successful biomedical professional means *"be[ing] a jack of all trades."* A student whose mentor directed the ER acquired a deeper awareness of what a *"vast operation"* this part of the hospital is, noting how *"you have to be very on your toes,"* since *"so much stuff happens"* there. Finally, a student considering a career in nursing explained how their experiences in a pediatric hospital taught them that *"being in the medical field means helping those around you. When interactions with the patient occur,"* they noted, *"it's all about helping."*

Students credited mentors with connecting them to professionals whose interests and expertise aligned with their own career aspirations. Highlighting their success here, one mentor explained their process for helping students acquire a working knowledge of professional life in different biomedical fields:

> *One of our students really wanted to know about heart surgery and heart surgeons. I set up a meeting between him and one of our surgeons and encouraged him to read about the profession and come up with 4–5 questions for his meeting. I think this was the highlight of his summer. Perhaps students could identify a type of professional that they would like to interview and drill down into how [the professional] got to where they are now and what their life is like?*

As students acquired what one termed *"a realistic idea of what to expect when I enter the workforce,"* they also learned about new career opportunities. For one student, METEOR's key takeaway was the realization that *"you don't have to be a doctor to work in a hospital*," as *"there are lots of jobs… that you don't need a medical degree for*." After learning about the diagnosis and management of a disease, one student said that instead of pursuing a career in general pediatrics, they were now contemplating specialized study in endocrinology. Along similar lines, a student with a prior interest in prenatal care indicated that in addition to wanting to *"work with babies by bringing them into this world*," they were now considering *"taking care of them after they are born*." *"I still have a passion for… helping with women's health*," this student reported, *"but now I have to make a decision on what field I love more."*

For many students, gaining a broader awareness of the numerous STEM occupations open to them was an empowering experience. As one student explained, METEOR *"allowed me to look at scientists through a different lens. I was able to see multiple fields and how a scientist isn't defined by one thing only*." Agreeing with this observation, another student described how METEOR changed their entire view of what scientists do. *"I always thought scientists were mostly focused on chemistry, and not on medicine,"* they remarked, *"but now I know that medicine plays an important role in science*."

As they realized that the skills they were acquiring could be used in multiple STEM jobs, students became more confident in their prospects for success in science and medicine. For some, the opportunity to observe professional scientists in their day-to-day lives provided a much-appreciated confidence booster. According to one student, METEOR *"prepared me because it helped me understand the environment of the workplace."* For others, it was the completion of research projects that produced this effect. As one student explained, *"While I was developing the research project, it really proved to me my potential. I didn't think I would even be able to do it on my own, but my mentors really helped me… and didn't babysit."* Regardless, students credited METEOR with giving them a deepened sense of themselves as *"science people,"* and with making them feel they belonged to the world of professional biomedical science. As one student explained:

> *Before METEOR, I had no self-esteem that I would even get into a program whatsoever. So, when METEOR went ahead and accepted me, I was so surprised… And so, it definitely empowered me into finding different opportunities… And it empowered me so much to where I now feel competent in my ability to apply to different programs.*

Students also described how METEOR made them more confident in presenting scientific information to others, even when their audiences include *"people who know more about [the subject] than I do."* *"Not to toot my own horn,"* one student said, *"but especially when I talk to patients, I have confidence now. Especially because I've had to present for biochemistry and mathematics*." This student also explained that METEOR familiarized them with a number of professional medical terms that, while at first *"scary,"* became incredibly useful when giving presentations.

Finding #3: Students advanced their understanding of science and medicine, and acquired some of the skills required for success in STEM and biomedical fields

If gaining exposure to the day-to-day workings of different medical professionals was an invaluable experience for students, so too did they relish the opportunity to advance their understanding of the various principles and techniques associated with laboratory-based biomedical research. Most regarded this as an eye-opening experience. Inspired by the *"passion"* that mentors brought to their research, students also appreciated the *"kindness and sincerity"* with which they were introduced to hands-on laboratory work that was often novel to them. Summarizing a common sentiment, one student explained how, when in the laboratory, their mentor *"gave me opportunities to try things I have never done before*."

Students welcomed these opportunities and found that the laboratory training they received was enormously beneficial. By observing doctors perform intubations, ultrasounds, and brain surgery, students became familiar with a number of different medical procedures. Through interactions with mentors and research teams, they acquired knowledge in a variety of different medical fields, including anesthesiology, biostatistics, cardiology, psychology, and virology. So too did they learn about different diseases, and about different ways of studying them. One student explained that METEOR showed them how to look at diabetes from a psychological perspective, while a program on COVID-19 helped another student *"learn more about the virus and what is happening."* After listening to a lecture on cardiology, a student expressed satisfaction at finally *"know[ing] what the heart does*." All of this was helpful not just because it allowed students to know *"what's going on"* in their science classes, but more importantly, because it helped them decide (as one student put it) *"what direction I want my research to go in*."

Mentors generally agreed that METEOR imparted new knowledge to students. But even though METEOR students came to the program with higher levels of interest and awareness than the typical high school student, their inexperience in professional research settings

presented challenges to mentors, who found some activities unhelpful for students. Speaking to this, one mentor noted how requiring a student to attend morning rounds *"be[came] boring for them as the information is too medically complex and not meaningful for [them]."*

On other occasions, mentors found themselves underestimating students' awareness of current scientific practices and theories. One mentor recounted how most of his students came into METEOR *"with a good foundation of scientific and technical skills that interns from other programs don't tend to have."* Similarly impressed by this, a colleague explained how METEOR shattered their *"preconception"* of having to *"hold [students'] hand[s] throughout the internship."* But when this was *"not the case,"* certain training activities proved unnecessary, leaving students with down time in their laboratories. To fill these unproductive moments, they recommended that students find *"one or two podcasts they can listen to before doing a write-up on [it], or a simple research question for a literature review activity."*

Some mentors concluded that METEOR devoted insufficient time to strengthening students' research and laboratory skills. Judging that the program was *"too much,"* one mentor believed that students' schedules were too filled with *"meetings and field trips,"* which *"cut into the time that we had to work with them on their project."* In a similar vein, a colleague explained that as *"our department has something going on all of the time,"* it was *"stressful"* for students and mentors to *"work around all of the interruptions to the schedule."*

Despite these difficulties, mentors discovered ways to help students sharpen their research skills. Some devoted their efforts to helping students *"think outside the box."* Others stressed the importance of persistence and hard work, and sought to help students become more resilient in the face of unanticipated research outcomes. Speaking to this, one mentor explained how they taught students *"the importance of accepting failure."* Often, they noted, initial hypotheses are proven incorrect, and when this happens, arriving at a solution means *"get[ting] the wrong answer a couple of times."* Reflecting on this lesson, this mentor observed how it served as a *"reminder… about the importance of being unafraid to be wrong."*

Feedback from students indicates that all of these lessons were learned. When asked about METEOR's impact, one student summarized what they had learned in three words: *"communication, resilience, and teamwork."* Echoing these remarks, other students noted how they *"learned how to properly communicate with my mentors,"* and shared how METEOR increased their confidence and comfort when *"talking with professionals and adults"* and *"answering questions"* from fellow scientists. Speaking to the importance of teamwork, one student came away from the program with an acute awareness of *"how essential it is to know the people around you."*

In addition to acquiring these skills, students found that METEOR gave them a greater sense of agency and independence, especially in research contexts. Though mentors guided students through the process of data collection and analysis, it was students who chose their research topics, and devised plans for carrying out their respective research agendas. Describing the effects of this approach, a mentor explained how *"giving [them] this agency and allowing [them] to make the decisions was important, because it made [them] think*

about what it meant to form a hypothesis and pursue the data required to answer that hypothesis." In their feedback, METEOR teachers and students also spoke of how important self-advocacy was for a self-directed program like this and suggested that leadership explicitly focus on techniques for helping students build up their self-efficacy skills.

In some cases, METEOR showed students how to advocate for themselves. Considering the possibility of becoming a research intern, one student explained:

> *You can advocate for what you want in an internship… Like if you're not getting exactly what you want in the internship, you should still say exactly what you want. Because at the end of the day, you're there at the program for a certain amount of learning and you should be learning what you want to learn.*

Students came away from laboratory training with an expanded understanding of the many important qualities needed for success in biomedical research. In addition to persistence, creativity, and patience, one student highlighted the need for curiosity, stating that *"a good scientist is someone that is dedicated to their work and the cause that they are curious about. They are always asking questions because they are never satisfied with a short answer*."

By developing these professional habits, students were able to make meaningful contributions to biomedical research. When discussing these, one mentor shared the following praise of their student:

> *[They are] the reason we now have an electronic database of our past, present, and future screening data, which we will be able to conduct a wide array of analyses on. We are hoping to have our intern back again for [their] senior project!*

As this indicates, METEOR enabled students to make considerable strides in terms of their STEM-related knowledge and abilities. Some students made direct connections between METEOR and later success on the STEM job market. One remarked on how they got an internship at NASA one year after completing the program. Drawing attention to the positive impact METEOR made on their life, this student said that *"I wouldn't have applied without METEOR getting me into research first off, because that helped me look for research opportunities, and that got me towards NASA*."

Recognizing how much they had benefited from the program, many recommended it to their high school peers and friends. Describing how they promoted this among classmates, one student summed up the benefits of METEOR by sharing how *"you become so much more open-minded to what you can do in healthcare, because a lot of people are like, 'Okay, I'll be a nurse or a doctor,' but there's so much more you can do."* Because of this, the student often tells their peers that they should *"take advantage of the opportunities you have, especially because we live in the DC area and there are so many in this area that you can take advantage of*."

Thematic Findings: Teacher Outcomes

Teachers' Motivations

Teachers who participated in METEOR did so out of a desire to grow students' interests in STEM, and to discover new ways to bring engaging STEM content and activities into the classroom. One teacher expressed a hope to "*deepen [students'] relationships with the natural world and better help them see the importance/presence of chemistry*." As this suggests, some teachers identified specific topics (not just chemistry, but also immunology techniques and bioinformatic analysis) they hoped to familiarize students with, while others expressed a desire for a more general understanding of how to translate laboratory research into classroom settings. As one teacher without much prior laboratory experience put it:

> *I'm the only member of my department who doesn't have a lab science background to my teaching. I'm also the only person whose background is primarily in teaching, which is like, honestly, like a good balance in our department. But I definitely feel like I needed to strengthen my lab skills to be able to authentically teach kids biotech.*

Echoing this, another teacher cited a desire to improve their instructional effectiveness in the classroom, explaining that *"there are some areas that I could improve in the way that I deliver instruction, the activities that I create, and the lesson plans that I write*."

Beyond the goal of discovering *"new ways to implement activities and lessons to enhance student learning experience,"* teachers were also drawn to METEOR because they identified with the project's explicit goal of building a more diverse, racially inclusive STEM workforce. One teacher explained that seeing *"all sorts of demographics represented in various fields of science is important to me*." Similarly highlighting the ways that racism and economic injustices have thrown up barriers to historically marginalized groups' participation in STEM careers, one teacher noted how important it was to "*be aware of the reality of… what it is for them to live in their skin, and that they do have a fundamentally different interaction with the world than I personally experience."* Another teacher highlighted the importance of helping minority students feel a sense of belonging in STEM and biomedical fields, stating that *"fundamentally, it's just as simple as taking a young person and putting them in an environment where they may or may not have ever imagined they [could] exist*."

Toward that end, teachers hoped that participating in the project could help their schools develop partnerships with CRI, which could then yield new employment opportunities for students and promote collaborative biomedical research more generally. As such, they came to METEOR seeking insights and strategies to help their students successfully pursue STEM and health-related careers. A final motivating factor in teachers' participation was METEOR's affiliation with GWU, which gave them the opportunity to obtain a STEM Master Teacher certificate.

Teachers' Impressions

Teachers' overall impressions of METEOR were generally favorable. Most teachers reported feeling supported throughout the project. As one put it, *"everyone in my lab was super welcoming. That was awesome."* Echoing this, another teacher praised mentors for making them feel *"highly valued and respected as both a scientist and educator."* They also said that feeling like an *"active member in the lab"* was a *"highlight"* of the project.

To be sure, some aspects of the training program produced confusion and frustration. At times, it was unclear to teachers why they had been placed in a particular laboratory, and some felt that the training they received was out of alignment with their actual needs and goals. For their part, GWU professors noted that they were not always immediately aware of the different skills teachers brought to METEOR. Those with a Career and Technical Education (CET) background often had different learning styles than those who had received training in biology, chemistry, or physics, and professors admitted that it *"took a little while to wrap our heads around that."* Speaking to this, one teacher without much prior laboratory experience described how *"I don't think I got everything out of it that I could have, because I didn't know how to navigate it."*

But most teachers found the training they received incredibly beneficial. Appreciating the time METEOR allowed them to devote to professional development, one teacher explained,

> *A lot of these ideas you don't get the chance to think about when you're teaching, because you're lesson planning and grading and doing classroom management and social emotional support and trying not to burn out yourself. And so [METEOR] gave me that space.*

Along very similar lines, another teacher told us that METEOR provided

> *A much-needed break from the classroom. I had the opportunity to think deeply about the experience I'd like to provide my students during the school year. Oftentimes, the school day is so focused on monitoring students, we don't put enough emphasis on appropriate preparation.*

Finding #1: Teachers learned about new research methodologies and practices, and about how to incorporate these into their teaching

For teachers, one of the most appreciated aspects of the METEOR program was the opportunity it afforded for learning new research methodologies and practices. Incredibly appreciative of the way that METEOR prioritized their own learning, teachers relished the opportunity to become students once again. One teacher explicitly commented on the role reversal inherent in METEOR, and appreciated the fact that the program was *"about my learning rather than always worrying so much about the learning of other people."* Some teachers found that METEOR helped sharpen their argumentative writing abilities. Others explained how the program *"broadened their horizons specifically around the*

social sciences," demonstrating the relevance of social science methods and theories in STEM and health-related research.

Especially helpful was the knowledge teachers acquired through participation in laboratory-based investigations. Reflecting on how laboratory work gave teachers space to foster their own scientific curiosities and ambitions, one teacher spoke at length about the benefits of this aspect of the program:

> *I felt like I wanted to do as much as I could. I didn't want to just be a pawn there. Like, if there was an opportunity for me to make an impact, you know, I wanted to make that impact. And I felt like I did. There were some things that I contributed, both to discussions with doctors, discussions with patients, and, like, behind the scenes, that were helpful and useful. And immediately put into action! I felt great about that. I felt like a part of the team.*

Through working in laboratory-based settings, teachers acquired *"updated science content knowledge"* on a range of topics. Interactions with practicing scientists allowed them to see the *"several different sides of… how investigations are carried out in real time, with real people."* They also provided teachers with an understanding of how to conduct research informed by real-world concerns. Speaking to this, one teacher was impressed to find that laboratory teams (including METEOR students) were often people of color who were working explicitly on health issues with higher incidence rates in those communities. The teacher noted how these lab teams approached this work:

> *They were specifically trying to improve early onset allergies and early onset diabetes in communities of color because they recognized through the research that those groups were at the highest risk. And I thought that the awareness and recognition and intentionality around that was awesome.*

It was experiences like these that led teachers to use words like *"groundbreaking"* and *"innovative"* to describe the laboratory aspects of METEOR. Articulating the consensus view, one teacher concluded that *"the research process really was the part that met and exceeded expectations."* Teachers also felt that the coursework component of METEOR was valuable. At times, however, they struggled with this. Some found the coursework insufficiently adaptable to classroom contexts. On this point, one teacher expressed dissatisfaction with how *"rigid"* this content was, saying that it was too *"focused on standards."* The emphasis on standards was seen to be incompatible with the desire to create lessons specifically tailored to students' needs. As one teacher put it,

> *I think that the professors had a very specific idea of what the products would look like, and they had to try to be flexible because they recognized that everybody's situation was different. So, like, while that flexibility was there, the feedback was still very much pushing you to try to make it a little bit more towards their expectations. I was teaching in a school where the curriculum itself was a little bit more flexible. And there was sort of a mismatch between that idea and the focus on doing standards and focusing on the NGSS. What would NGSS say about this? How can you incorporate NGSS? … I felt like was restricted and I was catering to that framework, rather than like building a lesson that really worked for the class.*

As this feedback suggests, teachers sometimes felt that their professional classroom experience (along with their deep knowledge of their own working contexts) was not always acknowledged in the GWU courses. Drawing attention to this, one teacher explained how

"our expertise wasn't always valued" in the GWU classroom, adding that *"our own knowledge of our teaching context wasn't always valued*."

Despite this, on the whole, teachers generally agreed that METEOR was relevant to their work as science educators and found that the training they received provided a useful *"jumping off point"* for developing new classroom content. Through their GWU coursework, some teachers realized that their curricula were outdated, and many applauded the way guidance from GWU professors helped them improve the quality of their lesson plans, lectures, assignments, and laboratory activities. Discussions with colleagues were also beneficial in this regard. According to one teacher, learning *"how [a fellow METEOR teacher] is embedding [STEM content] in the course has definitely been an interesting thing to discuss and talk about, and I think it's advanced my craft indirectly*."

Teachers were also able to translate their laboratory experiences into new and improved forms of classroom instruction. One teacher explained how their laboratory training enabled them *"to take the things that I was learning… and help my students create connections between research and education*." Another teacher gave a particular example of a research approach that they were able to apply to their classroom practice:

> *I'd love to give a more specific example. So, with the allergy team that I'm on they were… examining like anxiety around allergies. … They created a survey with like 4000 variables on it and they were compiling the data and looking for trends in the data. With my physics students, we do these labs where I let them design the lab and we look for trends in the data. So that is the big connection I'm making… While that's not directly related to allergies in teenagers, the process that they're following is, you know, analogous to the process that we're following.*

Regardless of how they benefited, teachers agreed that METEOR left them feeling more confident in their pedagogical abilities, and more capable of familiarizing students with the kinds of laboratory skills and techniques needed for success in the world of 21st century biomedical research.

At times, lack of awareness of infrastructural and legal constraints on the part of METEOR leadership made it difficult for teachers to maximize classroom applicability of the skills and techniques they learned. At some schools, the biomedical equipment needed for certain laboratory activities was unavailable, and at times, laws preventing those under the age of 18 from working with certain biomedical materials. This created a barrier to effective translation of METEOR content into classroom settings. One teacher who experienced these difficulties noted how *"it took several weeks to find a clear curriculum connection where I could transfer [what I was learning]*."

Along with infrastructural and legal obstacles, some teachers felt that GWU professors were too quick to transition from learning to questions of classroom applicability. They struggled to figure out how to incorporate newly acquired learning into their teaching practice.

As one teacher reported,

> *It was difficult for me to enter into a new space and for people to be like, okay, how are you going to implement this into your classroom? … I remember it was like, my first week in the summer course, [and] I was being asked how I thought I was going to incorporate this into the classroom. And I was like, I have no idea.*

From the perspective of these teachers, GWU professors' lack of flexibility hindered their ability to introduce students to new STEM content. One teacher who *"got some helpful tools"* from METEOR nevertheless explained how *"I didn't use a lot of the stuff because it did feel very rigid already."* Instead of *"'we know this is the best way to teach science. Use these techniques. Try this in your classroom. Go do this like this,'"* teachers wanted *"a little bit more of a conversation between the school context and the lessons that we were getting."* In their opinion, a better understanding of teachers' classroom situations would have allowed GWU professors to collaborate with them in negotiated discussions on how to best apply STEM concepts and ideas. Beyond this, some teachers felt that learning a broader range of STEM skills (for example, those in biotechnology) would have given them more choices when thinking about how to apply their learning to classroom contexts. GWU professors expressed similar sentiments and voiced a need for greater support of teachers attempting to adapt METEOR content for classroom use.

Even with these difficulties, however, it is clear teachers benefited immensely from METEOR. Once made aware of problems with the program, mentors reported making changes that enabled them to be *"responsive to where the teachers were and what they were thinking about."* Teachers appreciated these real-time adjustments, along with those necessitated by the onset of the COVID-19 pandemic. Though the transition to virtual learning was difficult, mentors provided advice on how to set realistic expectations for students, while also helping them modify lesson plans for use in online environments. Some mentors even helped teachers design specific assignments and activities for remote learning, including inquiry-based projects that students could complete independently. Teachers were incredibly appreciative of this guidance, and credited their METEOR mentors with helping them navigate the educational challenges posed by COVID-19. As one said, *"it ended up being a meaningful experience I will transfer to the classroom; it just didn't happen the way I thought it would at the beginning*."

Finding #2: Teachers learned how to build more inclusive STEM learning environments

In addition to learning how to bring biomedical laboratory research methods into the classroom, METEOR showed teachers how to create more inclusive STEM learning environments. Participating in the project impressed upon them the value of having open discussions with students, and of incorporating students' opinions, perspectives, and perceptions into classroom activities. Engaging with what students already know about a topic, one teacher explained, *"will allow the entire classroom to hear different preconceptions that often develop into misconceptions of the scientific information*." Beyond providing an opportunity to clear up these misconceptions, teachers learned that by

engaging more directly with students, they can create a curriculum more responsive to their needs, backgrounds, and circumstances. Through participation in METEOR, one teacher developed a suite of professional development resources designed to help colleagues support students who struggle with executive function. Another teacher reported that the project helped them better support students with autism or sickle cell disorder.

In addition to incorporating students' voices into classroom discussions, teachers learned how to create a more racially diverse form of STEM education—one attentive to the circumstances and concerns of a student population that is predominately African American or Black. In service of this goal, one teacher explained how they would prioritize the reading of documents and studies authored by scientists of color, which would help students see themselves reflected in the STEM workforce. Others voiced a desire to help students explore the impact of racial discrimination in STEM, noting that *"if you were to find a person of color in a lab, they're probably there as a tech, they're probably not there as a lead researcher*."

As this suggests, METEOR encouraged teachers to recognize the double bind that Black and African American students face. Drawing attention to this, one teacher reflected on how *"students who are not white and upper-middle class are often left out of academic settings because they don't possess the culture. Not only do they need to learn the content, they are also tasked with learning a new culture*." Recognition of this inspired teachers to develop strategies that would help Black and African American students overcome the exceptional barriers to STEM careers confronting them. As one teacher put it,

> *I needed to have more experience with research so that I could more correctly teach it, so that I would have more kids persist through. Because when I just think about my student population, they're going to face so many things when they get to a four-year school. Many of them are first generation college students. There is a certain GPA attached to maintaining scholarships and if they fall below it, they leave the program they're in. We know that imposter syndrome is a thing that plagues our kids. [T]he only way I know how to rectify that is to teach them really damn well, and that's what I was looking for [in METEOR].*

Voicing similar sentiments, another teacher noted that their students *"are going to have so many barriers to entry"* into the STEM and health professions. Given this, they concluded that *"one of the best ways I can prepare them to burst through those barriers is [by ensuring they are] incredibly competent*," and by helping them acquire advanced biomedical research skills.

If participating in METEOR gave teachers insights into how to craft curricula sensitive to the realities of racism, so too was the project beneficial in helping them tailor STEM education to students with different kinds of personalities and scientific aptitudes. One teacher noted how METEOR provided them an opportunity to *"dig into identity as an expression of profession*," and think about how students can choose different STEM and health career paths on the basis of their personalities and values, not just their knowledge and skills.

Another teacher spoke of how their training showed them how to help students devise research agendas linked to their real-world experiences and concerns. One teacher described their attempt to connect research to the things students care most about in this way:

> *What I'm doing now is I'm putting in the time finding out what they're interested in and making a science project out of that. … I had several kids looking to explore how the pandemic impacted kids' mental health [and] how screentime is related to kids' GPA.*

Another way teachers learned about how to create more inclusive learning environments was by incorporating theories, approaches, and perspectives from the social sciences into the classroom. Reflecting on how this impacted their teaching, one teacher who runs an annual science fair at their school explained how prior to participating in METEOR, they had *"pushed every kid into doing a traditional bench science project with, you know, an experiment and a hypothesis."* Having previously referred to social sciences as *"soft,"* METEOR completely changed their mind. *"That's one of the things that I learned this summer, is that in the real world there is no soft science."*

Along these lines, another teacher remarked on how METEOR helped them realize that their class consisted of two main groups: one that was effective at following laboratory procedures, and another that preferred to conduct research in a more independent, less linear manner. Not wanting students in either of these groups to develop negative attitudes toward science, this teacher noted how METEOR gave them a language for talking about the many different careers that exist within the STEM and health fields. Discussing these with students offered an opportunity to increase the appeal of STEM fields, and to promote a kind of "STEM for all" mentality. As they said,

> *How do I authentically serve both of those student populations because they're honestly very different? The students who are more a natural fit for researchers are definitely on a more traditional academic pathway, and then the students who are a more intuitive fit for tech [jobs] are definitely a non-traditional pathway?*

Recognition of these multiple pathways encouraged teachers to develop a more pluralistic form of STEM pedagogy—one that reduced barriers to access and success within STEM and health professions.

Finding #3: Teachers deepened their commitment to promoting students' access to STEM and health-related careers

In connection with this goal, many teachers came away from METEOR with a broader understanding of the range of STEM careers their students could pursue, and with a deepened commitment to helping them find entryways into different STEM and health fields. One teacher explained how after completing the METEOR program, they *"saw new careers that I can tell my students about that I personally didn't know about."* Some explained how METEOR broadened their view of what constitutes a STEM professional, prompting

recognition of the connections and areas of overlap between STEM fields, biomedicine, and the social sciences. As one teacher put it,

> *After this METEOR experience, I have a broader appreciation and viewpoint of the different science careers that are out there. And as I have the students that are doing these social science projects, I'll be able to better funnel them towards potential careers related to that.*

As this observation indicates, METEOR helped teachers more effectively contribute to their students' pursuit of STEM and health-related careers. One teacher reported that as a result of participating in METEOR, they were *"going to be able to push my students into fields in directions that I didn't even know about previously*." Others shared plans for helping students find laboratory-based employment opportunities, especially at Children's Medical Center (where CRI is based). One teacher noted that they had already begun to work with researchers on a program designed to give students more hands-on laboratory experience. As this teacher said,

> *I found a person who wants to create a welcoming lab, is very committed to improving representation in labs, in general, and, and believes in teaching, like not just doing [their] research, [but rather] believes in being a source of education, and that [they are] allowing me to create this ongoing relationship.*

This teacher was collaborating with the laboratory they worked with during the METEOR project to create a summer youth employment program for high school seniors. Along with this, they also expressed a desire to invite guest speakers into the classroom, and to convene school-wide meetings in which panels of scientists would talk about their backgrounds and their research. As they noted, ensuring student access to STEM careers is primarily about exposure, as well as cultivating the confidence in students to pursue a professional direction where there is no precedent in their community or their family, or where they may not feel like they belong. Said one, "*if they didn't come from a very affluent family or well-educated family, they're never going to see these things, [yet] they are fully capable of becoming these different professions*."

Another manifestation of teachers' deepened commitment to helping students become successful, thriving STEM professionals can be seen in their willingness to work directly with those completing the six-week program. Particularly was this the case when METEOR teachers and students came from the same school. Speaking to the opportunity the program provided for building relationships with students that extended from summer to fall, one teacher said that they *"would have liked to engage more with the students that came from my school."* Doing this would not only help teachers guide their students through the process but would also result in a *"better and deeper understanding of what [students] were supposed to get out of the program*." Along similar lines, another teacher remarked on how fostering closer relationships with METEOR students might help them feel like colleagues, and thus eliminate traditional classroom hierarchies in a very beneficial way.

Discussion & Recommendations

METEOR was a project that aimed to diversify the STEM pipeline by broadening access to scientific and biomedical careers among racial minorities. Through partnerships with George Washington University and the DC Public and Public Charter High School systems, staff at the Children's Research Institute created an intensive, six-week summer program that immersed high school students and teachers in the culture of professional biomedical research. METEOR's goals were to help students take the required steps toward careers in STEM and biomedical research, and to help teachers improve their abilities as STEM educators in the classroom. In service of these goals, the project provided students and teachers an opportunity to participate in laboratory experiments, to attend lectures and seminars, and to interact with practicing scientists on a day-to-day basis.

After six years of evaluation, Knology has determined that METEOR met each of the project's primary goals. The data we collected showed that METEOR deepened students' interests in science and STEM and health-related careers, that it made students more knowledgeable, and more confident in their prospects for success as STEM and health professionals, and that it made teachers more knowledgeable and effective classroom instructors. The program's successes in each of these areas speaks well to METEOR's value as an important tool for helping the STEM and health fields become more diverse, and more racially inclusive.

These significant achievements notwithstanding, we believe it is important to also call attention to several challenges METEOR encountered over the course of its six-year history, and to issue a series of general recommendations aimed at helping CRI staff improve the quality of future iterations of this or similar projects. As METEOR's success hinged on the extent to which students and teachers were able to forge meaningful relationships with mentors, CRI staff, and GWU professors, the following discussion focuses on several relationship-related obstacles the project faced.

Students' Relationships with Mentors & CRI Staff

For many students, the mentor-mentee relationship at the heart of METEOR was a highlight of the program. Some formed close-knit bonds with mentors and CRI staff, and applauded the way these individuals helped them advance their interests, knowledge, and career pursuits. Highlighting the importance of these relationships, one student explained how *"I really liked my mentors. I really connected with my person… I was text[ing] them all the time*." For some students, the ties they developed with their mentors were so strong that they persisted after the conclusion of the program. Noting this, one student wrote of how their mentor kept in contact with them, advising them *"about colleges… that are best for medical careers, and finding STEM opportunities."*

But this was not true for all students. At times, they found mentors and CRI staff to be distant, uninvolved, and seemingly uninterested in their academic progress. When asked

about this, one student mentioned that METEOR would benefit from more *"energetic"* CRI staff—that is, staff who *"actually enjoy being around kids."* Those unable to regularly interact with their mentors observed that METEOR sometimes felt *"a tiny bit disorganized*." Sensing that their laboratory work was out of alignment with the content of other enhancement activities, they reported *"being all over the place"* in their research.

Even those students who rated their mentors quite highly occasionally remarked on how they did not get as much time with them as they had expected. For some, this necessitated finding new, informal mentors, or greater reliance on the broader research team. For example, after making a serendipitous connection with a researcher in a different part of the hospital, one student explained how they *"asked them if they could mentor me on top of my mentor, since I knew my mentor was often out of town*."

In their feedback, mentors also drew attention to their inability to work as closely with students as they would have liked. This was particularly true for the early years of the project. A Year 1 mentor indicated that they felt *"frustrated by the fact that I wanted [them] to participate in an activity or work on a project but [they were] unavailable."* Along similar lines, a Year 2 mentor found themselves continually uncertain as to whether students were *"at a METEOR event, at home or otherwise*." Corrective action to address this problem began after Year 1, and by Year 3, CRI staff were sending weekly overviews of students' schedules to all mentorship teams. This administrative change alleviated much of the confusion and frustration mentors expressed during Years 1 and 2. Nevertheless, feelings of disconnection continued to surface in their feedback, as even in Year 3, mentors indicated difficulties in judging student interest in METEOR, and in determining whether or not the research they completed was actually helping their pursuit of biomedical careers.

Teachers' Relationships with Mentors and Professors

Throughout the project, METEOR teachers remained highly impressed with how committed their mentors and professors were to furthering their professional development. At the same time, they also regularly drew attention to a few challenging aspects of their relationships with them. More than anything else, they stressed the need for better communication between Children's National Medical Center, George Washington University, and the METEOR program lab facilitators. Clearer, more direct communication about expectations, activities, and the coordination of lab schedules around their GWU coursework would have been immensely beneficial, they concluded.

Among other things, better communication might have prevented misalignment between teachers' expertise and their laboratory assignments. One teacher said they would have preferred a conversation with METEOR leadership about suitable lab options ahead of time, and more transparency about how placements were made. This could have prevented the teacher from feeling like the time they spent thinking about labs they were interested in was akin to "*putting a lot of energy into something that ended up not really mattering*."

Teachers also believed that better communication would have improved teachers' ability to translate laboratory work into curricular content. Some teachers expressed frustration about a perceived lack of awareness of their schools' circumstances, and the specific needs of their students. One teacher explained that had more information been communicated about their situation, they might have been able to acquire research skills applicable to biotechnology (a focus of their efforts at the high school where they worked).

For their part, mentors highlighted a lack of rigorous follow-up with teachers after the conclusion of the program as another of METEOR's key challenges. They recommended that future iterations of METEOR be designed to include specific opportunities for follow-up.

Teachers' Relationships with Students

Throughout the project, teachers' primary interactions were with mentors and GWU professors. While appreciative of the knowledge- and skill-building opportunities these interactions provided throughout the course of the project, almost all METEOR teachers we heard from indicated a desire for more time with METEOR students. To be sure, opportunities for teacher-student interaction did exist, and when both teachers and students returned to the hospital campus in-person during Year 5, teachers' contracts explicitly required them to proactively engage with students. Given this, it is possible that in some cases, teachers were simply not taking advantage of existing opportunities for interaction with students. Yet even those who did attend brown bag lunches, lectures, and student presentations felt unsure of how to prepare for and participate in these events. This perhaps suggests that teachers were hoping for project leadership to manage their schedules more directly.

At the same time, teachers signaled a desire for additional learning activities designed to promote interactions with METEOR students. Given the fact that much of the teachers' training was geared toward helping them become effective STEM instructors, METEOR teachers believed that had more time been set aside for interactions with METEOR students (especially those from their own school), the process of translating their laboratory experiences and GWU coursework into curricular content for high school audiences would have gone much smoother. Perhaps activities aimed at fostering collaboration between METEOR teachers and METEOR students would have prevented difficulties like the following, which a GWU professor noted during Year 5 of the project:

> *Translation… [of] that summer experience into the classroom experience… that's where we still need to push. And I don't know what the solution is there, if it's, you know, just more time to develop these things out and wrestle with the ideas a little bit more before implementing them.*

This GWU professor also thought that scheduled student-teacher interactions might *"give teachers the space in their curriculum to do this work."*

Teachers also felt that building time with students into the program would have improved the quality of students' research experiences. One teacher described being *"a little taken aback"* when they saw a student's final product, and felt that more interactions among these

participant groups *"would have made the experience for [the students] a lot better and the products a lot better."* Echoing this, another teacher told us that:

> *I definitely wanted there to be a little more interaction between the students doing [METEOR] over the summer and the teachers. I don't feel like we got a lot of that. … It would be an interesting experience for all of us to be kind of colleagues in a sense.*

In addition to making their laboratory research more relevant, teachers thought they could help develop some of the non-technical skills required for success in the world of professional biomedicine. On this point, one teacher explained that as self-advocacy is not necessarily something all high school students possess, they could hold sessions during the METEOR program focused on developing this skill.

Recommendations

Throughout the course of this six-year project, METEOR steadily improved, as regular adjustments made by CRI staff resulted in better outcomes for both students and teachers. Given this, in what follows, we provide a series of recommendations that reflect lessons learned over the course of the project—many of which CRI staff have already implemented to a considerable degree. As in the previous section of this chapter, our remarks here focus on the relationships at the heart of the METEOR project.

Student-Mentor Relationships

Based on the feedback we received about student-mentor interactions across the project, we recommend that METEOR leadership work to strengthen the quality of these relationships in the following ways:

Include Mentors in the Recruitment Process

In Year 3, CRI staff began hosting an "interview day," where four mentors contributed to the student selection process. Expanding mentors' involvement in this process will help them learn more about the students they would be working with and would allow for them to pre-select those whose interests most closely align with their respective lab research.

Think Beyond Mentors to Mentorship *Teams*

Mentorship was crucial to METEOR's success, and most students reported benefiting immensely from the ability to shadow their mentors. Moreover, throughout the program, many students were able to forge informal mentor-mentee relationships with other scientists they encountered in their day-to-day work. To encourage these kinds of relationships, project leaders can look for ways to formalize the construction of mentorship teams—groups of hospital professionals who can jointly oversee and facilitate students' completion of the program. Developing these teams will help reduce the burden on individual mentors, will give students' access to a broader swath of STEM and healthcare professionals, and will increase students' chances of success in charting out a career path that aligns with their interests and aptitudes.

Focus More Explicitly on Students' Research Projects

To help ensure that students' research projects serve their career goals, early conversations with their mentorship teams should revolve around the development of research questions, the creation of a formal study methodology, and plans for data collection and analysis. Providing a research template for students to fill out will provide a more structured way for students to begin thinking about their work. Having students work with their mentorship team on these things from the very beginning of METEOR, with regular structured check points, will help them see the big picture and provide clarity to the process.

Create More Time for Relationship Building

To promote more regular contact between students and members of the mentorship team, METEOR leadership could schedule daily check-ins between these participant groups. In Year 6, this change was implemented by CRI staff, with positive impacts on student-mentor relationships. Another suggestion would be to structure students' schedules so that they spend at least two days of every week working in a mentorship team member's laboratory. Along with this, sharing students' schedules with mentors will help them better support their learning, as they will be apprised of each activity and requirement students have to attend and meet. This type of interaction between students and mentor teams was implemented in the later years of METEOR and should continue as a regular part of the METEOR program moving forward.

Teachers' Relationships with Mentors and Professors

Based on feedback received from across METEOR's six-year history, we recommend that leadership continue working to better understand teachers' needs and goals. Some specific recommendations include:

Match Teachers to the Laboratories Most Closely Aligned with their Needs and Interests

Being transparent about the process of laboratory assignments is important, as is giving teachers some input into this process. Mentors should be fully cognizant of teachers' existing knowledge and skills base prior to the program's inception and should be empowered to provide teachers with the particular kinds of resources and supports they need. For those with no or limited laboratory experience, mentors should share guidelines about norms and expectations. Doing this will help ensure teachers get as much as they can out of their laboratory experiences. Additionally, it is important that METEOR staff work with teachers to understand what types of equipment and resources they have available in their own classrooms. This will help to align lab-based projects and procedures with the learned skills and abilities teachers bring back to the classrooms.

Create Opportunities for Follow-up After the Conclusion of the Program

To see how effectively teachers have been able to translate their METEOR experiences into high school STEM content, it would be helpful if mentors and/or GWU professors conducted follow-up calls or visits. Post-program meetings with METEOR teachers could also lead to the

creation of plans for formally assessing the curricula teachers developed based on their experiences in the program.

Student-Teacher Relationships

The student and teacher components of METEOR existed independent of each other, and our evaluation showed that each was successful on its own. As this indicates, in order to be effective, METEOR does not need to exist with both components being run at the same time. Nevertheless, should future iterations of METEOR include student and teacher programs that are run simultaneously, we recommend that leadership build time into project schedules that allows for interaction and relationship-building between METEOR teachers and METEOR students. This goal could be realized in any of the following ways:

Create New Activities for Student-Teacher Dialogue

Creating activities that are specifically designed to promote student-teacher interaction could be quite beneficial for the program, as these would allow participants to share their respective experiences, to brainstorm idea for bringing METEOR content into the classroom, and to forge relationships that would continue to grow even after the program's conclusion.

Incorporate Students into Teachers' GWU Coursework

Bringing METEOR students into the GWU classroom environment would familiarize professors with the end users of the curricular content they help teachers design. Having informal pedagogical experiments with actual students would allow professors and teachers to test their ideas. At the same time, this experience could be a useful networking opportunity for METEOR students.

Tie the Program Back into School-Based STEM Education

To ensure that the new knowledge and skills METEOR students acquire provides a base for subsequent growth during the school year, involve school administrators in the project, who can make sure the METEOR experience pervades high school STEM curricula more generally. In addition to this, work with administrators and teachers to set aside time during the school year when past METEOR students can talk to incoming or prospective students about their experiences. Students may also relish being able to present their summer work to their peers in a live, in-classroom setting.

Conclusion

High school students with interests in STEM and health-related subjects frequently struggle to acquire the advanced training required for success as scientific and healthcare professionals. A particular "chokepoint" in the STEM pipeline is the transition from high school to college or university, where an absence of strong role models or professional connections can prevent aspiring STEM students from entering undergraduate programs in these fields. This problem is particularly trenchant for racial minorities, who face considerable obstacles to entering the STEM and health pipelines.

To help students bridge the gap between secondary and post-secondary STEM education, in recent years, a number of institutions have launched precollege outreach programs targeting those with strong attachments to science and medicine. In 2017, the Children's Research Institute (CRI) at the Children's National Medical Center secured NIH funding (Award 1R25HD090722-01) for such a program. Called "Mentored Experience to Expand Opportunities in Research version High School" (METEOR), it provided high school students and teachers throughout the Washington, DC metro area with short-term training opportunities in biomedical research. Lasting for six years, METEOR was structured as a series of six week-summer programs, in which students and teachers were familiarized with real-world research practices within a children's medical center. Gaining access to the inner workings of the world of biomedical research, METEOR participants had an opportunity to develop the kinds of knowledge and skills required for success in a variety of STEM and biomedical occupations.

METEOR's overall aims were to enhance science literacy, and to promote greater diversity in the biomedical research pipeline. The program sought to help students take the required steps toward careers in STEM and biomedical research, and to help teachers improve their abilities as STEM educators in the classroom. Our assessment revealed that METEOR accomplished these goals. Students came away from the program with deeper interests in science and medicine, with greater knowledge of scientific and biomedical careers, with increased confidence in their prospects for success as scientific and biomedical professionals, and with more of the knowledge and skills required for success in a variety of STEM and health-related fields. For teachers, METEOR yielded a knowledge of new research methodologies and practices, a better understanding of how to incorporate these methodologies and practices into their classroom teaching, and a deeper commitment to promoting the pursuit of scientific and biomedical careers across diverse groups of students. While certain aspects of the program proved challenging, our overall findings indicate that METEOR is well-positioned to help broaden the STEM and health pipelines, and to widen access to STEM and health-related professions among racial minorities and other marginalized groups.

References

Alfred, M. V., Ray, S. M., & Johnson, M. A. (2019). Advancing women of color in STEM: an imperative for US global competitiveness. *Advances in Developing Human Resources*, *21*(1), 114–132.

Centers for Disease Control and Prevention. (2014). *Practical strategies for culturally competent evaluation*. US Department of Health and Human Services.

Constan, Z., & Spicer, J. J. (2015). Maximizing future potential in physics and STEM: Evaluating a summer program through a partnership between science outreach and education research. *Journal of Higher Education Outreach and Engagement*, *19*(2), 117–136.

Danter, E., Field, S., Ardalan, N., & Flinner, K. (2018). *METEOR v. HS Year 2 Evaluation Report*. New Knowledge Publication #NIH.090.362.02. New Knowledge Organization Ltd.

Danter, E., Bhana, H., Ardalan, N., & Barchas-Lichtenstein, J. (2017). *METEOR V. HS: Summer 2017 Pilot Study*. New Knowledge Publication #NIH.090.362.01. New Knowledge Organization Ltd.

DePoy, E., & Gitlin, L. N. (1994). *Introduction to research: Multiple strategies for health and human services*. Mosby.

Hunt, P. K., Dong, M., & Miller, C. M. (2021). A multi-year science research or engineering experience in high school gives women confidence to continue in the STEM pipeline or seek advancement in other fields: A 20-year longitudinal study. *PLOS One*, *16*(11), e0258717.

Kemp, K., Swanberg, S., Kamel-ElSayed, S., Grogan, J., Williams, T., & Reed-Hendon, C. (2021). Addressing projected healthcare and STEM profession needs through a regional summer pipeline program. *Journal of STEM Education: Innovations and Research*, *22*(4), 1-18.

Kitchen, J. A., Sonnert, G., & Sadler, P. M. (2018). The impact of college-and university-run high school summer programs on students' end of high school STEM career aspirations. *Science Education*, *102*(3), 529–547.

Linnenbrink-Garcia, L., Perez, T., Barger, M. M., Wormington, S. V., Godin, E., Snyder, K. E., Robinson, K., Sarkar, A., Richman, L., & Schwartz-Bloom, R. (2018). Repairing the leaky pipeline: A motivationally supportive intervention to enhance persistence in undergraduate science pathways. *Contemporary Educational Psychology*, *53*, 181–195.

Mruck, K. & Breuer, F. (2003). Subjectivity and Reflexivity in Qualitative Research—The FQS Issues [17 paragraphs]. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *4*(2), Art. 23, *http://nbn-resolving.de/urn:nbn:de:0114-fqs0302233*.

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