FEATURE

Building a Mentorship-Based Research Program Focused on Individual Interests, Curiosity, and Professional Skills at the North Carolina School of Science and Mathematics

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Abstract: The North Carolina School of Science and Mathematics (NCSSM) offers students a wide variety of real-world opportunities to develop skills and talent critical for students to gain the essential professional and personal skills that lead to success in science, technology, engineering, and mathematics (STEM) careers. One of the key avenues available to gain research experience is the *Mentorship Program*. This program uses a unique pre- and co-curriculum that guides approximately 80 students each year to take a leading role in setting up and executing a research experience with professionals and scholars at local universities/corporations. The *Mentorship Program* is based entirely on students seeking out mentors of interest at partner institutions. Successful partnerships rely on a strong interest and goodwill among researchers and professionals to mentor as well as the appropriate structure and student preparation by the partner school. The program emphasizes that experiential learning is still a "classroom" academic program and not just an enrichment program, internship, or shadowing experience.

Keywords: STEM, STEM high schools, high school research, mentorship, skill and talent development

> "The *Mentorship Program* provides the opportunity for students to develop and practice soft skills such as resourcefulness, teamwork, professional communication, and taking responsibility for accomplishing desired goals."

Introduction

The North Carolina School of Science and Mathematics (NCSSM) is a public, residential, coeducational high school for academically talented juniors and seniors with a commitment to scholarship. This article highlights both the school and its focus on integrating academic research experiences into its curriculum but focuses on two unique aspects of its *Research Mentorship Program*: (a) permitting students to ask any researcher in the area to be a mentor and (b) designing a professional skills curriculum around a program where 80 students are working on 80 independent research projects in dozens of fields of study.

The school was established by the North Carolina General Assembly in 1978 to provide challenging educational opportunities for students with special interests and potential in the sciences and mathematics. The school opened in 1980 on the vacated Watts Hospital campus in

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Durham, North Carolina as the first school of its kind—a public, residential high school where students study a specialized curriculum emphasizing science and mathematics, without neglecting other essential areas of study, such as the humanities and the arts. Possibly the most remarkable item of note is that students and families pay no tuition, room, books, or board. If the student is admitted, it is free.

Today, specialized science, technology, engineering, mathematics (STEM) high schools are located across the United States. Many are connected together by the *National Consortium of Secondary STEM* Schools. In North Carolina, for example, 119 of the state's 358 high schools are identified as having a STEM focus (Arshavsky, Corn, Parker, & Stallings, 2011). When an institution's mission is to educate talented students to become leaders in STEM fields, as it is at NCSSM, providing students with significant research opportunities is a critical component in helping fulfill that mission. Research courses at the NCSSM provide students with a range of experiences working with faculty on campus, or with faculty and professionals at corporations or major research universities (Duke University, the University of North Carolina [UNC] Chapel Hill, North Carolina State University, North Carolina Central University), all of which are in close proximity to the school's campus. Affording students significant experiences working with research scientists, engineers, software developers, entrepreneurs, and others provides not only an opportunity for a different mode of learning in producing real results, but it also allows students to see firsthand what these professionals do in real-world settings, which has been shown to have a positive effect on students majoring in STEM disciplines in college (Subotnik & Tai, 2011).

School Background

At its founding (North Carolina General Assembly, 2007), NCSSM was envisioned as a catalyst for improving science and math educational opportunities and outcomes for students from across the state, and was one piece of an ambitious agenda that tied improving education in the state to transforming North Carolina's economy. Since its inception, although NCSSM has grown in size and has become a constituent institution of the UNC system, it has held remarkably true to its original legislative intent. The school's mission is

> to educate academically talented students to become state, national and global leaders in science, technology, engineering and mathematics, advance public education in North Carolina, and inspire innovation for the betterment of humankind through challenging residential and online programs driven by instructional excellence and the excitement of discovery. (North Carolina School of Science and Math, 2015, para. 1).

NCSSM accomplishes its mission through its residential high school program and through its engagement with students, teachers, and schools across the state through distance education, educational curriculum and content development, and professional development services.

Academic Program

NCSSM enrolls 680 residential 11th- and 12th-grade students who hail from the mountains to the Atlantic Ocean. During the 2014-2015 academic year, students enrolled at NCSSM represented 90 of North Carolina's 100 counties.

NCSSM instructors also reach statewide over 350 students per year in its online program and another 450 students per year via interactive video conference courses. Both virtual programs are growing. The school further serves the state through the creation and distribution of digital learning materials, faculty-led outreach unique to their field of study, and sponsorship of competitions and events focused on STEM education, including programs for both middle- and high school students in the summer.

The residential and distance education curriculum offers courses ranging from multivariable calculus and differential equations, to organic chemistry and astrophysics, to statistics and Advanced Placement (AP) computer science, to AP economics and wisdom, revelation, reason, and doubt. Although all of the courses offered are rigorous, the hallmark of NCSSM's academic program is facilitating student learning so that students not only gain in-depth knowledge within and among academic disciplines, but they also learn, through a problem-based approach, to apply their knowledge to solve real-world problems. This approach to teaching and learning can be found in classrooms across NCSSM's academic disciplines and is nowhere more evident than in research courses.

Overview of Research at NCSSM

Engaging in the process of research, although not a requirement for NCSSM students, is a common activity. Since NCSSM began tracking in 2012, an average of 58% of students participate in at least one research course or program, where they complete an independent research project either on-campus or off-campus during their years at NCSSM. NCSSM's 2012 Strategic Plan called for further expanding opportunities, for students to participate in real-world experiences. Using hands-on research experience as a teaching tool, NCSSM "students apply what they have learned in the classroom to real-world problems or unresolved and often ill-defined questions" (Temple, Sibley, Orr, & Merkel, 2010). Undergraduate research, or in this case extending research to high school students, also increases the chances that a student will pursue a degree in a STEM field in college (Subotnik, Tai, Rickoff, & Almarode, 2010)

and plays a positive role in the career development of students engaging in research by inviting students "into the community of researchers and scholars as colleagues" (Temple et al., 2010).

Although the above benefits are from studies mainly examining undergraduate students, the 2011 annual report of the American Association for the Advancement of Science notes,

> Research experiences for undergraduates energize biology majors to continue majoring in the subject, and the effect is stronger for members of minority groups that are currently underrepresented in academic science in the United States. *Interestingly, early participation in research (i.e., during the first or second college year) is particularly influential* [emphasis added]. Students' increased understanding of scientific processes and scientific thinking, as well as any gains in confidence in their own ability to think like scientists and contribute to the field, may enhance their overall ability to learn science. If so, then extending some form of biology research experience to general education students as well as life sciences majors, and offering that experience early in students' college careers, could help to bring about a deeper understanding of science for all students. (p. 29)

This study, coupled with the growing body of research pointing to the importance of authentic research experiences in encouraging students to persist in earning college degrees in STEM fields (Subotnik & Tai, 2011), has certainly increased interest in providing students with meaningful research experiences while in high school, which NCSSM has been doing since the 1980s.

Due to the variety of pathways available in NCSSM's residential program for pursuing research, students have multiple decisions to make during their junior and senior years to identify the best fit for their research desires/needs. Essential factors for deciding which pathway is the best fit for each student include identifying their discipline of interest (science, engineering, computer science, mathematics, humanities/social sciences), the extent of the time they wish to dedicate to research, their choice of year in which to begin, their preference for a research course with open enrollment versus a program with a competitive application process, and their personal goals for research (see Figure 1).

The first and largest of our research programs at NCSSM, the *Mentorship Program*, is a 2-year application-based program (see Table 1) with the course sequence including *Explorations in Mentorship* and *Senior Mentorship*. When the school opened in 1980, NCSSM science instructor Dr. Ross Baker saw the wisdom of setting up a program where instructors at NCSSM collaborated with research scholars and professionals to teach students the process of research. During *Senior Mentorship*, students travel to research universities and companies around the "Research Triangle" Durham/Raleigh/Chapel Hill area.

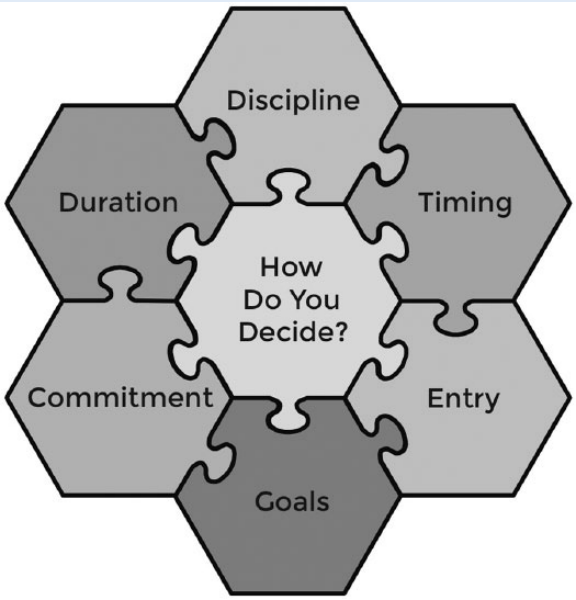

Figure 1. A guide for students exploring options for research at NCSSM.

Note. **The schematic provides the key aspects a student should consider when making decisions about which of the many research opportunities at NCSSM best fit students' needs and interests. NCSSM = North Carolina School of Science and Mathematics.**
Commitment: How much time and effort do you wish to dedicate to research?
Duration: How long do you want to continue your research experience?
Discipline: What field of study are you interested in pursuing in your research? (Engineering and technology, humanities, mathematics, science)
Timing: When would you like to begin engaging in a research experience?
Entry: Do you prefer to participate in opportunities without an application (non-competitive) or programs with an application (competitive)?
Goals: Why do you want to conduct research, and what do you aim to accomplish in your research experience?

Although this article focuses mainly on the *Mentorship Program*, there are many other avenues into research in NCSSM's residential program, including research conducted as part of a regular course in the core curriculum such as *Aquatic Ecology* or *Biomedical Engineering*, and single trimester *Research Experience* (*REX*) courses. *REX* courses are an excellent option with non-competitive enrollment available to all residential students. Currently, five different *REX* courses are offered as single-trimester courses in each core academic discipline and can be taken in either a student's junior or senior year. The structure of each course varies according to

Table 1. The *Mentorship Program* Course Sequence

Activity	Preparation		Execution		
	Junior Trimesters 1 and 2	Junior Trimesters 3 through summer	Senior Trimester 1	Senior Trimester 2	Senior Trimester 3
Professional skills instruction	none	Explorations in mentorship course meets 1 to 2 times per week	Senior mentorship curriculum; minimum of 3 hr of in- and out-of-class instruction per week	Senior mentorship curriculum; minimum of 3 hr of in- and out-of-class instruction per week	Continued instruction with students requiring presentation improvements
		6 hr of in- and out- of-class instruction per week	Students work toward a mini-grant proposal of their project.	Students rehearse and improve a presentation on their project	Student Oral Presentation at Research Symposium (8-12 min)
Program logistics	Marketing of opportunities	Assist students in mentor search; transport students to interviews with mentors; obtaining compliance for minors off-campus; planning of travel logistics	Management of travel logistics; obtaining compliance for minors off-campus; obtaining compliance via NCSSM Scientific Review Committee	Management of travel logistics	Arrangement of Research Symposium across all school research programs
	Application management/ selection		Students travel to mentor site 2 times per week	Students travel to mentor site 2 times per week	
Research mentor experience	none	Students initiate mentor search and contact (resume, cover email, interview skills)	Students execute the research process with mentor	Students execute the research process with mentor	Survey students and mentors on experience
		1:1 assistance provided for student and mentor as needed.	1:1 assistance provided for student and mentor as needed.	1:1 assistance provided for student and mentor as needed.	

Source. NCSSM = North Carolina School of Science and Mathematics
Note. NCSSM's *Mentorship Program* Is Noteworthy in Structuring Programmatic Instruction on Research, Logistical Support, and Building of Professional Skills. While NCSSM structures its program on an academic trimester timeline, other schools can implement some activities or implement on a different timeline.

the instructor, but essentially consists of group research activities with a theme focused on the instructor's expertise and most often provides opportunity for students to directly engage in the research process through an independent or group project.

For students interested in more intensive research opportunities in science, engineering, mathematics, or humanities, each of these disciplines offers the opportunity to apply for any of the seven *Independent Research "R"* courses where students work on their own projects mentored by an NCSSM research instructor. These *"R"* programs are designed for goal-oriented students certain about their dedication to engage in research for two to four trimesters and their commitment to a specific field of study in the early stages of their time at NCSSM. A *Summer Research Internship Program* connects both Online and Residential Program students, through a competitive application, to work with a project established and defined by a partner professional at a nearby university or corporation. In this 3- to 5-week summer program, students are housed at NCSSM, travel daily to work with their mentor, and communicate their work at a Summer Research Symposium.

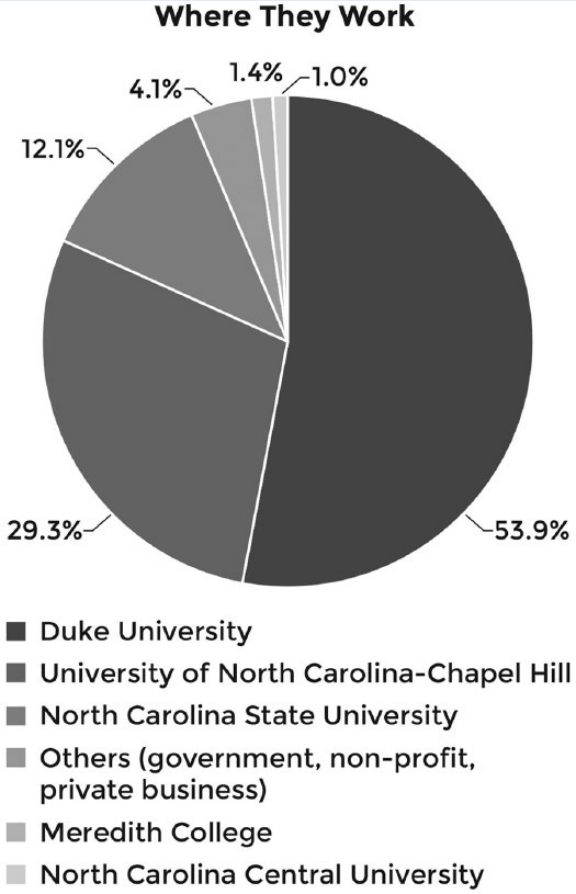

Figure 2. Research locations of NCSSM mentorship students.

Note. **The graph above shows the percentage of mentorship students working with mentors at each of the following locations over the past 3 years. The large majority of mentorship students are working with professionals and scholars at academic institutions. NCSSM = North Carolina School of Science and Mathematics.**

The *Mentorship Program*: Partnering to Provide Real-World Research Opportunities

The *Mentorship Program's* uniqueness is derived from its mix of more than 80+ volunteer mentors who provide real-world research opportunities for students, while NCSSM instructors provide the instruction necessary for high school students to approach research with confidence, professionalism, and self-reliance. The local research scholars and professionals serve as their research mentors in various areas of specialization, whereas the NCSSM instructor focuses on developing and guiding students' professional, communication, and foundational research skills. The collaborative role of the research mentor in guiding students' projects allows the *Mentorship Program* to serve more students with fewer faculty and provides enhanced access to both equipment and resources beyond the scope of the NCSSM budget. The students at NCSSM benefit greatly from the widely varied opportunities at universities and corporations as students meet their own goals.

Uniquely is that students do not choose from a curated list of mentors, but instead have the opportunity to identify any person of interest from business or academia from the Raleigh, Durham, Chapel Hill, and Research Triangle Park area (see Figure 2). Students are not restricted to "STEM" topics and can pursue any topic of interest. Students take the lead in developing a list of choices and contacting the potential mentor; the program instructors assist and guide the process. Instructors vet the choices to eliminate individuals who have previously asked not to participate, manage cases where multiple students request the same mentor, and provide opportunity to consider past mentors who are willing to mentor again in the student's area of interest. Students benefit from having freedom of choice as stated by a current student,

> Mentorship is a chance for you to explore what truly interests you and what you're truly passionate about. I knew going in that music and neuroscience was a very specific field so there wouldn't be a lot of previous research to go off of, but I still pursued it and was rewarded in the end with my experience even though it wasn't as 'safe' as my second option, cancer signaling pathways.

The *Mentorship Program* Course Sequence

The *Mentorship Program* is a three-trimester residential course (see Table 1). Students apply and are accepted based on grades, essay questions pertaining to their curiosity and research interests, and recommendations from faculty. The preparatory course, *Explorations in Mentorship*, uses a flipped instructional model and focuses on team activities and discussions in class, and individual activities and video lectures outside class.

Some of the *Explorations* course assignments (see Table 1) are designed to assist students in choosing their area of interest, searching for an appropriate mentor, reading and understanding the research of their potential mentors, and composing a professional resume and cover email to send to potential mentors. The focus is on the students' willingness to take ownership of these opportunities by identifying their research topics and finding their own research mentor.

If students are successful in both their coursework and obtaining a mentor in the *Explorations* course, they can then enroll in *Senior Mentorship*, in which students leave campus two afternoons per week for 21 weeks to meet with their mentors and work on their research projects. *Senior Mentorship*

instructors closely monitor the students' experiences and progress via bi-weekly small group meetings; individual meetings as needed; and a research journal where students record their daily research activities, their reflection of that day's experience, and their plan for the next travel date. *Senior Mentorship* students are expected to meet any requirements or assignments from their mentor, as well as graded assignments for the course. To emphasize that research is a process that can continue for years, students are required to create a web-based portfolio that contains key assignments for *Explorations in Mentorship* and *Senior Mentorship*, which they can then forward with them to undergraduate school.

This curriculum is informed by 35 years of NCSSM mentorship instructors' experience in addition to curriculum shared by NCSSM faculty in other research courses, publications of the *Council of Undergraduate Research*, National Science Teacher's Association *STEM Student Research Handbook* (Harland, 2011), and *Entering Research: A Facilitator's Manual* (Branchaw, Pfund, & Rediske, 2010),

By relying on volunteer mentors in dozens of differing academic and business disciplines, NCSSM cannot require the mentor to "teach" any particular skill. The only key requirement for the mentor is to provide the student with hands-on experience on a research project. NCSSM instructors focus on professional skill outcomes that are developed as part of the process: (a) curiosity, (b) resourcefulness and accepting failure, (c) ownership, (d) professional communication, (e) information literacy, (f) collaborative work, and (g) real-world awareness.

Outcome: Curiosity

The Mentorship Program provides students a framework to develop, challenge, and reinforce their interests given the vast freedom in choosing research topics, dependent only on securing a mentor. The level of passion a student has for a specific topic can be indicative of how dedicated the student will be to the overall experience. Allowing students to identify and pursue what makes them curious not only adds passion to learning, but also can drive the pathway students take in education and eventually in their careers. The range of domains students have pursued include art history, marine biology, law, philosophy, marketing, engineering, astrophysics, psychology, pediatrics, and computer science.

In the *Explorations* course, curiosity is identified by not only the topic, but also the methods or approaches taken by researchers, referred to as "core skills," and the settings available for research. Via several individual and group activities and assessments, students begin to narrow and defend their interest or disinterest in specific fields of study, topics, or methods such as clinical, fieldwork, computational, laboratory based/fabrication, reading/analyzing sources, knowledge/visual design, and the various settings of a researcher, that is, academic, corporate, nonprofit, or governmental. In the second half of *Explorations*, students pursue their curiosity via reading and analyzing published research.

During *Senior Mentorship* students actively pursue their curiosity through hands-on research. In that process, students learn to communicate through asking questions. One of the most common concerns expressed by mentors early in the process is that the mentors assume the students are bored because the student may not reveal any overtsigns of being curious and asking questions. Mentors mistake students' fear for boredom, and it is essential that students identify what it is they fear about asking questions. According to Temple et al. (2010),

> Another challenge is the reluctance of some students to ask questions. They labor under the notion that asking questions reveals a lack of knowledge they should have. Yet not asking questions can cause students to miss out on important information they need to continue a project. (p. 7)

This preliminary stage of asking questions out of curiosity evolves into the more mature stage of being able to think critically about their own research and the impact of their research on society such that they can share their own research findings.

Outcome: Resourcefulness and Accepting Failure

The *Mentorship Program* model demands that students be resourceful and able to address any problems they might encounter as their project progresses. Asking for help and support, or knowing where to find academic resources can be a challenge for the students at NCSSM and for high potential students in general (Ryan, Hicks, & Midgley, 1997). The design of the *Explorations* course includes frequent low-stakes assessments and assignments that allow students to find their own solutions to the problems that came up along the way. This preparation is essential for students entering the *Senior Mentorship* course where there is a strong expectation that students address challenges independently. For example, in the initial stages of research, students often obtain an unexpected result and immediately resort to asking their mentor, "What should I do now?" As students progress, they begin to proactively take steps to answer that question themselves by reading relevant literature, discussing with team members, and taking time to critically assess the situation so that they can bring their own ideas to the mentor while seeking further guidance.

The process of research inherently involves failure and, as opposed to the classroom experience, failure in research is not only a required part of the process but often failure is what leads to success. According to Temple et al. (2010),

> Students often think that research should proceed like classroom experiences where they do a proscribed set of activities and analyze them with already developed approaches. Often students become frustrated when they get unexpected or disappointing results during research. As a result, they try a few things and give up. (p. 8)

Senior Mentorship encourages examining failures as a path to success. Ultimately, students progress from asking questions for their mentor/NCSSM faculty to answer, to bringing their own solutions and answers to the table for feedback. Best said by a current student,

> You really shouldn't pursue this program solely for college applications. This will take a lot of hard work, dedication, and perseverance if you do it right. You'll experience some failures and frustration, but the 'getting up' will determine your character and successes in research.

Outcome: Ownership

Novice researchers are challenged by the necessity to drive their own experience. It is difficult for students to take ownership for their work in a program where faculty carefully guide the students and take responsibility for the actions of the experience. Guided experiences are a common approach to introducing research. In those experiences, students can view failure through the lens that the faculty member purposely chose, such as an experience that would fail or the faculty may actually provide the excuses for a bad experience or fix the failure for the student. When students are given the space and freedom to take control of their own experience, students begin to grasp that experiential learning is a cycle of planning, doing, reflecting, and planning to do it again with the new knowledge gained; they are responsible for each step in this cycle.

During *Senior Mentorship*, students summarize any problem or challenge they are having with their project, mentor, or research experience in their research journals and list the solutions they have devised. In alternating weeks, students meet in small groups with the senior mentorship instructor to discuss their experiences and advocate for any help they need with their research experience. Establishing ownership by the student requires that instructors often answer students' questions with the response, "I don't know. What do you think you should do?" This forces students to accept responsibility for setting their own goals, to drive progress on their project, and to accomplish their desired outcomes as well as successfully meeting their mentor's and the program's expectations.

Outcome: Professional Communication

High school students discover the need to communicate effectively throughout the college application and interview process and will continue to observe the outcomes of effective communication throughout their education and careers. The *Mentorship Program* allows students to practice these skills in a real-world setting as they market themselves to find a prospective mentor, apply appropriate etiquette in their professional interactions with their mentor's team, and effectively communicate the findings and impact of their research to others.

In the *Explorations* course, students begin by taking their basic resume and modifying it to create a research skills resume customized to the interests of a mentor. Students practice writing a cover email to recruit a potential mentor. The Mentorship instructor meets with each student to evaluate his or her written communication. In addition, students develop verbal communication skills by rehearsing and delivering a filmed short speech explaining to their mentor their interests in both being a researcher and their curiosity about the mentor's specific area of scholarship. Feedback from their peers about their verbal communication skills in that activity can inform students how best to improve their responses so they can be more confident in their first meeting with their mentor.

Senior Mentorship students are assessed by the instructors based on their oral and written performances on typical tasks required for success in many careers: promoting and delivering an idea ("elevator pitch" where students summarize their research question and research goals in 1 min), establishing funds for the plan (written grant proposal formally conveying the aims and relevance of the research), and reporting the outcome of the work (oral presentation of the research findings to a broad audience and written paper/poster targeted to experts in their field). The methods of assessment prove both interactive and energizing as students receive peer and instructor feedback along with video recordings of their own presentations for self-reflection.

Products of the student work were quite evident in the past 2 years include 13% of Mentorship students submitting for publication, 21% participating in a conference or research competition, 90% presenting their research to their research team, and 100% presenting at the NCSSM Annual Research Symposium.

Table 2. Program Evaluation Comments From Mentors: Strengths and Improvements of the *Mentorship Program*

Potential Changes
Representative research mentors' response to question: "What would you like to change about your experience with the Mentorship Program at NCSSM?"
Most mentors request additional time with the students or a unique meeting schedule outside our regular hours.
Some wish for clarification of expectations.
Timing of visitation . . . It may work out better to have students for longer amount of time per visit or have two visits on consecutive days so they may perform other types of experiments.
Advice for Future Mentors
Representative research mentor quotes to question, "List any advice you have for future mentors considering working with NCSSM students in our program."
"I enjoyed having a different perspective in the lab when working on our projects. I also enjoyed being able to ask a separate research questions linked to a project that may not have otherwise been able to be answered."
"Being able to discuss my research and current research in my field with such bright students allowed me to think outside the box about my own research."
"Don't be afraid to set stretch goals and give them responsibility and accountability for milestones toward them. These guys are good and with a little direction they will get a lot out of this."
"My advice is to set aside a manageable small project for the students. Really try to empower them to have their own project and understand the reasoning behind what they are doing."
"In the short time I've worked with NCSSM students I have learned not to underestimate their talents and to not be timid about assigning readings/projects that are at a college-level."
"My only advice is to take on a student when you truly have time to pour yourself into helping that student grow, learn, and mature. You cannot do it half-heartedly or in your spare time. Neglect is not education."
"You simply have to be prepared to mentor, or have someone in the group do that, you cannot just leave the student to find their way in the research."
Strengths
Representative research mentor responses to question, "What did you like best about the experience?"
"I always enjoy working with young people, their enthusiasm and desire to learn is so uplifting. They challenge you, appropriately and make your stay on your game, so to speak."
"I enjoyed working with someone so young, someone who was still trying to decide about their future. Usually, I mentor people who have already chosen science as an occupation. But, talking with the student about their goals, while providing some of my perspective along the way, made me feel that this experience will make an impact on the student and their future."
(this consistently is stated) "We have had the opportunity to work with many NCSSM students over the past few years in our lab. Overall the experience is consistently a positive experience because of the quality of student / individual that come from the school."
"NCSSM students are typically very bright, intellectually curious, eager and happy to have the experience. They are a lot of work, but they are also a lot of fun, and they typically bring good energy to the lab."

Note. The quotes above are direct quotes from the professionals and scholars who have served as a mentor in our *Mentorship program* over the past 2 years.

Outcome: Information Literacy and In-Depth Reading

Programs targeted at high school level students often immerse students into doing "hands on" research yet fail to address the fact that a core part of professional research, and being a researcher, is reading the research of others. The *Explorations* course places strong emphasis on information literacy skills, scholarly literature, and critical reading. As 11th graders in *Explorations*, students meet individually with a member of the library staff to work through their research topic, and to learn to navigate the various journals, databases, e-books, and the library's physical collection of books and journals. Citations, variety and breadth of research publication types, variability of publications in different research disciplines, and a structured process in how to read a scholarly article are all included in the curriculum. Students read articles using a guided questions inquiry and article summary template developed by the instructors. Whereas a mentor may require a student to read many articles, the assessed curriculum requires students to complete summaries for nine original research articles, three during *Explorations* and six during *Senior Mentorship*. Writing the summary for each research article emphasizes that mentors are not going to give quizzes to make sure students are reading background research thoroughly. Instead, they expect them to be disciplined and self-motivated to read and keep track of what they learn independently.

As the student matures in his or her search, synthesis and vocabulary skills, he or she begins to critically evaluate the published research and extend this curiosity to the point of asking original research questions and potentially even creating follow-up research questions and experiments to build on the published work of others (Temple et al., 2010).

Outcome: Collaborative Work

Participating in activities as part of a team is a common practice in the classroom, but it is rare that high school students have the opportunity to contribute in a substantive way to the thinking of a group of professionals. Many mentors express that they learn just as much from the student's perspective on their research study as the student learned from them (see Table 2). Both types of teamwork are implemented in the *Mentorship Program* and contribute to the development of skills required to act as an effective team member, such as learning to give and take constructive criticism, recognizing each member's role and responsibility in accomplishing their team's goals, taking part in decision making, and respecting others' ideas even if they are different from their own.

From the first day of *Explorations in Mentorship*, to the last day of *Senior Mentorship*, students are members of small groups composed of five to eight students for the purpose of collaborative learning. In the preparatory class, small groups interact to complete class activities and assignments, to brainstorm ideas, and to provide organized peer review via rubrics. During *Senior Mentorship*, students continue to work with a small group of peers to obtain feedback and guidance on assignments such as their elevator pitch and their research symposium presentation.

As students initiate their research experience in *Senior Mentorship*, they become an active member of their off-campus mentor's professional research team. As part of the curriculum, students are required to initiate communication with their mentor, give consistent progress updates to their mentor, and complete the tasks required to contribute to their part of the research project.

Outcome: Real-World Awareness

NCSSM's *Mentorship Program* provides students a broader awareness of the professional and academic work environment. In *Explorations*, students learn about research through instruction and assessments about (a) the university research structure such as academic structures, research regulations, and the role of grant support, (b) how success is defined by mentors and how mentors evaluate a student's potential, (c) the student's role and a sense of what a high school student can accomplish within a university research project, (d) the skills needed to read research articles that are written for the scholarly community, and (e) the expectation that they must read widely and extensively. Students enter the program with statements such as, "I want to research cancer," "I want to work with patients," and "I want to get something published this fall." The Mentorship curriculum helps establish "real world expectations" of their research interests, the scope of what they will accomplish, how "narrow" the focus of a research question must be, and the intense amount of background reading they must digest to understand their mentor's research. Because students generally receive a "no" from two potential mentors before getting a "yes," they also learn how to deal with rejection.

Once immersed in real-world research settings in *Senior Mentorship*, students gain a better picture of what it means to be a researcher, a better perspective of how their interests may lead to a potential undergraduate major or career path, a broader sense of research disciplines, and how completing a research question can be interdisciplinary. Feedback provided to the student by the mentor and mentor's team on their progress and growth allows the students to reflect on their experience in a manner beyond the scope of a formal assessment.

Best Practices and Options for Implementing a Mentor-Based Research Program

NCSSM's *Mentorship Program* benefits from numerous unique attributes: (a) a constituent institution of the UNC system; (b) a residential school, which provides flexibility in scheduling and transportation; (c) its proximal location to major research universities, institutions of higher education, and businesses; (d) its 30+ year focus on providing real-world learning opportunities for students; (e) a strong commitment of the state legislature to the school's mission; and (f) support of alumni and corporate foundations to fund its research programs. However, no matter the location or resources available to schools interested in implementing this type of program, there are various ways to apply the ideas and practices of this model on a smaller scale to potentially obtain similar outcomes.

Strengths of the Program Design

The Mentorship Program uses research as a gateway for students to discover their own unique interests. Many areas of research at partner institutions do not fit neatly into broad disciplines such as science, mathematics, and humanities, but instead represent broad areas of applied social science, natural sciences, and engineering that are not commonly found at the high school level. Students are encouraged to open their minds to all fields, and to recognize the interdisciplinary research that connects STEM and non-STEM fields of study.

Implementation of a pre- and co-curriculum in the *Mentorship Program* is a second key strength. Although literature on optimal practices for teaching high school students how to conduct research is limited, students are less likely to continue in research or acquire the foundational knowledge to be a researcher if they simply participate in the work without accompanying coursework focused on reflection and learning/practice of the skills of being a researcher (Matand, Wu, & Rollins, 2011; Shaffer et al., 2014; Temple et al., 2010). The references associated with the National Science Foundation (2013) solicitation for its Research Experience for Undergraduate grant program emphasize the key importance of mentoring and co-curriculum/training in the context of integrating students into research. The curriculum in *Explorations* builds in assessments that require students to demonstrate that they understand the professional, personal, and research skills required to be a professional researcher, beyond designing and completing a research question. NCSSM successfully extended a modified version of the *Explorations in Mentorship* curriculum to its online program students, although its goal is to prepare students for application-based research opportunities or to seek out a mentor on their own without further institutional support.

Third, the *Mentorship Program* experience allows students to be confident and prepared for working with a mentor in an academic or corporate site, as well as preparing them for both undergraduate and graduate research. At the national level, participating in a research experience at the undergraduate level correlates with enhanced interests in STEM and an increased potential of pursuing an advanced degree (Russell, Hancock, & McCullough, 2007). Anecdotally, many alumni cite their research experiences while at NCSSM as important to both their undergraduate major choices, as well as their career choices in STEM fields. Sixty percent of NCSSM students who complete a bachelor's degree earn their degrees in STEM fields. The *Mentorship Program* also builds connections to the community by demonstrating the students' talent to hundreds of academic and corporate professionals per year and highlighting the value of the education that the school provides for students from across North Carolina.

Finally, students are encouraged to approach failure with a positive attitude and constructive response. Unlike the new Advanced Placement Seminar/Research sequence, the program does not encourage certainty of the experimental design or outcomes of the collection of data, analysis, and conclusions. NCSSM students are often given ownership of a piece of a much larger research project and may not reach the stage of analysis and conclusion prior to the end of the program. Students learn the limitations and challenges of scholarly or professional research, and that research is always ongoing and does not neatly end or provide meaningful results when the academic term comes to a close.

Limitations of the Program Design

Both a strength and limitation of NCSSM's model is that students can be frustrated by the uncertainty and failure encountered in professional research, or disappointed that their extensive efforts solved only a very small piece of the mentor's broader research questions. Although the model requires extensive mentoring by the university partner to execute the research and provide content expertise, it also requires guidance and support by NCSSM faculty to help 16- to 18-year-olds understand that failure in the context of research is not only positive, but the path to discovery.

The expense of effectively running a program like *Mentorship* includes the costs associated with having faculty and staff specifically dedicated to the course, transportation resources, dedicated time of library staff to provide instruction, increased need for library resources required for student research, and the time necessary to complete the large variety of essential logistics. Logistics, which can be overwhelming, include complying with policies on minors for each student at each location, arranging safe and efficient transportation for students to be able to make the most of their limited time off-campus, driving students to interviews during the mentor search, obtaining approval for each individual project from our high school's Scientific Review Committee, scheduling all traveling students to be free the same three class periods each week, and communicating clear expectations to mentors and students.

The Mentorship programs at NCSSM rely on the generosity and donation of time of 80+ mentors each year. Without the volunteerism and goodwill of the mentors, these programs would not be possible. Feedback from mentors (see Table 2) indicates that the opportunity to work with NCSSM students is rewarding and leads them to continue contributing to our program. For example, mentors say they enjoy the energy that the NCSSM students bring to their environment, the mentoring opportunity that the mentor's staff gain, and the support NCSSM can offer mentors for grants, some of which have an outreach component by confirming the mentor's work with the students.

Because student interests drive the mentor selection process, some mentors continually support one or more NCSSM students each year, and others may only participate once or occasionally. The logistics of managing the mentor search process and mentor relationships is daunting and intensive. Establishing a sufficient pool of potential mentors willing to engage students works best in a location with multiple universities and suitable corporate entities, but could be implemented on a smaller scale in a location with at least one research institution and interested business partners.

Because the student establishes the relationship with the mentor and the mentor serves as a volunteer, NCSSM cannot control the experience. Mentors do not receive specific training on how to instruct high school students effectively. In addition, there is also wide variation in the amount of time the mentor interacts with a student. Some mentors provide direct training and guidance each day. Other mentors, due to time constraints, must share the majority of mentoring responsibility with their professional staff and graduate students.

Another limitation is a focus on high-performing students at NCSSM (as NCSSM's enrollment model selects high-achieving students from communities across the state) for selection into the Mentorship Program. Grades are a significant criterion in selecting *Mentorship program* students, and serve as a proxy indicator that students can manage the responsibility of the off-campus experience as well as manage the time commitment of mentorship in addition to the regular course load. The program design does not serve the low and moderate performing STEM interested students most at risk to leave STEM fields at the college level (Chen, 2015). However, allowing students to engage in some of the instructional components before application, improved schoolwide advising, and a lower student-to-faculty ratio in the program could broaden the program's reach. Another alternative, which NCSSM has found successful, is to offer a summer research program providing students dedicated time to focus on research without the added challenge of balancing the typical regular coursework. The criteria for selecting students in the summer program can then be based primarily on essay responses rather than grades.

Evaluating Outcomes

Students are currently evaluated on pre- and post-assessments of their confidence or skills. Based on these assessments, students completing the *Mentorship Program* show a large increase in preparedness for carrying out a wide variety of professional and research tasks compared with responses of their preparedness before entering *Mentorship*. This increased preparedness may seem like an obvious result of participating in any research program, so the next goal is to establish a more robust assessment of knowledge in understanding the context and process of research. A way the *Mentorship Program* can address this is to obtain pre-test and post-test responses from participants working with mentors in another NCSSM research program developed in 2013—the *Summer Research Internship Program* at NCSSM. The summer program has a similar number of student contact hours for research at the mentors' location, but no class time to implement the pre- or co-curriculum. In addition, the summer mentors are selected by the mentorship instructor prior to the students applying to the summer program, so the process of the mentor search, defining a research topic, and reading published research prior to the experience is not required for a summer student. If mentorship students are shown to be more prepared than summer research students, then it would indicate the value of incorporating curriculum to support student research experiences as well as the importance of students taking ownership by arranging for their own mentor.

Although organizations such as the Council for Undergraduate Research exist to promote the value of research as a teaching and experiential learning tool, it is still an emerging field to analyze the effectiveness and impact of engaging in research. The NCSSM Mentorship Program plans to implement a broader program assessment that follows student outcomes after graduation. Assessment of research programs at the undergraduate level suggests potential assessment models and measures of effectiveness. Several recent studies analyze summative reflections on the experience (see Schmitz & Havholm, 2015; Vieyra, Gilmore, & Timmerman, 2011) and the post-undergraduate outcomes of persistence and value of a research experience. Russell et al. (2007) indicate students who engage in a research experience are more likely to obtain an advanced degree and twice as likely to obtain a PhD, have more confidence, awareness, and understanding of how to conduct research, and increased interest in STEM.

Nationally, emerging research, based on the Undergraduate Research Student Self-Assessment (URSSA), documents students' pre- and post-assessments of their learning experiences, and gauges the likelihood that the research experiences changed or confirmed the

Table 3. Evidence of Enhanced Student Preparedness for Research, Professional, and Personal Skills Following Completion of the *Mentorship Program*

General Attribute	Specific Skill	Pre-Test Adequately prepared (strong confidence)	Post-Test Adequately prepared (strong confidence)	Pre-Test Unprepared (not confident)	Post-Test Unprepared (not confident)
Assertiveness	Take the initiative to move an independent project forward	44%	73%	8%	4%
	Set goals for your research and provide updates on your research progress	59%	91%	5%	0%
Critical thinking	Critically evaluate the research of others	16%	55%	36%	4%
	Identify and communicate the big picture of a research project	28%	84%	17%	0%
Effective Communication	Deliver a 1-2 minute summary of your research interests (or if applicable your research project)	27%	84%	17%	0%
	Relate and connect key resources to one another by writing a literature review	11%	69%	59%	0%
	Organize and present your research plan in a grant proposal	4%	77%	73%	0%
	Communicate the research process using your own research or someone else's research in a written formal research paper	11%	55%	43%	0%
	Communicate the research process using your own research or someone else's research in an oral presentation	16%	75%	32%	0%
Professionalism	Compose a resume and cover email to contact potential mentors	25%	88%	7%	0%
	Interview with a potential mentor to obtain a research opportunity	20%	59%	24%	3%
	Enter a mentor's workplace with an appropriate attitude for success	68%	89%	5%	1%
Research knowledge	Possess a strong foundational knowledge to support my research topic	23%	71%	23%	0%
	Read and summarize research articles in your field of interest	28%	91%	24%	0%
	Avoid plagiarism when summarizing others' published work	57%	88%	1%	0%
	Use in-text citations and format full citation lists accurately	49%	80%	9%	0%
	Formulate a research question based on previous knowledge in the field	21%	67%	24%	4%
	Design a method/plan to address a research question	13%	56%	16%	3%
	Analyze and interpret data	48%	75%	4%	1%
Resourcefulness	Search for a mentor of interest to contact for potential opportunities for research	31%	87%	16%	1%
	Search for, identify, and acquire appropriate articles for your research topic	24%	89%	24%	0%
	Identify ethical issues and form an opinion and a plan of action to deal with issues that arise	49%	68%	8%	7%

Note. Evaluation of students' preparedness was obtained by asking about students' self-assessed level of confidence in carrying out specific research and professional activities both before starting the *Mentorship Program* and following completion of the program. The three choices students had for preparedness levels were (a) adequately prepared (strong confidence), (b) moderately prepared (somewhat confident), or (c) unprepared (not confident). Because the curriculum was revised in 2015, not all attributes/outcomes described in this article are reflected in the survey.

students' plans to pursue STEM education and careers (Weston & Laursen, 2015). The findings using URSSA at Drexel University to assess non-STEM undergraduate researchers found learning gains and motivations to be similar to that of STEM researchers (Stanford, Rocheleau, Smith, & Mohan, 2015). Similar to Drexel, the NCSSM *Mentorship Program* outcomes are focused on a broader set of student outcomes (see Table 3) than STEM interest and persistence in STEM.

Conclusion

Although a primary objective for both high school and undergraduate education is to prepare students with the necessary skills for success in their continued education and ultimately in their career, it is often difficult to teach "soft skills" that employers commonly look for when hiring. In January, 2015, the New York Academy of Science released a report titled, "The Global STEM Paradox," detailing that although there are more STEM graduates than ever before, many STEM jobs go unfilled because of the lack of soft skills. Commonly, classrooms focus on the knowledge and specific skills required in the field of study and have less time to dedicate to teaching things such as leadership, critical thinking, communication, and teamwork that are critical to success in life and work. The *Mentorship Program* provides the opportunity for students to develop and practice soft skills such as resourcefulness, teamwork, professional communication, and taking responsibility for accomplishing desired goals. Development of these soft skills is not an explicit student learning objective for the course, but it is a primary objective of the program to empower students by the design of the pre- and co-curriculum and by giving students the responsibility to make their own decisions and to resolve their own problems.

Because more than 80% of students enter the path toward a STEM degree after they enroll in high school (Maltese & Tai, 2011), opportunities in high school are critical to a future interest in STEM. Students routinely enter the undergraduate environment with only a vague idea of what research entails in STEM and the breadth of research that occurs in social sciences and humanities. Students often have little exposure to reviewing existing literature in current journals, developing research proposals, and research methodologies, yet research will be a vital component of their education and possibly their careers. Students entering the program are high school juniors coming from all across North Carolina with a wide range of backgrounds and experiences; however, on finishing the *Mentorship Program*, students not only have all had firsthand experience with research, but also have worked side-by-side learning and implementing their soft skills with professionals in a real-world environment.

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References

American Association for the Advancement of Science. (2011). *Science Without Borders. AAAS Annual Report - 2011* (p. 29). Washington, DC: American Association for the Advancement of Science. Retrieved from http://www.aaas.org/page/aaas-annual-report-2011

Arshavsky, N., Corn, J., Parker, B., & Stallings, T. (2011, December). *North Carolina's STEM High Schools: An overview of current data.* Consortium for Educational Research and Evaluation–North Carolina. Retrieved from http://cerenc.org/wp-content/uploads/2011/11/STEM_Baseline-Report_11-02-2011.pdf

Branchaw, J., Pfund, C., & Rediske, R. (2010). *Entering research*. New York, NY: W.H. Freeman.

Chen, X. (2015). STEM attrition among high-performing college students in the United States: Scope and potential cause. *Journal of Technology and Science Education, 5*(1), 41-59.

Harland, D. (2011). *STEM student research handbook.* Arlington, VA: National Science Teachers Association.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*, *95*, 877-907.

Matand, K., Wu, N., & Rollins, L. (2011). Requiring research may improve retention in STEM fields for underrepresented women. *Council on Undergraduate Research Quarterly*, *31*(3), 13-19.

National Science Foundation. (2013). *Research Experiences for Undergraduates (REU)* (Program Solicitation NSF 13–542). Arlington, VA: Author.

The New York Academy of Science. (2015). Retrieved from http://globalstemalliance.org/media/filer_public/b8/68/b8683358-027a-4015-8807-811301744bbd/nyas_white_papers_ssf.pdf

North Carolina General Assembly. (2007). Higher Education. The North Carolina School of Science and Mathematics, Board of Trustees: G.S. § 116

North Carolina General Assembly. (2015). Retrieved from http://www.ncssm.edu/about

Russell, S. H., Hancock, M. P., & McCullough, J. (2007). Benefits of undergraduate research experiences. *Science(Washington)*, *316*, 548-549.

Ryan, A., Hicks, L., & Midgley, C. (1997). Social goals, academic goals, and avoiding seeking help in the classroom. *The Journal of Early Adolescence*, *17*, 152-171. doi:10.1177/0272431697017002003

Schmitz, H., & Havholm, K. (2015). Requiring research may improve retention in STEM fields for underrepresented women. *CUR Quarterly*, *35*(3), 13-19.

Shaffer, C. D., Alvarez, C. J., Bednarski, A. E., Dunbar, D., Goodman, A. L., Reinke, C., & Mel, S. (2014). A course-based research experience: How benefits change with increased investment in instructional time. *CBE-Life Sciences Education*, *13*, 111-130.

Stanford, J. S., Rocheleau, S. E., Smith, K. P., & Mohan, J. (2015). Early undergraduate research experiences lead to similar learning gains for STEM and Non-STEM undergraduates. *Studies in Higher Education*, 1-15. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/03075079.2015.1035248

Subotnik, R. F., & Tai, R. H. (2011, May). *Successful education in the STEM disciplines: An examination of specialized science, mathematics, and technology-focused high schools*. Presented at the National Research Council Workshop on Successful STEM Education in K-12 Schools, Washington, DC.

Subotnik, R. F., Tai, R. H., Rickoff, R., & Almarode, J. (2010). Specialized public high schools of science, mathematics, and technology and the STEM pipeline: What do we know now and what will we know in 5 years? *Roeper Review*, *32*, 7-16. doi:10.1080/02783190903386553

Temple, L., Sibley, T., Orr, A., & Merkel, C. (2010). *How to mentor undergraduate researchers*. Washington, DC: Council on Undergraduate Research.

Vieyra, M., Gilmore, J., & Timmerman, B. (2011). Requiring research may improve retention in STEM fields for underrepresented women. *Council on Undergraduate Research Quarterly*, *32*(1), 13-19.

Weston, T. J., & Laursen, S. L. (2015). The Undergraduate Research Student Self-Assessment (URSSA): Validation for use in program evaluation. *CBE-Life Sciences Education*, *14*(3).

Bios

Sarah E. Shoemaker, PhD, joined NCSSM faculty in 2012 to expand the Mentorship Program *and to develop research internship opportunities for students in the summer and throughout the North Carolina School of Science and Mathematics (NCSSM) academic experience. Although she has an extensive background in neuroscience research, she is interested in implementing inquiry-based learning methods and creating an environment that promotes both students' development as researchers and their effective communication of their research experience. She was a Faculty Institutes for Reforming Science Teaching (FIRST IV) Scholar focused on applying active learning, assessment, and diversity in teaching biology. She recently received a fellowship from the University of North Carolina (UNC) system to revise and further develop the* Mentorship Program *curriculum.*

Christopher Thomas, MS, MTSC, helped to launch NCSSM's Online Program and build program academic components, and currently coordinates academics and teaches earth science. Trained in geology/geochemistry and science communication, he received a fellowship with Dr. Shoemaker and Dr. Boltz to revise the Mentorship Program *curriculum pieces at NCSSM. He previously co-published on a National Science Foundation–supported grant that developed a high school to middle school peer mentoring model to teach climate change research, which included developing a co-curriculum and integration of university researchers. Prior to NCSSM, he was a lecturer in earth science at Indiana University–Purdue University–Indianapolis, where he received awards and fellowships in online and hybrid course development.*

Todd Roberts, EdD, is the chancellor at NCSSM. Prior to returning to North Carolina to become chancellor in 2010, he served as superintendent of the Ann Arbor Public Schools in Michigan. With his leadership, NCSSM continues to expand innovative educational opportunities and resources in science, technology, engineering, and math to students and teachers across the state. He holds a BA from Duke University and his master's and doctoral degrees from UNC at Chapel Hill.

Robin Boltz, PhD, is the director of Library, Instructional Technology and Communications. Her main area of research is gender differences in reading and reading behaviors. She joined NCSSM administration in 2011 and has led the library through its transition from library into learning commons. She collaborated with Mr. Thomas and Dr. Shoemaker to co-design the Mentorship Program *curriculum pieces at NCSSM. Prior to coming to NCSSM, she taught in the Granville County School system and has served as an adjunct at the School of Library and Information Science at UNC.*