Phase 4: Final Report
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Executive Summary

The fourth phase of the STEM 360 project was a two-year research investigation that was designed to expand the project by working with students from 5th through 6th grade, with a particular focus on teachers and their needs. As before, the project focused on supporting student STEM careers awareness, STEM learning and academic achievement, and STEM engagement and attitudes. This phase included more of an emphasis on STEM careers than it has in previous phases. Additionally, the fourth phase included teacher enrichment opportunities to support teachers in feeling confident in teaching STEM and about STEM careers and explored how the program impacted teachers' attitudes towards the role of free-choice learning resources in students' STEM learning.

During the 2022-2024 school years, a cohort of students participated in the STEM 360 program during their 5th and 6th grade years. Each year, a cohort of 5th and then 6th teachers also participated in the program. This final report presents final data collected from students who participated in the full STEM 360 program and 6th grade teachers.

The following are high level, findings:

STEM 360 Increased Students' STEM Career Awareness and Interest in Careers Related to Some STEM-Related Topics, but Room for More

- Teachers mentioned that the biggest impact of the program was on students' STEM career awareness and attributed this to the program exposing students to new STEM careers, increasing their interest in these careers, and making the careers seem attainable.
- One teacher who had participated in STEM 360 in previous years shared that this year's program seemed to be more successful in supporting STEM career awareness than in the past. This speaks to the STEM 360's team continued efforts to make STEM careers more central to the program.
- By the end of the program, students were able to identity a wider variety of STEM careers and there was an increase in students' STEM career aspirations.
- Teachers suggested connecting more with local people in STEM careers and providing resources for teachers to continue discussions about careers with students during class lessons.

STEM 360 Increased Student STEM Learning

- There was a higher rate of students passing the math state assessments among STEM 360 students than among the comparative group
- Program supported student STEM learning by increasing student interest in and attitudes towards STEM
- Students were supported in connecting program material to class lessons and seeing the relevance of. STEM in their lives.
- Teachers suggested connecting more to local trade careers, offering more experiences, providing teachers with the materials earlier, and providing SOL-formatting questions.

Evidence of STEM 360 Increasing Overall School Engagement

- STEM 360 students had a higher rate of attendance and lower rates of chronic absenteeism and out of school suspensions than the comparative group.
- The program supported engagement overall, not only with program experiences, but with learning more generally.

STEM 360 Increased Students' Participation in Some STEM Activities

- Students' participation in group-organized activities increased significantly between before and after the program.
- However, there was a slight decrease in participation in self-organized activities.
- Some students wanted to participate in STEM-related activities such as going to a STEM-related informal learning institution, doing STEM-related projects or experiments, taking STEM-related classes, and doing activities outdoors and in nature.

STEM 360 Increased Students' Attitudes Towards and Interest in STEM

- Student attitudes towards STEM increased between 4th and 6th grade.
- Students' interests in STEM-related topics in different areas such as Space Science, Earth Science, Life Science, Physical Science, Technology and Engineering, and Math increased.
- Math remained students' favorite school subject.

Program Experiences Engaged Students in STEM, But There is a Need for More Hands-On Activities

- As in the past, the STEM 360 program, particularly hands-on and problem-solving activities, continued to engage students.
- Students talked more about hands-on activities and the concepts behind the activities in Year 1 than Year 2. In Year 2, students talked more about demonstration activities such as the liquid nitrogen activity and that it was fun, rather than about the concepts behind the activity. A suggestion would be to include more open-ended, problem-solving, hands-on activities to better support both student engagement and learning
- Teachers shared that these experiences engaged students in a way that typical SOL-oriented curriculum did not.

Need for Increased Variety of Field Trips and Exposure to More Out-of-School STEM Learning Opportunities

- Students continued to enjoy going on field trips.
- Some students shared that they enjoyed going to VASSC, however others felt that they would like more variety of field trips.
- When students discussed where they might go to learn about STEM in their community, there was an increase in students referring to VASSC, however, there was a decrease in the variety of resources mentioned. This suggests the need for more variety in field trips and exposure to more local STEM learning experiences.

Existing STEM and Career Education Efforts at Schools

- There are already some STEM and career-related events (e.g., elective classes, fairs), it would be beneficial to connect to these efforts in some capacity.

STEM 360 Clearly Increased STEM Teaching Self-Efficacy and Impacted Teacher Practice

- STEM teaching self-efficacy increased for both STEM 360 and Control Group teachers.
- However, STEM 360 teachers were better able than Control Group teachers to explain how and why their STEM teaching self-efficacy and overall teaching practice changed since the beginning of the school year.
- STEM 360 teachers directly attributed the positive changes in their self-efficacy and practice to participation in the STEM 360 program.

- STEM 360 teachers' confidence in doing hands-on activities increased because they had support in implementing these activities and they observed the positive impact of these activities on students. Teachers shared that due to their increase in confidence, they planned to continue to do more hands-on activities with students.
- Control Group teachers were less clear than STEM 360 teachers about what STEM teaching opportunities they had over the year. One Control Group teacher's response suggests that the STEM 360 program could support her STEM teaching practice.

STEM 360 Increased Teacher STEM Career Awareness and Development Self-Efficacy

- Teacher STEM career awareness and development self-efficacy increased significantly for only STEM 360 teachers.
- Some, but not all teachers attributed this increase to STEM 360 program experiences.
- Control Group teachers mentioned that they needed more information about STEM careers
- Some teachers with previous STEM 360 experience mentioned that they thought the career focus in this phase of STEM 360 was much improved over previous years of the program; much more focused and much better integrated into all aspects of the program.

STEM 360 Teachers were Better Able to Explain Changes in Their Self-Efficacy in Supporting Student STEM Learning Outside of the Classroom

- Though both STEM 360 and Control Group Teachers' self-efficacy in supporting student STEM learning outside of the classroom increased**,** the STEM 360 teachers had a lot more to say than Control Group teachers about these changes and what influenced these changes.
- STEM 360 teachers were specific in discussing new concrete ways that they were supporting student STEM learning outside of the classroom (e.g., starting an engineering club, getting involved in other STEM-related clubs, or seeking out other community learning resources).
- STEM 360 teachers attributed these changes in their confidence and practice to program elements including some attributing these changes to collaboration with their STEM 360 Coach.
- Control Group teachers mentioned that they were unaware of local STEM learning opportunities and ways to support student STEM learning outside of the classroom.

STEM 360 Teachers Better Able to Explain How Outside of Classroom STEM Learning Experiences and STEM Learning Experiences in Students' Free-Time Support STEM Learning

- Though both STEM 360 and Control Group teachers' attitudes towards the role of school-connected STEM learning experiences outside of the classroom and experiences during students' free-time increased, STEM 360 teachers were better able to explain how these experiences supported student STEM learning.

STEM 360 Increased Teacher Awareness of Local STEM Learning Opportunities

- Though both STEM 360 and Control Group teachers shared useful information about additional local STEM learning opportunities., STEM 360 teachers were better able to explain how their views of these opportunities changed since last school year.
- STEM 360 teachers attributed increases in their awareness of local STEM learning opportunities to the STEM 360 program.

STEM Coach Effectively Supported Students and Teachers

- STEM 360 teachers continued to have a very positive experience working with their STEM Coaches. Teachers mentioned that they felt supported by the STEM Coaches and appreciated that the STEM Coaches were open to feedback.

Teachers Experiences Some Challenges in the Program, But Fewer Than in Previous Year

- Most teachers did not report any challenges participating in the program.
- Those that were mentioned included assuming students' prior knowledge, which made some activities challenging for students; school division constraints, and lack of buy-in from new administration; need for better alignment between program experiences and curriculum pacing (which has been mentioned in previous years); and more structure during field trips.

Introduction

STEM 360: Multiple Touch Point Informal STEM Engagement Program for Urban Underrepresented Youth is a Commonwealth of Virginia funded project and collaboration between the Virginia Air & Space Science Center (VASSC), the Institute for Learning Innovation (ILI) and four Hampton Roads area school divisions (Hampton, Newport News, Portsmouth, and Suffolk), and is currently in its fourth phase. The fourth phase of this project is a two-year research study that was designed to develop, test, and revise an innovative model for sustainable, scalable capacity-building in urban communities, cultivating STEM interests and capabilities of urban youth through informal STEM facilitation that results in an enduring involvement in STEM learning and participation, a greater awareness and interest in STEM careers and support of teachers to enhance the likelihood of these outcomes occurring.

In Phases 1 and 2, differing levels of program enrichment were evaluated with the most enriching level (Level 1) resulting in the most positive outcomes. In Phase 3, due to the Covid-19 pandemic, investigations of the relative efficacy of in-person, virtual, and hybrid modes of delivery were investigated.

In the previous three phases of STEM 360 the focus was on 4th and 5th grade students. Phase 4 expands the project by working with students from 5th through 6th grade student, with a particular focus on teachers and their needs. This age range is particularly critical for STEM interest and participation (cf., DeWitt, et al., 2013; Osborne, Simon, & Collins, 2003; Vedder-Weiss & Fortus, 2011; Staus, et al., 2020). As has been documented both in the U.S. and abroad, declines in STEM interest at this age can be directly tied to declines in youth choosing to major in STEM fields or even taking STEM coursework at the high school or university level, which in turn translates into declines in the number of qualified workers available to fill the growing number of STEM-related jobs and declines in the scientific literacy required to function successfully in an increasingly scientific and technological world (Lacey & Wright, 2009; Maltese & Tai, 2011; NRC, 2011; Tai, Liu, Maltese, & Fan, 2006).

A large body of research indicates that interest, including interest in STEM, has a developmental component related to the age of the learner. Studies suggest that from preschool through grades 4 (ages 10/11), children report widespread interest in a variety of natural phenomena, including many STEM topics (Gottfredson, 1981; Murphy & Beggs, 2005; Todt & Schreiber, 1998), but that this interest steadily declines through primary and secondary school with enduring interest in science being largely formed by age 13/14 (Lindahl, 2007; Ormerod & Duckworth, 1975; Tai et al., 2006). Thus, it appears that children's experiences (both in and out of school) before age 14 are critical to the formation of STEM interests that lead to the pursuit of related studies and careers (Dierking, et al., 2021; Tai et al., 2006). Research by Falk and colleagues (cf., Dierking, Falk & Staus, 2021; Falk, et al., 2015; Falk, et al., 2016; Shaby, et al., 2021; Staus, et al., 2020) has shown that these declines in interest and participation in STEM are neither monolithic nor inevitable. The key is recognizing and supporting the more fine-grained needs and interests of youth during this critical time period. The STEM 360 program provides an opportunity to create more customized and targeted support for STEM, as well as an opportunity to measure the efficacy of such targeted interventions.

Another key feature of STEM 360 is providing students with opportunities for STEM-related career awareness and exploration. According to experts (e.g., Cushing, et al., 2019; Knight, 2015), to achieve success in the rapidly changing and increasingly STEM-focused U.S. job market, students must begin seriously exploring STEM careers by the late elementary/early middle school years. Career exploration involves exploring the self and the world of work to obtain a better understanding of the general features of the self and learn about potential career options that might suit these features (Patton & Porfeli, 2007). Vocational exploration answers the question, "What kinds of work will be suitable to me?" The answer to this question often comes from a broad (in-breadth) exploration of possible vocational identities to increasingly deep (in-depth) exploration of core features of the self (interests, values, and life goals, for example) in relationship to specific career opportunities shared through formal and free-choice learning opportunities. Through this process, youth try to discover which careers might be more or less suitable choices for them (Porfeli & Lee, 2012). Auger, Blackhurst, and Wahl (2005) found that starting in the fifth grade, students begin to eliminate specific careers and develop career aspirations based on gender and social appraisals of careers. Thus, a key goal of STEM 360 in general, and the assessment part of the project in particular, is to determine how effectively the project supports youth awareness of and interest in STEM careers as well as how effectively it supports teachers' ability to actively facilitate career awareness amongst their students.

Program Overview

Phase 4 of the STEM 360 project explored how a combination of in- and out-of-school STEM learning experiences could support student STEM career awareness, STEM learning and academic achievement, and STEM engagement and attitudes. It also explored how these experiences and teacher enrichment could support teacher self-efficacy around teaching STEM and about STEM careers and their positive attitudes towards the value of free-choice learning resources for student STEM learning. In Years 1 and 2 four strategies were used to enrich the existing STEM learning environment: In-school Educational Outreaches; Field Trips to VASSC; STEM Coach Engagement and Support; and a Teacher Enrichment Workshop.

Field Trips provided opportunities to engage students in more immersive STEM learning opportunities at places such as the Norfolk Botanical Gardens, the Virginia Zoo, the Virginia Air and Space Science Center (VASSC), and Virginia Tech Agricultural Extension.

In-school education outreaches were 1-hour programs conducted by VASSC educators who had been identified as STEM Coaches. The structure of in-school and field trips differed between Years 1 and 2. In Year 1, there were three standalone in-school outreach programs, three pre-field trip programs and the corresponding three field trips. In Year 2, there were two themes, earth and space science, each had a pre-field program (focused on STEM careers), then a field trip, followed by a post-field trip program. See Table 1 in the Appendix for a list of experiences by year, topic, and corresponding Virginia Standards of Learning (SOLs).

STEM Coaches provided engagement and support for all participating schools. These VASSC educators served as a mentor to the students and teachers, conducted in-school education programs; attended *Field Trips* with the students; and supported and co-taught with teachers.

Teacher Enrichment Workshop was a 1-day event that was attended by teachers, STEM Coaches, and STEM 360 program staff. At the workshops, teachers were introduced to the program and activities.

Research Questions

Students

1. How and in what ways could a comprehensive suite of learning interventions – both in- and out-of-school - measurably improve youth STEM career awareness, STEM learning academic achievement, and STEM engagement and attitudes?

Teachers

2. How might a multi-pronged approach to teacher STEM enrichment increase:
    a. teacher self-efficacy around supporting student STEM career awareness and development and
    b. positive teacher attitudes toward the role of free-choice learning resources (e.g., museums, zoos, etc.) and local community assets in supporting student career awareness, academic achievement, and STEM engagement and attitudes?

Methodology[1]

Participants

This longitudinal study followed students from 5th through 6th grade over the 2022-2024 school years in a subset of Hampton Roads schools participating in the STEM 360 program. In each year of the study (2022-2024), we collected student (5th and 6th grade), teacher (5th and 6th grade), and classroom level data. Since some schools were part of a more in-depth assessment of the impacts of the program, the number of participants and types of student, teacher, and classroom data collected varied by school. See Table 2 in the Appendix for types of data that were collected by school, classroom, and the overall program.

Students[2]

STEM 360 Students: A total of 379 5th grade students from four schools in the Hampton and Portsmouth school divisions who were participating in the STEM 360 program were recruited and 212 students (46%) had consent to participate. Eighty percent of these students completed the end of program survey administered at the end of their 6th grade year (Year 2). Among this sample, we limited our analyses to students who participated in the STEM 360 program for the full two years (126 students). A smaller sample of 20 students from Andrews Elementary School were recruited to participate in in-depth interviews at the beginning and end of each school year. Some students moved out of the area during the 2 years. At the end of the two years, 11 of these 20 students participated in all 4 interviews. More than half of these students identified as female (7 female, 4 male).

[1] In-depth surveys were also administered to students and teachers in Andrews and Portsmouth in Year 1 and at the beginning of and midway through Year 2 to collect real-time data about their experiences in the program and about any initial impacts. These data are discussed in Year 1 reports and in the beginning and mid-year reports for Year 2.
[2] A control group of students was also recruited. However, we did not have enough students (n = 15) to conduct analyses.

See Table 3 in the Appendix for the number of participating students by school and demographic information.

Teachers

STEM 360 Teachers: In Year 1, 5th grade teacher data were collected[3]. In Year 2, we collected data from a sample of 6th grade teachers who participated in the STEM 360 program. Sixth grade teacher data were collected from three[4] participating school divisions (Hampton, Newport News, and Suffolk). Out of 10 6th grade teachers participating in the STEM 360 program, 7 teachers completed the survey. One of these teachers was part of the STEM 360 program in past years. Also, two teachers, one from Andrews and one from Phenix, also participated in an end of year interview. See Table 4 for information about teachers' teaching experience.

Control Group Teachers: Eleven teachers from four school divisions (Hampton, Newport News, Portsmouth, and Suffolk) were in a teacher control group. One of the 11 teachers was a first-year teacher, so she only responded to questions about the current school year. Since data about last year were not collected, only her open-ended question responses were analyzed.

Control group teachers' experience in teaching differed from the STEM 360 teacher group. (See Table 4). More than half had been teaching in general and science specifically for more than 10 years. Similar to the STEM 360 teachers, about a third of teachers reported that they had a master's degree in teaching, but no STEM-related degree or endorsement and a third of teachers had a STEM-related degree, but no degree in education. However, within the Control Group, a third of teachers had a degree or endorsement in science teaching specifically. And like the STEM 360 teachers, most of the Control group teachers were fairly new to their current school.

Classroom-Level

Observations of in-school and field trip[5] experiences were conducted at Andrews Elementary.

Study Design

Student Data

End of Program Surveys: All consented STEM 360 students were administered a single STEM 360 assessment at the end of the two-year program. This end of program assessment included a series of retrospective pre-test questions designed to capture changes in STEM career awareness, academic achievement, and STEM engagement and attitudes, comparing before and after the 2-year STEM 360 program. This assessment was based on existing validated research instruments used in earlier phases of STEM 360 (Falk, et al., 2016; Staus, et al., 2019), but the instrument was re-designed and shortened to both accommodate the realities of the older youth and the need to reduce the time required by youth to complete the survey.

[3] Fifth grade teacher data are discussed in the Year1 interim report.
[4] No 6th grade teacher data were collected from the Portsmouth school division.
[5] Due to schedule changes and conflicts, in Year 2, only one of the two field trips (Space Science theme) was observed.

The retrospective pre-test approach is an alternative to the traditional pretest/posttest surveys and has been shown to successfully and validly assess changes in outcomes such as interest (cf. Hill, 2020; Hwaleck, et al., 2021; Pratt, et al., 2000). This approach involves administering a survey after the program. This survey had two sets of questions. One set asked students to recall their experience and perception of themselves before the program (like a pre-test). The second set presented the same questions but asks students to think about their experience and current perceptions of themselves at the end of the program (like a post-test). Since students participated in the program in 5th and 6th grades, the survey questions asked students to think about themselves in 4th grade (before the STEM 360 program) and now at the end of 6th grade (after the STEM 360 program). Students' responses about their perception of themselves before and after the program were analyzed for any differences. The survey also included questions asking students about their experiences in the program.

Interviews: Student interviews were conducted in person with a small subset of STEM 360 students by a local researcher at the beginning and end of students' 5th grade year and then again at the beginning and end of students' 6th grade year. These students were pulled out of the classroom during the school day and interviews were conducted in a separate location in the school. Interviews were audio recorded and later transcribed. These interviews provided rich data about students' existing interests, participation, and job aspirations in general and specifically STEM as well as their experience in the STEM 360 program, and if they perceived that any changes in these STEM-related outcomes had occurred as a consequence of the STEM 360 program.

Teacher Data

End-of-Year Survey: All consented STEM 360 and Control Group teachers were asked to complete an online end of year survey that gathered information about any changes over the year in their self-efficacy in teaching STEM and supporting student STEM career development, their awareness of local STEM learning opportunities, and their attitudes towards learning outside the classroom and in students' free-time. As with students, a retrospective pre-test methodology was utilized. The questions about STEM teaching efficacy and beliefs and STEM career awareness were based on an existing validated and commonly used survey called the Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey (Friday Institute for Educational Innovation, 2012). The survey questions asked teachers to think about themselves last school year (before the STEM 360 program for STEM 360 teachers) and now at the end of this school year (after the STEM 360 program for STEM 360 teachers).

STEM 360 teachers were also asked about their overall experience in the program and their perceptions of effectiveness of STEM 360 for supporting students' STEM career awareness and STEM career development, STEM engagement and attitudes, and STEM learning and academic achievement.

Interviews: Two STEM 360 teachers participated in interviews which provided additional information about their experience with the program and their perceptions of the impact of the program on students. Teachers were also asked to share more contextual information about their students and their community.

Classroom-Level Data
Classroom observations were conducted in-person by a local researcher. Observations provided context for student and teacher experiences. And they provided further information about student engagement and interest.

Student Findings

STEM Career Awareness

Students were asked about their awareness of STEM-related careers. This was measured in two ways: 1) asking students to indicate whether certain careers use STEM (science, technology, engineering and/or math); and 2) whether they are interested in careers that relate to STEM. To examine any changes in their STEM career awareness and interest in STEM careers, students were first asked to respond to these questions thinking about what they thought in 4th grade (before the STEM 360 program) and then respond again based on what they think now at the end of 6th grade (after the STEM 360 program).

STEM Careers
To assess whether students considered certain careers to use STEM, students were presented with a list of careers, including those that are typically thought of as involving STEM (e.g., doctor, scientist), those that are less typically viewed this way (e.g., construction work, architect), and those that are not considered to use STEM (e.g., historian, actor). There was a significant increase between 4th and 6th grade in the number of careers that students viewed as STEM careers (mean of 6.6 to 7.3 careers, t= -1.929, df =125, p<.05)

Examining the specific careers, when students were asked what they thought in 4th grade, the most frequently mentioned careers were electrician (44%), mechanic (41%), meteorologist (40%), astronaut (39%), doctor (39%), and software designer 34%). The careers that were reported the least (mentioned by less than 15% of students) included librarian, journalist, mayor, writer, and golfer. Students identified a wider variety of careers as STEM careers at the end of 6th grade. The most frequently mentioned careers included astronaut (48%), electrician (48%), mechanic (47%), meteorologist (44%), software development (42%), and cybersecurity worker (42%). There were three careers whose identification rate increased by more than 10% from Grade 4 and Grade 6. These include construction worker (29% to 39%), architect (26% to 37%), and cybersecurity worker (28% to 42%).

There was also an open-ended question asking students to list other kinds of careers that use STEM and whether they would have listed those same careers in 4th grade. The most frequently mentioned careers included engineer (12%), teacher (10%), scientist (9%), mathematician (6%), and nurse (6%). It should be noted that students in Phase 4 of the STEM 360 program were more likely to mention that an engineer was a STEM career than in previous phases. For example, in Phase 3, only 1% of students indicated that it was a STEM career. Most students (74%) responded that at least some of the careers they listed they learned about after 4th grade.

STEM Career Aspirations

Students were asked close-ended and open-ended questions about their future career interests. They were asked about their interest in having careers that involve activities that relate to STEM. For example, they were asked to what degree do they agree that "I would like to have a job where I can make, design, or invent new things", or "I would like to have a job that uses science". Each item was coded, Totally Disagree -2, Disagree -1, Neither Agree or Disagree 0, Agree 1, and Totally Agree 2. Items were then added and divided by the number of items. The higher the number, the greater the respondents' aspiration. There was a statistically significant increase in students' STEM career aspirations between Grades 4 and 6 (from a mean of -.2116 to .0066; $t=3.320$, $df = 125$, $p < .001$).

What do I want to be when I grow up?

Students were asked the open-ended question, "What do you want to be when you grow up?". Comparing students' responses about their potential career before and after the program about half (47%) of the students reported that they were interested in the same career at 4th and at 6th grade and about half (47%) reported that their interest in careers changed. Unsurprisingly, many of the most common careers students mentioned in both 4th and 6th grade were an athlete (10% and 14%). Some other careers that students often indicated in the 4th grade were doctor (7%), teacher (7%), police officer (6%), and artist (5%).

There were some similarities and some differences in what careers students were interested in now in 6th grade. Some students continued to be interested in being a doctor (6%) and police officer (5%). However, some additional careers that students mentioned included a nurse (7%), a career that involved gaming or social media (5%), and hairstylist/nail tech (5%). Examining specifically the students whose career interest changed from 4th to 6th grade, 26% of these students reported that they were now interested in a STEM-related career.

Students were also asked why they were interested in their current chosen career and, if their career interest changed, why did they think it changed. Many students reported that they were interested in their current career for child-appropriate reasons like they simply liked it, thought it would be fun and interesting (26%). Others gave answers such as they like to help people (10%), and they have family support or family members who have that career (6%). Seventeen percent did not have a reason for why they chose their current career interest. The main reason students mentioned that they changed their current career interest was just that their interests had changed (13%).

Students who were interviewed were asked what they needed to do to achieve the careers of interest. Most students became more aware over the two years of the program of what was required to achieve their career goals, with many able to provide much more specific information. For example, during their first interviews, students might refer to needing to get good grades in general and later might refer to going to college or trade school, what they might need to study, and what specific skills would be required for the job. These students were also asked who they would go to, to ask for advice about pursuing a career. Most of these students mentioned asking family members both before and after the STEM 360 program. Only one student explicitly said during the first interview that they would not ask anyone at school and

then later, during the last interview, said that they would ask a teacher. They specifically referred to two elective class teachers (STEM teacher and a teacher who teaches career investigations).

Academic Achievement

Linda S. Pedron Dietz, Director of Accountability and Information Systems, Hampton City Schools assisted the project with examining any changes in academic achievement overall and in relation to STEM-related subjects. To do this, comparisons were made between 6th grade STEM 360 students (n=318) and a sample of non-STEM 360 6th grade students from across the division matched by age, socio-economic status, race/ethnicity and gender (n=1017).

The first comparison that was made looked at school attendance. Students in the STEM 360 program had a significantly higher school attendance rate than the comparison group (average attendance of 95% vs. 93%; $t(595)=3.74$, $p = 0.0002$). Similarly, there was a higher rate of chronic absenteeism (students with attendance of less than 90%) among the comparison group versus the STEM 360 group (20% vs. 12%). Rates of out of school suspensions were similar between the two groups.

All Hampton City School 6th grade students are required to take a standardized math test, but not a science standardized test. Therefore, only changes in math academic achievement were examined using school standardized test scores. A higher percentage of students in the STEM 360 program passed the math assessment than the comparison group (82% vs. 68%). A similar significant difference between STEM 360 students and controls were seen at the quarterly benchmark math assessments that were administered across the 6th grade year.

STEM Engagement and Attitudes

There were several sections of the STEM 360 survey that measured STEM engagement and attitudes. These included the degree to which students participated in different STEM-related activities, whether students had interests in STEM, and had positive attitudes towards STEM and specific STEM-related topics. Also, since family and peers can play an important role in youth STEM engagement and attitudes, students were asked about any family and/or peer support in their participation in STEM-related activities

Participation in STEM-Related Activities

One section of the survey asked students to report how frequently they participate in both group-organized and self-organized activities where STEM was more or less central to the experience. Items included group-organized activities such as visiting a museum, zoo, or aquarium and self-organized activities such as gardening or growing plants and building or taking things apart at home. See Table 5 in the Appendix for the list of activities. For each item, the responses were coded: Never 0, Rarely 1, Sometimes 2, Often 3, and Almost Every Day 4. The items were then added and divided by the number of items.

Between Grade 4 and 6, there was a statistically significant increase in student participation in group-oriented activities (from a mean of 1.22 to 1.320; $t = 1.505$, $df = 125$, $p = .067$). However, there was a slight, yet not significant, decrease in participation in self-organized activities. In addition, group-oriented activities and self-oriented activities were found to be highly correlated

(r =.746 for Grade 4 and r= .677 for Grade 6), indicating that the more a student participated in one type of activity, the more likely the student will participate in the other type of activity as well.

Students were also asked what other activities they participated in during 4th grade and then now. The most common activities students reported participating in at both time points were sports (23% to 29% of students), activities related to gaming and social media (14% to 14%), and outdoor activities (11% to 7%). Students also reported activities that they would like to try in the future. The future activities most frequently mentioned included sports (25%) and STEM-related activities (23%) such as going to a STEM-related informal learning institution, doing STEM-related projects or experiments, taking STEM-related classes, and doing activities outdoors and in nature.

Lastly, students were asked if their parents/caregivers or friends encouraged them to do any of the activities they listed. By encouragement, this could include general support, enabling students to participate in the activity, or having an interest in them participating in the activity. The activities students reported that were most often encouraged by their parents/caregivers included sports (32%), STEM-related activities (9%), art/music/writing (7%), and studying (5%). Activities that tend to be encouraged by friends also included sports (21%) and art/music/writing (6%) but also activities related to gaming and social media (12%), hanging out together (6%), and outside activities such as hiking, biking, and swimming (5%).

Attitudes towards STEM

There were two types of items that focused on STEM attitudes—those that measured more general attitudes and interests towards science, math, and engineering and those that explored specific STEM-related topic interests.

General Attitudes towards STEM: To measure Attitudes toward Science, Math, and Engineering, students were asked to what degree do they agree with a set of statements such as "I find science really interesting;" "I see how math relates to my life". All the items were coded: Totally Disagree -2, Disagree -1, Neither Agree or Disagree 0, Agree 1, and Totally Agree 2 and then added up and divided by the number of items included. The higher the number indicates the stronger and more favorable attitudes toward a given topic.

Attitudes improved significantly for all three STEM area between 4th and 6th grade. Attitudes towards Science increased from a mean of -.027 to 0.7 (t = 1.43, df = 125, p = 0.79). For Math, it increased from a mean of .5941 to 1.027 (t =4.182, df = 125, p<.001). And for Engineering, attitudes increased from a mean of -.178 to -.017 (t= 2.98, df = 125, p=.002). In addition, attitudes towards the three STEM areas showed statistically significant, though moderate, correlations (r = 2.65 between Science and Math, r = .455 between Science and Engineering, and r = 4.39 between Math and Engineering). This pattern was similar in Grade 4 as well.

Interest in STEM-Related Topics: The survey asked students to indicate to what degree they "like finding out about" a variety of STEM-related topics (e.g., what is in our solar system and how stars and planets form, how electricity is created and flows, and how pollution affects the environment and community. Items were divided into 6 different STEM Topic areas, including

Space Science, Earth Science, Life Science, Physical Science, Technology and Engineering, and Math (see Table 6 in Appendix).

To measure students' interest in each topic area, responses were coded as Totally Disagree -2, Disagree -1, Neither Agree or Disagree 0, Agree 1, Totally Agree 2. Then the items were added up and divided by the number of items included. The higher the value, the stronger one's interest in a given topic. Analyses show that students' interest in all STEM-related topic areas increased between 4th and 6th grade -- Space Science (.2016 to .4206, $t = 3.484$, $df = 125$, $p<.001$); Earth Science: (-.0298 to .1627, $t = 3.141$, $df = 125$, $p = .001$); Life Science: (.1012 to .2679, $t = 3.035$, $df = 125$, $p = .001$); Physical Science: (.0349 to .2095, t = 3.283, df = 125, p<.001); Technology and Engineering: (.1845 to .3155, t = 2.277, df = 125, p =.012); Math: (.2044 to .2877; t = 1.425, df = 125, p =.078). Interest in different topics is either moderately or highly correlated with each other. Some of the topics that were highly correlated were: Earth and Life Science (r=.707, p =.000), Physical Science and Life Science (r = .711, p=.000), and Space Science and Mathematics (r =.747, p=.000).

Favorite Subject

To learn more about student interests, we asked them about their favorite and least favorite subjects in 4th and 6th grade. Like previous STEM 360 Phases, the most popular subject was math and that was the case for both 4th and 6th grade (52% to 61%). Other favorite subjects at both time points included English language arts (13% to 12%) and science (11% to 14%). The main difference in students' favorite subject was for social studies which was reported less frequently in 6th grade (10% to 3%)

Students were also asked to explain why the subject they chose now was their favorite and if their favorite subject changed between 4th and 6th grade why they thought it changed. The most common reason students chose their current favorite subject was because it was easy, they understand it, or they are good at it (27%). Other reported reasons included that the subject was fun and interesting (16%), they don't know the reason (10%), and they liked their teacher (8%). Students indicated that they thought they changed their favorite subject either because the original subject became more difficult (16%), or they lost interest (9%). Sixteen percent of students did not have a reason for why their favorite subject changed.

STEM 360 Program Feedback

Favorite Memory

Students were asked about their favorite memories from the STEM 360 experience. Note that students mainly referred to activities from Year 2 rather than from the entire 2-year program. Students referred most often to the field trips in general (8%), the liquid nitrogen activity that the STEM Coach demonstrated (8%), and the career activities (5%). In Year 1,[6] students talked extensively about the hands-on activities, especially the Space Capsule Scramble or egg drop activity in which students collaboratively engaged in the engineering design process to create a device that would prevent an egg from breaking when dropped from a high place. One student noted that there seemed to be less hands-on activities in Year 2 than in Year 1 of the program.

[6] This finding comes from a survey that was administered to a subset of students at the end of Year 1.

One Thing Learned
In the survey, students mentioned learning about several topics. The most common topics they referred to included solar system and space (17%), properties of liquid nitrogen (6%), how to filter water (4%), and about STEM careers and how they work together (4%).

Favorite Field Trip & In-Class Lesson
Students thought positively about the program, but reported liking the Space Science experiences somewhat more than the Earth Science experiences. More than half of students reported liking the field trips (Space Science 65%; Earth Science 50%). Students indicated liking the field trips more than the in-school program experiences (Space Science pre-visit 40%, post-visit 42%; Earth Science pre-visit 37%, post-visit 38%).

Students were asked which field trip was their favorite and why. Students referred to field trips from Year 1 and 2. Forty-two percent of students mentioned a trip to VASSC as their favorite. Some didn't specify which trip to VASSC (13%). One reason students said it was their favorite was because of the movie or because of the activities and games. Below is how one student talked about his VASSC field trip experience [NOTE: he refers to VASSC as NASA]:

> *NASA was really fun. I learned that... I didn't know what the Apollo was until I went to the museum and I saw it was huge. I didn't know it was that big. I thought it was like a small little thing but no it's huge.*

A few students talked about a non-STEM 360 field trip that involved going on a boat and measuring the salinity of water. This field trip was mentioned in other interviews over the two years, presumably because students assumed that all STEM-related field trips were related to STEM 360.

Other students mentioned a particular trip with 23% favoring the Space Science trip and 4% favoring the Earth Science trip. A few students referred to the trip that included visiting the Virginia Tech Agricultural Extension because they enjoyed seeing the fish. Here is how one student described that field trip:

> *The NASA space Museum because we explored the building next to it last time like the fish and like stuff and it was fun like seeing the fish like what the fish eat. It was really cool....*

Students provided some reasons for why the Space Science field trip was their favorite including that it was fun, and they liked the topic. Students also remembered going to the zoo in Year 1 and enjoying seeing the animals (12%). Lastly, some students mentioned that a non-STEM 360 program field trip (from this or last year) was their favorite (10%).

Students were also asked about which in-school lesson was their favorite and why. Some students referred generally to a Space Science lesson saying that they enjoyed learning about space and planets (11%). Other lessons mentioned included the one with the liquid nitrogen demonstration (8%), learning about water filtration and designing virtual water filters (5%), and the career boot activity (3%). A couple of students specifically reported that they liked best the

pre-visit experiences because they give them opportunities to learn new things. An example of this latter preference was::

> *My favorite were the pre-visits because we were all knew* [sic] *to the stuff and it was cool to learn about something we've never learned before.*

Another student talked about their favorite experience, which was the field trip where they built water filters and contrasted it with the in-class lesson where they created virtual water filters. The student was very clear that he liked the field trip activity better since he was able to physically interact with materials:

> *I think it was because the water filter. Like I wanted to build an actual water filter to build one in real life. Not on the computer...I don't like [the] computer, I don't like that, I like hands what do you call it hands on. Yeah, hands on...Like you could sit here and read to me all day. And guess what? I'm not gonna listen to you. I like to use my hands.*

Describing STEM 360

In the surveys, students were asked how they would describe STEM 360 to a friend who does not go to the school. Student responses were like how students have described the program in previous STEM 360 Phases. The most common way students described it was as fun or cool. Students also mentioned that it involved science, field trips, and it was educational. Again, like past program Phases, some students described that the program was both fun and educational. For example:

> *I would describe it as fun and important if you want to know about the future things that you could turn out to be*

A few students referred to the STEM Coach and saw the coach as part of the program, creating a link between school and field trips as shown in the following student quote:

> *It's something extra that you get during science class. It's when your coach for the year comes to your class and teaches you about something STEM related then after you go on a field trip about the lesson.*

Here are a few more student descriptions of the program:

> *...you have fun you learn about science and math. And electronics and technology, and all that, it was like you can learn how to put things together and take them apart. And they can help you with any type of math or science you need help with.*

> *I would say STEM 360 is a thing where they come from the science museum down the street. And then they come into school and teach us about different things or go over stuff from field trips or different lessons.*

STEM 360 is where they come to the classroom we get to test out new things that we usually don't get to do. Like when he brought the nitrogen, that was cool because he filled my water bottle and like I thought I was drinking nitrogen...

exotically exciting and more fun. And hands on. Very, very good experience.

Feedback and General Reactions to STEM 360

In student interviews, students shared overall feelings about the 2-year program. Some students expressed disappointment that their participation in the program was ending:

Because we're not going to be able to like- do we even have science in seventh grade. Well, we are not going to be able to come to the classroom and like we're not going to see no more new stuff like from the science museum. And we're probably not going to have no more field trips.

Another student appreciated the opportunity to just learn:

You might not like everything but it's cool to still like learn about it and talk about it.

A few students mentioned that they would like more variety in the field trips and felt like they had gone to VASSC too frequently. A few students said that they now have no reason to go to VASSC on their own since they had sufficient experiences at the site because of the STEM 360 field trips.

Lastly, a few students talked about taking a STEM elective and some students confused that class with the STEM 360 program, again presumably assuming that all STEM-related activities were part of the STEM 360 program.

Awareness of Local STEM Resources

Students were asked during interviews about their awareness of local STEM learning opportunities. There was an increase in the number of students who mentioned the VASSC. However, the variety of resources students mentioned decreased over the course of the program. In the previous interviews (beginning of the program, end of Year 1, and beginning of Year 2) students also referred to other informal learning institutions such as the zoo, aquarium, and botanical gardens. This is likely because students had attended field trips to the Virginia Zoo, Norfolk Botanical Gardens, and perhaps the Virginia Aquarium in previous years. At the same time, there was an increase in students mentioning online resources (e.g., YouTube) and a decrease in mentioning school as a STEM learning resource.

One student, during the final interview mentioned that his brother is a resource for STEM learning and specifically engineering since his brother is in a high school focused on engineering. He appreciated that he could learn from this brother about engineering:

Interviewer*: When you think of engineering, what comes to mind?*

Student: *"My brother, because his Academy is engineering. And like, he makes these cool projects and he comes home with them, and I get to look at them and play with them.*

Interviewer*: So does he come home? And he talks to you? Or do you go to him? And you're like, hey, what do you get up to?*

Student: *I go to him, he's all the way in 11th grade is cool to have somebody that you can learn more stuff from instead of just having to find out on your own.*

Defining STEM, Science, and Engineering

During student interviews, students were asked about how they define STEM, science, and engineering and if they saw these as distinct in some way. Some students talked about STEM in terms of the individual subjects (science, technology, engineering, and/or math). Most commonly, students mentioned science and/or engineering. A few students felt that STEM was in some way different from science and engineering, but they weren't sure how to explain it. When asked to define science, the most common responses related to stereotypical notions of science (e.g., chemicals, atoms, experiments, labs). When asked to define engineering, students mainly referred to fixing and building things like cars and houses.

One student talked about STEM in a nuanced way, discussing how it is an interdisciplinary approach across the individual subjects:

Interviewer: *Is science and engineering different from STEM?*

Student: *I feel like you connect together somehow, in some way like, it all comes together as one. In science people and engineers have to come together and make a very, very good experiment. Like you might like make a volcano or something?*

Interviewer: *So you think science and engineering people work together?*

Student: *It has to be that way. Because if you have engineers, they have to make the stuff for you and then the scientists they have to discover what to make it with. So they have to work together to make something beautiful.*

Teacher Findings

Teacher Self-Efficacy Around Teaching STEM Concepts and Supporting STEM Career Awareness and Development

STEM Teaching Self-Efficacy

To measure any change in teachers' self-efficacy around teaching STEM concepts teachers were asked to what degree they agreed with a series of statements such as "*I am confident that I can teach STEM effectively".* All the items were coded: Totally Disagree -2, Disagree -1, Neither Agree or Disagree 0, Agree 1, and Totally Agree 2 and then added up and divided by the number

of items included. The higher the number, the higher the level of self-efficacy in teaching STEM concepts.

Between last school year and the end of this school year, teachers' STEM teaching self-efficacy increased for both the STEM 360 teachers (from a mean of 0.59 to 1.10) and the Control Group teachers (from a mean of 0.18 to 0.58). The increase was statistically significant for both groups (STEM 360: $t = -2.102$, $df = 6$, $p = .087$; Control Group: $t = -4.059$, $df = 9$, $p < .01$). It is important to point out that STEM 360 teachers started and ended with significantly higher STEM teaching self-efficacy than the Control Group teachers (before: $t = 1.913$, $df = 15$, $p = .075$, now $t = 2.005$, $df = 15$, $p = .063$).

Teachers discussed in what ways their confidence in teaching STEM changed and what might have led to these changes. STEM 360 teachers talked specifically about how the STEM 360 program supported them in teaching STEM. They mentioned that the program increased their content knowledge and introduced them to new hands-on activities and experiments. Also, having the opportunity to engage in the activities, especially before teaching students, prepared teachers for the class lesson and even inspired teachers to seek out additional activities as illustrated in these teacher responses:

> *Yes! I was very confident in the information because beforehand I was able to view the information and run the same test that students would be conducting in class while learning the content required. It was like a cool study session!*

> *It allowed me to look for new ways to implement STEM teaching throughout the year. There are suggestions to try, but seeing it first hand made me want to research and find new opportunities.*

Another teacher reported that the STEM Coach was very instrumental in supporting her in teaching STEM:

> *At the beginning of the last school year, my knowledge in STEM was pretty much online self-paced courses. Since working with such a wonderful partner, I have full confidence in certain areas in which she helps guide me. She was super supportive and if I had questions, she always made sure to help me with information and if we both were stuck, she went the extra mile to get the correct answer.*

Lastly, a teacher who has participated in STEM 360 in previous years mentioned that the program was more creative this year which helped both her and her students engage in STEM:

> *I feel more positive about implementing STEM instruction in my classroom teaching. This year was more creative than the past years of STEM 360. Students were taken to the next level and had to imagine, design, test, and revise their concepts. It was exciting this year.*

Among the Control Group teachers, a few talked about specific ways that their confidence changed. One teacher talked about a large change in confidence because she learned new methods and strategies for teaching STEM. One first year teacher mentioned that an IT support

teacher was a great resource by providing access to and strategies for using technology. Interestingly, one teacher who was not part of the STEM 360 program noted that she would benefit from professional development and resources to support her in teaching STEM:

> *I need more professional development on how to effectively integrate the lessons to be of quality and to help improve student understanding of the concept. For instance, with the SOL, how will they be able to retain that information for the SOL. Also, access to materials and lessons with time to effectively execute the activity or lesson has been a battle for the time being.*

Supporting STEM Career Awareness and Development

To measure any change in teachers' self-efficacy around supporting student STEM career awareness and development, teachers were asked to what degree they agreed with a series of statements such as "*I know where to find resources for teaching students about STEM careers".* All the items were coded: Totally Disagree -2, Disagree -1, Neither Agree or Disagree 0, Agree 1, and Totally Agree 2 and then added up and divided by the number of items included. The higher the number, the higher the level of self-efficacy in supporting student STEM career awareness and development.

Between last school year and the end of this school year, teachers' self-efficacy for supporting student STEM career interest and development increased for both the STEM 360 teachers (from a mean of 0.18 to 0.79) and the Control Group teachers (from a mean of -0.13 to 0.35). However, the increase was statistically significant for only the STEM 360 teachers (t = -1.576, df = 6, p = .08).

Some STEM 360 teachers attributed this change to just being exposed to new STEM careers and learning through the STEM 360 program what careers were considered to be STEM careers. One teacher specifically mentioned that the "Boots" activity was effective for supporting her students' and her own STEM career awareness. Additionally, a teacher who has participated in the STEM 360 program in previous phases felt that the program was more effective in focusing on STEM careers than it had been in the past:

> *I feel like the careers were focused on with more intentionality this year. In the past, the careers associated with the concept were almost an after thought. Now, they were front and center like "here is a problem in our world and we will introduce you to problem solving careers."*

Among the teachers in the Control Group, a few mentioned that they needed more information about STEM careers for their students. One teacher did refer to the StarBase program as being a good resource about STEM careers for her students.

The Role of Free-Choice Learning Resources

Self-Efficacy in Supporting Student STEM Learning Outside of the Classroom

To measure any change in teachers' self-efficacy around supporting student STEM learning outside of the classroom teachers were asked to what degree they agreed with a series of

statements such as "*I am able to infuse local STEM learning opportunities into a lesson by myself".* All the items were coded: Totally Disagree -2, Disagree -1, Neither Agree or Disagree 0, Agree 1, and Totally Agree 2 and then added up and divided by the number of items included. The higher the number, the higher the level of self-efficacy.

Between last school year and the end of this school year, teachers' self-efficacy in supporting student STEM learning outside of the classroom increased for both the STEM 360 teachers (from a mean of 0.429 to 1.143) and the Control Group teachers (from a mean of -0.074 to 0.370). The increase was statistically significant for both groups (STEM 360: $t = -2.176$, $df = 6$, $p = .036$; Control Group: $t = -2.000$, $df = 9$, $p=0.04$). Though this increased significantly for both groups of teachers, teachers' self-efficacy in supporting student STEM learning outside of the classroom was greater for STEM 360 teachers than Control Group teachers after the program ($t = 1.788$, $df = 14$, $p = .095$).

Though there was a significant increase in teachers' self-efficacy in supporting student STEM learning outside of the classroom for both STEM 360 and Control Group teachers, the STEM 360 teachers had a lot more to say about these changes and what influenced these changes. STEM 360 teachers discussed new concrete ways that they were supporting student STEM learning outside of the classroom and they attributed these changes to the program. This included activities such as starting an engineering club, getting involved in other STEM-related clubs, or seeking out other community learning resources:

> *I began an engineering club…I planned a STEM field trip for my engineering club this year. It allowed students to identify a problem involving force, motion, speed, and it was very cool. I don't think I would have tried it if it wasn't for STEM 360 this year.*
>
> *I sponsored the BETA club this year and worked with students on their robotics competition.*
>
> *I tried to look into more community-based programs, that align with the standards we were learning in class. Such as the watershed program with a River team.*

Another teacher mentioned that the program widened her network of local STEM learning opportunities and that the STEM Coaches were an important resource for making further connections to outside of classroom learning.

> *Although I do not have tons of connections within the community the same way other teachers may, I do feel confident that should they want to be more engaged outside of school I will be able to help point them in the right direction…..The STEM 360 program allowed me to make connections to the VASSC community that I did not previously have. If I have students interested, I know that I am able to reach out to our STEM coaches for resources.*

Only a few teachers in the Control Group shared any learning opportunities and even those teachers acknowledged that they were mainly unaware of how to support students STEM learning outside of the classroom as noted in these teacher responses:

I am aware of the multiple of local STEM learning opportunities. I just need to do better getting parents and students involved.

Outside of our STEM club within our elementary school, I am unaware of where to direct parents and students locally. (Other than summer camps at StarBase)

I have been exposed with some activities that have benefited me with activities, but they are very few and far between. I know of activities such as LEGOs, but that is primarily it.

Attitudes Towards Student Free-Choice STEM Learning Resources

Changes in teachers' attitudes towards the role of free-choice learning resources, learning outside of the classroom, and local community assets in supporting STEM learning was measured in a variety of ways. Teachers were asked the degree to which they agreed that "STEM experiences outside of the classroom (e.g., field trips) support student's STEM learning above and beyond what they learn in school." There was no difference in teachers' change in attitudes between the STEM 360 teachers and the Control Group. Positive attitudes increased significantly for both groups: STEM 360 teachers (from a mean of 1.29 to 1.71; t=-1.441, df=6, p=.09); Control Group teachers (from a mean of 1.3 to 1.7; t=-2.449, df=9, p<.05).

Teachers were also asked the degree they agreed that "learning outside of school, during student's free-time, supports student learning". This increased for both the STEM 360 teachers (from a mean of 0.86 to 1.43) and the Control Group teachers (from a mean of 1.2 to 1.5). And this increase was significant for both groups of teachers (STEM 360: t=-1.549, df=6, p=.086; Control: t=-1.741, df=10, p=.056.

STEM 360

Teachers were asked to describe an example of how STEM experiences outside of the classroom (e.g., field trips) support student's STEM learning above and beyond what they learn in school. Teachers from the STEM 360 program provided a variety of examples. One of the most common responses was that engaging students in STEM experiences outside of the classroom reinforces their learning. Teachers, like in teachers in previous year, reported that they observed students connecting their outside of the classroom experiences with in-class lessons. Here are some examples from teachers' responses:

The students were able to come to the museum and make water filters, this idea was later used in class to support a class video showing the community how to make them just in case the water is dirty around them.

I loved the field trip last year to the botanical gardens. I loved the dissection of the plants and when we began learning about it a month later, students referred back to the trip and what they did.

The field trips really helped to reinforce what we learned in school. Students were able to recall those experiences from the field trips while we reviewed our topics we covered.

One teacher also discussed that providing outside of the classroom learning experiences provided opportunities that the students might not otherwise have access to and that this had the potential to broaden students' perspective of local learning opportunities:

> *Most of my students do not get the opportunity to experience educational things outside of the school. Field trips are vital for them to see opportunities beyond the city they live in.*

There were very few examples given by teachers from the Control Group about how outside of the classroom STEM learning experiences can support STEM learning. One teacher did mention that such experiences can be an opportunity for students to see STEM in the real world:

> *Field trips allow the students to see STEM in use in real time and students will see that STEM is everywhere and not just a "fun" activity in the classroom.*

Teachers were also asked about how they learn about STEM learning experiences outside of the classroom. One STEM 360 teacher referred to learning from a STEM Coach:

> *I reach out to the coach that I had from the 360 Program, and she normally points me in the right direction.*

Other sources of information did not differ between the STEM 360 and Control Group teachers. Some teachers learned through their current or previous school districts either from email blasts or their colleagues. Here is how one STEM 360 teacher described how she learned about these experiences:

> *I am aware of opportunities outside of school because of email blasts from previous divisions I worked at, emails from our STEM coordinator at my current school, and colleagues who share on social media*.

Both a STEM 360 and a Control Group teacher mentioned that they sought out opportunities on their own in their community:

> *I research on my own or speak to other teachers or people in the science field to look for opportunities.* (STEM 360 Teacher)

> *I look into Children's museums and presentations in the area to consider visiting for field trips next year. (Planetariums, Watershed, Waste Management Facility (Solid).* (Control Group Teacher)

Lastly, one teacher from the Control Group reported needing further support in seeking these learning opportunities.

Availability of Local STEM Learning Opportunities

Teachers were asked what opportunities they were aware of in their community that would allow students to engage in STEM learning outside of school during their free-time. Teachers in both

groups referred generally and specifically to local experiences including informal learning institutions, school programs, and other community resources. Two STEM 360 teachers provided the most extensive and detailed lists of opportunities:

> *There are stem kits students can use, there is the CHROME club (Cooperative Hampton Roads Organization for Minorities in Engineering), there is the Living Museum, Aquarium, Zoo, Botanical Gardens, Ifly, Virginia Air and Space Center, Mariners Museum, Watermen's Museum, Sandy Bottom, Fort Monroe, VIMS, Jefferson Lab, and many more.*

> *We have great museums around here, including the VASSC and the VLM. Both of these centers have summer programs and regular programming as well. At CMS, as the STEM magnet school, we also have STEM clubs and activities as well.*

The Control Group teachers shared additional opportunities including Saturday Academy, Victory Elementary School (StarBase), Portsmouth Children's Museum, "Mad Science" of Hampton, Virginia Living Museum, Mariner's Museum, CoVA STEM Center, Busch Gardens Roller Coaster Tour, and the summer STEM Academy.

Teachers were then asked how, if at all, had their view of the possible opportunities created for STEM learning outside of school changed since last school year. STEM 360 teachers reported that the STEM 360 program helped them become more aware of local opportunities while also providing opportunities that teachers might not be able to. One teacher mentioned that the program inspired her to be creative in providing learning experiences and she understood the importance of making STEM accessible for student's continued learning outside the classroom:

> *It has made me consider getting more creative and thinking outside of the box to create these experiences for students…. Just to find more accessible ways for students to get challenged and problem solve in a way they can try again with their family or friends after getting introduced to it during school.*

Most teachers in the Control Group did not have a response to this question. However, one teacher pointed out the degree to which socioeconomic status plays a role in students' access to these types of resources. At the same time, she suggested that she could support students in seeing STEM more broadly and in ways that are accessible including in their own backyard:

> *The demographics and socio-economics plays a HUGE role in accessibility of resources and STEM learning outside of school, but I also believe that I could play a bigger role in it as well. Helping students realize that STEM is not only working with items in a science classroom, but it is also outside in their backyard.*

Lastly, teachers were asked about what barriers there might be to students engaging in STEM learning outside of school during student's free time. Teachers' responses were similar for both groups and with prior years. The tops barriers listed were transportation and distance to opportunities, followed by cost and parent involvement which includes willingness to participate

as well as parent availability. Interestingly, two teachers in the Control Group also referred to neighborhood safety as a barrier to engaging in these opportunities.

STEM 360 Experience and Impacts

Teachers who participated in the STEM 360 program were also asked about their overall experience in the program and for any feedback they might have to continue to improve the program. This included their perceptions of the effectiveness of STEM 360 for supporting student career awareness and STEM career development, STEM engagement and attitudes, and STEM learning and academic achievement. Teachers were also asked about the impacts of specific program components such as the varying types of experiences and working with the STEM Coach.

Highlights of STEM 360

When asked about highlights of the STEM 360 program, teachers reported engaging in program experiences including both in-class activities and field trips. Some activities teachers referred to included the liquid nitrogen demonstration and building water filters. Some teachers also appreciated seeing students' excitement during the different experiences. One teacher mentioned that working with the STEM Coach was a highlight:

> *The in-class examples were really fun for the class and I! We had a great time on each visit!! especially with the liquid nitrogen!!*
>
> *Getting to know my STEM coach was definitely a highlight. [STEM Coach] was a great resource to have and I think we made a great team.*
>
> *Being able to take students on field trips to allow more stem opportunities*

Student Impacts

Teachers were asked about the impact of the STEM 360 program on their students. All teachers reported that the STEM 360 program had a positive impact on their students. Teachers mentioned how students were engaged in the various program experiences and with learning more generally. The experiences reinforced learning since students were able to make connections to class lessons. A couple of teachers also mentioned that it was helpful that the program made STEM relevant to students' everyday lives:

> *It gave my students an opportunity to see that STEM is integrated in their everyday life, even if they aren't aware of it.*
>
> *STEM360 allowed my students to review material that we had been learning and reinforced it with real world examples. Students were able to recall certain facts from the movie we watched and connect to the lessons we were working on.*

Teacher Impacts

Teachers were also asked about the impact of the program on their teaching. All teachers reported that the program positively impacted their teaching. Some teachers mentioned that the program encouraged them to do more hands-on activities with their students because they saw the positive impact on students, and they felt more comfortable doing the activities by the end of the year. A couple of teachers were generally inspired to do more and be creative in their teaching in the next school year.

> *STEM360 gave me some new tools to be able to use in the classroom. I really liked the interactive filtration activity and would love to implement that into my teaching.*
>
> *The program has shown me how much students learn from experiments, and it encouraged me to do even more with them.*
>
> *It was so helpful in helping to grow rejuvenate my creativity and Ideas for the next school year*

In an interview, one teacher provided a specific example of how the program had an impact on her teaching, inspiring her to incorporate more hands-on activities in her regular teaching practice:

> *I started doing projects every quarter, which I've never done before, but I was like, look at these projects that Coach [name] is asking them to build something and create something. So after the first STEM 360, I had [the students] design a house and in their house they had to look for renewable energy resources and energy efficient appliances to put in their living room and stuff like that. And I don't think that they'd ever considered, this is your dream house, but the dream is to make a positive impact. The dream is to use less energy and think about conservation in your efforts…. I don't plan on ever doing anything the same way, and so I do think it's had an impact.*

STEM Career Awareness

All teachers agreed or strongly agreed that the overall STEM 360 program and the specific experiences significantly impacted overall student STEM career awareness (Table 7). In fact, this is the area where teachers observed the greatest impact. This was true for both the Space Science and Earth Science themed experiences. They felt that the program exposed students to new and different STEM careers, increased students' interest in STEM careers, it also made the careers seem attainable for students.

> *The students were more aware of what the careers were, not only that but they seen how obtainable these were in their lifetime to be in those listed careers.*
>
> *Prior to the program, a majority of my students had likely never been exposed to any of those careers. I heard some students talking about how they'd be interested in some of those careers.*

Teachers were asked to what degree the program supported students' interest in careers that related to a list of STEM-related topic areas. (See Table 8). They reported that the program mainly supported interest in careers related to Earth Science, Space Science, Physical Science, and Technology and Engineering. This was evidenced in student questions. Teachers heard students ask questions about careers that related to space, engineering, technology, and the environment. This makes sense given the focus of this year's program on Space and Earth Science. Here, in an interview, a teacher discusses one student who typically did not have good classroom behavior, but became inspired to pursue a space-related career because of the STEM 360 program:

> *[The students] really enjoyed space a lot. It inspired one kid in particular, who's kind of on the... He's smart, but his behaviors are bad, and I think it kind of motivated him to have an aspiration, how much that he likes space. And so, he mentioned to me that he wants to do some sort of engineering with NASA when he gets older…That was really good because every time we talk about space, he'll do his own research on the side, on the computer, and things like that.*

This same teacher then shared what aspects of the program were most successful in supporting this student's and other students' career aspiration:

> *I think the combination of the lesson that was here at school, and then seeing the 3D movie of how the astronauts are trained and prepare themselves to go into space. And then when we were at NASA, he got to see, like all the students, the different planets, and the facts, the different ships and satellites that they sent out there, very interactive stuff for them. It was just a whole new world outside of what you know around you. It was just something very different for them, and I think that was really helpful for them to learn and then actually physically get to see what they were learning.*

One teacher who has participated in previous phases of STEM 360 commented on how STEM careers were clearly more of a focus in this phase. In previous phases she tried to supplement the program by incorporating STEM careers since she felt it wasn't adequately covered. This year she felt that it was successful:

> *One of the problems I've had with STEM 360 was the careers. And so, I have this wall..it used to have all of these, you could be a mathematician, you could be a geologist, a botanist, a chemist, a marine biologist. You can study exobiology or hydrology. I had all of these types of careers as a way to supplement that, in STEM 360, the career was almost like the dinner mint. It was like, we're talking about all of this other stuff. And by the way, there was a career. I feel like the career focus is perfect. I love how it's been implemented now.*

This same teacher also mentioned that she appreciated the diversity of careers and people represented in the videos:

> *I really like the videos that kind of show examples of people in the career that are very short and sweet, and I love how diverse the videos were. There were women, there were men. They were from all over the United States.*

Teachers shared several ways in which the program could better support students' STEM career awareness. This included inviting people from the field to come to talk with students and share their on-the-ground experience. This has been expressed by teachers in previous years as well. One teacher suggested providing students with an authentic problem that they might encounter on the job, and they would need to work through the problem.

One teacher suggested in an interview that more time should be devoted to continued conversations about STEM careers after the field trips and during regular classroom lessons. She mentioned that this could include providing teachers with some materials that teachers can refer to and facilitate conversations where students reflect and debrief the career-related activities:

> *I would love a little poster that said, "STEM 360, these are your watershed careers." And had something that we could refer back to, because when we did our follow-up conversation, I don't think we spent too much time addressing it… I think that we spent a lot of time talking about the career and then a very short amount of time on the actual problem. And then we went on the field trip and when we got back, there wasn't enough time to go over, "Okay, so now that you took your quiz and you've seen these jobs in action, let's just take an impartial vote. Who would like to be this person, this person, this person? Why or why not?" And have more of a conversation. I like the collaborative board, but there really isn't much time to discuss why or why not. I think that would be a thing for me.*

Teachers provided ideas for possible community partners or resources that could support student STEM career awareness and development. They suggested the Elizabeth River Project, Dismal Swamp, the local naval shipyard (which has been mentioned several times in previous years), generally people in the field, the wastewater treatment facility, and landfills. One teacher suggested connecting with partners in the energy sector, which particularly relates to 6th grade curriculum:

> *I think that having the wastewater treatment facility, landfills, and other energy sources could be great supports to our students. Our 6th grade curriculum heavily covers environmental impacts and having community partners come in from the places we are learning about could be helpful. They know quite a bit more about their careers than I do*

STEM Learning and Academic Achievement

Most teachers (71%) agreed or strongly agreed that the overall STEM 360 program and the specific experiences (Table 7) improved student's STEM learning and academic achievement. Teachers reported that the program supported STEM learning by effectively engaging students in STEM. Teachers mentioned that having hands-on activities and just teaching outside of the textbook were successful strategies. The following quote is from a teacher who really struggled with classroom management this year and mentioned that the program did not impact her class as

a whole. But she saw how the program supported those students who did participate in their learning:

> *STEM360 provided fun, unique, hands on learning experiences for our students. This was different from what I usually did with them. The students who wanted to participate were able to learn in a different way. I think the filtration activity especially was able to solidify learning.*

One teacher shared that she felt that the activities generated rich conversations in her class. In this example, she shared a facilitated conversation where students were able to see the connections between issues around water quality and the economy:

> *. Some of them were very thought-provoking. I know that for the water quality, someone was like, "Well, how am I supposed to know how it is going to affect a PR person?" Or, "How is it going to affect the economy?" And I was like, "Well, the economy means..." And they were like, "Yeah, we don't know what that means." So I was like, "The economy is how money is being made in an area." I said, "So, let's say there's a water issue and people start getting sick. Can they go to their job?" And they were like, "No." I said, "So if no one's doing that job..." They were like, "Oh, then people aren't making their money. They may not be able to afford things."*

Some teachers offered suggestions for how the program could better support students' STEM learning and academic achievement. Ideas included relating material to local trade careers, offering more content and experiences, providing the teachers the materials earlier in the year to better prepare their students, and providing SOL-formatted questions to help students connect the program experiences to classroom content.

STEM Engagement and Attitudes

Most teachers agreed or strongly agreed that the overall STEM 360 program (86% of teachers) the specific experiences (see Table 7) supported student STEM engagement and attitudes. Again, teachers seemed to view the program experiences as better supporting STEM career awareness than other outcomes including STEM engagement and attitudes. Examining specific STEM-related topics, teachers reported that students were mostly engaged in Earth and Space Science. (See Table 8). Teachers mentioned that students enjoyed the hands-on activities and field trips. They also reported that the STEM Coaches were "fun and exciting". These components inspired students to want to learn more and be creative in their class work.

In an interview a teacher shared that providing students with open-ended problem-solving activities supported student engagement as well as learning. She provided an example of conversations she heard during the water filter activities. The teacher felt that the virtual activity provided more of an engaging opportunity for the students to problem solve:

> *The first field trip, I loved building the water filters, but I think I was even more excited for the post visit to do the virtual building of the water filters, because I think that some of [the students] discussed what to do and then they got annoyed that other people's*

didn't turn out and they were like, "See, I told you we should have…." And I said, "No, you guys, when we get back, you'll get to do your own online." And they liked that they got to try something new and that it didn't work, and they got to do it again and again. So, they really liked the virtual simulation because it was a trial-and-error analysis, which I thought was very, very cool.

This teacher goes on to explain how STEM 360 activities provide something that typical SOL-oriented curriculum does not. She felt that these activities allow students to be creative in solving problems, which supports learning:

I think that giving the students a chance to come up with their own ideas to solving problems isn't something they're given a chance to do very often in a SOL formatted world that we live in, where there's one answer… that's what you're supposed to find. So being able to find kids having discussions about, "Well, this is what I would do." "Well, this is what I think we should do.", And be able to talk about the pros and cons of why is this the best solution? Or "What should we do first?" Even when they were building their water filters, you could hear them saying, "Well, wait a minute, which layer should go on the top?" Or "Which layer should go on the bottom?" "Oh, this is what we should do next time if I was building my own." So, giving them a chance to be creative and problem solve….

Teachers provided a few suggestions on how the program might be improved to support students' STEM engagement and attitudes. These included incorporating more local engagement and real-life opportunities and examples and providing more interactive activities at the pre and post visits.

STEM Coach

Supporting Students

Virtually all (95%) teachers agreed or strongly agreed that the STEM Coach supported students overall and students' STEM career awareness, STEM learning and achievement, and their engagement and attitudes towards STEM. Teachers reported that the STEM Coaches were not only knowledgeable, but they were also caring and supportive towards students, passionate about the content, had a positive attitude, and were good at answering student. Here are some of the teachers' comments about the STEM Coaches:

The student had a ton of questions for the coach and she had an answer for everything, when [Coach] didn't [Coach] had no problem taking a moment to find out! my kids really loved [Coach]!

Coach [name] was knowledgeable, insightful, caring, and passionate when interacting with students. [Coach] is one of the best STEM educators I have ever met.

[STEM Coach] was WONDERFUL with my students. [Coach] came with a positive attitude daily and encouraged my students that best that [Coach] was able to. She provided excellent one to one help to my students who engaged with [Coach].

In an interview, a teacher shared that the STEM Coach adapted to students' needs and interests and engaged students authentically.

> *It was good. He was very energetic, more energetic than me because he does these little hops around the classrooms and stuff. But he was very involved with the kids when they were working on the paperwork stuff, helping them out, answering the questions, changing up the wording for them, because some of the stuff, their reading levels are low, and so they need help with understanding what the question is asking them. And he did really good with flipping it to where they can understand. So that was really good. I liked the experiments and things he had here. They really enjoyed him having … the liquid nitrogen… So they were asking him, "Can you put a balloon and things?" Actually, he went back and picked up more items that they requested to show them, so that was really good. And so, they'd never seen that before. And I thought that was really good that once he finished his lesson, he went back to the liquid nitrogen and started doing the objects that they asked him to put inside that were safe. He did that, and I thought that was really good that he wasn't just doing this to check off a box, but he was actually very engaged with the kids and gave them the opportunity to see the things that they wanted him to put inside of it.*

The only suggestion that one teacher offered was that the STEM Coach visit more often to keep "the information fresh on the students' minds." Otherwise, teachers felt that the STEM Coaches were phenomenal.

> *Well my coach was perfect sorry!*
>
> *I can't think of anything, they were fantastic!*
>
> *[Coach] can't. Coach [name] is a rock star.*
>
> *MY STEM COACH WAS THE BOMB!!!!!!!!!!!!!!!!! you guys honestly could take a pointer on two on how to deal with students. [Coach] kept them engaged the whole time!*

Supporting Teachers

All of the teachers agreed or strongly agreed that the STEM Coach supported them and that they had a lot of positive things to say. Teachers reported that they had good communication with their STEM Coach. A couple of teachers mentioned that their STEM Coach was open to feedback:

> *He chatted with me one on one to discuss how to best support my students. I gave him details about their individual needs and abilities and he adjusted to make the information accessible to all of my students.*
>
> *He was very adaptable. Anything I wrote down, and I had a whole page of notes that I left at my house, but anything that I wrote down as like, "I'm noticing this." He would say, "You know what? I'm noticing that too, or I feel like this too."*

Another teacher expressed that her STEM Coach supported her in her career more generally and was able to engage the students in a way that she couldn't:

> *[Coach] was so supportive to me both in the classroom and as a person. [Coach] was able to make connections with students that I wasn't able to and brought a different perspective. [Coach] provided me with support related to my own career as well.*

The only suggestion that one teacher offered was that she would like more communication with her STEM Coach.

Teacher Feedback

Teachers were asked what, if any, program challenges they experienced. Most teachers did not report any issues. One challenge that was mentioned involved the timing with buses which took away time from the field trip experience. Another teacher who participated in the program in previous years said her biggest challenge was that the program assumed students' prior knowledge:

> *I think that the biggest change for me was there was a bigger assumption of their prior knowledge. I think that when it was in fifth grade, it was more of a, "Hey you guys, let's introduce all of these concepts to you. You've never heard of these things before." Whereas, when we started with the watershed unit, it was like, you're already aware of so much of what's going on. You're very aware of what a watershed is, what major pollutants in the area would be. And a lot of the kids were just kind of wide-eyed. You almost assume that we're experts on this…The same thing happened with space... I think we were at the beginning of the space unit maybe, so I hadn't even taught space by the time [Coach] was introducing. So [Coach] was like, "You know these planets." And I think because there is some space taught in fifth grade, we introduce the planets, we talk about the difference between gas giants and terrestrial planets. They had some prior knowledge, but as far as space exploration, that's not taught in fifth. So that was all kind of brand new. "How would you build a space shuttle?" "What types of parameters would you have to put in place?" "Why is traveling to Mars so different than traveling to the grocery store here on earth?" And so I think that a lot of those questions kind of sparked some interest, but I don't think they had been posed in that way before.*

A teacher also mentioned that the vocabulary during the "Boots" quiz was too advanced for her students, which made it difficult for them to fully engage in the activity:

> *I don't feel like they really knew what was being asked of them. And so I think that kind of made some students feel some anxiety about what STEM 360 would be, because it was like, "All right, you guys, I'm Coach [Name]. We're going to take this boot quiz." And they were feeling a little defeated because they weren't really sure how to answer. It was posed as, "This is a survey to find out what your interests are." So they were like, "Yay."...And then they started answering questions and they were like, "I don't understand what the questions are." Because it was so... The vocab was very advanced.*

We would call it tier three. There wasn't much context to figure out what was the question really looking for, for it to be like, "Oh, you're a planner." Oh, okay. So to me, it should say something like, "Are you organized? Do you care about details and dates? Are you able to make deadline?" To me, that would be more geared towards a sixth grader's understanding

Another teacher shared with the STEM 360 team and in an interview that her school's administration changed during the year and that one of her biggest challenges was that the new administration did not prioritize the school's participation in the STEM 360 program. This made scheduling experiences very difficult.

Teachers were also asked about areas of program improvement. Most teachers did not have any suggestions and one shared that she appreciated that the program team is continually aiming to improve the program. One suggestion for improvement was to time the experiences with the course pacing. This is something many teachers have suggested in past years. One teacher mentioned that some of the curriculum was factually incorrect which made it awkward for the teacher to navigate.

Another teacher mentioned that downtime during field trips was difficult for her students. So, she suggested minimizing unstructured time:

The only thing is when we were there for the first session, we had a lot of downtime with... After their scavenger hunt, it was just like, "They can explore now." But that downtime was so long that it got crazy for us chaperones with keeping up with the children. I felt like we were starting to get disorganized a bit. And we had a lot of kids running around and extra... They were excited, but the excitement was starting to really take over, and mishandling things, and stuff like that. So I don't mind them having downtime, but I wish it was limited, like it had a start and end point, and then it transitions to something else, not just downtime waiting for the next group to be done because then we kind of lost control of our kids. The second trip was more back-to-back, so we didn't have that downtime like we did the first time, so that was really helpful and good. We stayed organized, and we had less mistakes or problems happening.

Lastly, one teacher suggested improvements for science teacher enrichment. She mentioned that it would be beneficial to use a similar teacher professional development model used for science teachers at the Jefferson Lab, a local US Department of Energy science laboratory. She described it as an ongoing series that walks science teachers through the science curriculum, standards, and hands-on experiences in depth. Together they discuss teaching strategies and potential problems that might arise. She mentioned that the local school division used to do a similar type of training. Here she explains the program:

*So for science teachers….what I would like is if you did something similar to what Jefferson Lab does. And so they have JSAT (*JLab Science Activities for Teachers*) every other Tuesday night, it's for two hours. The first hour is where they go over the curriculum and the content and get you familiar with your SOL standard…Then the second hour is where [they] do the lab and do the hands-on experiences.*

She then goes on to discuss how it might be used in STEM 360:

> *So if in the summer or in the early fall before STEM 360 starts…if the teachers were able to get together and go over the standards. "Okay, so let's talk about watersheds. You're supposed to understand source pollutions. You're supposed to understand the three main regional watersheds, the 14 major watersheds. You're supposed to understand how water quality is tested. This is what you're supposed to understand. Just start there".*
> *Then, say, "here's the experience that we want the students to have". So give us the worksheets, go over the questions and have us take down notes of, "do we like this question?" "What are some possible things that could go right or wrong?" Because that's how Hampton City Schools used to do our training. They used to have us come in, talk about the curriculum, practice making our anchor charts, go over the labs so that we could see, uh-oh, someone's going to have an issue with this. We used to have stream tables and some of the new teachers were like, "I just don't know how to set it up." So we'd help them set it up in advance. We'd walk around and assist each other.*

Discussion

Phase 4 focused on engaging a cohort of students from their 5th to 6th grade school years and 5th and 6th grade teachers in STEM educational experiences, as in previous phases. New to this phase was a focus on teacher enrichment to support teachers in teaching STEM.

Phase 4 analyses examined the following questions:

Students

1. How and in what ways could a comprehensive suite of learning interventions – both in- and out-of-school -- measurably improve youth STEM career awareness, academic achievement, and STEM engagement and attitudes?

Teachers

2. How might a multi-pronged approach to teacher STEM enrichment increase:
    a. teacher self-efficacy around supporting student STEM career awareness and development and
    b. positive teacher attitudes toward the role of free-choice learning resources (e.g., museums, zoos, etc.) and local community assets in supporting student career awareness, academic achievement, and STEM engagement and attitudes?

To address these questions, we compared student and teacher impacts between before they participated in the STEM 360 program and after. At the end of the fourth phase of STEM 360, there continues to be compelling evidence that the program has a positive impact on students and teachers. This was evidenced by direct student measures, teachers' observations of their students, and teachers' reflections about themselves Key conclusions based on the three main student learning outcomes and teacher outcomes from this study are discussed below.

STEM 360 Increased Students' STEM Career Awareness and Interest in Careers Related to Some STEM-Related Topics, But Room for More

Changes in student career awareness of STEM-related careers were measured in two ways: asking students to indicate whether a list of careers use STEM and whether they are interested in careers that relate to STEM. By the end of the program, students were able to identify a wider variety of STEM careers. Students also reported that some of the STEM careers were new to them. There was also an increase in students' STEM career aspirations.

Teachers noted that the biggest impact of the overall program on students was students' increased STEM career awareness. They mentioned that the program experiences supported students' STEM career awareness by exposing them to new STEM careers, increasing their interest in these careers, and making the careers seem attainable. They observed that students were mainly interested in the STEM areas that were specifically covered in the program (e.g., space, engineering, technology, and the environment).

One teacher who had participated in STEM 360 in previous years shared that this year's program seemed to be more successful in supporting STEM career awareness than in the past. This speaks to the STEM 360's team continued efforts to make STEM careers more central to the program.

Teachers still had suggestions for improvement. Like in previous years, 6th grade teachers mentioned that students would benefit from hearing local people from the field talk about their on-the-ground experiences and engaging in authentic job-related problems. Another suggestion was to have more time for continued conversations about STEM careers after program experiences for students to further discuss and reflect the STEM careers they were introduced to. This teacher mentioned that this could be accomplished by providing teachers with resources related to the careers that teachers could refer to and use to facilitate class discussions during their regular class lessons.

STEM 360 teachers also provided ideas for possible community partners who might further support students STEM career awareness. Some of these partners have been mentioned in the past and some are new.

STEM 360 Increased Student STEM Learning

Students in 6th grade took the Math state assessment. There was a higher rate of students passing the math state assessments among STEM 360 students than among the comparative group. There was further evidence of the impact of the STEM 360 program on STEM learning STEM 360 teachers observed that the STEM 360 program experiences supported students STEM learning by engaging them through activities such as hands-on and other types of activities, helping students make connections to class lessons, and made STEM relevant to students' everyday lives. Teachers also suggested ideas to further support student STEM learning. These included relating the material to local trade careers, offering more content and experiences, providing teachers with the materials earlier, and providing SOL-formatted questions (which has been mentioned in previous years).

Although teachers generally believed that the STEM 360 program increased student STEM learning, they tended to believe that these increases were around the edges of learning, e.g.,

interest and attitudes, rather than directly. The data from Hampton Schools in math would suggest direct improvements in STEM learning as a consequence of the program. These findings should be shared with teachers during future teacher preparation and teacher development times. As there is evidence that teacher expectations can be self-fulfilling (e.g., Archambault, Janosz & Chouinard, 2012; Gentrup, Lorenz, Kristen & Kogan, 2020).

Evidence of STEM 360 Increasing Overall School Engagement

Comparisons were made between students who participated in the STEM 360 program and those who did not. STEM 360 students had a higher rate of attendance and lower rates of chronic absenteeism and out of school suspensions than the comparative group.

There was additional evidence of the STEM 360 program supporting learning overall. STEM 360 teachers shared that students were engaged, not only with program experiences, but with learning more generally. Teachers noted that the program supported learning by helping students connect concepts to class lessons and making it relevant to students' everyday lives.

STEM 360 Increased Students' Participation in Some STEM Activities

The student survey measured the degree to which students participated in different STEM-related activities. Engagement in STEM was measured by students' reported participation in various group and self-organized STEM activities. Students' participation in group-organized activities increased significantly between before and after the program. However, there was a slight decrease in participation in self-organized activities. Students were also asked what activities they might want to engage in in the future. Unsurprisingly, about a quarter reported wanting to participate more in sports. However interestingly, a quarter of students also mentioned wanting to participate in STEM-related activities such as going to a STEM-related informal learning institution, doing STEM-related projects or experiments, taking STEM-related classes, and doing activities outdoors and in nature.

STEM 360 Increased Students' Attitudes Towards and Interest in STEM

Student attitudes towards STEM including science, math, and engineering all increased between 4th and 6th grade. In addition, students' interests in STEM-related topics in different areas such as Space Science, Earth Science, Life Science, Physical Science, Technology and Engineering, and Math increased. Lastly, students were asked about their favorite school subject in both grades. Like in previous phases, the most frequently reported favorite subject was math for both 4th and 6th grade.

Program Experiences Engaged Students in STEM, But There is a Need for More Hands-On Activities

Students and teachers reported that the STEM 360 program engaged students. As in previous years, students enjoyed hands-on activities. Teachers observed students especially engaged in hands-on and problem-solving activities such as the real and virtual water filter activities. They noted that program activities engaged students in ways that typical SOL-oriented curriculum did not. One teacher specifically mentioned that the program experiences were uniquely different from SOL-oriented curriculum because they allow provide students the opportunity to be creative in solving problems.

However, students talked more about hands-on activities in Year 1 than in Year 2 of Phase 4. One student noted that there were fewer hands-on activities in Year 2. In Year 1, students talked extensively about the egg drop activity and some also talked about making the harmonica. While discussing the hands-on activities in Year 1, students talked more about the concepts involved. For examples for the egg drop activity, students talked about the engineering design process and for the harmonica activity, they talked about the properties of sound. In contrast, in Year 2, the main activities students mentioned were not hands-on. The in-class activity that students mostly referred to, was the liquid nitrogen demonstration followed by career activities and the movies during the field trips. When students talked about the liquid nitrogen activity, they talked less about the concepts behind the activity and more about how fun it was. A suggestion would be to include more open-ended, problem-solving hands-on activities to better support both student engagement and learning. Teacher suggestions for further engaging students included connecting more to local opportunities and providing more hands-on activities.

Need for Increased Variety of Field Trips and Exposure to More Out of School STEM Learning Opportunities

As in previous years, students enjoyed going on field trips. While some students enjoyed going to VASSC, some felt that they go there on many field trips and would like to visit other places. Students were asked where they would go to learn about STEM in their community. While there was an increase in students mentioning VASSC, the variety of resources students mentioned decreased over the course of the program. This is likely due in part to students having visited a wider variety of informal STEM learning institutions in Year 1 than in Year 2. This would suggest the importance of exposing students to more local STEM learning experiences, which includes varying field trip locations.

Existing STEM and Career Education Efforts at Schools

Students at one of the STEM 360 schools mentioned taking electives and attending non-program school events that were relevant to the STEM 360 program. These included a STEM elective, a career investigations elective, and a career fair. It might be beneficial for the program to work in collaboration with these existing school efforts to reinforce learning without being redundant.

STEM 360 Clearly Increased STEM Teaching Self-Efficacy and Impacted their Practice

Though teachers' STEM teaching self-efficacy increased for both STEM 360 and Control Group teachers, STEM 360 teachers were better able to explain how and why both their STEM teaching self-efficacy and overall teaching practice changed. STEM 360 teachers attributed these changes to the program. They shared that the program supported them by increasing their content knowledge, exposing them to new hands-on activities, providing access to a STEM Coach and giving teachers the opportunity to engage in program activities before they introduced the activities to their students.

Additionally, STEM 360 had a positive impact on their practice by significantly enhancing some teachers' confidence in doing hands-on activities. This was because they had support in doing these activities and they had the opportunity to see the positive impact these activities had on students. As a result of this increase in confidence and observing the impact, some teachers shared that they planned to implement more hands-on activities with their students in the future.

Control Group teachers also mentioned that they had the opportunity to learn new strategies for teaching STEM over the year. However, they did not specify what the opportunities were. One did refer to an IT support teacher who was a great resource. Another teacher did note that she would benefit from professional development and resources to support her teaching STEM. The STEM 360 program might fit that need.

STEM 360 Increased Teacher STEM Career Awareness and Development Self-Efficacy
Teacher STEM career awareness and development self-efficacy increased significantly for only STEM 360 teachers. Some STEM 360 teachers attributed this change to STEM 360 experiences including being exposed to new STEM careers and the "Boots" activity. As previously noted, one teacher who participated in the program in previous years felt that that this year's program was more effective in focusing on STEM careers than in the past.

Control Group teachers mentioned that they needed more information about STEM careers. One teacher referred to the StarBase program, which had been mentioned by teachers in previous years, as a good resource for STEM careers. Several teachers with previous STEM 360 experience mentioned that they thought the career focus in this phase of STEM 360 was much improved over previous years of the program; much more focused and much better integrated into all aspects of the program.

STEM 360 Teachers Better Able to Explain Changes in Their Self-Efficacy in Supporting Student STEM Learning Outside of the Classroom for STEM 360
Teachers' self-efficacy in supporting student STEM learning outside of the classroom increased for both the STEM 360 and Control Group teachers. However, it is important to point out that the STEM 360 teachers had a lot more to say about these changes and what influenced these changes. STEM 360 teachers were specific in discussing new concrete ways that they were supporting student STEM learning outside of the classroom. Some of the ways that teachers supported students outside of the classroom included starting an engineering club, getting involved in other STEM-related clubs, or seeking out other community learning resources. Importantly, these teachers attributed these changes in their practice to the program. They discussed how the program and STEM Coaches were great resources in connecting students to local STEM learning opportunities. In contrast, the Control Group teachers mentioned that they were unaware of local STEM learning opportunities and ways to support student STEM learning outside of the classroom.

STEM 360 Teachers Better Able to Explain How Outside of Classroom STEM Learning Experiences and STEM Learning Experiences in Students' Free-Time Support STEM Learning
Attitudes towards the role of school-connected STEM learning experiences outside of the classroom and experiences during students' free-time increased for both STEM 360 and Control Group teachers. However, STEM 360 teachers were better able to explain how these experiences supported student STEM learning. STEM 360 teachers mentioned that these experiences reinforced learning, supported students in connecting to in-class lessons, and school-connected outside of classroom experiences enabled students to access these experiences.

STEM 360 Increased Teacher Awareness of Local STEM Learning Opportunities

STEM 360 and Control Group teachers mentioned a variety of local STEM learning opportunities that would be good for the program to keep in mind. However, STEM 360 teachers were better able to explain how their view of these opportunities changed since last school year. STEM 360 teachers reported that the STEM 360 program helped them become more aware of local opportunities while also providing opportunities that teachers might not be able.

STEM Coach Effectively Supported Students and Teachers
Teachers had a very positive experience working with their STEM Coaches. They reported that they were knowledgeable, passionate, had a positive attitude, and were caring and supportive towards students. Teachers mentioned that they felt supported by the STEM Coaches and appreciated that the STEM Coaches were open to feedback.

Teachers Experiences Some Challenges in the Program, But Fewer Than in Previous Year
Most teachers did not report any challenges participating in the program. Those that were mentioned included assuming students' prior knowledge, which made some activities challenging for students; school division constraints and lack of buy-in from new administration; need for better aligning program experiences to curriculum pacing (which has been mentioned in previous years); and more structure during field trips.

Conclusion

The main take home message is that STEM 360 continues to have positive impacts on students and teachers. The most striking finding was that this phase's targeted focus on STEM career awareness and development was very successful for students and teachers. In fact, this focus was more successful in Phase 4 than in previous phases. As in the past, students' STEM learning, interest, attitudes and participation in STEM activities increased. Further, with additional data supplied by Hampton City Schools administration, we were able to show that the program resulted in positive impacts on student overall academic achievement and in relation to STEM-related subjects and school engagement. Having access to district level data for the first time proved to be helpful in both understanding and describing the larger student impacts created by the STEM 360 program.

Focusing on teacher professional development in Phase 4 also was very successful. This targeted teacher support (e.g., teacher workshops, STEM Coach) resulted in increased teacher self-efficacy in STEM teaching, STEM career awareness, and supporting students STEM learning outside of school self-efficacy. The program also had positive impacts on teachers' awareness of local STEM learning opportunities, their understanding of how outside of classroom STEM-related experiences support STEM learning, and teachers' teaching practice. This all bodes well for continued teacher enrichment efforts in Phase 5.

With clear evidence of the positive impacts of the STEM 360 program, future iterations of the project can focus on making continued improvements in how to best meet the needs of both students and teachers. As in previous years, teachers suggested connecting more with people in local STEM-related careers to further support student STEM career awareness and aspirations. Also, throughout the phases and as shown in work in the larger field, hands-on activities have been shown to effectively support student engagement. The hands-on and problem-solving

activities that were implemented in Year 1 of Phase 4 were very successful in supporting students' engagement and learning. Some students still referred to some of these activities at the end of Year 2. However, there seemed to be fewer of these opportunities in Year 2. It is recommended that future phases include more of these types of activities. Additionally, students could benefit from increased variety in school field trips to further increase their STEM engagement and awareness of local STEM learning opportunities.

Overall, these findings demonstrate that the STEM 360 program continues to deliver significant value to students and teachers. As the project builds on Phase 4 efforts and learnings and moves on to Phase 5, we can further explore and refine the program elements for students and teachers at different grade levels.

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APPENDIX

Table 1. Program Experiences and VA SOLs for Years 1 and 2 by Topic

	Topic	Outreach	Pre-visit	Field trip	Post-visit	VA SOLs
Year 1	Sound	Bring on the Noise				Science 5.5
	Light	Lighten Up				Science 5.6
	Electricity	Electricity				Science 5.4
	Ecosystems		Living Planet	Virginia Zoo		Science 2.5, 3.4, 3.5, 4.3
	Soil & Plants		Soil Science	Norfolk Botanical Gardens		Science 3.6, 4.2, 5.2, 5.6
	Space & Physical Science, Engineering Design		Space Capsule	VASSC		Science 5.3, Math 4.14, 5.1 and 5
Year 2	Earth Science		Artemis Boots Quiz - Career Workshop	VASSC & VT Agricultural Extension	Matter of Fact	Science 6.1, 6.2, 6.5, 6.6, 6.8, 6.9
	Space Science		Artemis Boots Quiz - Career Workshop	VASSC	Our Solar System- Solar System Explorer	Science 6.1, 6.2, 6.3,

Table 2. *Types of data collected by school.*

Division	School	Students		Teachers		Classroom
		End of Program Surveys	Interviews	End of Year Surveys	Interviews	Observations
Hampton	Andrews	X	X	X	X	X
	Phenix	X		X	X	
Portsmouth	Victory	X		X		

	Westhaven	X	X	
Newport News	Crittendon Middle		X	
Suffolk	King's Fork		X	
Control Group			X	

Table 3. Survey Participant Descriptive Statistics

		#	%
White		27	21%
African American/Black		61	49%
Asian American		4	3%
Hispanic/Latine		4	3%
Other		30	24%
Total		126	
Boy		59	47%
Girl		63	50%
Other		4	3%
Total		126	
Hampton	Andrews	35	28%
	Phenix	66	53%
Hampton Total		101	80%
Portsmouth	Victory	11	9%
	Westhaven	14	11%
Portsmouth Total		25	20%
Total		126	

Table 4. Teacher Participant Descriptives

	STEM 360 Teachers	Control Group Teachers
Years Teaching		
First year teacher		
5 or less	29% (2)	36% (4)
6-10	43% (3)	0% (0)
11-20	14% (1)	36% (4)
More than 20	14% (1)	18% (2)
Didn't respond	0% (0)	9% (1)
Total	7	11
Years Teaching Science		
First year teacher		
5 or less	57% (4)	45% (5)
6-10	29% (2)	0% (0)
11-20	14% (1)	45% (5)
More than 20	0% (0)	9% (1)
Didn't respond	0% (0)	0% (0)
Total	7	11
Years Teaching at this School		
First year teacher		
5 or less	71% (5)	73% (8)
6-10	29% (2)	27% (3)
11-20	0% (0)	0% (0)
More than 20	0% (0)	0% (0)
Didn't respond	0% (0)	0% (0)
Total	7	11
Degrees/Certifications		
Masters in Teaching with no STEM-related endorsement/degree	29% (2)	27% (3)
STEM-related degree/endorsement with no teaching degree/endorsement	29% (2)	27% (3)
STEM-related teacher endorsement	0% (0)	27% (3)
Other	0% (0)	9% (1)
Didn't respond	43% (3)	0% (0)
Total	7	10

Table 5. STEM-Related Activities

Group-organized activities	Self-organized activities
Visit a science museum	Garden or grow plants at home
Visit a zoo	Do science kits, experiments, or stuff like that at home
Visit an aquarium	Watched any videos or shows about science, technology, engineering, or math (e.g., tv shows, online videos, Netflix shows, etc.)
Participate in an out-of-school activity about science, technology, engineering, or math	Build or take things apart or repair things

Table 6. Topic Interest Survey Items

Space Science	Earth Science
What is in our solar system and how stars and planets form	How to measure soil quality
What it's like on other planets and exploring space	Why water is an important natural resource
How the earth and moon move	How to find ways to protect and clean water
How astronauts protect resources like water and air in space	How pollution affects the environment and community
How research in space can help problems on earth	
Life Science	Physical Science
How to grow food and flowers	How electricity is created and flows
What are different types of ecosystems	How sound is created and moves
How animals adapt to their environment	How light is created and moves
How the food chain works	What are different types of energy
	How solar energy works and can be used
Technology and Engineering	Math
How spaceships and vehicles are made	How to solve puzzles or other math problems
How technology can be used to protect the environment	How to measure the speed, size, mass, or area of things
How to solve problems by planning, creating, and testing solutions	How to make different shapes and patterns out of stuff
How to design new games or toys	How to collect and analyze data

Table 7. *Percentage of teachers who reported that program experiences supported STEM career awareness, STEM learning and academic achievement, and STEM engagement and attitudes somewhat or a lot.*

		STEM Career Awareness	**STEM Learning & Academic Achievement**	**STEM Engagement & Attitudes**
Space Science	Pre-Visit	86% (6)	71% (5)	86% (6)
	Field Trip	100% (7)	86% (6)	86% (6)
	Post Visit	100% (7)	86% (6)	86% (6)
Earth Science	Pre-Visit	86% (6)	86% (6)	86% (6)
	Field Trip	100% (7)	86% (6)	86% (6)
	Post Visit	100% (7)	86% (6)	86% (6)

Table 8. Percentage of teachers who reported that the STEM 360 program supported students' interest in STEM topic areas and related careers.

	STEM Career Awareness	**STEM Engagement & Attitudes**
Earth Science	71% (5)	86% (6)
Space Science	71% (5)	86% (6)
Life Science	57% (4)	71% (5)
Physical Science	71% (5)	71% (5)
Math	43% (3)	57% (4)
Technology & Engineering	71% (5)	71% (5)