Follow-up study of STARBASE Minnesota participants

Phase II: Long-term program impact and community supports available to sustain learning

Follow-up study of STARBASE Minnesota participants

Phase II: Long-term program impact and community supports available to sustain learning

March 2011

Prepared by:
Caryn Mohr and Dan Mueller

Wilder Research
451 Lexington Parkway North
Saint Paul, Minnesota 55104
651-280-2700
www.wilderresearch.org

Contents

Contents (continued)

Figures

Figures (continued)

Acknowledgments

The following Wilder Research staff made important contributions to the completion of this evaluation:

Mark Anton
Katie Broton
Jacqueline Campeau
Marilyn Conrad
Louann Graham
Jennifer Maxfield
Dan Swanson
Brittney Wagner

We also wish to thank STARBASE Minnesota staff and Executive Director Kim Van Wie for their ongoing help with this evaluation. Appreciation is also extended to Amy Roberts, Kathryn Olson, and Jenifer Marier of the Minnesota Department of Education for their help with high school graduation data, and to Chief Master Sergeant Lance Olson of the U.S. Air Force for his help with military-enrollment data. Thank you to the former STARBASE Minnesota students now in college who provided valuable feedback through our survey. Finally, we greatly appreciate the time and information provided by the STEM practitioners participating in our program inventory and key informant interviews.

Summary

> *"STARBASE Minnesota is a 501(c)3 nonprofit organization whose purpose is to inspire and educate inner-city youth in science, technology, engineering, and mathematics."* —STARBASE Minnesota

STARBASE Minnesota is a week-long science, technology, engineering, and math (STEM) program for students in fourth and fifth grades. Students solve scientific and engineering challenges through a hands-on curriculum in a technology-rich aerospace environment. Established in 1993, the program aims to increase the STEM-related knowledge, skills, and interest of urban youth for greater academic and lifelong success. More than 30 Minneapolis and St. Paul elementary schools partner with STARBASE Minnesota each year. The program hosts entire grade levels within schools during the school year and is located at the 133rd Airlift Wing of the Minnesota Air National Guard Base. STARBASE Minnesota is funded in large part by the U.S. Department of Defense STARBASE program, and is sponsored by the Minnesota National Guard.

STARBASE Minnesota contracted with Wilder Research to conduct a follow-up study of participants to assess the program's long-term impact on their academic achievement and interest in STEM. Wilder Research conducted the study in two phases. Phase I examined the program's impact on high school students' interest, motivation, knowledge, and skill development in STEM, as well as their career interest in STEM including the military (Broton & Mueller, 2009). Phase II assessed the program's impact at high school graduation and beyond, examining on-time high school graduation, college enrollment, and interest and involvement in STEM during college. Phase II also explored the opportunities available in the local STEM community for students to continue their STEM learning beyond participation in STARBASE.

Study design

Wilder Research used a rigorous matched-comparison design to assess the long-term impact of participation in STARBASE Minnesota. Former STARBASE students were matched one-to-one with demographically and academically similar peers who did not participate in the program. Program effects were examined through analysis of differences between these two groups on student outcome measures. Differences were further explored based on cohort, dosage, and demographic characteristics. At the time of the study, STARBASE was offered to fourth- and sixth-grade students. Those attending in fourth-grade only constituted the low-dosage group, and those attending in both fourth and sixth grades constituted the high-dosage group.

Phase I followed-up on three cohorts of Saint Paul Public Schools (SPPS) students who participated in STARBASE as 4th-grade students and were enrolled as 10th-, 11th-, or 12th-grade students during the 2008-09 school year. Phase II followed-up on the latter two cohorts in fall 2010 and is the focus of this report. Wilder Research's Phase II study of STARBASE Minnesota was designed to address six core study questions:

1. What proportion of STARBASE Minnesota study participants graduate from high school on time? Are STARBASE participants more likely to continue in high school and graduate on time compared to similar students who did not participate in STARBASE?

2. What proportion of STARBASE Minnesota study participants enroll in college? Are STARBASE participants more likely to enroll in college compared to similar students who did not participate in STARBASE?

3. Is greater exposure to STARBASE (i.e., fourth- and sixth-grade participation vs. fourth-grade participation only) linked to higher educational attainment?

4. What programs currently exist to support and foster continued STEM learning, achievement, and career exploration after participants complete STARBASE?

5. To what extent do STARBASE Minnesota study participants access STEM programs and opportunities after completing STARBASE? What programs or opportunities do they find most helpful?

6. What additional programs or supports are needed to foster continued STEM learning, achievement, and career exploration after STARBASE?

To address Phase II questions, researchers compared STARBASE and comparison students on outcome measures related to on-time high school graduation and college enrollment. College enrollment data was provided by the National Student Clearinghouse, and high school graduation data by the Minnesota Department of Education. Additionally, Wilder Research administered a Web-based survey to gather information on college students' long-term interests and engagement in STEM areas following their participation in STARBASE. To assess program availability and gaps in the broader local STEM community, Wilder Research conducted a STEM program inventory as well as key informant interviews with local STEM leaders. Finally, data on students' military enrollment was provided by a U.S. Air Force official.

Major findings

Although the primary focus of the study was addressing the core study questions, available data enabled researchers to perform a number of analyses beyond these six questions. Following are overall findings, which sometimes extend beyond the six core questions identified in the original study proposal. Findings specific to the core study questions are highlighted separately in Figure 1 at the end of this section.

Overall findings

Taken together, Phase I and Phase II of Wilder Research's follow-up study of STARBASE Minnesota participants suggest possible long-term program impacts on students' high school graduation; college enrollment; and interest in STEM areas, and technology in particular. Because differences between STARBASE and comparison students were significant in some but not most cases, results should be viewed as promising but not definitive. Survey results also indicated that former STARBASE students have very positive feelings about the program even a decade later. The initial study suggested there may be stronger program impacts for those who receive a higher level of exposure to the program. Phase II analyses were limited by the small size of the low-dosage group and possibly influenced by demographic differences between the low- and high-dosage groups, and this pattern was not observed in the second phase.

STARBASE appears to enhance students' STEM-related interests, yet there may be gaps between their interests and ability to pursue those interests following STARBASE. Former STARBASE students enrolled in college in fall 2010 generally indicated STARBASE increased their STEM interest or understanding, but a majority said they did not participate in other STEM activities after STARBASE. Further, key informants described a number of barriers to accessing local STEM programs faced by underserved populations such as the urban students targeted by STARBASE. The STEM program inventory compiled information on 171 STEM programs or organizations, and 109 serving elementary, junior high, or high school students in St. Paul. This information can be used by program staff to help connect their graduates to ongoing STEM learning opportunities.

Beyond contributions to STARBASE's understanding of its own impacts, the study has the potential to contribute valuable information to the broader local STEM community. Key informants conveyed a keen interest in enhancing networking and collaboration within Minnesota's STEM community. In fact, Wilder Research's Phase II study coincided with early development of the Minnesota STEM Network, a new statewide network working to increase the state's effectiveness in providing STEM education. In this sense, the study is nicely timed to contribute valuable information to efforts to enhance networking

and collaboration in the local STEM community that could help support students' STEM interests.

Findings by data source

Following are more detailed findings, organized by the source of the data. Findings are presented in the areas of high school graduation, college enrollment, participant feedback, military enrollment, STEM program inventory, and key informant interviews.

High school graduation

Former STARBASE participants appeared to have an advantage over comparison students in on-time high school graduation, although with one exception results were generally not statistically significant. Highlights follow:

■ Overall, former STARBASE participants appeared to have higher on-time high school graduation rates than comparison students (81% and 75%, respectively).

■ Differences between the groups were not significant except in the comparison of high-dosage to comparison students in Cohort 2. In this case, a significantly higher percentage of high-dosage STARBASE (81%) than comparison (70%) students in Cohort 2 graduated from high school on time.

■ In Cohort 1, a higher percentage of low- than high-dosage STARBASE students in the study sample graduated on time, although the sample size for the low-dosage group was very small.

■ For context, in 2009 the four-year, on-time graduation rate for the St. Paul Public School District overall was 65 percent. This figure differs from the graduation rate reported for the STARBASE study sample in that it excludes students who transferred out of the district (SPPS, 2011).

College enrollment

STARBASE students also appeared to have an advantage over comparison students in college enrollment. Again, with one exception differences between STARBASE and comparison students were generally not statistically significant. Results also suggest potential program impacts on college enrollment for two demographic groups targeted by the program: low-income students and minority students. The advantage observed for high-dosage students in Phase I was not observed in Phase II analyses which were limited by the small size of the low-dosage group and possibly influenced by demographic differences between the low- and high-dosage groups. Highlights follow:

- Results suggest that STARBASE participants have an increased likelihood of enrolling in college, although differences were not statistically significant except in the case of the low-dosage comparison.

- Overall, 60 percent of STARBASE and 52 percent of comparison students enrolled in college by fall 2010.

- A significantly higher percentage of low-dosage STARBASE students (71%) enrolled in college than their matched pairs (43%).

- Results also suggest program impacts for low-income students and minority students. A significantly higher percentage of lower-income STARBASE than comparison students attended college (63% vs. 52%). Similarly, higher percentages of Black and Asian or Pacific Islander STARBASE students enrolled in college than their matched pairs, although those differences were not significant.

- Overall, STARBASE students also appeared to have an advantage over comparison students on a few protective factors associated with future degree completion, although differences were not significant. These included enrolling in college immediately following high school graduation, completing the first year, and returning fall of the second year.

Participant feedback

Wilder Research conducted an online survey of former STARBASE participants attending college in fall 2010. Thirty-six students responded to the survey, providing information on their current interests and career plans, and reflecting back on their experience with STARBASE and the program's impact on them personally. A decade after their participation, these former STARBASE students still had very positive feelings about the program. Survey results also suggest STARBASE helped expose students to potential STEM careers even if it did not influence their career decisions. The gap between their interest and participation in STEM following STARBASE suggests they faced barriers to participation in other opportunities, and program staff intend to use the STEM program inventory to help connect graduates to other opportunities. Survey highlights follow:

- Almost all students (97%) said STARBASE was a valuable learning experience.

- Most (72-78%) said STARBASE increased their interest in STEM, or helped them understand those areas better.

- A majority (58%) reported that STARBASE helped them learn about STEM-related careers, although fewer indicated the program had actually influenced their career

plans (19%). Phase I results also suggested the program helps students learn about different STEM career options, with nearly three-quarters of students in high school at the time reporting that STARBASE helped them learn either a lot or some about STEM-related careers.

■ Those who indicated STARBASE increased their interest in STEM areas were asked about each area separately. Almost all (96%) indicated the program increased their interest in technology, followed by engineering and science (81-85%) and math (58%). Although based on a small sample, students' attribution of an increased interest in technology to STARBASE resonates with the Phase I finding that in high school STARBASE students had a stronger interest in technology than comparison students.

■ Asked how much interest they currently have in STEM areas, most students answered "some" or "a lot" in relation to science (89%), technology (83%), and math (75%), and a majority answered "some" or "a lot" in relation to engineering (56%).

■ Fifty-eight percent of students indicated they had decided on a major or field of study, and those students were fairly evenly split between STEM-related and social science or liberal arts fields.

■ Asked how much interest they currently have in getting a job related to science, technology, engineering, or math, most students (81%) indicated "some" or "a lot."

■ Students were asked to reflect on the most important thing they gained from participation in STARBASE. One in four students described an appreciation of science or STEM areas or an understanding of scientific principles. The top five responses also included an appreciation for or knowledge of technology specifically, knowledge of their own personal interests or learning style, a fun experience or the joy of exploration, and experience working on a team.

Military enrollment

Although not a core study question, data were collected on students' entry into the military specifically in addition to their interest in STEM-related careers in general. Military-enrollment data reported here serve as an indication, but should be viewed with caution. These data were limited based on challenges with identifying some students in the military database based on information available for those students. Further studies could explore ways to better assess former participants' subsequent involvement in uniform or civilian military careers. Findings follow:

■ Conservative estimates suggest that from 2-4 percent of STARBASE and comparison students had entered the military by the fall after their high school graduation (Cohort 2) or the subsequent fall (Cohort 1).

■ Statistical tests were not performed on these data due to limitations with the data and our understanding that they likely reflect conservative estimates of those who had actually enrolled.

STEM program inventory

Wilder Research conducted a STEM program inventory to examine programs available to support and foster continued STEM learning, achievement, and career exploration after students exit the STARBASE program. For study purposes, the inventory emphasized programs serving 4th-12th grade students in the St. Paul area. Information compiled through the inventory documents a range of opportunities available to former STARBASE participants and other area students. Inventory highlights follow:

■ The final STEM program inventory includes information on 171 programs or organizations, including 134 serving St. Paul and 109 serving elementary, junior high, or high school students in St. Paul.

■ Science was the most frequently reported STEM program area (reported by 75% of all programs), although engineering (59%), technology (42%), and math (38%) were fairly well represented as well.

Key informant interviews

In summer and fall 2010, Wilder Research staff conducted 28 key informant interviews with 29 representatives of local STEM organizations to identify areas of need or gaps in available STEM programs and supports. While the STEM program inventory documented a variety of STEM opportunities for students, key informants described gaps in the populations served and barriers to program access for underserved populations. Highlights from the key informant interviews follow:

■ Despite program availability, key informants suggested there are a number of barriers to accessing available programs for underserved students such as the urban students in STARBASE Minnesota's target population.

■ Key informants described gaps in participation of several groups, including minority populations, girls, students from low-income families, students perceived as "at-risk" for various reasons, and teenagers.

- Key informants described a number of barriers that students, and in particular those in the underserved populations, face to accessing the available STEM programs. These included transportation, cost, awareness of available opportunities, not having a champion of STEM programming within their school, competing demands on time, language and cultural barriers, and other challenges.

- Key informants also perceived some gaps in local STEM programming. Their responses suggested programming could be enhanced by providing more engineering-focused, college-preparation, career-readiness, interdisciplinary, and service-learning opportunities; using technology to engage students in STEM learning; strengthening classroom STEM curricula and teachers' instructional capacity; integrating longer-term STEM projects; and providing demographically similar role models for students.

- Key informants perceive many important benefits of collaboration, and great potential for advancement through enhanced collaboration and networking.

Findings by study question

For reference, Figure 1 highlights the findings specifically pertaining to the six core study questions articulated earlier in this section.

1. Study questions and results summary

Study question	Data source	Results summary
1. On-time high school graduation	Minnesota Department of Education	■ Overall, former STARBASE participants appeared to have higher on-time high school graduation rates than comparison students. ■ 81% of STARBASE and 75% of comparison students graduated from high school on time. ■ Differences not statistically significant except between high-dosage (81%) and comparison students (70%) in Cohort 2.
2. College enrollment	National Student Clearinghouse	■ Results suggest that STARBASE participants have an increased likelihood of enrolling in college. ■ Overall, 60% of STARBASE and 52% of comparison students had enrolled in college. ■ Differences not statistically significant except between low-dosage (71%) and their matched pairs (43%). ■ Results also suggest possible program impacts for low-income and minority students. A significantly higher percentage of lower-income STARBASE than comparison students attended college (63% vs. 52%). Higher percentages of Black and Asian or Pacific Islander STARBASE students enrolled in college than their matched pairs, although those differences were not significant.

Study question	Data source	Results summary
3. Dosage effect	Minnesota Department of Education and National Student Clearinghouse	▪ Phase I results suggested a higher STARBASE dosage may result in a greater likelihood of an impact. Phase II dosage analyses were limited by the small size of the low-dosage group and demographic differences between the groups, and this pattern was not observed in that phase. ▪ Any future studies should continue to explore program impacts based on level of exposure.
4. Availability of programs to continue STEM learning	STEM program inventory	▪ The STEM program inventory collected information on 171 programs or organizations, 134 of which serve St. Paul and 109 of which serve elementary, junior high, or high school students in St. Paul. ▪ Science was the most frequently reported STEM program area (75% of all programs), although engineering (59%), technology (42%), and math (38%) were fairly well represented as well.
5. STEM involvement after STARBASE	Wilder Research survey of former STARBASE Minnesota students enrolled in college in fall 2010	▪ Most of the surveyed students (72-78%) said STARBASE increased their STEM interest or understanding, but a majority (69%) said they did not participate in other STEM activities after STARBASE. ▪ 17% reported facing challenges to participating in other STEM activities, such as being too busy, being unaware of other opportunities, or facing transportation or other challenges. ▪ Early in their college careers, 14% indicated they had participated in STEM-related activities, clubs, or programs at their college.
6. Additional supports needed to sustain STEM learning	Key informant interviews	▪ Despite availability, key informants suggested there are a number of barriers to accessing programs for underserved populations. ▪ There may also be gaps in local STEM programming, and key informants suggested a variety of ways it could be enhanced.

Issues to consider

Wilder Research's follow-up study of STARBASE Minnesota participants provides the program with valuable insights about its potential long-term impact. On a community level, the study also contributes information on existing programming, gaps, and opportunities for collaboration that may be valuable to the broader local STEM community. Based on study findings, following are several program- and community-level considerations that may be instructive to STARBASE staff and other STEM practitioners. Finally, possible directions for any future follow-up studies of STARBASE Minnesota participants are presented.

Program considerations

Sustaining students' STEM interests and learning

Taken together, results of the college-student survey and key informant interviews suggest there may be a gap between interest in STEM-related programming and ability to access such programming for students who face income, cultural, or other barriers. STARBASE staff recognize the importance of sustaining their students' STEM interests and learning after they exit the program, and the STEM program inventory emerged from this recognition. Program staff intend to use this information to help connect STARBASE graduates to opportunities after they complete STARBASE.

Sharing expertise

Study findings suggest that STARBASE Minnesota has expertise in a couple of areas cited by key informants as gaps in local STEM programming, such as technology integration, career exposure, and classroom integration. These findings suggest a potential role for STARBASE Minnesota in the larger STEM community to serve as a mentor or role model for other programs looking to strengthen these areas. Mechanisms for sharing this knowledge are already in place given the STARBASE Minnesota Executive Director's and board's active involvement in the Minnesota STEM Network and their efforts to convene STEM practitioners through the Network's meetings.

Community considerations

Connecting students to programs

The STEM program inventory documents a range of opportunities available to area students, yet key informants suggested there are underserved populations that face a number of barriers to accessing available programs. Information compiled through the inventory can be used by practitioners, schools, and parents to help link students to accessible opportunities. To this end, inventory data will ultimately be shared with the broader STEM community. Further, as noted in the key informant interviews, increased collaboration among STEM practitioners or between STEM programs and other community groups may also enhance their ability to reach underserved populations.

Connecting practitioners to practitioners

Results of the key informant interviews suggest there is keen interest in increasing networking among practitioners and collaboration within and beyond the local STEM community. The STEM program inventory can contribute to enhanced collaboration and networking by increasing awareness of existing opportunities and contact persons. In

these ways the study is nicely timed to contribute to momentum toward networking and collaboration in the broader local STEM community.

Building on the STEM inventory

Research staff involved in compiling the STEM program inventory identified insights that may be instructive to others interested in building on or learning from these efforts. There are considerations related to determining the scope of the inventory, identifying program contacts, updating program information, seeking permission, ensuring consistency of information provided, generating index and search categories, addressing duplicate program listings, and delivering the information to intended audiences. These considerations are discussed in depth in the final section of the report.

Future study directions

Examining the impact of program dosage

Phase I study results suggested that a higher STARBASE dosage may result in a greater likelihood of a STARBASE impact. Phase II analyses were limited by the small size of the low-dosage group and possibly influenced by demographic differences between the low- and high-dosage groups, and this pattern was not observed in the second phase. Any future studies should continue to explore program impacts based on level of exposure.

Continued follow-up of Phase I Cohort 3

It also seems beneficial to consider continued follow-up of Cohort 3 from the Phase I study. These students were enrolled in 10th grade in 2008-09 and would graduate from high school in spring 2011 if graduating on time. This was the largest cohort from the initial study. It would be instructive to see whether STARBASE-comparison group differences in high school graduation and college enrollment rates would be consistent with the differences observed with the Phase II follow-up of Cohorts 1 and 2, as well as to examine Cohort 3 former participants' reflections on their STARBASE experience and possible influences on career choices.

Assessing impact on career choices

Additional follow-up is needed to make strong claims about any long-term program impacts on students' career choices. Results of the Phase II survey of college students were limited based on the sample size and difficulties obtaining student e-mail addresses for some colleges. In following-up with college students in any future studies, researchers and program staff can work to identify other ways of contacting those students. Also, students

were in their first or second year in college and may not have made a career choice yet. Longer-term follow-up would be needed to more fully assess any impact on career choice.

Assessing impact on military interest

The Phase I study found that significantly more STARBASE (46%) than comparison (31%) students indicated at least a little interest in joining the military in high school (Broton & Mueller, 2009). Although not a core study question, data on military enrollment were collected as part of the Phase II study but should be viewed with caution due to limitations with the data. In any future studies, researchers and program staff can consider ways to better track participants' subsequent involvement in civilian or uniform military careers in association with strengthening the assessment of impact on STEM career choices in general. Better ways to match study participants with the Department of Defense database can be explored. For example, researchers can work with someone knowledgeable about the database at study onset to better understand the types of identifying information that would be needed to better match both STARBASE and comparison study participants.

Introduction

Overview

STARBASE Minnesota is a week-long science, technology, math, and engineering (STEM) program for students in fourth and fifth grades. The program is funded in large part by the U.S. Department of Defense and sponsored by the Minnesota National Guard, and serves more than 3,400 students each year from more than 30 urban schools in Minneapolis and St. Paul.

In 2007, the Minnesota State Legislature appropriated funding for a follow-up study assessing long-term impacts on academic achievement as a result of participation in STARBASE Minnesota (Laws of Minnesota 2007). To this end, the Minnesota Department of Military Affairs contracted with Wilder Research to conduct a follow-up study of program participants. Phase I of the study assessed the potential impact of participation in STARBASE Minnesota on high school students' interest, motivation, knowledge, and skill development in STEM, as well as their career interest in STEM including the military. Phase I results are available in a report on Wilder Research's website (Broton & Mueller, 2009).

This report presents results of Phase II of the study, which followed two cohorts of former STARBASE Minnesota participants beyond high school, examining their on-time high school graduation rates, college enrollment, and long-term STEM interest and involvement following STARBASE. The study also examined the impact of program dosage on educational attainment. A rigorous matched-comparison design was used in which former STARBASE students were matched one-to-one with demographically and academically similar peers who did not participate in STARBASE. Because STARBASE staff recognize the importance of sustaining students' STEM interests and learning once they exit the program, the Phase II study also examined the availability of programs in the broader local STEM community and additional programs or supports that may be needed to continue former students' STEM learning after STARBASE.

Study context

The core purpose of Wilder Research's overall study is to examine the long-term impact of STARBASE Minnesota on participants' academic achievement and interest in STEM. Beyond this core purpose, the study also holds potential contributions to the larger local STEM community. Wilder Research's Phase II study coincided with the development of the Minnesota STEM Network, a statewide network working to increase the state's

effectiveness in providing STEM education and to facilitate networking and collaboration among Minnesota's STEM providers. Results of the STEM program inventory and key informant interviews conducted as part of this study are well-timed to inform these efforts in the larger STEM community.

Program description

STARBASE Minnesota offers school-year and summer programming for fourth- through sixth-grade students, as well as field experiences for college students in the education program at the University of St. Thomas. Following are descriptions of STARBASE Minnesota's student programs, including its core school-year program as well as summer programming for students. The core program is the focus of this study. Finally, a brief description of the national STARBASE program is provided.

STARBASE Minnesota

Core program overview

STARBASE Minnesota is a week-long science, technology, engineering, and math program. At the time of this study, the program was offered to students in fourth and sixth grades. Beginning in the 2010-11 school year, the program is now offered to fourth and fifth grades. Students use a hands-on curriculum in a technology-rich aerospace environment to solve scientific and engineering challenges. The 20-hour program emphasizes integrated and hands-on STEM learning, scientific-inquiry skills, engineering design, mathematical concepts, real-world applications, and career exposure. Established in 1993, and academically strengthened beginning in 2000 and throughout subsequent years, the program's purpose is to increase the knowledge, skills, and interest of urban youth in STEM for greater academic and lifelong success.

More than 30 Minneapolis and Saint Paul elementary schools partner with STARBASE Minnesota each year, and many have been doing so for several years. The program hosts entire grade levels within schools during the school year and is located at the 133rd Airlift Wing of the Minnesota Air National Guard Base. There is no fee for participation; schools are responsible for providing transportation and student lunches. Classroom teachers and assistants attend with their students. Funding is provided primarily by the U.S. Department of Defense and supported by the Minnesota National Guard. Corporations in the community such as Delta Air Lines, 3M, Medtronic, Stratasys, Seagate, Lockheed Martin, BAE Systems, General Mills, Ecolab, Boston Scientific, Toro, and others provide volunteer, in-kind, and/or financial support.

Students are taught by teachers licensed in the state of Minnesota. At the beginning and end of each program, students are administered pre- and post-tests to measure change in knowledge and application of STEM skills and their career interests, as well as attitudes toward STEM subjects. Additionally, school teachers are given pre- and post-lessons for their classes at school and a curriculum overview with alignment to state and national standards. Students participate in post-STARBASE "Clubhouse" activities via the STARBASE website, and earn lanyards and pins for successful completion of STEM lessons.

Core program descriptions by grade

In the fourth-grade program, STARS 1, students test the earthly limits of flight as they explore current and future design challenges which push the boundaries of speed, atmospheric barriers, and ever increasing numbers of aircraft in the sky. The student engineers develop and utilize their scientific inquiry skills as they formulate questions, test predictions, and conduct experiments related to air, motion, rocketry, and heat in the attempt to design a flight vehicle of the future. Students then apply this knowledge as they design their own aircraft using Pro/ENGINEER computer animated design software and as they build, launch, and test a rocket. An essential part of the students' scientific investigations and applied engineering are the math and technology concepts and tools used throughout the program, such as data collection, median, mode, range, measuring, estimating, and navigation using GPS technology. Throughout the program, students have the opportunity to learn about and explore STEM-related careers and how they can pursue those careers in their future.

In the fifth-grade program, STARS 2, students develop and utilize their STEM skills as they attempt to answer the question, "How can we engineer robotic and human missions to Mars?" Students investigate the planetary conditions of Mars and identify the design and engineering needs of its rover and human Mars exploration missions. Students conduct scientific experiments integrating math, technology, and engineering to learn more about Newton's Laws of Motion, robotics, the atmospheres of Earth and Mars, air pressure, friction, heat transfer, and the vacuum of space. They learn about units of measurement, estimating, and coordinate graphing, as well as explore technology-based designs and functions. Students experience the work of real life scientists and engineers as they use Pro/ENGINEER software to design a rocket and a Mars colony. They use robotics software to program and test Mars rovers. Throughout the five-day program, students have the opportunity to explore various STEM careers and the path they will need to take to reach their own career goals through challenge videos, a career exploration website, and letters of advice they write to themselves about how they can achieve their career goals.

Summer programming

Between 2000 and 2006, STARBASE Minnesota also provided programming to eighth-grade students who were enrolled in Saint Paul Public Schools summer school for academic reasons. At the request of the school district, this STARBASE summer program emphasized the reinforcement of math concepts, not broad-based STEM learning. Eighth-grade participation was not considered in this study for these reasons and due to the small number of participants.

Since 2007, STARBASE Minnesota has provided a supplementary summer program called the Next Generation Summer Camp for fourth- through sixth-grade students in the Twin Cities metropolitan area. Built around engineering concepts, the program's premise is a mission to Mars. Students map the surface of Mars, design rockets and rovers needed for exploration, and plan and design a future city on Mars. This 20-hour program serves approximately 500 youth each summer.

National program

STARBASE Minnesota is a program of the U.S. Department of Defense (DoD). The national program aims to motivate students underrepresented in STEM to explore learning and improve their skills in those areas (DoD STARBASE, n.d.). The U.S. DoD STARBASE program currently operates in 34 states. STARBASE Minnesota and this study are funded in large part by the U.S. DoD.

Study purpose

STARBASE Minnesota utilizes a program logic model that defines the need, solution, and expected outcomes of the program for students and teachers. The logic model identifies a number of expected initial outcomes during the STARBASE program, intermediate outcomes within a year of participating in STARBASE, long-term outcomes within junior and senior high school, and a long-term vision for beyond high school. Some research on other STARBASE programs has been conducted to examine intended initial impacts (Lee-Pearce, et al., 1998), and STARBASE Minnesota has conducted some small follow-up surveys to gauge intermediate and long-term impacts (Van Wie, 2001, 2006). The purpose of Wilder Research's study is to learn more about the expected long-term outcomes in high school (Phase I) and at high school graduation and beyond (Phase II).

Contents of the report

Core study questions and outcomes relative to these questions are highlighted in the Summary. The body of the report, however, is organized by data source rather than study question due to the wealth of analysis that took place beyond the six core questions. Within each section, researchers explore findings relative to applicable study questions as well as findings from additional analyses that were performed beyond the questions identified in the original study proposal. A brief summary of major findings is provided at the beginning of each results section. The report concludes with a discussion of issues for program staff and local STEM practitioners to consider based on study findings. The report is organized as follows:

- **Study methods**

- **High school graduation** data from the Minnesota Department of Education

- **College enrollment** data from the National Student Clearinghouse

- **Participant feedback** gathered through Wilder Research's online survey of college students

- **Military-enrollment** data from the Department of Defense Global Directory Service

- **Key informant interviews** conducted by Wilder Research with local STEM leaders

- **STEM program inventory** compiled by Wilder Research

- **Issues to consider**

Finally, the report Appendix provides supplemental information, including college students' complete written responses to open-ended survey questions, a list of organizations represented by key informants, and a copy of the student survey.

Study methods

This section presents the study methods, describing the two phases of the study, the matched-comparison design, data sources, and types of analyses that were used. A copy of the survey instrument is provided in the Appendix. Following this section on study methods, the remainder of the report presents detailed results from each data source.

Study phases

As previously described, Wilder Research conducted its follow-up study of STARBASE Minnesota participants in two phases. Phase II results are the focus of this report. Phase I results were presented in a June 2009 report available on Wilder Research's website (Broton & Mueller, 2009).

Phase I

Wilder Research's study of STARBASE Minnesota students followed former participants into high school and beyond. Phase I of the study included three cohorts of Saint Paul Public Schools (SPPS) students who participated in STARBASE as 4th-grade students and were enrolled as 10th-, 11th-, or 12th-grade students during the 2008-09 school year. The purpose was to assess the potential impact of participation in STARBASE Minnesota on high school students' interest, motivation, knowledge, and skill development in STEM, as well as their career interest in STEM including the military.

For purposes of study eligibility, students were required to participate in STARBASE in fourth grade to maximize their potential exposure or dosage, as they could have participated again in sixth grade and even in the summer before eighth grade. Additionally, these students must have been enrolled in SPPS in third grade when they took achievement tests in math and reading. Researchers had several reasons for using these criteria. The St. Paul school district was chosen because the majority of students served by STARBASE come from this district, and it seemed likely that study results found in St. Paul would apply to Minneapolis since the two districts serve similar student populations. Additionally, these student cohorts participated in STARBASE after it was strengthened academically and after the STARBASE student record system was improved, which was important to the feasibility of this study. This study group also likely represented a more stable student population by requiring students to be enrolled in SPPS in third and fourth grades as well as in high school and therefore excluding more transient students.

Phase II

Phase II of the study, which is the focus of this report, followed-up on the latter two cohorts in fall 2010. The second phase examined program impacts on high school graduation, college enrollment, and long-term STEM interest and involvement. Looking beyond STARBASE into the broader local STEM community, the Phase II study also examined the availability of additional programs or supports that may be needed to continue former STARBASE students' STEM learning once they exit the program.

For purposes of Phase II, the two study cohorts were defined as follows:

- **Cohort 1:** 12th grade in 2008-09 and potential college enrollment in fall 2009 (146 students or 73 matched pairs)

- **Cohort 2:** 11th grade in 2008-09 and potential college enrollment in fall 2010 (270 students or 135 matched pairs)

Matched-comparison design

Wilder Research's follow-up study of STARBASE Minnesota participants used a rigorous matched-comparison design to enable researchers to credibly determine what effects the program may have had. The effects of the STARBASE program were studied through analysis of differences between these two groups on student outcome measures. During the Phase I study, former STARBASE students were matched one-to-one with demographically and academically similar peers who did not participate in STARBASE. These matches were retained in Phase II to facilitate ongoing comparisons between STARBASE and comparison group students.

Matching procedures

To be eligible for the comparison group in Phase I, students must have been enrolled in SPPS as a 10th-, 11th-, or 12th-grade student during the 2008-09 school year and during their 3rd- and 4th- grade years. Additionally, in fourth grade, they could *not* have attended an elementary school that participated in STARBASE or had a special emphasis on math, science, or technology (e.g., Crossroads Science). Students who met these criteria were then screened using STARBASE program records to ensure they had not participated in the program. Those matched pairs who were in 11th or 12th grade in Phase I constituted the Phase II study sample. A total of 416 participants were included in the Phase II study, including 208 matched pairs.

A multi-stage matching methodology was used to match STARBASE and comparison students on nine observable characteristics. Student pairs were required to match on the following four characteristics: grade level in 2008-09, high school attended in 2008-09,

third-grade math achievement test level score, and third-grade reading achievement test level score. Additionally, pairs needed to match on at least one of the following five characteristics in fourth grade: economic status, English Language Learner status, special education status, gender, and race or ethnicity. Most student pairs matched on all or most of these demographic characteristics. The matching technique used and the high match rate on all nine characteristics helped ensure that differences between the STARBASE and comparison groups were not likely due to demographic or academic characteristics. Additional technical details on the matching procedure are provided in the Appendix of the Phase I report (Broton & Mueller, 2009).

Characteristics of Phase II pairs

Figure 2 provides the demographic characteristics of STARBASE and comparison group students in Phase II of the study. As indicated above, student pairs were required to match on one or more of these five demographic characteristics, in addition to matching on all four of the following characteristics: grade level in 2008-09, high school attended in 2008-09, third-grade MCA math level score, and third-grade MCA reading level score. Overall, there were no statistically significant differences found between the two groups on these demographic characteristics.

2. Profile of matched pairs in Phase II

Characteristic		STARBASE N=208	Comparison N=208	Significance (McNemar or Z-tests of proportions)
Free or reduced-price lunch[a]	Eligible	75%	80%	ns[b]
	Ineligible	25%	20%	
English Language Learner[a]	Yes	43%	42%	ns[b]
	No	57%	58%	
Special education[a]	Yes	11%	7%	ns[b]
	No	89%	93%	
Gender[a]	Male	46%	46%	ns[b]
	Female	54%	54%	
Race/ethnicity[a]	White (not Hispanic)	20%	18%	ns[c]
	Asian or Pacific Islander	51%	55%	
	Black (not Hispanic)	21%	18%	
	Hispanic	7%	7%	
	American Indian or Alaskan Native	1%	1%	

ns   *no statistically significant differences between groups*

[a]   *Characteristic as of 4th grade.*

[b]   *Based on McNemar.*

[c]   *Based on Z-tests of proportions.*

Demographic characteristics of Phase II matched pairs were also examined by cohort and dosage level. By cohort, the only statistically significant difference found ($p<.05$) was in the Special Education status of STARBASE vs. comparison group students in Cohort 2. In this analysis, Cohort 2 STARBASE students were significantly more likely to be categorized as Special Education (13%) than their matched pairs in the comparison group (6%). By dosage, the only significant differences found were with Black and Asian or Pacific Islander students. The low-dosage STARBASE group had significantly fewer Asian or Pacific Islander students (29%) than the high-dosage (56%) and comparison (55%) groups. The low-dosage group also had a significantly higher percentage of Black students (34%) than the high-dosage (17%) and comparison (18%) groups.

Data sources

Data were gathered through from several different sources, depending on the study question in focus. Following are descriptions of the sources of each type of data, including high school graduation, college enrollment, participant feedback, military enrollment, and STEM program data.

High school graduation data

The Minnesota Department of Education (MDE) provided high school graduation data for STARBASE and comparison students. Wilder Research supplied the MDE with student-level data, and MDE provided aggregate counts of the high-dosage, low-dosage, and comparison students falling into each of the following three categories:

- Graduated from a public Minnesota high school on time (defined as end of the 2008-09 school year for Cohort 1 and end of the 2009-10 school year for Cohort 2)

- Continued to be enrolled in a public Minnesota high school the subsequent fall (fall 2009 for Cohort 1 and fall 2010 for Cohort 2)

- Did not graduate from a public Minnesota high school on time and was not enrolled in a public Minnesota high school the subsequent fall

Graduation status was determined based on a student having a MARSS (Minnesota Automated Reporting Student System) status end code indicating graduation. It is possible that some students falling into the third category could have graduated from a private or out-of-state school. Because enrollment in and graduation from private schools is reported only in aggregate, the MDE was not able to link individual study participants to private school records.

College enrollment data

College enrollment data for STARBASE and comparison students was obtained from the National Student Clearinghouse (NSC). Using study participants' first name, middle initial, last name, and date of birth, the NSC searched its national repository of information from postsecondary institutions. Information provided by the NSC included the following: whether a student was found at a participating postsecondary institution, the college code and name, enrollment beginning and end dates for each term reported, the student's last enrollment status reported for each term (e.g., full-time, half-time, less than half-time, leave of absence, withdrawn, deceased), graduation status, college sequence if the student attended more than one school, college state, and whether the college is two-year or four-year and public or private.

Participating educational institutions submit information to the NSC on their students' enrollment status multiple times throughout a term. Wilder Research submitted its request to the NSC in November 2010. Therefore, enrollment data received reflect the most recent data submitted to the NSC at that point in the fall term.

According to the NSC, this repository provides enrollment data from more than 3,300 institutions representing more than 92 percent of national postsecondary enrollment. The NSC provided Wilder Research with a list of the Minnesota colleges with 1,000 or more students not reporting to the Clearinghouse: Brown College, Rasmussen College (Eden Prairie, Mankato, and St. Cloud), and The Art Institutes International Minnesota. The vast majority of participants in our study who enrolled in college attended school in Minnesota (91% of STARBASE and 93% of comparison students).

Participant feedback data

In November-December 2010, Wilder Research conducted an online survey of former STARBASE students who were enrolled in college in fall 2010. The survey was designed to explore the extent to which STARBASE participants accessed STEM programs and opportunities after completing the program, and the programs or opportunities that they found most helpful. Survey questions also addressed participants' current interest in STEM and the military, their perceptions of the impact of STARBASE, and any challenges they faced to participating in other STEM activities after STARBASE.

Data from the NSC was used to identify students eligible to participate in the survey. Based on NSC data, 117 former STARBASE participants were enrolled in college in fall 2010 and therefore eligible. To locate students' e-mail addresses, Wilder Research searched online college and university student directories where available. In cases where a college or university did not make student e-mail addresses available online, Wilder Research staff called the school to request that information. In some cases, a

college registrar or other representative was willing to e-mail potential participants on Wilder Research's behalf and ask students to share their e-mail addresses if they were willing to participate. As a final step, Wilder Research staff used Wilder's organizational account to search for potential respondents on the social-networking site Facebook, and sent a standard message with survey information and an invitation to provide their e-mail address to several students located this way. Despite intensive efforts to locate students' e-mail addresses, availability of e-mail addresses varied to a large extent by school, and in some cases e-mail addresses were unavailable for a school offering a high concentration of technical programs. E-mail addresses were obtained for a total of 72 of the 117 potential respondents.

Surveys were available online for six weeks. Respondents were sent an initial e-mail notification, two reminder e-mails, a deadline extension e-mail, and a final reminder e-mail. Respondents were offered a $10 gift card to either Target or Walmart as an incentive for completing the survey. A total of 36 students completed the survey (50% of those contacted for the survey, and 31% of those eligible). All 36 answered "yes" to an initial screening question verifying that they had participated in the STARBASE program at the Minnesota Air National Guard base. Due to limitations in e-mail address availability and the somewhat low response rate, results should be viewed as instructive but not necessarily representative of all former STARBASE students now enrolled in college.

Military enrollment data

With the help of STARBASE Minnesota staff, researchers submitted a request for military-enrollment data to a local contact in the U.S. Air Force with the rank of Chief Master Sergeant. This data does not directly address a Phase II study question, but was sought to provide an indication of the number of former STARBASE vs. comparison group participants entering the military. The Department of Defense Global Directory Service was searched for names of study participants. A total of 14 study participants were matched through these efforts.

The database includes all branches of the military, and the specific branch of service was indicated for each of the students who were matched. Individuals appear in the military database only if they are currently serving in the military, so it is possible that a study participant could have served and since separated. Additionally, some potential matches could not be verified because a middle initial was not available. For these reasons, this data likely represents a conservative estimate of those who had actually entered the military as of the time of our analysis.

STEM program data

Wilder Research gathered information on program availability, needs, and gaps in the broader local STEM community through two sources: interviews with local STEM leaders, and an inventory of local STEM programs. The key informant interviews and STEM program inventory are summarized briefly here, and described in detail in those sections of the report.

From June-October 2011, Wilder Research sent STEM program inventories to more than 180 contacts in the local STEM community. The final inventory includes 171 program or organizational listings provided by 65 organizations. For study purposes, the inventory emphasized programs serving 4th-12th grade students in the St. Paul area, although the final inventory also includes information on a large number of programs serving other parts of the Twin Cities metro area, the state as a whole, and other populations.

In summer and fall 2010, Wilder Research staff also conducted 28 key informant interviews with 29 representatives of local STEM organizations. Interviews were conducted over the phone with the exception of one taking place in person. Key informants were asked to discuss needs or gaps in the types of STEM programs offered and populations served, as well as their organizations' activities and interests in the area of collaboration.

Data analysis

Wilder Research's follow-up of STARBASE Minnesota participants combines a rigorous matched-comparison design with qualitative analyses of key informant interviews and open-ended survey comments. Following are descriptions of the specific analyses performed in Phase II of the study.

Types of analysis

The Phase II study includes both quantitative and qualitative analyses of data, depending on the type of data in a given analysis. Figure 3 summarizes the analyses conducted for each data source incorporated in the study.

3. Data sources and types of analysis

Data source	Data type	Analysis
1. High school graduation data from the Minnesota Department of Education	Aggregate data for STARBASE and comparison students	- STARBASE vs. comparison - Statistical tests (Pearson's chi square, Z-tests of proportions) - By dosage
2. College enrollment from the National Student Clearinghouse	Individual student-level data for STARBASE and comparison students	- Matched-comparison design - Statistical tests (Pearson's chi square, Fisher's Exact, McNemar, Breslow-Day) - By dosage
3. Participant feedback from Wilder Research survey of college students	Individual-level self-reported data from STARBASE students	Frequency distributions (i.e., overall percentages reporting each response)
4. Military enrollment data from the Department of Defense Global Directory Service	Individual-level data for STARBASE and comparison students	- STARBASE vs. comparison - Frequency distributions (i.e., percentages entering the military)
5. Key informant interviews conducted by Wilder Research	Interviewer notes from 28 interviews	Qualitative analysis of responses by question to identify key themes
6. STEM program inventory compiled by Wilder Research	Descriptions of 171 STEM programs or organizations provided by 65 organizations	- Frequency distributions (i.e., percentages of programs by key program characteristic). In some cases, researchers categorized programs based on information available for purposes of analysis. - Information compiled for the primary purpose of developing a resource directory.

The following descriptions of the directional hypothesis, tests for statistical significance, and analyses based on dosage level pertain to the quantitative analyses of high school graduation data and college enrollment data. Statistical tests were not performed on the survey or military-enrollment data based on the survey's small sample size and the aforementioned limitations with the military-enrollment data, nor were they applicable to the key informant interviews or STEM program inventory.

Directional hypothesis

When analyzing results, researchers used a directional or one-tailed hypothesis because of the assumption that STARBASE students would perform better than the comparison group on outcome measures, and that high-dosage STARBASE students would perform better than low-dosage students (Lee-Pearce, et al., 1998). Because one-tailed tests can be less conservative than two-tailed tests, they should be clearly supported by theory. Use of a one-tailed test also means that statistically significant differences are reported only if they support the directional hypothesis. In other words, if a statistically significant difference had emerged in which the comparison group outperformed the STARBASE group, or in which the low-dosage group outperformed the high-dosage group, it would not have been reported.

If a non-directional or two-tailed hypothesis had been used in the Phase II study, the statistically significant results reported here would have changed as follows. There would not have been a statistically significant difference in on-time high school graduation between high-dosage and comparison students in Cohort 2. There also would not have been a statistically significant difference in college enrollment between Cohort 2 low-dosage STARBASE students and their matched pairs, or between low-income STARBASE and comparison students.

Testing for statistical significance

A statistically significant difference is one that exceeds the amount of variation that could be expected by chance. Statistical significance is noted in this study where $p<.05$, meaning that there is less than a 5 percent probability that the finding resulted by chance. Researchers used *Pearson's chi square* (X^2) and *Z-tests of proportions* in analyzing aggregate high school graduation data. *Pearson's chi square* was used in the overall comparison of all STARBASE to comparison students, and *Z-tests of proportions* in comparisons among high-dosage, low-dosage, and comparison students. The *Z-tests of proportions* enabled researchers to pinpoint the specific group comparisons where significant differences occurred between those who did and did not graduate from high school on time (i.e., between high-dosage and comparison students in Cohort 2). The remainder of this section focuses on the analyses of college enrollment data, where categorical data was available at the individual student level.

Four statistical tests were used for analyses involving college enrollment data: *Pearson's chi square, Fisher's Exact, McNemar,* and *Breslow-Day.* The specific test depended on the sample size, whether matched pairs were used in the analysis, and the number of variables. Analyses involving two categorical variables used the *Pearson's chi square* and *Fisher's Exact* test statistics in cases where matches were not used, and the *McNemar* test in cases involving matched pairs. In other words, *Pearson's chi square* and *Fisher's Exact* were used for comparisons among STARBASE students, and the *McNemar* test was used for comparisons between STARBASE students and their matched pair. The determination of whether to use the *Pearson's chi square* or *Fisher's Exact* statistic was based on the sample size, with *Fisher's Exact* used in cases where there were expected counts of less than five in individual cells and *Pearson's chi square* used with larger sample sizes.

Some analyses involved three categorical variables, examining the relationship between two variables stratified by a third variable. For example, researchers examined the relationship between college enrollment and STARBASE participation, stratified by income. In these cases, both the *Breslow-Day* and *McNemar* tests were used. *Breslow-Day* provided an omnibus test of the homogeneity of odds ratios across categories of the stratification variable. An odds ratio compares whether the probability of an event (e.g., college

enrollment) is the same for two groups (e.g., STARBASE group and comparison group). *Breslow-Day* tests the null hypothesis that all odds ratios are equal across the stratification variable (e.g., whether the probability of college enrollment for STARBASE and comparison group students is the same for each income category). A significant *Breslow-Day* statistic tells us that odds ratios are not equal across each category of the stratification variable. For example, *Breslow-Day* tells us that the probability of attending college for STARBASE vs. comparison group students is not uniform across income categories.

Breslow-Day provides an omnibus test across all categories of the stratification variable, but does not pinpoint categories where significant differences are occurring. Therefore, researchers used the *McNemar* test in conjunction with *Breslow-Day*. *McNemar* tests were performed to determine significance of differences between the two variables of interest *within* each category of the third stratification variable. In the example here, *Breslow-Day* tells us odds ratios are not uniform across income categories, and *McNemar* helps us pinpoint that there is a significant difference in college enrollment specifically in the low-income category.

Dosage

Indicator measures were further examined by cohort as well as dosage or level of exposure to STARBASE. The Phase I study found some indications that a higher STARBASE dosage may result in a greater likelihood of a STARBASE impact, and potential differences based on program dosage continued to be assessed in Phase II. These analyses separated former STARBASE students into low- and high-dosage groups, as follows:[1]

■ **Low-dosage group:** Participated in STARBASE in fourth grade only (35 students)

■ **High-dosage group:** Participated in STARBASE in both fourth and sixth grades (172 students)

Eighth-grade participation was not considered in the construction of the dosage variable because the eighth-grade summer program did not emphasize broad-based STEM learning, and there were very few students in the sample who attended STARBASE in eighth grade. Therefore, students with a low dosage attended STARBASE in fourth grade, did not attend in sixth grade, and may or may not have attended in eighth grade. Students with a high dosage attended STARBASE in fourth and sixth grades, and may or may not have attended in eighth grade. Most of the schools that STARBASE students attended in fourth grade participated in STARBASE again two years later when those students were in sixth grade, providing the opportunity for many students to have a high dosage level.

---

[1]   Dosage level was not known for one STARBASE student.

High school graduation

> Overall, former STARBASE participants appeared to have higher on-time high school graduation rates than comparison students, although differences were not significant except between high-dosage and comparison students in Cohort 2. In this case, a significantly higher percentage of high-dosage STARBASE than comparison students in Cohort 2 graduated from high school on time.

The Minnesota Department of Education (MDE) provided aggregate high school graduation data for STARBASE and comparison students, indicating whether students 1) graduated on time, 2) continued to be enrolled in high school the subsequent fall, or 3) did not graduate and were no longer enrolled in high school. As described in the Study Methods section, data reflect graduation from and enrollment in public Minnesota high schools, as student-level data was not available from private schools. Therefore, it is possible that some students falling into the third category graduated from a private or out-of-state school. Due to the small numbers of students falling into the latter two groups, categories were consolidated into the following two groups for purposes of analysis: graduated on-time (Category 1 above) and did not graduate on-time (Categories 2 and 3 above). Results from analyses of this data follow.

On-time graduation

Overall, STARBASE students appeared to have higher on-time high school graduation rates than comparison students. Differences were not significant except in the case of high-dosage vs. comparison students in Cohort 2. Overall, 81 percent of STARBASE and 75 percent of comparison students graduated from high school on time. By level of program exposure, 81 percent of high-dosage STARBASE students, 80 percent of low-dosage, and 75 percent of comparison students graduated from high school on time (Figure 4). For context, in 2009 the four-year, on-time graduation rate for the St. Paul Public School District overall was 65 percent. This figure differs from the graduation rate reported for the STARBASE study sample in that it excludes students who transferred out of the district (SPPS, 2011).

Separating students by study cohort, on-time graduation appeared to follow the expected pattern in Cohort 2, with the highest percentage of high-dosage STARBASE students graduating on time (81%), followed by low-dosage STARBASE students (74%) and then comparison students (70%). The difference between high-dosage and comparison students in Cohort 2 was significant. In Cohort 1, a higher percentage of low- than high-dosage STARBASE students graduated on time, although differences in that cohort were not significant. Sample sizes for the low-dosage group were small, and there were some

demographic differences between the low- and high-dosage groups as discussed in the Study Methods section.

4. On-time high school graduation: High-dosage vs. low-dosage vs. comparison students

		N^a	Percentage graduating on time[b]	Significance (Pearson X^2 or Z-tests of proportions)
All study participants	STARBASE	207	81%	ns[c]
	Comparison	208	75%	
All study participants	High-dosage	172	81%	ns[e]
	Low-dosage[d]	35	80%	
	Comparison	208	75%	
Cohort 1	High-dosage	57	82%	ns[e]
	Low-dosage[d]	16	88%	
	Comparison	73	82%	
Cohort 2	High-dosage[f]	115	81%	*[e,f]
	Low-dosage[d]	19	74%	
	Comparison[f]	135	70%	

* p<.05

ns no statistically significant differences between groups

[a] The Minnesota Department of Education (MDE) provided aggregate data on the 208 comparison group participants and the 207 STARBASE participants for whom the level of program dosage was known.

[b] "On-time" defined as graduating from a public Minnesota high school by the end of the 2008-09 school year for Cohort 1 and the end of the 2009-10 school year for Cohort 2.

[c] Based on Pearson X^2.

[d] It should be noted that sample sizes for the low-dosage group are small.

[e] Based on Z-tests of proportions.

[f] A significant difference (p<.05) was found between the high-dosage and comparison groups, but not between the high- and low-dosage groups or low-dosage and comparison groups.

College enrollment

Results suggested that program benefits may extend beyond high school graduation to college enrollment. Overall, results suggest that STARBASE participants have an increased likelihood of enrolling in college. Differences were not statistically significant except in the case of the low-dosage comparison. In this case, a significantly higher percentage of low-dosage STARBASE students enrolled in college than their matched pairs. Results also suggest there may be program impacts for two demographic groups targeted by the program: low-income students and minority students. Former STARBASE students attending college also appeared to have an advantage over comparison students on a couple of protective factors indicative of future degree completion, although again differences were not significant.

Following are results from Wilder Research's analysis of college enrollment data. As described in the Study Methods section, data was provided by the National Student Clearinghouse (NSC). For purposes of these analyses, researchers defined college enrollment as having ever attended college, regardless of the student's final enrollment status. Cohort 1 students were eligible to graduate from high school in spring 2009, and Cohort 2 in spring 2010. Therefore, for Cohort 2 students these measures largely reflect whether they enrolled in college immediately upon high school graduation. Results are presented in two sections: one focusing on rates of college enrollment, and one focusing on predictors of future degree completion.

College enrollment

Students' college enrollment status was examined to address the core study question of whether STARBASE participants are more likely to enroll in college than similar students who did not participate in the program. Results were examined by cohort, level of program dosage, and demographic characteristics. Information is also reported on characteristics of the colleges students attended.

Overall and by cohort and dosage

Results suggest that STARBASE participants have an increased likelihood of enrolling in college. Overall, 60 percent of STARBASE and 52 percent of comparison students enrolled in college by fall 2010. Differences were not statistically significant except in the case of the low-dosage comparison, where a significantly higher percentage of low-

dosage STARBASE students (71%) enrolled in college than their matched pairs (43%) (Figure 5).

5.   College enrollment: Overall and by cohort and dosage

		N[a]	Percentage enrolling in college STARBASE	Comparison	Significance (McNemar)
All study participants		208	60%	52%	ns
Cohort	Cohort 1	73	66%	60%	ns
	Cohort 2	135	56%	48%	ns
Dosage	High	172	58%	55%	ns
	Low	35	71%	43%	*[b]

*   *p<.05*

ns   *not statistically significant*

[a]   *Refers to the number in each group of the matched pairs comparison (e.g., 208 STARBASE students were compared to 208 comparison students).*

[b]   *It should be noted that this test is based on a relatively small sample size.*

When looking only at STARBASE students, a higher percentage of low-dosage than high-dosage STARBASE students in our study enrolled in college (Figure 6). However, as previously stated this was based on a relatively small sample of low-dosage students and there were some demographic differences between the low- and high-dosage groups.

6.   College enrollment: STARBASE students by dosage

		N	Percentage enrolling in college	Significance (Pearson X^2)
Dosage	High	172	58%	ns
	Low	35	71%	

ns   *not statistically significant*

Among high-dosage participants, differences in college enrollment between STARBASE students and their matched pairs did not vary significantly for either Cohort 1 or Cohort 2. Among low-dosage participants, a significantly higher percentage of STARBASE than comparison students in Cohort 2 enrolled in college, and a higher percentage (but not significant) of STARBASE than comparison students in Cohort 1 enrolled (Figure 7). Again, results for the low-dosage group should be viewed with caution due to the small sample sizes and demographic differences compared to the high-dosage group.

7. College enrollment: High vs. low dosage by cohort

		N^a	Percentage enrolling in college		Significance (McNemar)
			STARBASE	Comparison	
High dosage	Cohort 1	57	63%	63%	ns
	Cohort 2	115	55%	50%	ns
Low dosage[b]	Cohort 1	16	75%	50%	ns[c]
	Cohort 2	19	68%	37%	*

* $p<.05$

ns   not statistically significant

[a]   Refers to the number in each group of the matched pairs comparison (e.g., 57 STARBASE students were compared to 57 comparison students).

[b]   These analyses should be viewed with caution due to the small sample sizes.

[c]   Note the small sample size. There may not be enough power to detect a statistically significant difference.

Looking only at STARBASE students by cohort, higher percentages of low-dosage than high-dosage students in our study enrolled in college in each cohort, although again these analyses were based on small samples of low-dosage students and there were some demographic differences between the dosage groups (Figure 8).

8. College enrollment: STARBASE students by cohort and dosage

	N^a	Percentage enrolling in college		Significance (Pearson X^2)
		High dosage	Low dosage	
Cohort 1	73	63%	75%	ns
Cohort 2	134	55%	68%	ns

ns   not statistically significant

[a]   Note the small sample sizes for low-dosage students (Cohort 1 included 57 high-dosage and 16 low-dosage students; Cohort 2 included 115 high-dosage and 19 low-dosage students).

By demographic characteristics

Differences in college enrollment between STARBASE and comparison students were also analyzed by demographic characteristics. Significant differences were found when looking at income status. As a proxy for income status, researchers looked at students' eligibility for free or reduced-price when they were in fourth grade. The significant *Breslow-Day* omnibus test suggests that enrollment patterns varied by income status.

Looking within income categories to pinpoint where the differences occurred, a significantly higher percentage of lower-income STARBASE than comparison students attended college (63% vs. 52%) (Figure 9). This suggests that STARBASE may increase low-income students' likelihood of enrolling in college.

The *Breslow-Day* omnibus test also suggests that enrollment patterns varied by race, although differences within race categories were not significant. In some cases, smaller sample sizes for individual races may have made it difficult to detect a statistically significant difference. Among Black students, a higher percentage of those who had participated in STARBASE than their matched pairs enrolled in college (70% vs. 53%), although the difference was not significant. Similarly, a higher percentage of former STARBASE than comparison Asian or Pacific Islander students enrolled in college (68% vs. 56%), although again the difference was not significant (Figure 9).

9. College enrollment: By race, gender, and income status

		N[a]	Percentage enrolling in college		Significance (McNemar)	Significance (Breslow-Day)
			STARBASE	Comparison		
Race[b,c]	Asian or Pacific Islander	93	68%	56%	ns	**
	Black (not Hispanic)	30	70%	53%	ns	
	White (not Hispanic)	23	48%	57%	ns	
Gender	Female	104	63%	56%	ns	ns
	Male	87	59%	48%	ns	
Free or reduced-price lunch	Eligible	151	63%	52%	*	***
	Ineligible	35	57%	54%	ns	

*   *p<.05*

**   *p<.01*

***   *p<.001*

ns   *not statistically significant*

[a]   *Refers to the number in each group of the matched pairs comparison (e.g., 93 STARBASE students were compared to 93 comparison students).*

[b]   *Analysis excludes Hispanic and American Indian or Alaskan Native participants due to insufficient numbers in each group.*

[c]   *Note the smaller sample sizes. In some cases, there may not be enough power to detect a statistically significant difference.*

Note.   *Student pairs were not required to match on every demographic characteristic. These analyses exclude pairs that did not match on the specific characteristic of interest. For example, the analysis based on free or reduced-price lunch status excludes 22 pairs that did not match on this variable.*

By college characteristics

As shown in Figure 10, STARBASE and comparison participants in our study who enrolled in college were similar in the characteristics of the colleges they chose. The vast majority of both STARBASE and comparison students who enrolled in college attended an in-state school, with 91 percent of STARBASE and 93 percent of comparison students enrolling in a Minnesota college or university. A majority of both STARBASE and comparison students enrolling in college enrolled in public (72% and 71%, respectively) and four-year (70% and 67%, respectively) colleges or universities.

10. College enrollment: By college characteristic

		Percentage enrolling in each type of college		N[a]	Significance (McNemar)
		STARBASE	Comparison		
Public vs. private	Public	72%	71%	69	ns
	Private	28%	29%		
2-year vs. 4-year	2-year	30%	33%	69	ns
	4-year	70%	67%		
Minnesota vs. outstate	Minnesota	91%	93%	69	ns
	Outstate	9%	7%		

ns   not statistically significant

[a]   Refers to the number in each group of the matched pairs comparison (e.g., 69 STARBASE students were compared to 69 comparison students).

Note.   In cases where a student attended more than one college, these analyses reflect the first college the student attended.

Predictors of degree completion

Beyond analyses needed to address core study questions, Wilder Research staff also analyzed several factors indicative of students' future degree completion. Adelman's *Toolbox Revisited* (2006) identified protective factors and risk factors associated with future completion of a bachelor's degree. Wilder Research staff conceived several variables based on Adelman's work, examining whether students a) enrolled in college immediately or delayed enrollment, b) ever changed colleges, c) completed their first year, d) returned for their second year, e) attended a summer term, f) had a withdrawn status for any term, and g) were ever enrolled less than full-time. Figure 11 summarizes the variables created for these analyses. Importantly, these variables could not be

constructed entirely consistently with Adelman's due to limitations on available data, and therefore should not be viewed as representative of Adelman's work.

Variable construction

In constructing the variables, Wilder Research staff combined NSC data with data from the federal Integrated Postsecondary Education Data System (IPEDS) (U.S. Department of Education, n.d.). NSC data included student-level data on the specific schools attended, dates of each term attended at a given school, and the final reported enrollment status for each term (i.e., full-time, half-time, less than half-time, leave of absence, withdrawn, deceased). IPEDS data enabled researchers to identify the calendar system of each school attended by a student, and by extension the number and lengths of terms students would have attended at a given school if they completed a full academic year.[2] Consistent with previous analyses, Wilder Research staff again used a directional hypothesis, meaning researchers expected that STARBASE students would out-perform comparison students on the protective and risk factors associated with future degree completion.

---

[2] Possible calendar systems included semester, quarter, trimester, four-one-four plan (four courses taken for four months, one course taken for one month, and four courses taken for four months), and other calendar systems (U.S. Department of Education IPEDS, n.d.).

11. Predictors of degree completion: Variables constructed based on NSC and IPEDS data

Newly constructed variable	Modeled after[a]	Definition
Immediate enrollment	Adelman's NODELAY variable	Enrolled in college the summer or fall following their on-time high school graduation. Those not having this status either had delayed enrollment or had not yet enrolled.
Enrolled + changed colleges	Adelman's MULTINS variable	Attendance at more than one college was reported for the student. This variable was calculated only for students who had ever enrolled in college.
Immediate enrollment + completed first year	Adelman's NOSTOP variable	Based on the school's calendar system, the student completed the number of scheduled terms from fall to spring for the school year. This variable was calculated only for students who had immediately enrolled in college.
Immediate enrollment + returned for second year	Adelman's NOSTOP variable	Based on the school's calendar system, the student was enrolled fall of their second year (student may have taken time off during the first college year following initial enrollment). This variable was calculated only for students who had immediately enrolled in college.
Enrolled + attended summer term	Adelman's SUMMER variable	Ever attended a college summer term. This variable was calculated only for students who had ever enrolled in college.
Enrolled + ever withdrew	Adelman's WRPT Ratio	Had a final enrollment status of "withdrawn" reported for any term. This variable was calculated only for students who had ever enrolled in college.
Enrolled + ever half-time or less	Adelman's PARTTIME variable	Had an enrollment status of "half-time" or "less than half-time" reported for any term. This variable was calculated only for students who had ever enrolled in college.

[a] Variables were conceived based on several variables identified in Adelman's Toolbox Revisited (2006) as predictive of successful completion of a bachelor's degree. However, variables could not be constructed entirely consistently with Adelman's due to limitations on available data, and therefore should not be viewed as representative of Adelman's work.

Note. Wilder Research staff combined student-level data provided by the National Student Clearinghouse with institution-level data from the federal Integrated Postsecondary Education Data System to construct these variables representing risk and protective factors associated with future completion of a bachelor's degree.

Results by cohort

Figure 12 compares STARBASE and comparison students on the risk and protective factors by cohort. Overall, STARBASE students appeared to have an advantage over comparison students on a couple of the protective factors, and were similar to comparison students on other factors, although differences were not significant.

Adelman identified "no delay of entry" as a protective factor predictive of future successful completion of a bachelor's degree (Adelman, 2006, p. xxvi). In Wilder Research's analysis, higher percentages of STARBASE than comparison students enrolled in college immediately following their high school graduation. In Cohort 1, 64 percent of STARBASE and 55 percent of comparison students immediately enrolled in college, defined here as summer or fall following their spring 2009 high school graduation. In Cohort 2, 56 percent of STARBASE and 48 percent of comparison students immediately enrolled, defined as summer or fall following their spring 2010 high school graduation. The remaining students in each group either had delayed entry or had not yet enrolled in college as of fall 2010. Differences were not statistically significant (Figure 12). Looking at the two cohorts combined, 59 percent of STARBASE and 50 percent of comparison students immediately enrolled in college (N=193 matched pairs, *p*=.05).

Adelman identified students ever having a part-time status as a risk factor negatively influencing their probability of degree completion (Adelman, 2006, p. 67). Among students who had ever enrolled in college, the percentages of STARBASE and comparison students who were ever less than full-time were the same overall (23%), but varied by cohort. Fifty percent of STARBASE and 32 percent of comparison students in Cohort 1, and 5 percent of STARBASE and 17 percent of comparison students in Cohort 2 who had ever enrolled in college were less than full-time at some point. Differences were not significant (Figure 12). Again, there were more possible terms of enrollment for Cohort 1 than Cohort 2.

Withdrawing from or repeating 20 percent or more of all courses in which a student enrolled was also identified as a risk factor in Adelman's work (Adelman, 2006, p. 192). Wilder Research staff constructed a simplified variable based on data available looking at whether students had a final enrollment status of "withdrawn" for any term in which they had enrolled. Similar percentages of STARBASE and comparison students who had ever enrolled in college had a final enrollment status of "withdrawn" reported for any term. Seven percent of the STARBASE and comparison students in Cohort 1, and 5 percent of the STARBASE and 2 percent of the comparison students in Cohort 2 who had ever enrolled in college had a withdrawn status (Figure 12).

12. Predictors of degree completion: By cohort

		N^a	Percentage with characteristic		Significance (McNemar)
			STARBASE	Comparison	
Immediate enrollment	Cohort 1	58	64%	55%	ns
	Cohort 2	135	56%	48%	ns
Enrolled + changed colleges[b]	Cohort 1	28	18%	14%	ns
Immediate enrollment + completed 1st year[b]	Cohort 1	18	94%	89%	ns
Immediate enrollment + returned for 2nd year[b]	Cohort 1	18	94%	78%	ns
Enrolled + attended summer term[b]	Cohort 1	28	11%	7%	ns
Enrolled + ever withdrew[b]	Cohort 1	28	7%	7%	ns
	Cohort 2	41	5%	2%	ns
Enrolled + ever half-time or less[b]	Cohort 1	28	50%	32%	ns
	Cohort 2	41	5%	17%	ns

ns   not statistically significant

[a]   *Refers to the number in each group of the matched pairs comparison (e.g., 58 STARBASE students were compared to 58 comparison students).*

[b]   *Note the smaller sample sizes. In some cases, there may not be enough power to detect a statistically significant difference.*

Note.   *Because the earliest Cohort 2 could have enrolled in college is fall 2010, some characteristics were analyzed for Cohort 1 only.*

The remaining factors were analyzed for Cohort 1 only due to the longer period of time those students could have possibly been enrolled in college. First, among Cohort 1 students who had immediately enrolled in college, researchers examined the percentages who a) completed their first year and b) returned for a second year. Ninety-four percent of STARBASE and 89 percent of comparison students who had enrolled immediately following high school graduation completed their first year of college. Looking at those who returned for a second year, 94 percent of STARBASE and 78 percent of comparison students who had enrolled immediately returned the fall of their second year of college. This analysis did not factor whether students took time off during their initial college year. Differences were not significant (Figure 12).

Use of summer terms was another factor identified by Adelman as contributing to degree completion (Adelman, 2006, p. xxv). A slightly higher percentage of Cohort 1 STARBASE (11%) than comparison (7%) students who had ever enrolled in college had attended a summer term. Finally, Adelman also found some evidence that attending multiple institutions can reduce the probability of degree completion, whereas formally transferring from a community college to a four-year institution or from one four-year institution to another can increase the probability. Wilder Research's analysis found that among students who had enrolled in college, similar rates of Cohort 1 STARBASE and comparison students (18% and 14%, respectively) had ever changed their colleges. The variable constructed for this analysis did not distinguish among types of transfers. Again, differences in these analyses were not significant.

Results by dosage

College enrollment characteristics were also analyzed by level of program dosage. There were no statistically significant differences between low- and high-dosage STARBASE students in their enrollment characteristics. It may be worth noting, however, that a higher percentage of low- than high-dosage students enrolled in college immediately following their high school graduation (71% vs. 56%, respectively). However, as discussed previously in the report, the size of the low-dosage group in our study sample was relatively small and there were some demographic differences between the two groups.

Participant feedback

Approximately a decade later, former STARBASE students now attending college who responded to our survey overwhelming indicated that STARBASE was a valuable learning experience. There appeared to be a gap between their level of interest in STEM following STARBASE, however, and their access of other STEM programs. Most said STARBASE increased their interest in or understanding of STEM areas, but a majority said they did not participate in other STEM activities after STARBASE. Most said they currently have interest in getting a STEM-related job and a majority said STARBASE helped them learn about STEM careers. Fewer indicated the program has actually influenced their career plans. A third of the former participants indicated their participation in STARBASE continues to impact them today.

Following are results from Wilder Research's survey of former STARBASE participants who were enrolled in college in fall 2010. The survey took place 9-10 years after students were initially eligible to participate in the STARBASE program. A total of 36 participants completed the online survey in November-December 2010. In addition to closed-ended questions, the survey included several open-ended questions asking participants to provide written comments. In cases where most or all respondents answered an open-ended question, their responses are categorized into themes in this section and provided in full in the Appendix. As described in the Study Methods section, due to limitations in e-mail address availability and the somewhat low response rate, results should be viewed as instructive but not necessarily representative of all former STARBASE enrolled in college in fall 2010. In particular, survey results should not be viewed as representative of those pursuing military interests, as the survey was administered only to those enrolled in college at the time. Results are presented in the following areas:

- Current interest in STEM

- Current interest in the military

- Involvement in other STEM activities after STARBASE

- Perceptions of STARBASE

Current interest in STEM

Students were asked several questions to gauge their current interest and involvement in STEM. Asked how much interest they currently have in STEM areas, most answered "some" or "a lot" in relation to science (89%), technology (83%), and math (75%), and a majority answered "some" or "a lot" in relation to engineering (56%) (Figure 13).

13. Level of interest in science, technology, engineering, and math (N=36)

How much interest do you currently have in…	A lot	Some	Very little/ None
Science?	14 (39%)	18 (50%)	4 (11%)
Technology? (e.g., computers)	16 (44%)	14 (39%)	6 (17%)
Engineering?	7 (19%)	13 (36%)	16 (44%)
Math?	14 (39%)	13 (36%)	9 (25%)

Fifty-eight percent of the students indicated they had decided on a major or field of study. Those who had decided were fairly evenly split between STEM-related and social science or liberal arts fields (Figure 14).

14. College major or field of study

Have you decided on a major or field of study in college? (N=36)

Yes	21 (58%)
No	9 (25%)
Don't know	6 (17%)

Open-ended question: If yes, what is your major or field of study?[a] (N=21)

Science/engineering[b]	9 respondents
Social science/liberal arts[c]	9 respondents
Other[d]	3 respondents

[a] Response themes developed by Wilder Research based on students' responses.

[b] Responses categorized here include the following: chemical engineering, mechanical engineering, biology, genetics, nursing, pharmacy, "biomedical science and astronomy," "geology and anthropology," and "pediatrician."

[c] Responses categorized here include the following: social science, liberal arts, psychology/child psychology, political science, and broadcast journalism.

[d] Responses categorized here include the following: "speech-language hearing sciences and child psychology," "outdoor education with a focus on Native American studies," and "law enforcement and environmental studies."

Note. Two respondents indicated they were "interested in" or "would like to study" the field they indicated, suggesting they may not have formally decided on the field.

Those who had not yet decided on a major or field of study were asked whether they were considering a STEM-related discipline. A third of those students indicated they were, and a majority indicated they did not know (Figure 15).

15. Considering major or field of study in STEM if undecided (N=15)

Are you considering a major or field of study in a science, technology, engineering, or math discipline? This would include any field that emphasizes skills in one of these areas.

Yes	5 (33%)
No	2 (13%)
Don't know	8 (53%)

Note. *This question was asked only of those who answered "no" or "don't know" when asked, "Have you decided on a major or field of study in college?"*

All respondents were asked whether they have taken or are planning to take any additional STEM classes in college beyond what is required. Again, it is important to consider that questions were posed early in students' college careers, especially in the case of Cohort 2 who had just graduated from high school the preceding spring. At this time, 42 percent of students reported they have or plan to take more STEM classes than required (Figure 16).

16. STEM coursework (N=36)

Have you taken or are you planning to take any additional science, technology, engineering, or math classes in college beyond what is required?

Yes, more than what's required	15 (42%)
No, only what's required	13 (36%)
Don't know	8 (22%)

Asked how much interest they currently have in getting a STEM-related job, most students (81%) indicated "some" or "a lot." Forty-two percent indicated interest in getting a job teaching STEM specifically (Figure 17).

17. STEM job interest (N=36)

How much interest do you currently have in…	A lot	Some	Very little/ None
Getting a job <u>related to</u> science, technology, engineering, or math?	9 (25%)	20 (56%)	7 (19%)
Getting a job <u>teaching</u> science, technology, engineering, or math?	2 (6%)	13 (36%)	21 (58%)

Only 14 percent of students indicated they have participated in any STEM-related activities, clubs, or programs at their college or university, although again the question was posed early in their college career and during some students' first college term (Figure 18).

18. Participation in STEM activities (N=36)

At your college or university, have you participated in any activities, clubs, or programs related to science, technology, engineering, or math?

Yes	5 (14%)
No	31 (86%)

Note.   *The five respondents answering "yes" were asked to indicate the types of activities in which they have participated. Their answers included the following: "geology club," "environmental club and weather club," "environmental science club and related philanthropic excursions," "doing research in a lab on kidney failure," and "doing a lot with technology in biology and psychology classes."*

College students' interest in the military

College students were also asked specifically about their current interest in the military. Importantly, these results should not be viewed as representative of all former STARBASE students given that the survey was administered only to students enrolled in college in fall 2010. Phase I asked students when they were in high school to indicate their interest in joining the military, and significantly more STARBASE (46%) than comparison (31%) students indicated at least a little interest in joining the military in high school (Broton & Mueller, 2009).

As shown in Figure 19, asked whether they are currently enrolled in any form of the military, all 36 college student respondents answered "no," as might be expected given the small sample of college students and that the survey was not administered to those who enrolled in the military and were not attending college. A relatively small percentage (17%) indicated interest in joining the military, which again might be expected given the survey sample.

19. College students' level of interest in joining the military (N=36)

How much <u>interest</u> do you have in joining the military?

A lot	1 (3%)
Some	5 (14%)
Very little/none	30 (83%)

Compared to students indicating STARBASE increased their interest in STEM (72%), a smaller percentage of the college students surveyed indicated STARBASE increased their interest in the military (22%) (Figures 20 & 28). Again, this might be expected given the composition of the survey sample.

20. Impact of STARBASE on college students' interest in joining military (N=36)

Do you think STARBASE increased your interest in joining the military?	
Yes	8 (22%)
No	28 (78%)

One of the college students surveyed (3%) reported having participated in any military-related activities, clubs, or programs at their college or university at this early point in their college career (Figure 21).

21. Participation in military activities in college (N=36)

At your college or university, have you participated in any activities, clubs, or programs related to the military (e.g., ROTC)?	
Yes	1 (3%)
No	35 (97%)

Note. *The respondent answering "yes" specified ROTC when asked to indicate the type of activity.*

Involvement in other STEM activities after STARBASE

Students were also asked several questions intended to address the core study question related to the extent to which former STARBASE students access other STEM opportunities after exiting the program. Although 72 percent of students said STARBASE increased their interest in STEM, only 17 percent reported participating in other STEM-related activities, clubs, or programs in elementary, junior high, or high school (Figures 22 & 28). Taken together, these findings suggest a gap between students' interest in and access to available STEM programming. The six students indicating they had participated in other STEM-related activities were asked to describe the types of activities in which they participated, and those they found most helpful. Their written responses to these questions are provided in the Appendix.

22. Participation in other STEM activities after STARBASE (N=36)

After participating in STARBASE, did you participate in any other activities, clubs, or programs related to science, technology, engineering, or math when you were in elementary, junior high, or high school?

Yes	6 (17%)
No	25 (69%)
Don't know	5 (14%)

The same six students who had indicated they participated in other STEM-related activities in elementary, junior high, or high school were also asked whether they became involved in any of these activities because of STARBASE. One answered "yes," two answered "don't know," and the remaining three answered "no" (Figure 23).

23. STARBASE influence on participation in other STEM activities (N=6)

Did you get involved in any of these science, technology, engineering, or math activities or programs because of STARBASE?

Yes	1
No	3
Don't know	2

Note. *This question was asked of those who answered "yes" when asked, "After participating in STARBASE, did you participate in any other activities, clubs, or programs related to science, technology, engineering, or math when you were in elementary, junior high, or high school?" Asked to specify the activities or programs, the respondent answering "yes" here indicated, "I got interested in Environmental Science as an off-shoot of what I learned at STARBASE."*

Students were asked whether they faced any challenges to participating in other STEM activities after STARBASE, and 17 percent indicated they had. Examples of barriers those students faced include time constraints, transportation, and lack of awareness of available opportunities (Figure 24). It is possible that due to their young age at the time of STARBASE participation, students may not have been fully aware of barriers they faced to program access, such as their parents' awareness of opportunities or program cost, for example. As discussed later in the report, key informants described a number of barriers they perceive underserved students as facing to accessing the available STEM opportunities.

24. Challenges to participation in other STEM activities

Did you face any challenges to participating in other science, technology, engineering, or math activities, clubs, or programs when you were in elementary, junior high, or high school? (N=36)

Yes	6 (17%)
No	28 (78%)
Don't know	2 (6%)

If yes, which challenges did you face? (N=6)[a]

I was too busy with other activities.	5
Transportation would have been difficult.	4
I was not aware of what other opportunities were available to me.	4
Opportunities did not fit my specific interests.	3[b]
There were not enough opportunities available to me.	2
I needed to be home to care for my sibling(s).	2
My parents or caregivers were not aware of other opportunities.	1
Available opportunities were too expensive.	1
Opportunities were not applicable to me based on my age, gender, or other factors.	0
Other challenges.	0

[a] *Participants were presented with response options and asked to indicate all that apply.*

[b] *Participants selecting this response option were asked to explain. Their written explanations included, "I am more interested in geology, and I never saw any clubs that had anything to do with that," "There were limited opportunities and none was to my interest," and "Math team."*

Six students (17%) indicated there were STEM-related opportunities they would have liked to participate in during elementary, junior high, or high school but that were not available to them (Figure 25). Those six were also asked to describe the types of opportunities they would like to have had, and their written comments are provided in the Appendix.

25. Availability of other STEM opportunities (N=36)

Were there any science, technology, engineering, or math opportunities you would have liked to participate in but that were not available to you in elementary, junior high, or high school?

Yes	6 (17%)
No	22 (61%)
Don't know	8 (22%)

Eight percent of the current college students indicated they had participated in military-related activities such as Junior Reserve Officers Training Corps (JROTC) in junior high or high school (Figure 26).

26. Participation in military activities (N=36)

When you were in junior high or high school, did you participate in any activities, clubs, or programs related to the military (e.g., JROTC)?

Yes	3 (8%)[a]
No	33 (92%)
Don't know	0 (0%)

[a] *Participants were asked to indicate the types of activities, clubs, or programs in which they participated. One indicated ROTC, one indicated JROTC, and one indicated NJROTC (Naval Junior Reserve Officers Training Corps).*

Perceptions of STARBASE

Finally, students were asked about their perceptions of the STARBASE program specifically. Several questions asked students to reflect on their experience in STARBASE, what they remember most from the experience, and the program's impact on them personally. This survey took place 9-10 years after study participants were in fourth grade and initially eligible for STARBASE. Even a decade later, students were able to recall a number of specific program elements. Asked what they remember most, students described a number of STARBASE experiences, such as building and launching rockets, seeing aircraft in person, learning about rockets and airplanes, flight simulations, and getting code names, for example. Respondents' written comments are summarized in Figure 27 below and provided in full in the Appendix.

27. What students remember most about participating in STARBASE (N=36)

What do you remember most about participating in STARBASE?[a,b]

Building and launching rockets, airplanes, gliders, or kites	16 (44%)
Being on the base/seeing airplanes and helicopters in person	14 (39%)
Learning about rockets or airplanes	12 (33%)
Flight simulations	10 (28%)
Getting code names	10 (28%)
Other activities or experiments	9 (25%)
Having fun/being excited to go to STARBASE	5 (14%)
Working as a team	5 (14%)
Learning about physics or other scientific concepts	4 (11%)

[a] *Response themes developed by Wilder Research based on students' responses.*

[b] *Students' responses could be placed in multiple themes, so percentages do not sum to 100 percent.*

Note. *Respondents' complete comments are provided in the Appendix.*

Students indicated positive feelings about the program and its impact on them personally. Almost all students (97%) said STARBASE was a valuable learning experience. Most (72-78%) said STARBASE increased their interest in STEM or helped them understand these areas better (Figure 28).

A majority of students (58%) reported that STARBASE helped them learn about STEM-related careers, although fewer indicated the program had actually influenced their career plans (19%). In both cases, a third of the respondents indicated they "don't know" (Figure 28). The seven respondents answering that "yes," STARBASE had influenced their career plans were asked to explain in a follow-up open-ended question, and their written comments are provided in the Appendix. Phase I results also suggested the program helps students learn about different STEM career options. In the initial study phase, nearly three-quarters of high school students reported that STARBASE had helped them learn either a lot or some about STEM-related careers, and this was particularly the case for high-dosage students (Broton & Mueller, 2009).

28. College students' overall perceptions of STARBASE (N=36)

Do you think STARBASE…	Yes	No	Don't know
Was a valuable learning experience?	35 (97%)	0 (0%)	1 (3%)
Helped you <u>understand</u> science, technology, engineering, or math better?	28 (78%)	2 (6%)	6 (17%)
Increased your <u>interest</u> in science, technology, engineering, or math?	26 (72%)	4 (11%)	6 (17%)
Increased your interest in the military? This could include interest in the military in general as well as interest in joining the military.	8 (22%)	24 (67%)	4 (11%)
Helped you learn about careers related to science, technology, engineering, or math?	21 (58%)	3 (8%)	12 (33%)
Has influenced your career plans?	7 (19%)	17 (47%)	12 (33%)

Those who indicated STARBASE had increased their interest in STEM areas were asked about each of the four areas separately. Almost all of those students (96%) indicated the program increased their interest in technology, most (81-85%) indicated the program increased their interest in engineering and science, and a majority (58%) indicated STARBASE increased their interest in math (Figure 29). Although these results are based on a relatively small number of students, students' attribution of an increased interest in technology due to STARBASE seems to resonate with the Phase I study finding that in high school STARBASE students had a stronger interest in technology than comparison group students.

29. Impact of STARBASE on interest in science, technology, engineering, and math (N=26)

Specifically, do you think STARBASE increased your interest in…	Yes	No	Don't know
Science?	22 (85%)	3 (12%)	1 (4%)
Technology? (e.g., computers)	25 (96%)	1 (4%)	0 (0%)
Engineering?	21 (81%)	4 (15%)	1 (4%)
Math?	15 (58%)	9 (35%)	2 (8%)

Note. *This question was asked only of those who answered "yes" when asked, "Do you think STARBASE increased your interest in science, technology, engineering, or math?"*

Asked about the most important thing they gained from participation in STARBASE, one in four students described an appreciation of science or STEM areas or an understanding of scientific principles. The top five responses also included an appreciation for or knowledge of technology specifically, knowledge of their own personal interests or learning style, a fun experience or the joy of exploration, and experience working on a team (Figure 30). Students' complete written comments are provided in the Appendix.

30. Most important thing gained from participation in STARBASE (N=36)

What was the most important thing you gained from your participation in STARBASE?[a,b]	
Appreciation of science or STEM areas/understanding of scientific principles	9 (25%)
Appreciation for, knowledge of, or interest in technology specifically	7 (19%)
Gained knowledge of personal interests or learning style	7 (19%)
Fun experience/joy of exploration	6 (17%)
Experience working on a team	5 (14%)
Knowledge of aircraft/space	4 (11%)
Career exploration	4 (11%)
The experience of seeing airplanes/helicopters in person	3 (8%)
I don't remember/don't know	3 (8%)
Experiencing science in a different way	2 (6%)
Better understanding of military aircraft/airway uses	2 (6%)

[a] *Response themes developed by Wilder Research based on students' responses.*

[b] *Students' responses could be placed in multiple themes, so percentages do not sum to 100 percent.*

Note. *Additional concepts expressed by one respondent each include the following: seeing that women can excel in science, hands-on activities, the learning experience in general, learning to work independently, and gaining an understanding of the importance of history. Respondents' complete comments are provided in the Appendix.*

Students were also asked generally whether they think participation in STARBASE continues to impact them today. A third (33%) answered "yes," compared to 19 percent who answered "no." The remaining students indicated they did not know (Figure 31). The 12 respondents answering "yes" were asked to explain how their participation in STARBASE continues to impact them, and their written comments are provided in the Appendix.

31. Current impact of STARBASE (N=36)

Do you think your participation in STARBASE continues to impact you today?

Yes	12 (33%)
No	7 (19%)
Don't know	17 (47%)

Finally, students were given the opportunity to provide any additional comments for the STARBASE program. A number of students took this as an opportunity to comment on the positive nature of the experience overall or express that it should be available to other students. There written comments are summarized in Figure 32 and provided in full in the Appendix.

32. Final comments (N=28)

Are there any final comments you would like to share with the STARBASE program?[a,b]

It was a great experience. I had a lot of fun.	17 (61%)
STARBASE should continue to be available to students. More students should have this experience. Older students could benefit from the experience as well.	10 (36%)
It's a great program.	4 (14%)
STARBASE provides a great opportunity to or helped me explore science and careers. I was inspired.	4 (14%)
No/none.	4 (14%)
Thank you for the experience!	3 (11%)
I learned a lot.	2 (7%)

[a]   *Response themes developed by Wilder Research based on students' responses.*

[b]   *Students' responses could be placed in multiple themes, so percentages do not sum to 100 percent.*

Note.   *Additional concepts expressed by one respondent each include that the respondent would recommend the program to any child interested in science, and that based on survey questions the respondent was concerned about a program emphasis on future military recruitment. Respondents' complete comments are provided in the Appendix.*

Military enrollment

Estimates suggest that from 2-4 percent of STARBASE and comparison students had entered the military by the fall after their high school graduation (Cohort 2) or the subsequent fall (Cohort 1), although researchers perceive these to be conservative estimates. Further studies could explore ways to better assess former participants' subsequent involvement in uniform or civilian military careers.

Based on searches conducted in the Department of Defense Global Directory Service, five of the former STARBASE participants (2%) and nine of the comparison group participants (4%) were enrolled in the military in fall 2010 (Figure 33). However, as described in the Study Methods section, these are likely conservative estimates of the number who had entered the military. Statistical tests were not performed on this data due to its limitations. To more accurately assess former participants' subsequent participation in military careers, either in uniform or as civilians, researchers would need to find additional ways of following up on participants and better matching them with the Department of Defense database.

33. Military enrollment

	N	Record of military enrollment	
		Yes	No
STARBASE[a]	208	5 (2%)	203 (98%)
Comparison[b]	208	9 (4%)	199 (96%)

[a]   All five students were in the high-dosage group, and four of the five were in Cohort 2. Three entered the Navy, one the Army, and one the Marines.

[b]   Five of the nine were in Cohort 1. Four entered the Army, two the Navy, two the Marines, and one the Air Force.

Note.   As explained in the text, these are likely to be conservative estimates of the number enrolling in the military. Due to the small number enrolled and our inability to verify matches for every student, statistical tests were not performed on this data.

STEM program inventory

The **STEM program inventory** documents a range of opportunities available for former STARBASE Minnesota participants and other area students to pursue and sustain their STEM interests and learning. However, as explored in the following section, there appear to be a number of barriers to accessing available programs for underserved populations. Information gathered through the inventory provides STARBASE staff with concrete information about programs available to their students, and can ultimately be used to foster broader networking and collaboration in the STEM community that can help link students to programs.

Wilder Research conducted an inventory of STEM organizations and programs to examine the opportunities currently available to support former STARBASE participants and others in the Twin Cities metropolitan area, with a particular focus on St. Paul. Following are descriptive statistics on the programs included in the inventory, including organizational type, STEM program areas, region, and population served. Respondents were asked to select among discrete categories for their organizational type and STEM program areas. In other cases, Wilder Research staff manually categorized programs for purposes of analysis based on their inventory responses. Programs for which information was not reported on a particular program characteristic were excluded from those analyses.

Inventory background

In June, Wilder Research sent the program inventory to approximately 125 representatives of STEM organizations in the Twin Cities who had previously participated in Community of Practice meetings in STEM organized, in part, by STARBASE Minnesota for the purpose of strengthening collaboration and improving the appeal of and access to STEM. Beyond this original sample, additional contacts were identified through completed inventories and the key informant interviews conducted as part of the study. In total, from June-October 2011 inventories were sent to more than 180 contacts representing approximately 100 organizations. To encourage responses, Wilder Research staff engaged in extensive follow-up in the form of reminder e-mails, phone calls, and deadline extensions. Still, the final inventory should not be viewed as an exhaustive list of all St. Paul-area STEM programs.

The final inventory includes listings for 171 STEM programs offered by 65 organizations. In some cases, a single organization offers more than one program and therefore has more than one listing. In other cases, a STEM organization has a listing although they do not

offer specific youth programming. In many cases, those not responding were either individual teachers or organizations that do not offer STEM-focused programming.

For study purposes, the inventory emphasized programs serving 4th- through 12th-grade students in the St. Paul area that would be available to former STARBASE Minnesota students once they completed the program. However, the information compiled also includes information on a number of programs serving other parts of the Twin Cities metro area as well as some programs serving other portions of the state. Additionally, a majority of the programs represented in the inventory serve the metro area, although the inventory also includes a large number serving the state of Minnesota as a whole. Most of the programs serve the population in focus, although the inventory also includes some programs serving teachers, early elementary students, college students, or a general audience.

Beyond the purposes specified in the study proposal, STARBASE Minnesota also intends to share inventory results with the broader local STEM community. To this end, Wilder Research staff transferred inventory results into a spreadsheet and developed a template for pulling information into a printed directory. Inventory results will ultimately be used beyond this study to increase awareness of and access to local STEM opportunities available to students.

As a courtesy, Wilder Research sent a draft version of formatted program listings back to inventory respondents for their review. Respondents were notified that information could ultimately be shared with the broader STEM community and public, and were invited to make any edits or additions to their listings. Along with e-mailing the draft listings, Wilder Research also sought permission to share contact information from several respondents who had not explicitly provided this permission on their original inventory. Although the courtesy e-mails did not require a response, respondents for 137 of the 171 program listings actively verified or updated their information through this process.

Analysis of results

A core study question addresses what programs currently exist to support and foster continued STEM learning, achievement, and career exploration after participants complete STARBASE. Information gathered through the inventory provides STARBASE staff with concrete information about programs available to students in the St. Paul area once they complete STARBASE. Beyond the program descriptions and contact information provided directly to STARBASE through the inventory, researchers analyzed inventory results to assess the types of programming available and any gaps in programming available to sustain former STARBASE students' STEM learning.

Programs available to sustain learning

As shown in Figure 34, information collected through the inventory suggests a number of different types of STEM-related programs exist to support students in the St. Paul area once they exit STARBASE. Of the 171 programs in the inventory, a total of 134 serve St. Paul and 109 indicated they serve elementary, junior high, or high school students in St. Paul. Science was the most frequently reported STEM program area (reported by 75% of all programs), although engineering (59%), technology (42%), and math (38%) were also fairly well represented.

34. Characteristics of STEM inventory programs

Characteristic[a]	Programs	
	Number	Percentage
Offers STEM programs/services for 4th-12th grade students (N=171)		
Yes	160	94%
No	11	6%
Organization type (N=171)		
Business/industry	17	10%
Education institution	128	75%
Military	3	2%
Museum	11	6%
Nonprofit	53	31%
Other government	12	7%
Program area (N=159)		
Science	119	75%
Technology	67	42%
Engineering	94	59%
Math	60	38%
Other	35	22%
Population served (N=163)		
STEM providers	8	5%
Elementary (K-6) students	94	58%
Junior high (7-9) students	95	58%
High school (10-12) students	84	52%
Teachers	19	12%
General audience	15	9%

34. Characteristics of STEM inventory programs (continued)

Characteristic[a]	Programs	
	Number	Percentage
Geographic area[b] (N=163)		
St. Paul	134[c]	82%
Minneapolis	133	82%
Metro area	157	96%
Greater Minnesota	56	34%
School day vs. non-school day[d] (N=133)		
School day	46	35%
Outside of school day	103	77%
Gender emphasis[d] (N=115)		
Girls only[e]	15	13%
Boys only	2	2%

[a] Percentages sum to more than 100 percent because individual programs may fall into more than one category for each characteristic.

[b] Categories developed based on a question asking respondents to provide the geographic areas of the program's primary population. "Metro area" is defined here as serving at least one community within the Twin Cities metro area, which could include a suburb, a city neighborhood, or the metro area as a whole, for example. "Greater Minnesota" is defined as serving the state as a whole or an individual community outside the metro area.

[c] 109 of the 134 indicated they serve elementary, junior high, or high school students.

[d] Includes only those programs serving elementary, junior high, or high school students.

[e] Includes a couple of programs open to both genders but indicating a strong outreach emphasis on girls.

Note.   The STEM inventory includes listings for 171 programs. In some cases, complete information was not provided on a program's characteristics. Respondents were asked to select among discrete categories for organizational type and STEM program areas. For other characteristics, Wilder Research staff categorized programs for purposes of analysis based on information provided. In cases where reasonable assumptions could not be made about a particular characteristic of a program, it was excluded from this analysis.

Approximately two-thirds of the programs in the inventory were able to provide annual program participation figures. As shown in Figure 35, more than 600,000 participants were reported by these programs, although it should be assumed that students attending more than one program in a given year were duplicated in the figures reported. Programs varied widely in their size, from a teacher-in-residence program reaching one participant in a year to a university-affiliated nonprofit open to the public.

35. Annual program participation

Number reporting data/Total N	Total number of participants	Range	Mean	Median
113[a]/171 (66%)	603,530	1-180,000	5,341	400

[a] *Excludes figures reported for three STEM-themed public television shows (10 million, 5 million, and 5 million), as well as duplicated figures reported for a couple of programs. Nevertheless, it should be assumed that figures duplicate students attending more than one program in a given year.*

Note. *Respondents were asked to indicate the number of program participants in 2009. A number of respondents did not provide this information. Some indicated that data were approximations or reflected a slightly different time period, such as 2008-09 or 2010. Participation was requested in aggregate and therefore cannot be broken down by age served or geographic region given that many programs serve multiple age groups and regions. Additionally, figures include programs serving teachers, STEM providers, or a general audience. In a number of cases, programs serve a general audience or teachers in addition to students, and participation was provided only in aggregate.*

Gaps in programming

Researchers analyzed inventory data to investigate whether program offerings for individual STEM areas varied by the age group or geographic area served, or by the program's school-day vs. non-school day status. As shown in Figure 36, results suggest that the percentages of programs in each STEM area were fairly consistent across the program characteristics of interest. However, although the inventory asked respondents to select the program's main areas of emphasis, it is possible that in some cases respondents selected program areas that were not a primary focus. As in the inventory results overall, across these characteristics the highest percentage of STEM programming was in the area of science, although other categories and especially engineering had a fairly strong representation.

36. Program characteristics by STEM area

		N	Percentage of programs by STEM area			
			Science	**Technology**	**Engineering**	**Math**
Age group	Elementary	94	74 (79%)	34 (36%)	49 (52%)	35 (37%)
	Junior high	95	71 (75%)	38 (40%)	55 (58%)	36 (38%)
	High school	84	59 (70%)	36 (43%)	43 (51%)	27 (32%)
Geographic area	St. Paul	134	94 (70%)	51 (38%)	71 (53%)	47 (35%)
	Minneapolis	133	94 (71%)	51 (38%)	70 (53%)	46 (35%)
	Metro area	157	112 (71%)	66 (42%)	89 (57%)	59 (38%)
	Greater MN	56	41 (73%)	28 (50%)	30 (54%)	23 (41%)
School day vs. non-school day	School day	46	33 (72%)	18 (39%)	29 (63%)	18 (39%)
	Outside of school	103	76 (74%)	43 (42%)	62 (60%)	42 (41%)

Despite program availability, results from the key informant interviews suggest there is often a gap between availability and access for populations facing income, cultural, or other barriers. Importantly, these barriers may be faced by a number of the urban students targeted by the STARBASE program. Key informant interview results are described in depth in the following section.

Key informant interviews

Key informants indicated there are currently gaps in area STEM programs' outreach to some student groups, including minority populations, girls, students from low-income families, students perceived as "at-risk" for various reasons, and teenagers. Key informants described a number of barriers that students, and in particular those in the underserved populations, face to accessing the available programs. These include transportation, cost, awareness of available opportunities, competing demands on time, language and cultural barriers, and not having a champion of this type of programming within their school. There may also be gaps in the types of programming available, and key informants suggested a number of ways local programming could be enhanced. STEM organizations are currently collaborating within and outside the STEM community in a number of ways, and they are keenly interested in pursuing additional opportunities for collaboration. Key informants perceive many important benefits of collaboration, and great potential for advancement in this area.

Wilder Research conducted key informant interviews with St. Paul-area STEM leaders to identify areas of need or gaps in available STEM programs and supports. Questions addressed needs or gaps in the types of programs offered and populations served, as well as organizations' activities and interests in the area of collaboration with other STEM organizations. In summer and fall 2010, Wilder Research staff conducted 28 key informant interviews with representatives of local STEM organizations, including one interview with two representatives of a single organization. This section presents a qualitative analysis of their interview responses.

Key informants represented the following organization types: zoos, parks, and planetariums (5 representatives); museums (4); school districts (4); higher education (4, including 1 individual also representing a school district); nonprofits or academic consortiums supporting mentoring or workforce development (3); direct providers of programming to students (2); organizations supporting and delivering STEM competitions (2); environmental organizations providing programming for teachers or students (2); business (1); libraries (1); a statewide education and business coalition (1); and media (1). A few interviewees were also directly affiliated with the Minnesota STEM Network. It should be noted that although only two are listed here as providers of direct programming, other key informant organizations such as museums also provide direct programming. A complete list of the organizations of participating key informants is provided in the Appendix.

Needs and gaps

In order to address the core study question related to what types of additional programs or supports may be needed to foster continued STEM learning after STARBASE, key informants were asked to discuss areas of need or gaps in STEM programs and supports, both with regard to the types of programs and populations served. Their feedback suggests gaps in the populations served and, related, significant barriers to participation among underserved populations. Key informants also perceived some gaps in current STEM programming. Following is a summary of their responses in this area.

Barriers to access

Key informants were asked to describe any barriers they perceive to accessing the available STEM programs outside the regular classroom. Barriers they cited included transportation, cost, awareness of available opportunities, not having a champion within the school, residing in Greater Minnesota where fewer opportunities may be available, competing demands from students' other responsibilities, language and cultural barriers, and student interest or engagement. Each area is described in detail below.

Transportation

The most frequently cited barrier was transportation. Key informants described transportation to and from programs occurring outside of the school day as a major barrier to participation for a number of students, in particular those from low-income families. For these families, transportation poses barriers both in cost and in scheduling if parents need to work multiple jobs, for example. For students who ride the bus to school, transportation home can be difficult if class times occur outside of bus schedules. High school students may be busy with jobs and other responsibilities, and transportation can serve as yet another barrier to participation in programs that may have a fee and other barriers. For some students, transportation is more than a matter of traveling to and from home and school. One museum representative said that in of the schools they serve, a quarter of the children are homeless.

Key informants' responses made it apparent that when it comes to STEM programming, opportunities should not be viewed in terms of what is available for metro-area youth vs. what is available for youth in Greater Minnesota. Within the metro area itself, transportation poses a significant barrier to many youth. Key informants described challenges associated with transporting urban students to programs in the suburbs, transporting suburban students to programs inside the Twin Cities, and transporting students from one city to programs across the river. For example, one museum

representative described youth spending significant amounts of time on city buses to travel from Minneapolis to a program available only in St. Paul.

In describing transportation as a barrier, a couple of key informants indicated the potential helpfulness of bringing programming to the students at schools or other local venues, or exploring opportunities for collaboration or additional funding support in this area. One wondered whether there was potential for the metropolitan bus system to provide free transportation to these programs and events. Another key informant said that if their program did not cover participants' transportation costs, they would not be able to participate. Another described partnering with a school social worker to identify students eligible for a scholarship that can be applied toward transportation costs.

Cost

Related to transportation, another barrier to participation frequently cited by key informants was program cost. For example, one key informant said that in Minneapolis and St. Paul, parents may be unable to pay an additional $100 fee even if they strongly desire having their child participate in a program. A few key informants described the importance of offering scholarships, grants, and discounted rates where possible to make programs accessible to low-income students.

Awareness

Another key barrier that emerged was awareness of the opportunities available and of the breadth of organizations offering STEM programming. A number of key informants expressed concern over students and parents being unaware of the opportunities available to them. Marketing these opportunities involves reaching families who may not have access to computers or whose culture may not embrace the value of informal education. Programs need to engage parents and help parents see the value in the programming, and teachers can play a role in following through on the program information that is provided to them.

One key informant described how a key role of the Minnesota STEM Network will be to aid in building awareness of STEM resources, and potentially serve as a portal for parents, students, and practitioners to access up-to-date information on available programs. Another key informant spoke of a desire for STEM organizations to learn from each other how best to market to diverse populations.

Champion within the school

Interviews also suggested that teachers often play a critical role in linking students with opportunities. Attending a school or class without a teacher who recognizes the value of

this type of programming and champions students' participation can be a barrier to participation. Addressing the importance of having a champion in the school, one key informant said that students participating in competitions come from the schools with teachers championing this type of programming. Similarly, another key informant described their organization's ability to make inroads in a school as dependent on supportive teachers and curriculum requirements. One of the key informants representing a museum said that a student's participation in their programming often comes down to a teacher who went the extra mile to encourage and support the student. This key informant sees this scenario more often in affluent schools, and described a need to address the issue in less privileged schools.

Providing a specific scenario of how a champion teacher can make a difference in program access, one key informant described a teacher who has her 10th-grade students do a science project, and routinely connects the best to science fair and research paper competitions. This key informant said teachers can register themselves as sponsors within a competition who will serve as student mentors and receive records of those students' projects and how they did. As another specific example, this key informant described a private school that offers incentives in the form of extra credit to students doing a science fair project for the first time.

One key informant described the importance of teachers recognizing the role of this type of programming and its place within the larger instructional context, and seeing their own role as a teacher as encompassing active support for this type of programming. Related, a few key informants spoke of a need for more coordination on the part of school districts among their out-of-school programming or between their in-school and out-of-school programs. One suggested creating a school-based STEM liaison position that could coordinate out-of-school opportunities, although there was also recognition of the budget issues facing public schools. These comments suggest that where needed, enhanced coordination on the part of schools or school districts may assist individual teachers in championing and linking their students to opportunities.

It seems important to recognize that teachers may face barriers themselves to serving in this role. A few key informants addressed the time constraints and curricular requirements teachers face. For example, teachers may worry that opportunities taking place during the school day will take too much time away from other activities, and may not see how an outside STEM opportunity complements and extends classroom activities. Planning and networking around STEM opportunities may also be difficult in light of immediate issues and required meetings during teachers' work day. In the case of opportunities taking place outside the school day, teachers may need incentives to volunteer their time given competing demands on it.

Greater Minnesota

Even though the Twin Cities metropolitan area cannot be viewed as a singular, contained region to those facing transportation barriers, it seems that residing in Greater Minnesota can be a barrier to participation in STEM opportunities outside the classroom. Some key informants said there are fewer such opportunities or competitions outside the metro area. Organizing activities in Greater Minnesota can also be challenging for organizations that may need to draw on volunteers or subject-matter experts from the metro area. For example, one key informant described efforts to arrange for women working in STEM areas to talk with college students. Holding these activities outside of the metro area would require many of these women to drive substantial distances, and there may be a small pool of potential recipients in any given outstate location. Another key informant described a need for multiple-district STEM coordinators in rural areas because it is infeasible for the organization to connect with individual teachers in each rural area.

Students' other responsibilities

Other significant responsibilities faced by youth can also prove to be substantial barriers to participating in programs outside the school day. For example, older siblings may need to care for younger siblings, and this may be particularly the case for minority populations, girls, or youth whose parents may need to work on Saturdays or who come from a single-parent family. Youth also face homework responsibilities, and older youth may need to hold a job to make money. These responsibilities pose time and logistical constraints to participating in additional programming.

Language and cultural barriers

Key informants also described language and cultural barriers to some students' participation. For example, some immigrant families may have come from a situation in which their basic safety was at risk, and an organization recruiting girls for participation in a week-long program may be perceived as a threat. One key informant described the importance of using mentors to reach across cultural barriers to help diverse populations see the benefits to the family. In some cases, children from immigrant families may have strong English-language skills, but the program may face language barriers in communicating with parents.

Cultural barriers are not necessarily strictly based on differences in race, ethnicity, and country of origin. As one key informant explained, some people feel more comfortable in their own neighborhood and feel unsure of whether they belong in activities taking place outside of their geographic comfort zone. In that sense, a program's physical location can pose a barrier outside of transportation issues alone.

Student engagement

Finally, in some cases students may not face other significant barriers to program participation, but their own engagement or enthusiasm level may pose a barrier. They may not see STEM areas as fun or exciting, or as applicable to their own demographic group. In some cases it may be a matter of showing youth that they can succeed in these areas. For some students, this may require using an interdisciplinary approach that connects STEM areas to the arts, for example. Technology can also be used as a means to making math and other STEM activities exciting and relevant to youth, as can service-learning that places concepts in a real-world context and helps students see the impact they can have. For older youth, the challenge in some cases may be engaging youth in STEM learning in a way that complements other needs or interests such as finding a job. One key informant described "word of mouth" as an important tool in generating student engagement. When youth see peers making new friends, having wonderful experiences, and winning awards, they become interested.

Gaps in programs or supports

Key informants were asked whether there are any needed STEM programs or supports that are currently missing. As described below, their responses suggested local STEM programming could be enhanced by providing more engineering programming in addition to the highly regarded programs that currently exist, using technology more extensively to engage students in STEM learning, strengthening classroom STEM curricula and teachers' instructional capacity in those areas, offering more college-preparation and career-exploration opportunities, providing more interdisciplinary instruction, offering more service-learning opportunities, integrating more longer-term STEM projects, and providing demographically similar role models for students.

Engineering

There was the sense among interview responses that there are a few strong engineering-focused programs or organizations that are highly regarded among local STEM practitioners and perceived as filling an important niche, but that there are fewer options available in this than other STEM areas such as natural sciences or math. A couple of key informants suggested a need for additional engineering programming for older youth in particular. Possible barriers to offering this type of programming raised by a couple of interviewees included a lack of awareness of various types of engineering and engineering careers, as well as a perception that programming focusing on or incorporating engineering is more challenging to design than programming in other STEM areas. A couple of key informants perceived an increasing interest in engineering with engineering now appearing in the state science standards, and one noted that schools

may need support for how to address the new standards.[3] Engineering appeared fairly well represented by programs participating in Wilder Research's STEM program inventory, but it is possible that some of those programs offer engineering tangentially rather than as a primary focus area.

Using technology to engage students

Key informants also indicated there are currently missed opportunities for using technology to engage students in STEM programming. Technology can be used to make programming seem more exciting, and also to align programming with students' ways of life. This was raised as an issue for classroom as well as outside-the-classroom programming. For example, one interviewee said if students had access to state-of-the-art technology such as iPhones for math activities, they would be more excited and engaged. Another described how students' learning methods are changing, and said staying stagnant in instructional methods fails to recognize these changes and students' emerging abilities. A couple described opportunities for integrating science and technology, in recognition of the prevalence of technology in many aspects of students' lives. Technology was also described as a tool for sustaining students' interest following their completion of a program. For example, one key informant described adding features to their program's website that enable students to continue engaging in related activities with their peers. It was noted, however, that technology can also be a barrier, such as for students who may not have Internet access.

Curriculum needs

Though interview questions focused on STEM programming outside the classroom, several key informants described a need for more curricular support in these areas for classroom teachers. With instruction focusing on standards in core subjects in recent years, teachers may need more support to address new science standards now in place. A couple of key informants also expressed concerns over students not having science class very frequently, or elementary teachers not having a strong science background. Some specific areas of need cited included support for engineering-related instruction, described above, as well as incorporation of more project work such as science-fair projects. Based on a couple of interviewees' remarks, there is potential for collaboration among STEM organizations, business and industry, and school districts to offer supports and teacher training in this area.

---

3   The Minnesota Academic Standards: Science K-12 are available from the Minnesota Department of Education (2010) at
http://education.state.mn.us/MDE/Academic_Excellence/Academic_Standards/Science

College preparation and career exploration

Some key informants also described a need for more opportunities that prepare youth to pursue STEM fields in college and beyond. In the words of one interviewee, many programs delve into a particular interest area and are designed to engage a young person, but fall short of illustrating related career options and individuals in those careers. Another key informant described a need to link minority and low-income students in particular with college visits, career fairs, and assistance with filling out college and financial aid applications. Students who are not at the top of their class and consequently not receiving scholarships may also need outside assistance in these areas, even if they are not at the low end of the GPA range. High school students may also be unaware of the range of post-secondary options, such as institutions where they can pursue a technology-based trade and graduate in a couple of years with specific job skills, sometimes in an emerging area. STEM-related internship opportunities may be one tool for helping students meet employment needs and explore career options.

Interdisciplinary instruction

Key informants also emphasized the need for more STEM programming that is interdisciplinary in nature, tying STEM areas in with other disciplines. They also described a need for STEM programming that integrates various STEM areas themselves. There was a sense that the "S," "T," "E," and "M" in STEM are often treated as separate fields, and that doing so fails to recognize connectivity among STEM areas and their interplay with other disciplines. Helping students and teachers recognize these linkages may be an important tool for raising awareness of the breadth of real-world STEM applications, as well as reaching students who may not see themselves in traditional notions of STEM.

Various examples of ways STEM areas can be integrated with each other and with other disciplines were provided. One key informant described connecting science with the arts to help youth learn scientific concepts and understand arts from a science perspective and vice versa. Another described connecting gardening to STEM concepts around environmental sustainability. Technology can also be integrated into other curriculum areas. Describing the merits of science fair projects, another key informant explained that such projects can involve writing, math, statistical, critical thinking, logic, ethics, scientific methodology, research, self-discovery, and public-speaking, among other skill areas.

Integrating STEM areas may require some creativity, such as integrating math into a program whose focal point is science. As one key informant expressed, when curriculum requirements allow little room for science, showing ways science can reinforce math and language arts concepts can help teachers see its importance and connections to standards. Inside and outside the classroom, showing students the creative, multidisciplinary,

multisensory aspect of science can engage them, reach more students, and show that science is not a perfunctory activity. It was pointed out that ultimately, doing so can help advance larger ideas.

Service learning

Related to building awareness of STEM's reach into various aspects of life, key informants also suggested a need for helping students see how they can make a difference with STEM. In the words of one key informant, STEM instruction has the potential for engaging lessons, and failing to make STEM learning meaningful misses this connection. Service learning can help students see concrete ways they can use STEM to make a difference and give back to their community. Another key informant pointed out that it could be very powerful to engage minority students in using STEM to give back to their communities of origin. For example, Native American students could receive support in becoming the forestry managers on a reservation, rather than others performing these roles. In this sense, STEM programming would be both service-oriented and community-based, engaging students in making a difference within their own communities.

Longer-term projects

While there was recognition of the role and importance of informal, hands-on learning, some key informants also suggested room for more long-term, inquiry-based STEM learning in which students take a full project from concept to conclusion. Such project-based learning can help students see the full scientific process. Regardless of whether students pursue a STEM field, such projects can teach ways of thinking that are important in various aspects of life, according to key informants. The example was given of how redecorating a bedroom might require science project skills such as considering the options, evaluating one's skill set, determining areas that require outside help, and executing the plan. Incorporating science fair projects into curriculum was suggested as a means of facilitating more of this type of learning.

Demographically similar role models

A few key informants also suggested a need for programming that provides role models from the same demographic groups as students. This could include women working in STEM fields who can mentor girls, mentors within the same racial or ethnic group, and older students mentoring younger students, for example. In the words of one key informant, demographically similar mentors can help reach across cultural barriers.

Continuity of programming

Several key informants also described the importance of providing students with continuity in programming, or sustaining their STEM interests and learning over time. In the words of one key informant, "What we need to be able to do is help connect the experiences all the way into college." According to this interviewee, this involves not only engaging students in STEM through classroom learning, but also holding that interest over time through outside-the-classroom experiences.

Gaps in populations served

After addressing missing programs or supports, key informants were asked specifically whether there are any student groups not being reached by STEM programs. Their responses suggested that there are gaps in participation of several groups, including minority populations, girls, students from low-income families, students perceived as "at-risk" for various reasons, and teenagers.

Minority groups

Key informant interviews suggested that in some cases minority groups are still not being reached by STEM programs. Different populations were mentioned. One key informant described struggling to boost participation among African American boys and, to a lesser extent, African American girls. Other key informants described difficulties in engaging Native American or Hmong students. A couple of key informants noted that many students dropping out of school are not being reached, citing this as a missed opportunity in terms of the potential for afterschool programs to contribute to student retention. One key informant not in the business of direct service perceived a potential lack of recruitment of minority youth including African American and Hispanic students. In some cases, this could reflect a stigma associated with being at school, and offering programs at community centers may help overcome this stigma, in this key informant's opinion.

Perceived reasons for gaps in participation include barriers to participation faced by the students as well as challenges in overcoming those barriers faced by practitioners. In the words of one key informant, existing gaps are not intentional but rather reflect barriers on both sides of the equation. On the student side, there may be language barriers as well as environmental barriers related to a student's upbringing or family views on informal education. Youth from minority groups may not have received the message that STEM is for them. Older siblings may also need to care for younger siblings, and some immigrant families may be struggling to meet basic needs. On the practitioner side, practitioners may need to learn strategies for communicating with diverse populations, offering culturally relevant programming, and otherwise overcoming barriers faced by those students. For example, instruction may need to be differentiated to work for English

Language Learner (ELL) students. There may also be a need for more professional development in the areas of reaching out to and working with diverse populations. Practitioners may also need to explore options such as using demographically similar mentors to span cultural barriers, or collaborating with organizations serving the immigrant community or specific minority populations to reach those families.

Girls

Key informants cited existing programs specifically serving girls, but also suggested more needs to be done to convey to girls that STEM is for them, and ultimately to close the gender gap in STEM fields. Importantly, key informants pointed out that these messages may need to be given at critical points in time when girls may be self-selecting out of science such as in late elementary school and middle school. In the words of one key informant, girls may be self-selecting out of science as early as fifth and sixth grade, so that age may be one critical point to reach them. In the words of another, middle school girls need STEM experiences to counter peer pressure that may result in their disengaging from STEM interests. They may be less susceptible to peer pressure in later high school years, but middle school is a critical period in this interviewee's opinion. Echoing this theme, another key informant said that in middle and junior high, students are beginning to eliminate STEM careers and girls need to be given the message that it is good to be skilled in math, for example.

The point was made that girls need to see positive role models working in STEM fields, such as women working in STEM fields visiting schools and helping girls see that they, too, can be an engineer, for example. These messages may help counter other messages girls may receive from the media and broader society. Beyond societal messages, there may be additional barriers to reaching girls in some cases such as girls staying home to care for younger siblings, for example. One key informant also suggested that organizations may need to more intentionally gear their programming to interests, wants, and needs of girls.

Low-income students

As described earlier, students from low-income families may face a number of barriers to participation in STEM activities outside the classroom. Barriers such as transportation are more impactful to low-income students, for example. Some families may be struggling to meet basic needs. In some cases, grant funds may help organizations target outreach to these populations or schools serving high concentrations of children living in poverty. A few key informants referenced organizations using grant funds to help reduce poverty as a barrier to participation, or being open to finding financing for this purpose. To the extent possible, offering scholarships or discounted rates can also help make programs accessible to a broader population. In some cases, Title I students may be

eligible for scholarships but students ineligible for Title I and associated scholarships may still be unable to afford the programs.

"At-risk" youth

Some key informants spoke in general of a need to reach students who are "at-risk," underserved, or disenfranchised. These concepts are inextricably linked with poverty and societal barriers based on race and ethnicity, as described earlier. However, they are discussed separately here to convey that factors placing these children at a disadvantage based on their demographic characteristics are external and not intrinsic to those characteristics themselves. Students may also be "at-risk" due to lack of parental support and involvement, teacher failure to extend opportunities to all students, or other factors. As articulated by one key informant, the achievement gap in STEM skills should be targeted in addition to the gaps in reading and math specifically. In this interviewee's words, this achievement gap represents a huge opportunity gap.

Teenagers

Asked whether some groups of students are being left out of programs, several key informants cited middle school or junior high students, high school students, or teenagers in general. Key informants perceived these years as critical ages to reach students who may be exploring and beginning to eliminate career options. They may also be challenging ages to reach students in light of homework, job, and other responsibilities students may face. In some cases, engaging these students may require engaging them in ways that address other needs such as employment. A couple of key informants noted that minimizing transportation, cost, and other barriers can make programs accessible to older students facing competing demands on their time, as can incorporating STEM programming more into the school day.

As a counterpoint, it should be noted that one key informant said that in her role as a parent, she has perceived a deficit in programming for elementary students as opposed to older youth. Although the general consensus was that additional outreach was needed to older youth, discrepancies in perception may point to the need for additional awareness of available STEM opportunities, described in more detail in the following section on collaboration.

Collaboration

Key informants were asked about their organization's collaboration with other programs to foster STEM learning, achievement, or aspirations. They were asked to describe current collaborations as well as collaborations they would like their organization to develop. Finally, they were asked to describe what they perceive as the benefits of collaboration. Some of the strongest themes to emerge from the key informant interviews were in the area of collaboration. Key informants expressed that STEM organizations are currently collaborating with other entities in a number of ways, and that they are keenly interested in pursuing additional opportunities in this area. Key informants perceive many important benefits of collaboration, and great potential for advancement through enhanced collaboration and networking.

Current collaborations

Key informants are currently collaborating with many types of organizations and for many purposes. They described collaborations with business and industry; museums and nonprofits; school districts, universities, and other educational partners; foundations; and government entities. They described a number of different purposes for their existing collaborations. Examples include partnerships for the purposes of funding, reaching specific populations, developing curriculum or addressing standards, fostering career exploration or college-readiness, providing opportunities dealing with specific topics, offering professional development, recruiting volunteers, and networking in general.

Desired collaborations

Beyond current collaborations, key informants were asked whether there were any other collaborations they would like their organization to develop. A prevalent theme emerging from the interviews was that key informants desire and see great potential in additional networking among members of the STEM community, as well as with outside organizations willing to partner with the community. Key informants also described a number of specific collaborations they would like to pursue with a range of organizations.

Networking among the STEM community

A number of key informants described a desire for more networking among STEM practitioners in general. Practitioners want to know the spectrum of organizations and resources available, for their own awareness as well as that of the general public. Illustrating this concept, one key informant envisioned a "fabric of services" in which the complete landscape of STEM services is known and individual practitioners see how their niche fits into this broader picture. This fabric would include STEM-focused

organizations as well as other entities willing to partner with or support efforts within the STEM community. Key informants articulated numerous benefits that could occur from increased networking within the STEM community, which are described in full in the following section on benefits of collaboration.

Several key informants cited the development of the new Minnesota STEM Network as laying the groundwork for enhanced networking. In fact, increasing networking and building awareness of resources are among the Network's primary objectives. In the Minnesota STEM Network's own words,

> The Minnesota STEM Network is working with SciMathMN to move Minnesota from 'a Land of 10,000 STEM Initiatives' toward a coordinated, effective, and efficient network of STEM education providers. In the months and years ahead we will develop networks within Minnesota regions, map existing STEM assets, and work to leverage new investments in STEM education (SciMathMN, n.d.).

Specific collaborations

In addition to expressing interest in broader networking overall, key informants also described a number of specific partners with whom they see potential for enhanced collaboration. Key informants see potential for additional partnerships within and outside the STEM community, and for a variety of specific purposes depending on their own unique niche within the community. Following are examples of the types of potential partners they mentioned. For illustrative purposes, an example of a potential partnership is described for each.

■ **Arts organizations**. Example: Building partnerships with arts organizations to offer interdisciplinary learning integrating art with science.

■ **Business and industry**. Example: Partnering with businesses willing to hire interns or open their doors to expose students to potential careers.

■ **Community groups**. Example: Collaborating with community groups such as Latino, Somali, or Hmong organizations to serve specific populations.

■ **Government**. Example: Networking with science and math coordinators within the state Department of Education.

■ **Higher education**. Example: A museum partnering with a university for the purpose of professional development.

■ **Museums**. Example: Museums collaborating with other museum curators to share resources and ideas.

- **Nonprofit organizations**. Example: Forging partnerships around service learning.

- **Parks**. Example: Partnering with parks to extend learning and incorporate the natural world, or to base afterschool or summer programs within parks.

- **Preschool or child care programs**. Example: Partnering with child care organizations to encourage enthusiasm about science in young children.

- **School districts**. Example: Working with school districts to incorporate program offerings into science units and assist teachers in implementing science curricula.

- **Trade associations**. Example: Collaborating with trade associations in the area of workforce development.

Benefits of collaboration

Finally, key informants were asked to describe what they perceive as the benefits of collaboration. They described a number of benefits, which are presented below. Many of the benefits cited are interrelated. For example, enhanced opportunities to share ideas and skills lead to better programming. As another example, creating opportunities for individual organizations to specialize in their program contributions can lead to greater efficiency.[4]

Collaboration not competition

Throughout the interviews, key informants described existing and potential collaborations in the spirit of mutually beneficial relationships. Collaboration was clearly and consistently described in positive terms. Though evidenced throughout their comments, a few key informants outright articulated their perception that collaboration is not a threat but rather an opportunity for mutual growth. In the words of one, groups work in "collaboration not competition." Another referenced an evaluation report describing how through established relationships and shared purpose, individual partners can make compromises in good faith for the betterment of the larger partnership. Other key informants described how organizations can empower each other and how, especially in a challenging economy, individual entities can help each other through collaboration. One key informant used a sales analogy to illustrate that rather than viewing the market as a pie of a certain size, it is important to recognize that the pie becomes much larger through collaboration. In the words of another, one organization is not better than another; each has its own niche, and the whole is greater than the sum of the parts.

---

4   As a resource for promoting effective collaboration, Wilder Research provides a free online tool for assessing how a collaboration is doing based on 20 research-tested success factors (Wilder Research, n.d.).

Awareness

A number of key informants cited building awareness of program offerings within and beyond the STEM community as an important benefit of collaboration. As articulated by one key informant, collaboration facilitates awareness within the STEM community of what is "going on in the landscape of STEM." Awareness of the complete landscape can help STEM organizations see potential opportunities for sharing resources and helping each other, especially in difficult economic times. A couple of key informants also noted that this awareness is important to enable programs to differentiate themselves and avoid "stepping on toes," and that it is a prerequisite to the STEM community being able to map out available program offerings and any gaps in ages and populations served.

Beyond the STEM community, key informants noted that collaborating with others pursuing similar interests can generate more visibility. Further, building awareness about an organization can help with funding, and can also serve funders who want to understand the STEM landscape. In this sense, collaboration can help forge linkages between providers, audience, and supporters. A couple of key informants also cited the potential for collaboration to increase awareness of messages in addition to programs. In their opinion, organizations can more effectively communicate ideas by collaborating on the messages being conveyed.

Networking

Echoing the earlier theme that they would like to see enhanced networking among the STEM community, key informants cited networking as one of the primary benefits of collaboration. Networking was cited as a benefit in and of itself as well as a means to other benefits, such as enhanced visibility and stronger impact. In the words of one key informant, collaboration facilitates connections that prove valuable. As noted earlier, the Minnesota STEM Network was referenced as a means for broad-scale networking.

Better outputs

Key informants also said collaboration can result in better outputs or programming. As articulated by one key informant, "If you work in a silo, you're not nearly as effective." Collaboration brings different skill sets and ideas to the table which can strengthen the final product. Moreover, the vision of the final product itself may be expanded and enhanced as a result of collaboration.

Sharing ideas and strategies

Several key informants described how collaboration is beneficial in the opportunities it presents for sharing ideas as well as strategies for overcoming challenges. One key

informant described how through collaboration, an organization has a wealth of resources at its disposal rather than solely its own staff and area of expertise. This can make an organization aware of ideas it would not have conceived working solely within its own narrow track, according to this interviewee. In the words of another key informant echoing this theme, "I see that it mutually changes organizations and allows them to grow in ways that they didn't know they needed to grow." Addressing the potential for sharing strategies, another key informant pointed out that similar STEM organizations share many of the same challenges and can talk through ideas for overcoming them.

Sharing skills

Related to other concepts cited here such as better outputs and efficiency, key informants also cited the potential to share skills and enhance any single organization's skill set as a benefit of collaboration. As one key informant explained, "We can't all possibly be experts at everything," and collaboration allows individuals to focus on what they do best and tap resources and expert knowledge in other areas. Another described how collaboration brings together people willing to share their skill sets. For example, one partner might bring money and another might bring equipment or location to the collaboration. As another example, one partner might contribute programming and another might bring volunteer recruitment, which some key informants described as a challenge.

Specialization

Related to sharing skills, a couple of key informants noted that collaboration enables individual entities to specialize in their areas of strength, and tap into external resources in other areas. One interviewee provided an example of how efficiencies can be gained by each partner contributing their area of expertise to program planning rather than individual organizations each executing every aspect. To illustrate, this key informant described an existing collaboration in which their organization develops a program, and a partnering organization uses its connections to build and organize audiences to attend the program. They have found this to be a much more efficient use of time than their own organization planning and executive every aspect of the program.

Replication

Key informants also mentioned replication as a benefit of collaboration. Sharing information about effective programs can enable those programs to be implemented elsewhere and help avoid the need to "redesign the wheel." Through collaboration, organizations can learn from each other and select and replicate best practices. These practices might include aspects of program design as well as specific strategies, such as ways of marketing to students of diverse populations. One key informant indicated a

desire for the STEM community to take a 10-year retrospective look at what have been the best programs, and identify whether any strong programs no longer taking place hold potential to be revived in a sustainable way. As noted by this interviewee, "Reinventing these programs is what's inefficient about what we're doing."

Efficiency

Based on its various benefits, key informants noted that collaboration can lead to greater efficiency. As discussed earlier, collaboration holds potential for organizations to heighten awareness of program offerings; share ideas, skills, and resources; specialize in their areas of strength; and replicate best practices. Collaboration can allow individual partners to specialize in their own areas while focusing on larger shared priorities. Beyond shared and coordinated ideas and skills, collaboration through shared facilities, training materials, and other physical resources may also hold potential for generating efficiencies.

Real-world linkages

A few key informants also described how through collaboration, STEM programs can incorporate real-world experiences for students. These linkages can facilitate experiential learning opportunities, leadership opportunities, and career exploration, for example. A few interviewees described the importance of incorporating opportunities to expose students to potential careers, such as by enabling students to visit places of work, see the work in action, and talk to individuals in those careers. Mentors are another tool for exposing students to potential careers and helping them understand their real-world applications. In a broader sense, collaboration with organizations outside the STEM community can help students understand why they are learning STEM concepts and how they relate to their lives.

Ultimate benefits to children and society

A few key informants tied benefits of collaboration to their ultimate impact on children and society. In the words of one, collaboration is ultimately about reaching and stimulating children so that they will "have effective and wonderful lives and build an effective and wonderful society." Similarly, another expressed that when there's a natural fit for collaborating with another organization, more kids are reached and with greater benefit.

Addressing benefits to the broader economy, one key informant noted the wealth of resources in the Twin Cities in the form of STEM-related companies headquartered in the area and the expertise they house. This interviewee expressed the importance of tapping these resources in order to grow jobs in the state. Another spoke of collaboration as essential to broader cultural change. In this interviewee's opinion, collaboration is

needed to understand how students are being served overall, and to engage the broader public in pursuit of desired cultural change.

Other benefits

Following are other benefits of collaboration mentioned by one or a couple of key informants:

■ **Sharing physical resources**, such as facilities or training materials.

■ **Continuity**, or sustaining students' interest by being able to connect them to other programs once they complete one.

■ **Comprehensiveness** across program availability through coordination and identification of any gaps.

■ **Flexible hours** attained through the ability to refer students to another program at a different time if one is inaccessible based on scheduling.

■ **Leveraging** work through doing more with less and shared promotion of messages.

■ **Outreach** to more students in general, and more difficult-to-reach students in particular.

Issues to consider

Study results suggest a possible gap between interest in and access to available STEM programming for underserved populations, such as the urban students targeted by STARBASE. Connecting students to ongoing STEM-learning opportunities is viewed by STARBASE staff as a critical piece in sustaining students' interests and skills after they exit the program. The STEM program inventory compiled through this study can be used by STARBASE staff and others to help link underserved students to available STEM opportunities. Further, there appears to be keen interest in increased networking and collaboration within the local STEM community, and study results are well-timed to inform these efforts. Possible areas of expertise for STARBASE Minnesota to contribute through collaboration include technology integration, career exposure, and classroom integration, in addition to other program strengths. Finally, priorities for any future follow-up studies of STARBASE Minnesota participants should include further investigation of the potential impact of program dosage and possible program effects on career choices.

Wilder Research's follow-up study of STARBASE Minnesota participants provides the program with valuable insights about its long-term impact. On a community level, the study offers information on existing programming, gaps, and opportunities for collaboration in the broader local STEM community. Based on study findings, following are several program- and community-level issues for consideration. Finally, possible priorities for any future follow-up studies of STARBASE Minnesota participants are presented.

Program considerations

Sustaining students' STEM interests and learning

Previous short-term studies of STARBASE Minnesota (Van Wie, 2006) and STARBASE Atlantis (Lee-Pearce, et al., 1998) have shown initial program effects, including increased understanding of science and math concepts. Phase I study results suggested that the long-term impact of STARBASE might be enhanced by greater exposure to the program, meaning participation in both fourth and sixth grades vs. fourth grade only. STARBASE staff recognize the importance of sustaining their students' STEM interests and learning after they exit the program, and the STEM program inventory conducted in Phase II emerged from this recognition.

Taken together, results of the college-student survey and key informant interviews suggest there may be a gap between interest in STEM-related programming and ability to access such programming for students who face income, cultural, or other barriers. STARBASE staff intend to use information compiled through the program inventory to help connect STARBASE graduates to other area STEM programs. It is possible that linking students to ongoing STEM programming following their exit from STARBASE could result in even stronger long-term outcomes.

Sharing expertise

Study findings suggest that STARBASE Minnesota has expertise in a couple of areas cited by key informants as gaps in local STEM programming. These findings suggest a potential role for STARBASE Minnesota in the larger STEM community to serve as a mentor or role model for other programs looking to strengthen these areas. Mechanisms for sharing this knowledge are already in place given the STARBASE Minnesota Executive Director's and board's active involvement in the Minnesota STEM Network and their efforts to convene STEM practitioners through the Network's meetings. Examples follow:

■ *Technology integration*. Key informants indicated a need for greater use of technology to engage students in STEM programming. STARBASE Minnesota heavily integrates technology into its programming, and both the Phase I and Phase II study results suggest the program may have an impact on students' long-term interest in technology.

■ *Career exposure*. Key informants cited a need for more opportunities that expose students to potential STEM careers and individuals working in those careers. Both Phase I and Phase II results suggest STARBASE helps students learn about different STEM career options.

■ *Classroom integration*. Several key informants described a need for more STEM-related curricular support for classroom teachers, and interviews suggested that teachers often play a critical role in linking students with STEM opportunities. Working with school districts to incorporate program offerings into STEM units and assist teachers in implementing science curriculum was cited as a potential area for further collaboration. STARBASE Minnesota has taken key steps to align and integrate its programming into the classroom, and may have valuable expertise and experiences to offer in this area.

■ *Other areas*. STARBASE Minnesota staff can consider other areas of expertise that may be beneficial to share in the local STEM community given study findings.

Community considerations

Connecting students to programs

The STEM program inventory documents a range of opportunities available for area students to pursue their STEM interests and learning, yet key informants suggested there are underserved populations that face a number of barriers to accessing available programs. Results of the STEM program inventory can be used by practitioners, schools, and parents to help link students to accessible opportunities. Further, as noted in the key informant interviews, increased collaboration among STEM practitioners or between STEM programs and other community groups has the potential to help reach underserved populations.

Connecting practitioners to practitioners

Results of the key informant interviews suggest there is keen interest in increasing networking among practitioners and collaboration within and beyond the local STEM community. Practitioners cited a number of desired collaborations and perceived benefits of collaboration. Information compiled through the STEM program inventory can contribute to enhanced collaboration and networking by increasing awareness of existing opportunities and contact persons. To this end, STARBASE Minnesota intends to share inventory results with the broader local STEM community. In this way, the study is nicely timed to contribute to momentum toward networking and collaboration in the broader local STEM community.

Building on the STEM inventory

Wilder Research dedicated substantial amounts of staff time to the administration of and follow-up on the STEM program inventory. Information was collected from respondents in user-friendly Microsoft Word fillable forms, and later transferred to an Excel spreadsheet by research staff. Fields in the spreadsheet can be pulled into a Microsoft Word template to generate printed program listings, or transferred to a database for potential creation of an online resource directory. Research staff also prepared a document defining each field in the spreadsheet to facilitate its use by STARBASE Minnesota staff. Research staff involved in compiling the inventory identified several insights that may be instructive to those interested in building on or learning from these efforts:

■ *Ongoing updates*. Program availability changes continually, and very regularly in the case of programs offered on a quarterly or seasonal basis. Ideally, a program directory system would incorporate a simple mechanism for practitioners to continually update their information, or links to websites giving up-to-date registration information. In the case of the STEM inventory conducted as part of this study, organizations that change program offerings every few months provided a general overview of available programming.

- *Snowball samples*. Widely distributing the inventory is critical to its comprehensiveness. Beyond the original respondent list, Wilder Research staff identified "snowball" sample groups through the recommendations of inventory respondents and key informants. Others could consider soliciting more active assistance with ensuring inventory comprehensiveness by asking respondents to forward or "snowball" the inventory form themselves.

- *Permission*. There are privacy considerations when contact information is solicited for public distribution. Wilder Research sought permission to share respondents' contact information via the inventory form. Communicating the intended uses of information and seeking permission as needed upfront are important, and may also influence the information respondents choose to provide. For example, a high-level administrator may share contact information for some purposes, but may provide a general organizational contact number or e-mail for wide distribution.

- *Consistency*. Respondents varied widely in the level of program detail they provided. Giving respondents a sample listing upfront could help illustrate the type of information desired, and ensure more consistency across listings. Wilder Research's creation of a program listing template should facilitate this process in the future.

- *Discrete categories*. Respondents were allowed to provide some requested information in different ways. For example, ages served were provided in years and grade levels, as well as more general terms such as "elementary." Moreover, grade levels were at times described differently, such as categorizing seventh grade as middle school vs. junior high. Due to these discrepancies, Wilder Research staff manually categorized programs in some cases for purposes of analysis based on the information provided. Providing concrete categories for respondents to select among could automate this process.

- *Duplicate entries*. In a number of cases, multiple contacts responded for a single organization, sometimes providing duplicate information on the same program. Wilder Research staff manually unduplicated the program listings. Future efforts to update or build on this information will have a substantial advantage in that the final spreadsheet includes unduplicated program listings and a primary contact person for each. Still, it seems important to be aware of the potential for duplication.

- *Multi-site programs*. Some programs, such as STEM programs operating nationwide, are offered by more than one organization. In these cases, Wilder Research staff determined that it would be helpful to know the various organizations and locations offering a program, and included multiple listings for a single program when it was provided by different organizations.

- *Scope*. The STEM inventory conducted for this study was designed to serve specific study purposes, and therefore emphasized programs serving 4th- through 12th-grade students in the St. Paul area. Although the final directory includes a number of programs serving different regions or populations, those interested in building on this inventory should be aware of this emphasis. They may want to focus on increasing the representation of programs serving other populations, such as prekindergarten or college students, teachers, a general audience, or rural students, for example.

- *Delivery*. Technology is changing at a rapid pace, and it seems important to consider the ways the intended audience obtains program information and registers for programs. Preferred modes of delivery and types of contact information shared may vary depending on the audience. As an example, to a parent used to researching program options online, websites and an online directory may hold appeal.

- *Indexes*. Program information is perhaps most useful if it can be organized or searched by various audiences according to their interests and needs. Identifying possible indexes or search fields in advance can shape the types of information that is requested from respondents, and the way it is requested. For example, discrete fields that respondents can check based on their subject areas (e.g., rockets, dinosaurs, chemistry) or objectives (e.g., service learning, career exploration) can later be turned into search fields or index categories.

Future study directions

Examining the impact of program dosage

Phase 1 study findings suggested that greater exposure to STARBASE may enhance program impacts in some areas. This pattern was not observed in Phase II analyses, which were limited by the small size of the low-dosage group and possibly influenced by demographic differences between the two groups. Any future studies should continue to explore program impacts based on level of exposure given the program's offerings for two different grade levels as well as the promising findings in the initial study phase.

Continued follow-up of Phase I Cohort 3

It also seems beneficial to consider continued follow-up of Cohort 3 from the Phase I study. These students were enrolled in 10th grade in 2008-09 and would graduate from high school in spring 2011 if graduating on time. This was the largest cohort from the initial study. It would be instructive to see whether STARBASE-comparison group differences in high school graduation and college enrollment rates would be consistent with the differences observed with the Phase II follow-up of Cohorts 1 and 2, as well as

to examine Cohort 3 former participants' reflections on their STARBASE experience and possible influences on career choices.

Assessing impact on career choices

Additional follow-up is needed to make strong claims about any long-term program impacts on students' career choices. Results of the Phase II survey of college students were limited based on the sample size and difficulties attaining student e-mail addresses for some colleges. For example, it is possible that some students who could not be contacted for the survey may have been more likely to be pursuing a STEM-related career given their attendance at a community and technical college, for example. In following-up with college students in any future studies, researchers and program staff can work to identify other ways of contacting those students. Also, students were in their first or second year in college and may not have made a career choice yet. Longer-term follow-up would be needed to more fully assess any impact on career choice.

Assessing impact on military interest

The Phase I study found that more STARBASE than comparison students indicated an interest in joining the military in high school. In high school, study participants were asked to indicate how much interest they had in joining the military (i.e., a lot, some, a little, or none). Nearly half (46%) of the STARBASE students reported having at least a little interest in joining the military, including 6 percent who reported a lot of interest. Three in 10 comparison students indicated they had at least a little interest in joining the military, including 5 percent who indicated a lot of interest. The overall difference between the groups was statistically significant (Broton & Mueller, 2009).

Although not a core study question, data on military enrollment were collected as part of the Phase II study but should be viewed with caution due to limitations with the data. In any future studies, researchers and program staff can consider ways to better track participants' subsequent involvement in civilian or uniform military careers in association with strengthening the assessment of impact on STEM career choices in general. Better ways to match study participants with the Department of Defense database can be explored. For example, researchers can work with someone knowledgeable about the database at study onset to better understand the types of identifying information that would be needed to better match both STARBASE and comparison study participants.

References

Adelman, C. (2006). *The Toolbox Revisited: Paths to Degree Completion From High School Through College.* Washington, D.C.: U.S. Department of Education.

Broton, K., & Mueller, D. (2009). Follow-up study of STARBASE Minnesota participants: Program impact in high school. St. Paul, MN: Wilder Research. Available on Wilder Research's website at http://www.wilder.org/research

DoD STARBASE (n.d.). Vision statement. Retrieved March 4, 2011, from http://starbasedod.org/

Laws of Minnesota 2007, chapter 45, article 3, section 2, subdivision 3.

Lee-Pearce, M.L., Plowman, T.S., & Touchstone, D. (1998). STARBASE-Atlantis, a school without walls: A comparative study of an innovative science program for at-risk urban elementary students. *Journal of Education for Students Placed at Risk, 3(3),* 223-235.

Saint Paul Public Schools (SPPS) (2011). 4-Year completion trend: Saint Paul Public Schools. St. Paul, MN: Office of Accountability, Planning and Policy; Department of Research, Evaluation and Assessment; Saint Paul Public Schools. Retrieved March 17, 2011, from http://datacenter.spps.org/sites/2259653e-ffb3-45ba-8fd6-04a024ecf7a4/uploads/SPPSGradRate_DistrictTrend_2010.pdf

SciMathMN (n.d.). Introducing the Minnesota STEM Network. Retrieved February 18, 2011, from http://www.scimathmn.org/mnstemnet.htm

STARBASE Minnesota (n.d.). About STARBASE Minnesota. Retrieved March 4, 2011, from http://www.starbasemn.org/aboutus/aboutus.html

U.S. Department of Education Institute of Education Sciences (n.d.). Integrated Postsecondary Education Data System. Washington, D.C.: National Center for Education Statistics. Reference retrieved March 1, 2011, from http://nces.ed.gov/ipeds/

Van Wie, K. (2006). *Midrange efficacy report: What do STARBASE participants retain after 3 months?* STARBASE Minnesota internal document, Saint Paul, MN.

Van Wie, K. (2001). *Longitudinal study: Survey of former STARBASE students.* STARBASE Minnesota internal document, Saint Paul, MN.

Wilder Research (n.d.). Collaboration Factors Inventory. St. Paul, MN: Wilder Research. Available on Wilder Research's website at http://wilderresearch.org/tools/cfi/

Appendix

Responses to open-ended survey questions

Key informants' organizations

Student survey

Responses to open-ended survey questions

After participating in STARBASE, did you participate in any other activities, clubs, or programs related to science, technology, engineering, or math when you were in elementary, junior high, or high school? If yes, please indicate the types of activities, clubs, or programs in which you participated (N=6):

> I've done multiple science fairs since STARBASE.
>
> I joined Robotic club in high school.
>
> In my elementary school, I [attended] Space Camp and Aviation Camp in Huntsville, Alabama. My elementary school also had flight simulators which I was a part of flying.
>
> Knight Crew Leaders and Admission Possible.
>
> I participated in a new program at my elementary which partnered with STARBASE, I believe. My elementary received flight simulators, and I was one of the few people in a test group to learn about airplanes, the phonetic alphabet, and how to fly a flight simulator.
>
> I spent many hours volunteering to clean up lake shores and riverbanks in the interest of environmental safety and health. In high school, I led a group that cleaned up all of the pollution and trash on the shores of Lake Hiawatha in Minneapolis. Also, in high school I planted trees and retained their health as part of many Earth Day and Environmental Week initiatives.

After participating in STARBASE, did you participate in any other activities, clubs, or programs related to science, technology, engineering, or math when you were in elementary, junior high, or high school? If yes, which of these activities, clubs, or programs did you find most helpful (N=6)?

> Science fairs helped [me] learn how to carry out scientific experiments.
>
> Robotic club was fun and interesting.
>
> Both programs highly influenced me in the science field.
>
> Admission Possible.
>
> The one I described is the only one, and I found this very helpful because I gained confidence in myself by working hard at something extra that wasn't required and I learned so much about airplanes that I never knew.
>
> Cleaning up various places was really eye-opening for me.

Were there any science, technology, engineering, or math opportunities you would have liked to participate in but that were not available to you in elementary, junior high, or high school? If yes, what types of opportunities would you like to have had? (N=6)

> More of an opportunity to participate in aerospace and astronautics.
>
> I would like to have [had] an astronomy class because space, our galaxy, the universe, and stars really amaze me. I really think that astronomy is a subject that students nowadays do not get enough of.
>
> Joining math club in high school and middle school.
>
> A friend of mine went to Farnsworth Elementary school and they do a lot of things with aerospace, and I wish my school had a program like that.
>
> Having hands-on experience.
>
> I should have paid more attention in biology because I was really interested but it got a little complicated for me. Maybe joining the computer club, biology, and chemistry club would have helped me out a lot more. I have always been interested in the aeronautics field because I attended a school that is specifically geared towards that area, but I just found other interests I wanted to go into.

What do you remember most about participating in STARBASE? (N=36)

> I remembered making bottle rockets and seeing different airplanes. The experience and opportunity of learning [about airplanes] was a great experience that I will never forget. I looked forward every time I went to STARBASE.
>
> Making models of stuff, graphing unseen landscapes, visiting airplane hangars with old WWII stuff.
>
> Making rockets and testing them out. Also, meeting new people who [had] a lot of experience with math and science, and filling out a booklet.
>
> The different types of planes that were stationed there, such as the Blackbird.
>
> Building a kite, and watching a cool video about the Wright bros.
>
> I remember that kids in our school used to be excited to be in fourth and sixth grade, just so that they could go to STARBASE (well, at least my siblings and I). I remember being part of a team, and doing many activities together. I remember constructing something at a table with my classmates. I remember doing a simulation, where we were in some kind of fake aircraft, and we were crashing, or losing oxygen? But I just remember being short on time to figure out how to save our lives. It was fun.

Building and shooting rockets on the final day, the space ship activity where every student pretended to be a captain, worker, astronaut, and etc. It was fun when we had to solve problems on the ship as a team.

I remember making a kite. Then as a member of a group we tried to reenact the Apollo 13 scene. I remember going in a helicopter, too. Shortly after, in school in my science class we built a rocket because of our field trip.

The flight simulators.

Going there for five days and learning about airplanes, flying.

I remember creating [callsigns], touring the planes, and doing mini experiments during that whole week at STARBASE.

Making an airplane out of light material wood and paper.

What I remember most about participating in STARBASE was exploring the flight stimulation and understanding [how] an airplane functions.

The airplane tour and making rockets.

Launching rockets that we made.

We learned about airplanes and other transportation systems via air. I also remember being able to tour a plane and play a helicopter video game.

The experience of being on the base itself, with all the planes.

The air stimulate program, building a rocket then launching it, having code names, and having plenty of fun!

I remember [learning] about molecules, different planes. I also remember making a rocket that we launched and [visiting] the St. Paul airport.

Learning about physics, and space-related topics, getting lucky and actually getting to do the flight simulator and failing horribly at flying an airplane. Getting code names at the beginning and certificates at the end.

Going there and seeing all the different kinds of planes.

Getting to pick nicknames and looking inside planes.

We made glider planes and making our own rockets to launch.

What I remembered most was the nicknames that we came up with. I remembered telling my friend to make his name 'What' because it would be funny. I also remember all the fun activities that we participated in like the flight simulation with the joy stick which was super fun. Also we made airplanes and tested out to see whose flew the farthest and I believe I won. One memory I remembered the most was missing one day of the five, the one where the students got to tour the helicopter.

To be honest I don't remember much about STARBASE but I recall something about rockets. There [was] a man who was talking to us about rockets, I think. And there was something about airplanes.

Making up nicknames for ourselves because that was what we were going to be called by and doing a flight simulator.

The marshmallow activity when it got squished because of the pressure in the machine.

Newton's laws, looking at the aircrafts at the base, building planes, learning about the different aircrafts.

I remember doing different projects and learning about different airplanes. I remember trying to construct something off of the movie Apollo 13 I believe it was. I was the captain and I was in charge of leading the group which I had a lot of fun doing.

I remember watching Popular Mechanics for Kids, working in groups in order to build the best flying paper airplanes, getting nicknames, and filling out that activity book.

I might confuse this with some other program since it was pretty long ago. I remember we all gave ourselves nicknames, and mine was Caramel. We were shown a plane (the Blackbird) and were told it was (one of) the fastest planes in the world. Even faster than the speed of sound. There was also an interactive computer simulation.

Coming up with nicknames for ourselves.

I remember the nicknames we got to have, and I remember learning some of the things like about how airplanes work. I also remember getting a folder with a lot of things in it.

We got to do flight stimulation.

I remember we went on field trips to learn about airplanes, and we got to participate in activities.

I remember entering the program with a limited understanding of math and science and emerging with a better grip on the subjects (and a less hateful disposition when it came to learning either of those disciplines).

Do you think STARBASE has influenced your career plans? If yes, please explain (N=7):

> It really helped me better understand how aerodynamics works.
>
> STARBASE has increased my interest in science because I always thought science was about rocks and the earth alone. However, learning about airplanes (how airplanes fly, and the parts of airplanes) has made me realize that science is a very broad field, there are endless possibilities that I can do and enjoy all at once.
>
> I believe STARBASE is very [influential] and helpful because I remember being a fourth- and sixth-grader visiting STARBASE. I was extremely happy to see all the technology and scientific [things] that are actually being made.
>
> While attending STARBASE, I was highly interested in joining the Air Force.
>
> After STARBASE I wanted to get into a major that was uniform based. My interest built up into being a police officer, and then moving to DNR afterward.
>
> It made me realize I do not want a career in the science area.
>
> I realized at STARBASE that while I enjoyed learning about science and was relatively good at it, I don't have the drive to have a career in it and I'm better staying in the arts.

What was the most important thing you gained from your participation in STARBASE? (N=36)

> The joy of exploration and teamwork as well.
>
> Learning about physics stuff that's applicable every day.
>
> The learning experience and the fact that I [got] to see all sorts of things when I participated.
>
> Learning more about science and technology and how they both combine together. The most interesting thing to me was making the rockets and testing them. I think I've learned that I am more of a hands-on learner.
>
> The most important thing I gained from STARBASE participation was understanding that technology is infinite.
>
> I had a lot of fun, and I realized that I learn best when I'm interested in the material.
>
> An interest in tech.
>
> The importance of history.
>
> The different types of technological advancements.

Teamwork.

The names and types [of] Air Force airplanes.

I gained the experience of learning something non-traditional outside of the classroom. Although I was learning a lot, I didn't feel like it because I was having fun while learning.

Being exposed to science in a way that was not common in school. The astronomy aspect interested me the most and it brought our class closer together.

I don't know.

I learned a lot of things about aeronautics and it honestly led me to wanting to be an astronaut or pilot but as I grew older, I found other passions and changed my route but most definitely, being a part of the aeronautics field is second to what I love doing now.

Advances in technology.

Learning about aircraft.

I [gained] lots of knowledge about airplanes and [that] maybe [in] the future there would better technology.

I'm not following the science/technology/engineering path, but I would say that it made me realize that the field was more open to women than I originally thought it was as a child. We had these leaders for our trip, and I remember there was at least one of each gender. Also, I always remembered the plane because I thought it was one awesome aircraft.

Interest in planes and maybe being a pilot.

I learned a lot about science and myself through the process, like I am not interested in science as my career but it still is a little bit interesting.

Science can be fun.

Don't remember.

Learning about space.

A better understanding of how the military uses their airway transportation.

I don't remember, therefore I do not know or remember what I gained from my participation in STARBASE.

Teamwork.

Working as a team and learning to work independently.

Working together.

It's really hard to remember back in fourth grade, but I do remember everyone in my class being excited to go and do the different activities.

It was really fun, and it really helped me understand better the science behind it all.

At the moment, I think I really appreciated technology.

The most important thing I gained was learning that science is not just about minerals and rocks, but airplanes, space, and just about everything else is a part of science.

Seeing a helicopter up close.

I gained the knowledge of science, math, technology, and engineering through STARBASE at a young age, and that was something important for me.

I gained a respect and a better understanding of science and math that alleviated most of my fears about learning the topics.

Do you think your participation in STARBASE continues to impact you today? If yes, how so? (N=12)

I continue to look back upon my experience in STARBASE because I have thought about being a teacher, and being a teacher at STARBASE possibly through math is always an option. I look at all the things that interested me at STARBASE and think about if I would like to do something like that in the future.

I understand and can explain how flight works.

STARBASE has made me want to become an astronaut someday. I want to be able to explore space, but that would be something I'd want to do once I retire.

That there was no gravity.

It impacts me because I am still really interested in airplanes.

It showed me the importance of our country's history in aviation and engineering. However, it also showed me that aviation and the military was not the career path for me.

It showed me that it was okay to be a girl who was interested in science. It wasn't nerdy if it genuinely made you happy.

I still think about what I have done, and what it felt like to be in STARBASE and the friends I have made.

It helped me understand how important teamwork was.

I still struggle with mathematics, even in college. But I can remember some of the things I learned at STARBASE and find better ways to cope with the problems.

It taught me to work in a team as well as work independently and taught me how to respect others as well as myself.

I pay a lot of attention to what goes on in space with NASA and what not with the airlines. In regards to the military, I am way more interested in the Air Force than any other branch. I dream of flying my own plane, though I don't have perfect vision. I have always and still do want to be an astronaut. I take a lot of interest in things of that sort.

Are there any final comments you would like to share with the STARBASE program? (N=28)

STARBASE was a blast. I think that there should be more opportunities like this for elementary school students, maybe even in high school so that students can have the learning experience.

I had a great time at STARBASE and it has been a wonderful experience for me and my friends!

I think it's a wonderful program and I will always remember that experience. It's a memory that made elementary school for me.

It was a great experience and I had a lot of fun.

STARBASE provides a great opportunity for kids to explore science and in some cases find something that they would like to do in their careers.

It was a fun and great experience.

Thanks for the opportunity and for having [participated in] the STARBASE program.

The STARBASE program is something that all [schools] should have because it opens lots of options for students.

No.

I think STARBASE is a great program, and I hope my elementary school and other schools continue to make it a part of their classes! And I will always remember J Bird.

My experience there taught me a lot.

I really enjoyed the activities that were done when I was in fourth and sixth grade. Not to forget, it was fun to visit STARBASE.

It was an awesome program that taught me many things. It was also a fun and amazing program to experience and [I] would love for all other students to [have] had the same experiences that I did, including the helicopter tour that I missed.

STARBASE is a great program, and I would definitely encourage for it to go on. If I ever have kids one day, I would love for them to be a part of it. I know that a lot of programs struggle to keep up with the economy being so, but STARBASE is a program that should be kept around for a long time. I was inspired when I was younger.

No.

I enjoyed being a part of the STARBASE program.

I think it's a great program, although I haven't really thought about it since then. But reminiscing about it now reminds me of how excited I was about the program. I would recommend creating a junior high program as well (if that doesn't exist already) because then it could retain kids' interest in the math, science, and technology. Thanks for that experience!

Thank you very much for allowing me the opportunity to go through STARBASE.

No.

This program was a lot of fun. I would highly recommend it to any child interested in science.

I only realized after taking this survey that a big aspect of this program is future military recruitment of elementary children. That, at least, is what many of these questions have led me to believe. Other than that unfortunately disturbing aspect, it was a great experience.

It was a really fun program in general, and I think it should still be an opportunity for younger generations to come. Although I don't remember much from it, I believe that it can change many students' lives and give them a direction.

I was just remembering the other day about how much fun I had at STARBASE. It was a great experience, and I briefly considered being a pilot.

I think it is a good program and it should keep being available to young children in elementary school.

None.

STARBASE was a lot of fun.

From what I can remember of my participation, I really enjoyed this program a lot and it would really be a great idea for the younger generation to experience also.

STARBASE is a great program and it should definitely continue. I feel sorry for students who do not have the opportunity to experience STARBASE. It was one of the highlights of my elementary years.

Key informants' organizations

In summer and fall 2010, Wilder Research staff completed 28 key informant interviews with representatives of local STEM organizations, including one interview with two representatives of a single organization. Following is a list of participants' organizations:

■ 3M

■ Alley Institute

■ The Bakken Museum

■ Como Park Zoo and Conservatory (two representatives)

■ Como Planetarium

■ CREED Project

■ H2O for Life

■ Hennepin County Library

■ High Tech Kids

■ James Ford Bell Museum of Natural History

■ Mad Science and Schoolhouse Chess of Minnesota

■ Mentoring Partnership of Minnesota

■ Minneapolis Public Schools

■ Minnesota Center for Engineering and Manufacturing Excellence

■ Minnesota Planetarium Society

■ Minnesota Zoo

■ Normandale Community College

■ Saint Paul College (interviewee is also affiliated with Saint Paul Public Schools)

■ Saint Paul Public Schools (two separate interviews, in addition to the interviewee affiliated with both Saint Paul College and Saint Paul Public Schools)

- Science Museum of Minnesota

- SciMathMN (organization is spearheading the Minnesota STEM Network)

- STARBASE Minnesota

- Twin Cities Public Television

- Twin Cities Regional Science Fairs

- University of Minnesota College of Science and Engineering (interviewee is also affiliated with the North Star STEM Alliance and the Minnesota STEM Network)

- University of Minnesota Humphrey School's Center for Science, Technology, and Public Policy

- The Works

Student survey

STARBASE survey

We are working with STARBASE Minnesota to look at former participants' interests and future plans. STARBASE is the 5-day science, technology, engineering, and math (STEM) program at the Minnesota Air National Guard base. You may have participated in the program in 4th grade or both 4th and 6th grade.

Please take a few moments to complete this survey. The information you provide will help us learn more about the impact of the STARBASE program as well as what other opportunities are available for students interested in science, technology, engineering, or math. Your answers will be kept confidential. At the end of the survey, you will be given the opportunity to have a $10 gift card to Target or Walmart mailed as thanks for your participation.

1. Did you participate in the STARBASE program at the Minnesota Air National Guard base? You may have participated in 4th grade, 6th grade, or both.

   ☐[1] Yes

   ☐[2] No [If no, respondent has completed survey and should be thanked for their participation.]

2. What do you remember most about participating in STARBASE?

   _____

   _____

Current interest in STEM

3. How much interest do you currently have in…

	A lot	Some	Very little/None
a. science?	☐[3]	☐[2]	☐[1]
b. technology? (e.g., computers)	☐[3]	☐[2]	☐[1]
c. engineering?	☐[3]	☐[2]	☐[1]
d. math?	☐[3]	☐[2]	☐[1]

4. Have you decided on a major or field of study in college?

   ☐[1] Yes

   ☐[2] No (Skip to question 6.)

   ☐[8] Don't know (Skip to question 6.)

   ☐[9] Not applicable (Skip to question 6.)

5. What is your major or field of study? _____ (Skip to question 7.)

6. Are you considering a major or field of study in a science, technology, engineering, or math discipline? This would include any field that emphasizes skills in one of these areas. For example, accounting would be considered a math discipline, and nutrition a science discipline.

☐[1] Yes ☐[2] No ☐[8] Don't know ☐[9] Not applicable

7. Have you taken or are you planning to take any additional science, technology, engineering, or math classes in college beyond what is required?

☐[1] Yes, more than what's required ☐[2] No, only what's required ☐[8] Don't know ☐[9] Not applicable

8. How much interest do you have in getting a job <u>related to</u> science, technology, engineering, or math?

☐[3] A lot ☐[2] Some ☐[1] Very little/None

9. How much interest do you have in getting a job <u>teaching</u> science, technology, engineering, or math?

☐[3] A lot ☐[2] Some ☐[1] Very little/None

10. At your college or university, have you participated in any activities, clubs, or programs related to science, technology, engineering, or math?

☐[1] Yes ☐[2] No

If Yes, please indicate the types of activities, clubs, or programs in which you have participated:

_____

_____

Current interest in the military

As you might recall, STARBASE is located on the Minnesota Air National Guard base, and you probably had a member from the Guard speak at graduation. We are interested in learning about former STARBASE participants' interest in the military to help us understand the impact of the program. Individual students' information is <u>not</u> shared with colleges or recruiters.

11. Are you currently enrolled in any form of the military?

☐[1] Yes. What branch are you in? _____ What is your rank? _____ (Skip to question 13.)
☐[2] No

12. How much <u>interest</u> do you have in joining the military?

☐[3] A lot ☐[2] Some ☐[1] Very little/None

13. Do you think STARBASE increased your interest in joining the military?

☐[1] Yes ☐[2] No ☐[8] Don't know

14. At your college or university, have you participated in any activities, clubs, or programs related to the military (e.g., ROTC)?

☐¹ Yes   ☐²No

If Yes, please indicate the types of activities, clubs, or programs in which you have participated:

_____

_____

Experience with STARBASE

15. Do you think STARBASE was a valuable learning experience?

☐¹ Yes   ☐² No   ☐⁸ Don't know

16. Do you think STARBASE helped you <u>understand</u> science, technology, engineering, or math better?

☐¹ Yes   ☐² No   ☐⁸ Don't know

17. Do you think STARBASE increased your <u>interest</u> in science, technology, engineering, or math?

☐¹ Yes   ☐² No (Skip to question 19.)   ☐⁸ Don't know (Skip to question 19.)

18. Specifically, do you think STARBASE increased your <u>interest</u> in…

	Yes	**No**	**Don't know**
a. science?	☐¹	☐²	☐⁸
b. technology? (e.g., computers)	☐¹	☐²	☐⁸
c. engineering?	☐¹	☐²	☐⁸
d. math?	☐¹	☐²	☐⁸

19. Do you think STARBASE increased your interest in the military? This could include interest in the military in general as well as interest in joining the military.

☐¹ Yes   ☐² No   ☐⁸ Don't know

20. Do you think STARBASE helped you learn about careers related to science, technology, engineering, or math?

☐¹ Yes   ☐² No   ☐⁸ Don't know

21. Do you think STARBASE has influenced your career plans?

☐¹ Yes   ☐² No   ☐⁸ Don't know

If Yes, please explain: _____

_____

Involvement in other STEM programs

22. After participating in STARBASE, did you participate in any other activities, clubs, or programs related to science, technology, engineering, or math when you were in elementary, junior high, or high school?

☐¹ Yes   ☐² No (Skip to question 25.) ☐⁸ Don't know (Skip to question 25.)

If Yes, please indicate the types of activities, clubs, or programs in which you participated:

_____

_____

23. Which of these activities, clubs, or programs did you find most helpful?

_____

_____

24. Did you get involved in any of these science, technology, engineering, or math activities or programs because of STARBASE?

☐¹ Yes   ☐² No   ☐⁸ Don't know

If Yes, which activities/programs were these?

_____

_____

25. Did you face any challenges to participating in other science, technology, engineering, or math activities, clubs, or programs when you were in elementary, junior high, or high school?

☐¹ Yes   ☐² No (Skip to question 27.)   ☐⁸ Don't know (Skip to question 27.)

26. Which challenges did you face? (Check all that apply.)

☐¹ I was not aware of what other opportunities were available to me.

☐² My parents or caregivers were not aware of other opportunities.

☐³ There were not enough opportunities available to me.

☐⁴ Available opportunities were too expensive.

☐⁵ I was too busy with other activities.

☐⁶ Transportation would have been difficult.

☐⁷ I needed to be home to care for my sibling(s).

☐⁸ Opportunities did not fit my specific interests. Please explain: _____

☐⁹ Opportunities were not applicable to me based on my age, gender, or other factors.

   Please explain: _____

☐¹⁰ Other challenges. Please explain: _____

27. Were there any science, technology, engineering, or math opportunities you would have liked to participate in but that were not available to you in elementary, junior high, or high school?

☐¹ Yes   ☐² No   ☐⁸ Don't know

If Yes, what types of opportunities would you like to have had?

_____

_____

28. When you were in junior high or high school, did you participate in any activities, clubs, or programs related to the military (e.g., JROTC)?

☐¹ Yes   ☐² No   ☐⁸ Don't know

If Yes, please indicate the types of activities, clubs, or programs in which you participated:

_____

_____

29. What was the most important thing you gained from your participation in STARBASE?

_____

_____

30. Do you think your participation in STARBASE continues to impact you today?

☐¹ Yes   ☐² No   ☐⁸ Don't know

_____

_____

31. Are there any final comments you would like to share with the STARBASE program?

_____

_____

32. Are you a Twin Cities college student participating in the Power of YOU program?

☐¹ Yes   ☐² No

33. We appreciate your participation in the survey, and are offering a $10 gift card to Target or Walmart for those who participated. Would you like to receive your gift card?

☐¹ Yes   ☐² No [If "No," respondent has completed the survey.]

34. To which store would you prefer your gift card?

☐¹ Target   ☐² Walmart

35. Would you like that sent certified or regular mail?

REGULAR MAIL: If we send the gift card regular mail, we cannot guarantee its arrival and cannot send a new one if you do not receive it.

CERTIFIED MAIL: If you select certified mail, please be aware that someone from your household will need to be home during the day when the mail carrier comes to sign for the letter. After three attempts the card will be sent back to us and we will automatically resend it regular mail.

☐[1] Regular   ☐[2] Certified

Please provide your name and mailing address so we can send the gift card to you. Your address will not be shared with anyone outside of this study. Your gift card will take 2-4 weeks to arrive.

Name:

Street:

Unit/Apt #:

City:

State:

Zip:

Thank you!