2015-16 STEM Pathways Evaluation

Final Results of a Three-Year Pilot Project of Informal STEM Education Partnership

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Acknowledgments

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

Mark Anton	Marilyn Conrad
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Summary

STEM Pathways is a partnership between five informal STEM organizations—The Bakken Museum, Bell Museum of Natural History, Minnesota Zoo, STARBASE Minnesota, and The Works—with the Minneapolis Public Schools (MPS) and the Minnesota Department of Education (MDE). The purpose of this collaborative effort is to raise the access, enthusiasm, and academic achievement of young people in STEM and their preparation for future STEM careers through a deliberate and interconnected system of STEM learning opportunities. Further, STEM Pathways tests a model for collaboration and its potential for expansion and replication across more grade levels, schools, organizations and communities.

As part of a three-year pilot project, STEM Pathways partner organizations (informal STEM education organizations working with MPS and MDE) began the first year in 2013-14 with an intensive collaboration process to learn about each other's programs, make concept and theme connections, develop shared tools and strategies, and plan for project implementation. STEM Pathways began offering activities to fourth- and fifth-grade students at six MPS elementary schools in 2014-15 and continued in 2015-16.

Evaluation

A core component of the STEM Pathways project is ongoing evaluation to inform programming as well as future efforts for the STEM Pathways collaborative. STEM Pathways participates in rigorous, independent evaluation conducted by Wilder Research during the three-year pilot project. Evaluators assess the implementation and outcomes of the project using a student survey, small-group interviews, academic data, a teacher survey, and interviews with MPS leaders and STEM Pathways partner representatives. This report summarizes outcome findings from student surveys and academic data over the two years of program implementation (2014-15 and 2015-16), as well as evaluation findings from data collected through surveys and interviews with students, MPS teachers and leaders, and partners during the second program implementation year.

Student survey results

A survey was administered to fourth- and fifth-grade students in the six STEM Pathways schools in MPS in fall and spring. The survey assessed students' STEM awareness, attitudes, interests, and activities. Results are reported for 255 Cohort 1 students who completed the survey in fall 2014, spring 2015, and spring 2016, and for 345 Cohort 2 students who completed the survey in fall 2015 and spring 2016. Changes in students'

responses in these areas over time may be associated with participation in STEM Pathways. In 2015-16, Cohort 1 students were fifth graders and Cohort 2 students were fourth graders. Cohort 2 survey responses are compared to those of Cohort 1 in fourth grade.

Results by topic area

Survey results are summarized by the following topic areas: awareness and relevance of STEM, STEM interest and confidence in STEM abilities, interest in STEM subjects, application of STEM to problem solving, and careers using STEM. The survey items were a series of statements with the response options: "agree a lot," "mostly agree," "agree a little," "don't agree," and "don't know." Those who agreed a lot or agreed mostly were considered to be in agreement with an item.

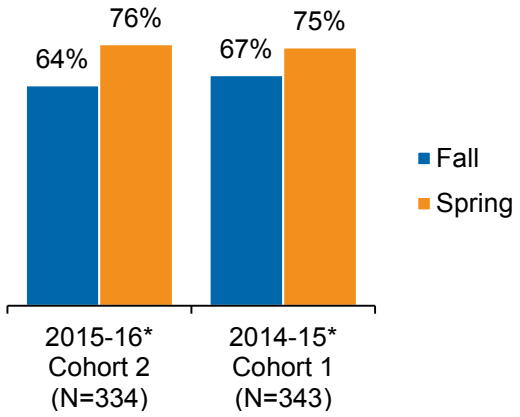
Overall, the comparison between fourth-grade survey results of Cohort 2 in 2015-16 and Cohort 1 in 2014-15 indicates that Cohort 2 had stronger results. For Cohort 1, survey results were stronger overall at the end of their fifth-grade year (spring 2016) than at the end of their fourth-grade year. Figures 1-8 illustrate some of the findings. Results in detail can be found in *STEM Pathways Student Survey Results through 2015-16 School Year* (Mueller & Gozali-Lee, 2016).

Awareness and relevance of STEM

Students' awareness of STEM and belief in its relevance increased in both cohorts. For Cohort 2 fourth graders, agreement increased significantly from fall to spring for three of the four items in this topic area. These three items concerned the importance of STEM knowledge to students' futures, their awareness of STEM in the world around them, and their knowledge of STEM-related out-of-school activities. In Cohort 1, agreement with the first two items also increased significantly in the fourth-grade year and continued to increase slightly in the fifth-grade year. Agreement with the third item (their knowledge of STEM-related out-of-school activities) increased significantly in fifth grade and was a significant increase over the two-year assessment period. Agreement with a fourth item in this topic area (frequently doing STEM-related out-of-school activities) did not change significantly in either cohort over time.

1. Cohorts 2 and 1 in fourth grade: STEM knowledge is very important to my future

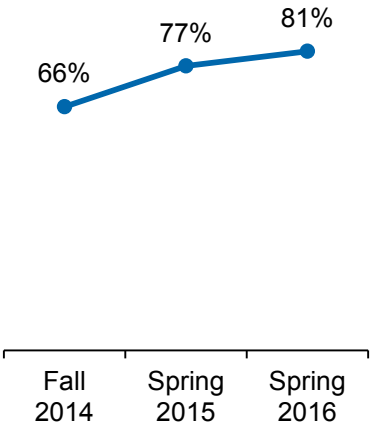
Percentage of students who "agree a lot" or "mostly agree"



**The change in agreement with the item from fall to spring is statistically significant (p<.05).*

2. Cohort 1 in fourth and fifth grade: STEM knowledge is very important to my future [a]

Percentage of students who "agree a lot" or "mostly agree"



Note: The change in agreement with the item from fall 2014 to spring 2015, and from fall 2014 to spring 2016, are statistically significant (p<.05).

[a] *Includes 246 students who responded to this item at all three time points.*

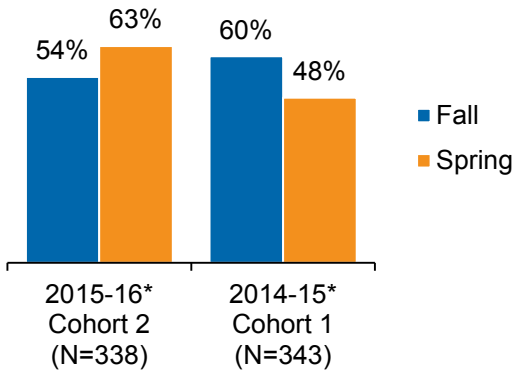
STEM interest and confidence in STEM abilities

Agreement with liking to learn STEM and being really good at STEM increased significantly from fall to spring among Cohort 2 fourth graders. In Cohort 1, agreement with liking to learn STEM increased significantly in fourth grade but agreement with being really good at STEM decreased significantly. However, agreement with this latter item increased significantly in fifth grade so that the level of agreement at the end of fifth

was nearly the same as at the beginning of fourth grade. Agreement with wanting to do more STEM-related activities and thinking one would be good at a job that uses STEM did not change significantly in either cohort over time.

3. Cohorts 2 and 1 in fourth grade: I am really good at STEM

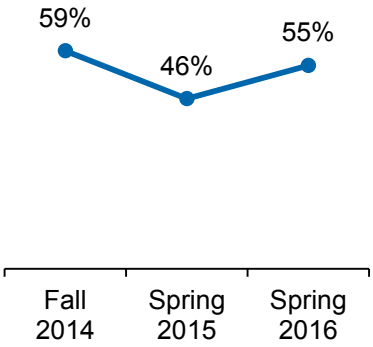
Percentage of students who "agree a lot" or "mostly agree"



**The change in agreement with the item from fall to spring is statistically significant (p<.05).*

4. Cohort 1 in fourth and fifth grade: I am really good at STEM [a]

Percentage of students who "agree a lot" or "mostly agree"



Note: The change in agreement with the item from fall 2014 to spring 2015, and from spring 2015 to spring 2016, are statistically significant (p<.05).

[a] *Includes 249 students who responded to this item at all three time points.*

Interest in STEM subjects

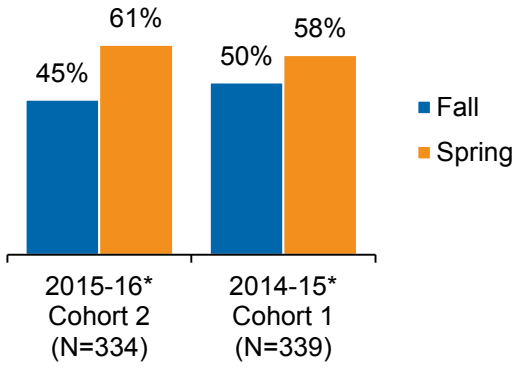
Students were asked if they liked learning each of the four STEM subjects. The percentage of fourth graders in Cohort 2 and Cohort 1 who liked learning engineering increased sharply from fall to spring. In Cohort 1, the increase in agreement seen at the end of fourth grade was maintained at the end of fifth grade. Relatively high percentages of fourth graders in both cohorts liked learning the other three STEM subjects (science, technology, and math) in both the fall and the spring. In Cohort 2, agreement with liking science decreased a small (but statistically significant) amount from fall to spring. In Cohort 1, the percentage who liked learning technology increased significantly from the beginning of fourth grade to the end of fifth grade.

Application of STEM to problem solving

Agreement with applying STEM to problem solving increased significantly from fall to spring among Cohort 2 fourth graders, which concerned using technology to solve problems and thinking like an engineer to design solutions to problems. Among fourth graders in Cohort 1, there was a significant increase in agreement with the engineering item but not with the technology item. The increase in the engineering item was maintained through fifth grade.

5. Cohorts 2 and 1 in fourth grade: I think like an engineer to design solutions to problems

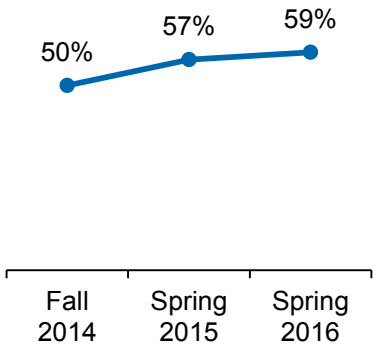
Percentage of students who "agree a lot" or "mostly agree"



**The change in agreement with the item from fall to spring is statistically significant (p<.05).*

6. Cohort 1 in fourth and fifth grade: I think like an engineer to design solutions to problems [a]

Percentage of students who "agree a lot" or "mostly agree"



Note: The change in agreement with the item from fall 2014 to spring 2016 is statistically significant (p<.05).

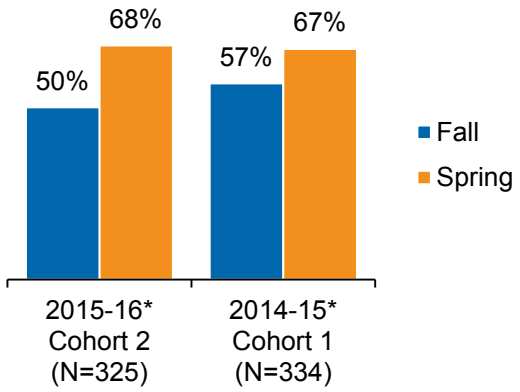
[a] *Includes 246 students who responded to this item at all three time points.*

Careers using STEM

In both cohorts, fourth graders' agreement increased significantly for the item concerning knowing about many jobs that use STEM (Figure 7). In Cohort 1, this agreement continued to increase in fifth grade (Figure 8). There was no significant change for fourth graders in either cohort for the two other career-related items: thinking one would be good at a job that uses STEM (mentioned above) and wanting to have a job that uses STEM. The level of agreement with these items did not change over the two school years in Cohort 1.

7. Cohorts 2 and 1 in fourth grade: I know about many jobs that use STEM

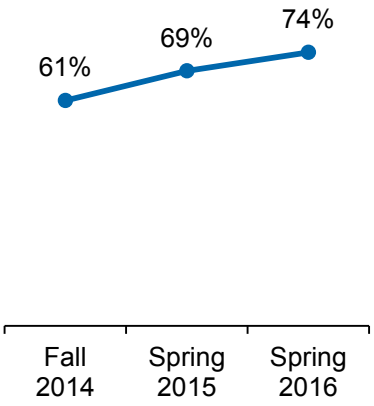
Percentage of students who "agree a lot" or "mostly agree"



** The change in agreement with the item from fall to spring is statistically significant (p<.05).*

8. Cohort 1 in fourth and fifth grade: I know about many jobs that use STEM [a]

Percentage of students who "agree a lot" or "mostly agree"



Note: The change in agreement with the item from fall 2014 to spring 2016 is statistically significant (p<.05).

[a] *Includes 237 students who responded to this item at all three time points.*

Overall results of the student survey do not indicate advantages for underrepresented students.

Small-group interviews with students

Small-group semi-structured interviews were conducted with fifth-grade students who participated in STEM Pathways in both fourth and fifth grade. Forty-four students were interviewed in an effort to gain a more in-depth understanding of their experiences in STEM Pathways and attitudes towards STEM.

Results from small-group interviews indicate that:

- STEM Pathways experiences are fun, different from and better than other field trips and classroom visits.
- Students made connections between their STEM Pathways experiences and their classroom learning.
- Students are more confident in their STEM knowledge because of participating in STEM Pathways.
- Students are more interested in STEM careers because of participating in STEM Pathways.
- Students have positive feelings about STEM, in general.

While the overall results from the student interviews are positive, the results also pointed to areas for program improvement. These include:

- Students have varied understandings of STEM Pathways.
- Students did not recognize that their STEM Pathways experiences involved math.
- Students recognize primarily surface-level connections between the programs provided by STEM Pathways partners.
- Students recognized they still have a lot to learn about STEM, and many see STEM learning as challenging, which creates mixed feelings related to their confidence in their abilities to do STEM.

Student achievement results

STEM Pathways' long-term goal is to increase student academic achievement in STEM, especially in underrepresented groups (low-income students, racial/ethnic minorities, and females). Evaluators compared STEM Pathways students with similar peers attending other MPS schools on Minnesota Comprehensive Assessments, Series III (MCA-III) math, reading, and science scores, and on student attendance.

Overall, there was no evidence found at this point for an academic achievement advantage among students who participated in STEM Pathways. Results indicated that differences between the treatment and comparison groups in spring 2016 MCA-III performance and one-year MCA-III growth tended to be small and not statistically significant in almost all instances. Although the differences were small, they generally favored the comparison group over the treatment group. This pattern occurred in all three cohorts for the subjects assessed (math, reading, and science). Some of the differences in academic achievement in favor of the comparison group over the treatment group were stronger and statistically significant for some demographic groups. School attendance rates in 2015-16 were the same or almost the same in the treatment and comparison groups in all three cohorts.

Results of Minneapolis Public Schools leader interviews

Wilder Research interviewed MPS leaders to get their views on the implementation and accomplishments of STEM Pathways, including its benefits to the district, teachers, and students, as well as suggestions for changes or improvements. Eight MPS leaders participated, including five principals of the six STEM Pathways schools. Leaders viewed their collaboration with STEM Pathways positively.

Several benefits to teachers, students, and the schools were mentioned, including the following:

- Increasing student enthusiasm for STEM and providing exposure to STEM careers.
- Increasing student enthusiasm for science and math classes in school.
- Providing learning opportunities to students who might not have access to the STEM activities outside of school.
- Providing materials and communication to teachers to highlight areas of connection between STEM Pathways activities, state standards, and the MPS curriculum.
- Providing teaching materials and supports, as well as inspiring teachers to build on the motivation and excitement in their own teaching of STEM.
- Helping teachers integrate STEM into other areas of the curriculum, such as literacy.
- Increasing teacher awareness of opportunities for professional development that could improve the way they teach or integrate STEM in classrooms.
- Enhancing schools' ability in delivering STEM education.

All leaders said they would like STEM Pathways to continue, and most would like STEM Pathways to expand to other grades and schools.

Results of teacher survey

Wilder Research conducted a web survey with fourth- and fifth-grade teachers from the six STEM Pathways schools in spring 2016. The survey asked teachers about their experiences with STEM Pathways and its impacts on them, their students, and their school. Twenty teachers (59%) completed the survey.

All teachers in the survey indicated that STEM Pathways:

- Supports the state standards and the MPS curriculum in meaningful ways.
- Had a positive impact on their school, on them as a teacher, and on their students.
- Increased students' interest in STEM learning and improved their learning in STEM subjects.

All teachers indicated that they would like their school to participate in STEM Pathways again next year.

Results of STEM Pathways partner representative interviews

Wilder Research also interviewed twelve representatives from the STEM Pathways partner organizations, including steering committee and implementation team members. Representatives were asked about their views on the STEM Pathways implementation and accomplishments, including impacts on their organization and implications for informal STEM education organizations.

Representatives of the STEM Pathways partner organizations indicated several successes from the second year of implementation including:

- Better articulation of the primary goal (compared to the previous year's evaluation findings), which is to increase student engagement and interest in long-term STEM learning and increase student interest in STEM careers.
- Partners' enthusiasm and commitment to working together.
- Alignment of STEM Pathways lessons with the state math and science standards and MPS curriculum.
- Development of common language and shared messages across organizations.

Being a part of the collaborative gives partners the following benefits:

- Networking opportunities with other informal education organizations, discussing common goals, sharing successes and challenges and learning from each other, and brainstorming new ideas.
- Better visibility and credibility.
- Opportunity to be part of research and evaluation work.
- Opportunity to work more closely with school partners.

Issues to consider

Overall, STEM Pathways was successfully implemented in the second year. Student survey results were stronger for both cohorts, and students in the small-group interviews reported that they were more interested and more confident in STEM because of their participation in STEM Pathways. Results also suggest that more attention may be needed to advance STEM interest, knowledge, and attitudes of underrepresented students, in part because their baseline interest and confidence tend to be lower than that of students not from underrepresented groups. It also seems important to communicate clearly to students

and teachers about STEM Pathways and its goals, including the interconnected concepts among STEM Pathways partner programs and the use of math in STEM Pathways experiences. Findings also highlight the complex and challenging nature of STEM learning, including that students may need encouragement to develop confidence in their STEM abilities, such as recognizing their efforts, progress, and growing skills. It seems important to continue providing programming to advance STEM interest, knowledge, and attitudes of students, especially the underrepresented students.

STEM Pathways' potential effects on student academic achievement were examined using MCA tests, which are considered long-term indicators of the program impact. Significant achievement-related effects may be unlikely in the short term, but could emerge after multiple years of program exposure.

MPS leaders and teachers viewed the project and the collaboration with the partners positively. Teachers wished to have more opportunities for professional development, including how to conceptualize STEM as an integrated discipline, and how to incorporate the STEM Pathways resources into classroom learning more effectively. They also wanted additional materials and resources, such as math and life science pages in the Student Portfolio, materials in Spanish, incentives for students who made learning progress, and more STEM professionals come to speak to classes about their careers.

MPS leaders indicated that more coordination between teachers and partner organizations is important, as teachers could incorporate more about the field trip lessons in their classrooms. Leaders also recommended more communication with teachers ahead of time regarding lessons and expectations. Recognizing the many benefits to students and teachers, MPS leaders wished that more schools and grade levels could receive STEM Pathways programming.

Partners had several ideas for strengthening STEM Pathways, including more opportunities to grow professionally. Partners also aspire to work collaboratively to develop best practices for STEM learning in informal settings, share outcomes and measurements, and to become an expert in the STEM field.

Looking forward

Having completed the three-year pilot project, partners continue to focus on strategic planning and action for the next phase. Through this process, STEM Pathways partners recognize the importance of and are committed to fostering a collaborative systems approach to inspire the next generation of STEM-literate decision-makers and problem solvers. The goal of STEM Pathways is to ensure that all young people have opportunities to engage in high-quality STEM learning experiences—over time and in a variety of

settings—that lead them to develop the STEM mindset necessary to become the creative, STEM-skilled thinkers and innovators of the future. Core activities of the next stage of STEM Pathways include:

- Supporting and expanding the network of informal STEM educators that STEM Pathways has created.
- Facilitating access to a system of high-quality and interconnected STEM learning experiences for youth through informal STEM education organizations across school years, in collaboration with schools and districts and in alignment with and support of core curriculum and standards.
- Promoting cross-organizational leadership to create and prioritize a culture of collaboration that builds authentic connections between organizations, people and programs; that articulates shared vision and goals; and utilizes shared measurement to evaluate progress.
- Building effective funding and sustainability strategies.

Introduction

STEM Pathways is a partnership between five informal STEM organizations—The Bakken Museum, Bell Museum of Natural History, Minnesota Zoo, STARBASE Minnesota, and The Works—with the Minneapolis Public Schools (MPS) and the Minnesota Department of Education (MDE). The purpose of this collaborative effort is to raise the access, enthusiasm, and academic achievement of young people in STEM and their preparation for future STEM careers through a deliberate and interconnected system of STEM learning opportunities. Further, STEM Pathways tests a model for collaboration and its potential for expansion and replication across more grade levels, schools, organizations and communities.

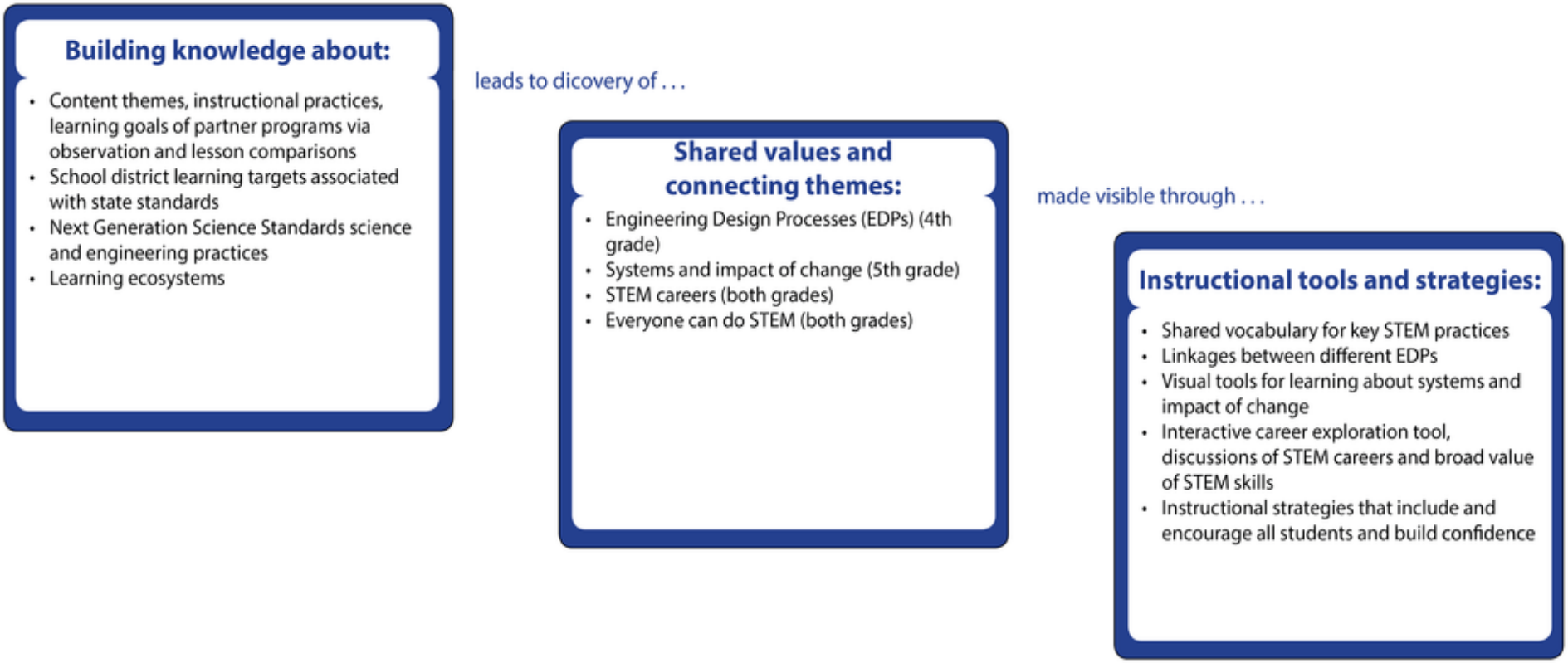
The partnership was launched in 2012 with the following objectives:

- To provide deliberate, coherent, and connected pathways of meaningful in-school and out-of-school STEM learning experiences that contribute to a local STEM learning ecosystem and lead to the achievement of shared youth outcomes.
- To test a new model and culture for how informal STEM education organizations work together, emphasizing collaboration, shared vision, goals, knowledge, strategies, and measurements.

STEM Pathways partners chose to test this model in fourth and fifth grades, based on current program offerings for schools provided by partner organizations. To identify partner schools, STEM Pathways worked with MPS leaders to identify and recruit schools with diverse student populations, where school leadership and teachers had previously demonstrated interest in and support for STEM education, and where at least some STEM-related community partnerships were in place. School principals received detailed information about STEM Pathways including the benefits and commitment required by their school. All six schools identified for participation chose to be part of this pilot project.

During the planning year of the project (2013-14), STEM Pathways partner organizations worked collaboratively to: learn about each other's organizations and programs; explore important topics in formal and informal STEM education fields; determine the overarching themes and concepts connecting the STEM Pathways partner programs; and create common tools, strategies, and messages that would help students experience long-term and interconnected STEM learning. This process is illustrated in Figure 9. The collaborative efforts of developing common goals, strategies, tools and measurements shared by multiple organizations to build interconnected learning experiences for students is a major shift in the culture of informal STEM education organizations, which have traditionally worked independently in their service to schools.

9. STEM Pathways collaboration process



Source: STEM Pathways

In the second year (2014-15), STEM Pathways began offering programming in fourth- and fifth-grade classrooms at six schools in MPS and continued to do so in the third year (2015-16). The six schools participating in STEM Pathways include four K-5 schools, one K-8 school, and one 3-8 school. Revision of existing and creation of new instructional tools also occurred during the second and third years, informed by program evaluation.

Wilder Research serves as the independent evaluator of STEM Pathways for this pilot project. As such, Wilder Research worked closely with the STEM Pathways partners to design the evaluation and with MPS to implement the evaluation activities.

Content of the report

This evaluation report focuses on the third and final year of the STEM Pathways pilot project (the second program implementation year) and includes short-term project outcomes for schools, teachers, and partners during the 2015-16 school year. Student outcomes are reported for both implementation years: 2014-15 and 2015-16.

The report is organized into the following sections:

- Partnership efforts
- Research methods
- Implementation
- Outcomes
- Looking forward

Partnership efforts

The STEM Pathways steering committee, which consists of key representatives from informal STEM organizations, MDE, and MPS, has met regularly since the project began in 2013-14. Additionally, working meetings are held for STEM Pathways educators and steering committee members to learn about each other's organizations and make connections between them, explore best practices in STEM education, and plan for instructional tools to be developed. Implementation team and grade-level workgroups meet to develop teaching materials, and plan and coordinate the activities for fourth- and fifth-grade students.

STEM organizations' leaders and educators and MPS leaders and teachers participated in four working meetings during the planning year. These meetings covered topics on: identifying the common concepts and language for Engineering Design Processes (EDPs) used by partner organizations; learning about the Next Generation Science Standards (NGSS), Minnesota science standards and MPS science curriculum learning targets; research-based practices for engaging students in writing about science; and developing the STEM Pathways logo.

The STEM Pathways steering committee and educators continued to meet to refine and advance project efforts during the first program implementation year. Working meeting topics and task force efforts during this year included: developing the STEM Pathways Portfolio and Career Interactive; continuing to learn about MPS learning targets; adapting the concepts of natural ecosystems to imagine a local STEM learning ecosystem, including its components and resources to thrive; sharing best practices among partners; and defining STEM Pathways values and key messages. A STEM Pathways representative and the MPS K-8 STEM Curriculum Specialist also met with fourth- and fifth-grade teachers and principals at each school to provide information about the project, answer questions and share instructional tools. At the end of the school year, an informal focus group was also held with teachers to gain their perspective on project successes and opportunities for improvement.

At the beginning of 2015-16, the second implementation year, evaluators shared findings from the first implementation year with the STEM educators and leaders and MPS leaders. Partners used the findings to improve programming, including revision of existing and development of new instructional tools as well as a teacher guide. For example, following the meetings, a grade-level workgroup met to strengthen activities (especially on building students' confidence in STEM), share ideas for improving connections between partners, and discuss a career focus. Individual partner organizations further considered evaluation findings to varying degrees. The STEM Pathways project director met with the classroom teachers at each school to share evaluation findings, listen to teachers' interpretations of

findings, and encourage use of STEM Pathways instructional tools. Responsive interviews were conducted with some students by an evaluation consultant in the middle of the program year to gauge their attitudes toward and understanding of their experiences learning STEM in general and with STEM Pathways specifically. The interviews were used to inform programs and program delivery.

The steering committee met ten times throughout the second program year to discuss the future of STEM Pathways beyond the pilot year and participate in strategic planning. The steering committee also worked with evaluators to add small-group interviews with students to the formal evaluation plan, based on the findings from first-year student survey and the mid-year responsive interviews, to better understand students' perspectives on their STEM Pathways experiences and their attitudes toward STEM.

STEM Pathways partner representatives have presented the work of STEM Pathways at several national and local professional conferences throughout the years and published in a refereed journal.

Focus of work in the second program implementation year

Partners were asked during interviews to describe STEM Pathways' goals, and if and how the goals have evolved since the beginning of the project. In describing STEM Pathways, several partners mentioned that the primary goal is to increase student engagement and interest in long-term STEM learning and increase their interest in STEM careers.

> *STEM Pathways is a collaboration of five Twin Cities informal STEM education institutions, Minneapolis Public Schools, and the Minnesota Department of Education to increase the long-term interest and academic achievement of students in STEM and to create an illuminated pathway to future STEM careers. – Partner interviews*
>
> *We are hoping students will become more excited about STEM as they understand all the ways it can be applied in their lives. They gain excitement, interest, skills, and realize [that] it is something they can do going forward. They see themselves in it, so they are developing a STEM identity. – Partner interviews*
>
> *It is intended to test and implement a sequence of STEM learning experiences provided by community organizations in classrooms, connecting with the formal school day, looking at impacts of connected experiences on both outcomes related to interest and engagement and career as well as academic indicators for students. – Partner interviews*
>
> *We offer either field trips onsite or offsite or both, opportunities at schools with science and engineering, and more insight into careers and what people actually do, with the hope of inspiring students toward careers in STEM. – Partner interviews*

Partners felt that STEM Pathways has stayed true to the original primary goal, but the focus of work to achieve this goal has evolved since the beginning of the project. Partners said that the work has changed to be less about building a deliberate sequence of experiences, and more about providing a combination of high-quality STEM experiences for students. There has been more attention given to developing a model for collaboration between formal and informal education institutions and among informal STEM education organizations. Partners also recognized that, even though the focus of the pilot project has been on programs for schools, the collaboration has provided value for the educational services of partner organizations. Over the two implementation years, the purpose and goals of STEM Pathways have become further defined and articulated.

> *I think that the goals are still similar to what they were at the origin…– Partner interviews*
>
> *I think the goals have pretty much stayed the same. We have shifted course on how we got to those goals, so we are focusing more on the objectives [now]. – Partner interviews*
>
> *We have always been focused on the student experience, but one of the things that started to become clearer is this model between the partnerships between the different organizations, including the school district and the Department of Education, just as a model for collaboration in ways that an informal education can support formal education. Also, really in a way that we as an informal educational organization can support each other and look at the way we complement each other and can work together instead of in competition. – Partner interviews*
>
> *I think that we broadened our scope to think about what the impact/value is of all the STEM education services that these organizations provide, not just the ones that occur during the school days. – Partner interviews*
>
> *I guess I would say that initially the idea of a deliberate or clearly sequenced set of experiences with instructional tools was a much stronger component, over time that has loosened up to not be so dependent on a set sequence of events, which was originally part of the model. – Partner interviews*
>
> *The goals have not so much evolved, but have become more clear and succinct. – Partner interviews*

Research methods

In consultation with the STEM Pathways steering committee, Wilder Research developed an evaluation plan for the two project implementation years. Research methods are described below.

Research design

Wilder Research's evaluation has implementation and outcome components addressing the following goals:

- **Implementation evaluation.** Assess project implementation and provide feedback useful for strengthening implementation efforts.
- **Outcome evaluation.** Assess short-term outcomes for project activities and provide initial reporting on long-term indicators reflective of major project goals.

Research questions

The evaluation efforts were guided by the following research questions:

Implementation questions

The implementation component of the evaluation is an important mechanism for understanding project efforts that seem effective and for providing feedback useful for strengthening project activities. Key research questions associated with the implementation evaluation include the following:

1. How successfully is the STEM Pathways model being implemented?
2. What partner and school characteristics are associated with strong implementation? In what ways can implementation be strengthened?
3. How well does the collaboration function, and how can it be strengthened?
4. How effective is professional development, and what are its future needs?
5. What are the core components of the program model and conditions for replication?

Outcome questions

The outcome component of the evaluation addresses changes in systems, perceptions, and student outcomes related to STEM. During the first and second evaluation year, outcome measurement focused on initial system changes, short-term outcomes associated with project activities, and initial measurement of student outcomes reflective of long-term project impact. Research questions for this component of the evaluation include the following:

6. Does the STEM Pathways model enhance the short- and long-term outcomes of populations underrepresented in STEM?
7. How well does the model work for specific underserved populations, and in what context?
8. What impacts does the model have on informal STEM education organizations?
9. What impacts does the model have on classroom teachers?
10. What are the implications for the field of informal science education?

Data collection procedures

Data collection procedures for the evaluation are described below. Specific research questions addressed through each method are denoted.

STEM Pathways partner interviews
(Questions 1-5, 8, 10)

In spring 2016, Wilder Research conducted one-to-one phone interviews with STEM Pathways partners regarding the goals, implementation, and accomplishments of STEM Pathways and about suggestions for changes or improvements for STEM Pathways in the future. Interviews were conducted with members of the steering committee and members of the implementation team. Respondents included the project director for STEM Pathways as well as three representatives from STARBASE, and two representatives each from The Bakken Museum, Minnesota Zoo, The Works Museum, and The Bell Museum of Natural History. Similar interviews were conducted in spring 2015.

Minneapolis Public Schools leader interviews
(Questions 1-4, 6, 7, 9, and 10)

Wilder Research conducted one-to-one phone interviews with MPS leaders in spring 2016, including five of the six school principals, the Director of Elementary Education,

the K-8 STEM Curriculum Specialist, and K-8 STEM Curriculum Integration Specialist. The survey asked MPS leaders about the implementation and accomplishments of STEM Pathways, including its benefits to the district, teachers, and students, as well as suggestions for changes or improvements for STEM Pathways in the future. Similar interviews were conducted in spring 2015.

Teacher survey
(Questions 1-4, 6, 7, 9, and 10)

Wilder Research conducted a web survey with fourth- and fifth-grade teachers from the six STEM Pathways schools in spring 2016. The survey asked teachers about their experiences with STEM Pathways, and its impacts on them, their students, and their school. The survey was completed by 20 out of 34 teachers (59%). Between one and five teachers in each school participated in the survey. Sixteen of the respondents (70%) were fourth-grade teachers and four (30%) were fifth-grade teachers. The teacher survey was not conducted in spring 2015. As mentioned earlier, STEM Pathways representatives held an informal focus group with teachers to gain their perspective on project successes and opportunities for improvement after the first year of project implementation.

Student pre-post survey
(Questions 1, 6, and 7)

A survey was administered to fourth- and fifth-grade students at the six STEM Pathways schools in MPS. The first cohort of students (Cohort 1) attended STEM Pathways schools for two years, in 2014-15 as fourth graders and in 2015-16 as fifth graders, experiencing two years of STEM Pathways programming. The student survey was administered to this cohort in fall 2014 (baseline assessment), and repeated in spring 2015 and spring 2016, providing the opportunity to examine potential changes in their survey responses over two school years. The second cohort of students (Cohort 2), who were fourth graders in the 2015-16 school year, experienced one year of STEM Pathways programming. They took the survey in fall 2015 (baseline assessment) and then again in spring 2016, providing the opportunity to examine potential changes in their survey responses from the beginning to the end of the 2015-16 school year.

The survey was administered to students as a group in their classrooms by Wilder Research staff. After a brief explanation of the survey, Wilder Research staff read the questions and students provided their answers on paper-and-pencil survey forms. A few students who were absent on the day the survey was administered completed it later. Students' parents or guardians were informed about the survey by letter and could have their child excluded from the survey if they wished by contacting the school.

Student survey results are reported for those who completed all or most of the survey each time it was administered to their class. For Cohort 1 (fifth graders in 2015-16), 255 students completed all or most of the survey the three times it was administered over two school years. For Cohort 2 (fourth graders in 2015-16), 345 students completed all or most of the survey in both fall 2015 and spring 2016. Sixteen close-ended survey items were included at all the survey administration points.

Small-group interviews with students
(Questions 1 and 6)

In spring 2016, small-group semi-structured interviews were conducted with fifth-grade students who had been participating in the program for two years. Eleven interviews with groups of four students (a total of 44 students) were interviewed to get in-depth understanding of their experiences in STEM Pathways. Two interviews were conducted at each of five STEM Pathways schools, and one interview was conducted at the remaining school. Parents were required to give consent in order for students to participate in the interviews. Demographic information was compiled to help ensure that the students selected for interviews were representative of the student population as a whole. Based on the desire for demographic representation, preferred interviewees were selected in advance of the interviews; if those students were absent from school, back-up interviewees were included instead.

Academic achievement and attendance data
(Questions 6 and 7)

This evaluation provides student achievement results on indicators reflective of long-term project goals. Data are presented in the areas of math, science, and also reading, in recognition of the potential broader impact of STEM on student development. It is important to recognize that moving the needle on these indicators takes time, and numerous factors contribute to that effort. However, monitoring these indicators during and beyond the pilot project period is important in that ultimately, longer-term participation could increase MPS students' success in STEM areas and narrow achievement gaps. Data are provided from the Minnesota Comprehensive Assessments, Series III (MCA-III), in math, science, and reading.

School attendance is included in the second year evaluation as a student outcome measure.

Data analysis

Minneapolis Public Schools leader interviews and STEM Pathways partner interviews

Evaluators reviewed the interview transcripts and organized the respondent comments by key themes. As appropriate, these comments were also organized by the position or role of the respondents in their organization or in the project.

Student survey

Data are analyzed to examine changes in students' responses over time. Response options to the survey items were: "don't agree", "agree a little", "mostly agree", "agree a lot", and "don't know." Those who agreed a lot or agreed mostly were considered to be in agreement with an item. Statistical tests (McNemar Test, two-sided) were conducted to determine whether change over time in the percentage of students responding "agree a lot" or "mostly agree" to each item was statistically significant ($p<.05$). When the terms "significant" and "not significant" are used in describing such changes in responses, these terms are referring to the results of the statistical tests. For Cohort 1, the significance of changes in responses was assessed over the first school year (fall 2014 to spring 2015), the second year (spring 2015 to spring 2016), and the full two school years (fall 2014 to spring 2016). For Cohort 2 fourth graders, changes were assessed over the 2015-16 school year, from fall 2015 to spring 2016. The changes occurring in Cohort 2 fourth graders' responses in 2015-16 were compared to those occurring for Cohort 1 students during their fourth-grade year, 2014-15.

Differences in survey responses to each survey item were also examined by student demographic characteristics, including gender (male, female), free- or reduced-price lunch eligibility (eligible, ineligible), race/ethnicity (students of color, white), and ELL status (ELL, non-ELL). We tested for differences in the percentage of students who responded "agree a lot" or "mostly agree" to each survey item within the categories of each characteristic (female vs. male, eligible vs. ineligible for free/reduced-price lunch, etc.). In both Cohort 1 and Cohort 2, we tested for these differences in spring 2016 (using Fisher's Exact Test, two-sided).

In addition, evaluators tested to determine changes in responses to each survey item over time among the student demographic groups. That is, we examined changes among males, females, those eligible for free/reduced-price lunch, those ineligible for free/ reduced-price lunch, students of color, white students, ELL students, and non-ELL students. For Cohort 1 these changes were examined for statistical significance (using

the McNemar Test, two-sided) from fall 2014 to spring 2016, and for Cohort 2, from fall 2015 to spring 2016.

Only statistically significant differences ($p<.05$) are reported from the analyses of change by student characteristics.

Small-group interviews with students

The evaluator reviewed interview transcripts and organized the respondent comments by key themes.

Student academic achievement

To assess student achievement, the evaluation uses a quasi-experimental design and analyzes data for cohorts of fourth- and fifth-grade students in the six STEM Pathways schools (treatment) and similar students in non-STEM Pathways schools (comparison). All schools are in MPS.

The evaluation includes cohorts of fourth- and fifth-grade students in these schools in 2014-15. Another cohort of fourth-grade students was added in 2015-16. Figure 10 shows the study cohorts.

10. STEM Pathways cohort groups

	2014-15	2015-16
Cohort 0	5th grade	6th grade
Cohort 1	4th grade	5th grade
Cohort 2	-	4th grade

Academic performance of the STEM Pathways cohort students (treatment) were compared with those of same-grade students from non-STEM Pathways schools (comparison). The evaluation uses a statistical technique (propensity score matching – using exact or one-to-one matching) to match the treatment and comparison group students at baseline, so that the potential effects of STEM Pathways treatment on student outcomes are not confounded by differences in student characteristics between the groups that could influence student achievement. These characteristics include students' prior academic achievement (MCA-III math achievement level in the spring prior to when treatment students received STEM Pathways) and several student demographic characteristics (free or reduced-price lunch eligibility, ELL status, special education status, gender, and race/ethnicity).

Potential STEM Pathways effects were examined through analysis of differences between the treatment and comparison groups in each of the three cohorts on student achievement

measures: MCA-III math, reading, and science (Cohort 1 only) scores. Differences in student achievement between the treatment and comparison groups were examined in each cohort overall and within demographic subgroups. A detailed description of the research design and statistical techniques used in analyzing the student academic data and the findings is presented in another report, STEM Pathways Student Academic Achievement *Results for the 2015-16 School Year* (Mueller & Gozali-Lee, 2016).

Overall strengths and limitations of methodology

Strengths

The study data were collected from multiple perspectives, including STEM Pathways partners, MPS leaders, teachers, and students. Survey and interview instruments were developed thoughtfully and collaboratively with the STEM Pathways steering committee and allowed for triangulation of respondent perspectives on several topics (e.g., partners and MPS leaders identified the status of collaboration). Overall, response rates were high, especially on the student survey. Additionally, the MPS Research, Evaluation, and Assessment (REA) department provided student demographics and academic achievement data for treatment and comparison students.

Limitations

Results of student surveys (i.e., changes in their responses from fall to spring related to STEM learning, interests, and activities) may be associated with participation in STEM Pathways. However, caution is needed in attributing these results to STEM Pathways as students may have had other STEM experiences in and out of school during the same period that could have also contributed to the changes. Additionally, comparisons to perspectives of non-participating students were not available as it was not feasible to conduct the student survey in a comparison group.

Small-group interviews were conducted in English, and 25 percent of students who participated were English Language Learners. Although students were told the researcher was fluent in Spanish, they chose to speak in Spanish on only a few occasions. While the students seemed able to express their thoughts in English, it is possible that their responses may have been different if an interpreter were present.

MCA-III tests were used to assess student academic outcomes in math, science, and reading proficiency. These tests are the academic achievement measures administered to students statewide each spring, and serve as accountability measurement tools in Minnesota. We consider MCA-III test results to be long-term indicators of potential effects of the

program. Measurement for short-term outcomes to assess student comprehension on specific subtopics/units of STEM was not available.

Data privacy and research consent

Wilder Research worked with the MPS REA to ensure evaluation procedures were consistent with district data privacy and research consent requirements. Wilder Research and MPS developed a data confidentiality agreement at evaluation onset safeguarding data security, and REA approved evaluation plans. REA also reviewed and approved all data collection instruments and consent procedures used in the course of this evaluation.

Implementation

STEM Pathways' goals for implementation include:

- Providing students with access to multiple STEM Pathways partner programs.
- Providing connections between STEM Pathways partner experiences via shared messages, vocabulary, concepts and instructional tools.
- Offering high quality, relevant STEM experiences for STEM Pathways students.

In both years of pilot project implementation, fourth- and fifth-grade students received almost 30 programming hours from STEM Pathways partners. The following are the grade-level program descriptions.

Programs for students

Fourth-grade programs

In the fourth-grade STEM Pathways program sequence, students participate in real world STEM learning that helps them see a bigger picture of how STEM works and how it relates to them, specifically around the practices and process of science and engineering and STEM careers. The following organizations offer fourth-grade programs:

The Works Museum

Program hours: 3-hour field trip

Students travel to the museum to explore interactive museum exhibits and participate in the Maze Engineering Workshop. Students use the Engineering Design Process to design and construct their own maze, pinball or pachinko game to take home. They experiment with changes in speed and direction and the effects of gravity and friction.

The Bakken Museum

Program hours: 1 assembly hour, 2 classroom hours and a 3.25-hour field trip

On the first visit to the school, Bakken educators invite all fourth graders to explore what it means to "Wonder, Try, Discover, Share"—important habits of every scientist and engineer. On the second visit, fourth-grade students apply "Wonder, Try, Discover, Share" as they re-invent the battery, practice supporting their claims with evidence, and learn the importance of taking risks and making mistakes in the process of discovery. Next, students visit The Bakken Museum to participate in a hands-on workshop and a guided exhibit tour to explore magnetism and electricity. During the tour, students also explore the history of science and

invention via storytelling and interactive exhibits. Every student takes home materials to construct an electromagnet for their own experiments. The final classroom experience is led by a Bakken educator and a volunteer from the STEM workforce who help students connect the STEM they do in school to real careers while they engage in problem solving to explore a real world challenge involving electromagnetism and energy.

STARBASE Minnesota

Program hours: 20 hours

At STARBASE Minnesota, students learn to be engineers as they design solutions to challenges related to traveling from Earth to Space. As students design rockets, rover programs, landers, and other prototypes, including 3D printed rocket fins, they develop and utilize science knowledge and skills related to forming questions, conducting experiments, inertia, heat transfer, properties of air, and more. Students apply math skills such as data collection, median, measurement, estimation, and graphing as tools in the engineering process.

Fifth-grade programs

The fifth-grade STEM Pathways program sequence builds on the fourth-grade sequence and introduces additional connecting themes. STEM Pathways fifth-grade programs address the complexity and impact of change on systems. The following organizations offer fifth-grade programs:

Minnesota Zoo

Program hours: 4-hour field trip

Through the Minnesota Zoo's Zoo Safari program, students learn about animals and their habitats and participate in the Bare Necessities class. In this class, students learn about how ecosystems function and make predictions of impacts on habitats as a result of changes in ecosystems. Students gain deeper understanding of ecosystem dynamics and greater appreciation for the important roles everyone can play in the system. Following the workshop, students tour the Zoo's exhibits.

Bell Museum of Natural History

Program hours: 1 classroom hour and a 4-hour field trip

The program *Honey Bees, Pollinators, and Food* examines human interdependence with nature. Student scientists exercise critical thinking and literacy skills as they explore the concept of biological diversity, the process of science, and the connection between our food and a healthy environment. Students use scientific tools and processes—such as microscopes, forceps, and dissections—to make observations of the anatomy of bees and flowers. Students learn about current research at the University of Minnesota and apply their knowledge about

pollinators as they plan meals, and discuss and analyze the impact of the disappearance of pollinators on the meals they've prepared. A tour of the Bell Museum's dioramas allows the students to see some of the native habitats that are beneficial to pollinators. This program is structured to empower student scientists to learn more about where their food comes from, and how humans are connected to the many processes and relationships in obtaining food and maintaining a healthy environment.

STARBASE Minnesota

Program hours: 20 hours

At STARBASE Minnesota, student engineers develop and utilize their knowledge of energy transfer and energy systems, properties of air, Newton's Laws of Motion and more as they design a mission from launch, to landing, to living on Mars, including designing and testing 3D printed prototypes. Students apply math skills related to coordinate graphing, calculating mean, volume, area, and graphical data analysis as they complete their mission.

MPS program

In addition to the above programs, students can choose to participate in the MPS STEM program.

GEMS/GISE

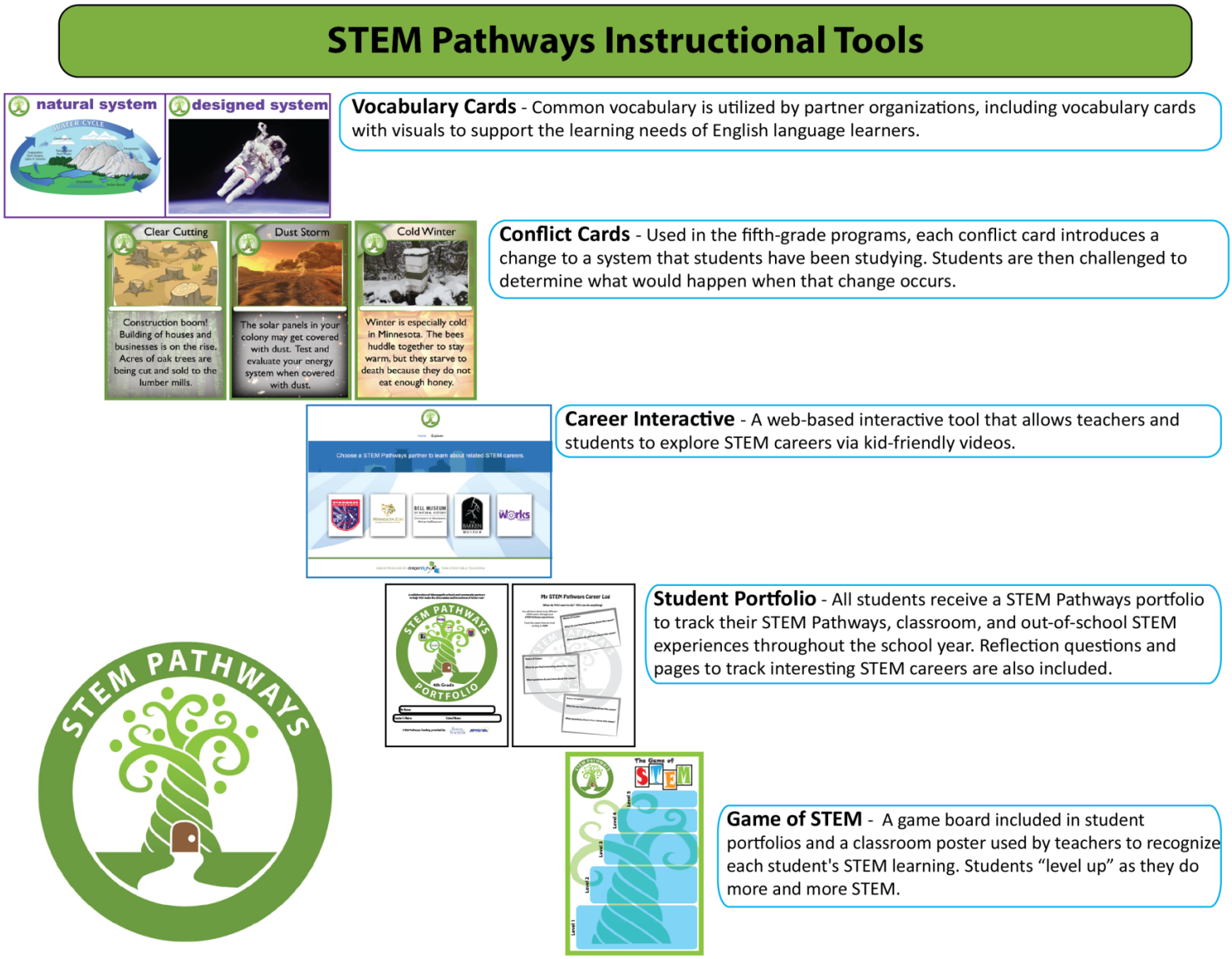
Afterschool and summer program

Girls in Engineering, Mathematics and Science (GEMS) and Guys In Science and Engineering (GISE) are elective afterschool and summer programs designed specifically for fourth- through eighth-grade students in all MPS schools. Project- and problem-based learning experiences promote integration of engineering and technology concepts, content, and process. Students participate in an academic culminating event involving a design challenge.

Instructional tools for teachers and partners

In addition to connecting themes and concepts, STEM Pathways programs use shared instructional tools and messaging (Figure 11). Vocabulary and conflict cards are intended for use by partners as part of STEM Pathways programs, while the career interactive, Student Portfolio and game of STEM are provided to teachers for use in their classrooms, to extend STEM learning beyond the classroom, and to promote further pursuit of STEM.

11. STEM Pathways Instructional Tools



Source: STEM Pathways

A teacher guide was developed between the first and second implementation years, based on teacher feedback during the informal focus group held in the spring of 2015. This guide included detailed information about partner programs and instructional tools.

In the survey, most teachers (84%) reported that they used the reflection pages of the STEM Pathways materials as a resource, and over 60 percent said they used career resources and/or activities in the Student Portfolio (Figure 12). Less than half of teachers (47%) said that they used the game of STEM as a resource.

12. Resources used by teachers

Did you use…	N	Yes	No
Reflection pages	19	84%	16%
Career resources	19	68%	32%
Activities in the Student Portfolio	18	61%	39%
Game of STEM	19	47%	53%

Teachers described how they used the different resources in their classes; their responses are summarized below. A few teachers also mentioned some challenges in using them.

Reflection pages: All teachers who responded 'yes' to this question said they used the reflection pages after participating in STEM Pathways programming. Teachers did not mention any issues with the reflection pages or give suggestions for improvement.

Career resources: Teachers felt that the career resources were a good way for students to learn more about different STEM careers and they reported using career resources to make connections between STEM Pathways experiences and STEM professionals who work in related fields. Three teachers noted that they experienced technical difficulties while trying to view the videos.

Student Portfolio: Teachers described the Student Portfolio as a supplemental component for students to work on independently, and provided specific examples of what the Student Portfolios covered, including circuitry and magnetism. Two teachers said that they did not consistently use the portfolios with their students.

Game of STEM: Teachers thought that game of STEM had great ideas for classroom activities and felt that it was useful in engaging students before and after STEM Pathways experiences. A couple of teachers noted that it was a bit difficult and time intensive to use, which they said discouraged them from fully utilizing it.

STEM Pathways partners also reported using several tools and resources that were developed and prioritized by STEM Pathways to varying degrees, including:

- Shared vocabulary represented on vocabulary cards
- Common concepts and themes
- Engineering Design Processes
- Conflict cards
- Graphics to help students recognize and develop confidence in teamwork, creativity, perseverance and increased STEM skills
- Career resources
- Handouts with the STEM Pathways logo
- Student Portfolio
- Program passport with participation stamps

The tools and resources most commonly mentioned by partner organizations as the most valuable to them were:

Career resources

> *I think the resources related to STEM careers have been the most valuable – easiest scheme to carry across from all of the organizations – easy to relate jobs to other organizations and the skills are broadly applicable. Those resources for teachers are also most valuable. – Partner interviews*

Graphics/handouts

> *I think the four graphics [used at STARBASE] have been really helpful, because some of the stuff we work through with students is really challenging, and that can be frustrating. But we can remind them what they've learned and how much perseverance they have shown. We remind them it is part of the process and they are doing great at it, even though they're frustrated. – Partner interviews*
>
> *[In the] handout they receive, they see … the STEM Pathways graphic, these big-picture thinking ideas that I described, using creativity and collaboration and teamwork. I think that's been really useful to tie it all together. – Partner interviews*

Student Portfolio/worksheets

> *For the [Student] Portfolio, we developed a take-home activity [about electromagnets]. The Portfolio was valuable as a reflection piece. It allowed us to get insight into how [students] saw their experience. – Partner interviews*

> *I think the teachers really liked the worksheets that helped students reflect. They were part of the Portfolio. – Partner interviews*

Perspectives from partners, MPS leaders, teachers, and students

The following section provides results from interviews with STEM Pathways partners and MPS leaders, the teacher survey, and small-group interviews with students in spring 2016. The findings are organized by research questions.

Research question 1.

How successfully is the STEM Pathways model being implemented?

Overall, STEM Pathways partners, MPS leaders, and teachers felt that they successfully implemented STEM Pathways in 2015-16. Partners felt that their commitment to working toward a common goal of improving student learning was a major accomplishment of this collaborative. MPS leaders and teachers appreciated the materials and communication between partners and teachers throughout the year to highlight areas of connection between STEM Pathways activities and the Minnesota state standards and MPS curriculum. They also described how STEM Pathways promoted student STEM learning and interest by showing them the connections between what they learn in class and STEM applications in the real world. In the small-group interviews, students described their STEM Pathways experiences as special, fun and helpful to their learning.

Finding: Partners share a common goal of making a positive impact on students and value the commitment of working together.

> *[The biggest accomplishment has been the] collaboration on a scale and ground level to move this project from concept to implementation, making a commitment to do what is best for kids with little incentive/funding. I think that is the greatest accomplishment in my mind. – Partner interviews*
>
> *It is a valuable model of how organizations can work together and accomplish more as a whole than as individual organizations. – Partner interviews*
>
> *I think it is the shared goal of having an impact on students. The biggest takeaway is that we really want to have a positive impact on these students and, by working together, we can. – Partner interviews*
>
> *I really think it is that commitment by each institution to … STEM … in this community to help students see themselves [as scientists and engineers] and create that STEM identity for their … future[s], for filling jobs and being informed and educated citizens going forward. – Partner interviews*

Finding: MPS leaders felt that STEM Pathways promotes student STEM learning and interest by showing them the connections between what is learned in class and STEM

applications in the real world and, in particular, by raising their awareness of STEM-related careers.

> *Looking through 4th grader responses, you can see several students talking about wanting to be an astronaut, or a mathematician, and not just typical careers like doctor or teacher. There are a whole lot of future prospects and career paths that have opened up. – MPS leader interviews*
>
> *They [STEM Pathways educators] have been great with providing resources and real-life applications in STEM careers and how STEM activities can help their [students'] growth and development as future career folks. Its been a really big positive. – MPS leader interviews*
>
> *I know that they're putting it more at the forefront. Kids are more interested in being a scientist or an engineer, or looking at math through a different lens, where you can apply it to different careers out there. – MPS leader interviews*
>
> *One of the ways the community partners amped up is what students don't get to see in the classroom, [which] is different careers in STEM fields. So when they go to organizations, they get to see scientists and engineers and mathematicians working in fields they may not know are available, and they get to explore the careers – have a real world application where they get to see engineers in action, see the careers they could be when they grow up. – MPS leader interviews*

Finding: STEM Pathways lessons align with Minnesota academic standards, according to MPS leaders, partners, and teachers. Leaders noted that partner organizations provided materials and communication to teachers to highlight how STEM Pathways activities connect with state standards and district curriculum.

> *They work with the district folks to make sure what the standards are that we are going to focus on. People get that information and will talk with teachers, help teachers highlight curricular areas. It's a team effort. Both math and science have a million standards, so I think these are opportunities for the partners to pull out what standards they're going to focus on so the teachers can do that too. – MPS leaders*
>
> *I think what I see is the alignment between standards and what's happening in school, tying it to learning outside of school walls. Kids aren't learning a separate thing outside of school; they can see the connections between what they've done and work in the building here. We worked hard to bring alignment, and the communication [between us and partners] was really helpful. – MPS leader interviews*
>
> *A number of teachers have commented to me that they appreciate the way it has helped prepare their students better for the MCAs. I think it has been a nice way for the teachers to have some exciting examples for the students of the things they will get to do this year to bring science and engineering to life. That can be intimidating to teach, so our work can supplement their own lessons and strengthen their own curriculum. – Partner interviews*
>
> *Teachers consistently tell us... that the [STEM Pathways] program and curriculum are relevant and reach [the] standards… – Partner interviews*
>
> *I would say by providing materials, training, coming to talk to staff at the beginning of the year. It's been beneficial to have reconnection through the year for questions and follow up. – MPS leader interviews*

All teachers in the survey agreed or strongly agreed that STEM Pathways supports the state standards and the MPS curriculum and does so in meaningful ways (Figure A1).

Finding: Students indicated that STEM Pathways experiences helped them learn and are fun, different from, and better than other field trips and classroom visits.

> *They're way better… because it's a fun way for me to learn.*
> *– Small-group interviews with students*
>
> *The STEM Pathways field trips are the ones that actually really, really helped. The other ones let us learn too, but we didn't really get to do much.*
> *– Small-group interviews with students*
>
> *It helps you with your education, and plus you get to do things that you don't get to do anywhere else. – Small-group interviews with students*
>
> *I like STEM because it's special. You don't get to do that every day.*
> *– Small-group interviews with students*

Research question 2.

What partner and school characteristics are associated with strong implementation? In what ways can implementation be strengthened?

A number of characteristics relevant to strong implementation emerged during the three-year pilot program. Both partners and schools indicated the importance of clear communication. Partners also pointed to the importance of networking, understanding each other's programs, collaborative professional learning opportunities, and shared evaluation to implementing connected STEM learning experiences for schools. When it comes to working with schools, partners noted that program implementation was most effective at schools where STEM learning is a priority and where there is strong teacher and/or principal advocacy for participation in STEM Pathways. MPS teachers, principals, and district leaders highlighted qualities of STEM Pathways that make it a strong and unique program that enhances and inspires STEM learning in schools that they would like to see continue and expand to more students and schools. These characteristics include: connections to real-world applications of STEM, exposure to STEM careers and the broad value of STEM skills in the workplace, alignment with district curriculum and state standards, and inspiring excitement for STEM learning for students and teachers alike.

At the end of the first implementation year, Wilder conducted interviews with STEM Pathways partners and MPS leaders to provide feedback that could help partners improve collaboration and implementation in the second implementation year. Partners and leaders reflected that more time for planning, communication, and reinforcing shared goals is important for successful implementation. Partners specifically mentioned interest in better implementing shared vocabulary and crosscutting concepts, practices, and core

ideas strategically across partner programs. The challenge of collaborative development of instructional tools was also noted—partners indicated interest in more collaborative involvement in the development and use of instructional tools. However, from a practical perspective, small development teams were required to develop tools on schedule. Partner educators expressed eagerness for more time to work together. MPS leaders recommended more communication with teachers about schedules and activities and asking for their feedback; teachers also made recommendations for improved communication during an informal focus group at the end of the first implementation year.

These findings led partners to develop a teacher guide that included detailed logistical and programmatic information, improvements to the Student Portfolio, increased use of shared vocabulary and other instructional tools by partner educators, and a focus on instructional strategies to increase student confidence in their STEM abilities.

Both partners and MPS leaders pointed to the importance of sufficient and sustainable funding for effective program implementation over time.

Finding: Overall, there seems to be clearer understanding of the focus of the work during the second implementation year.

Findings from the second implementation year show that MPS leaders, teachers, and STEM Pathways partners have clear and consistent articulations of the project's primary goal, which is to increase student engagement and interest in long-term STEM learning and increase student interest in STEM careers.

> *We offer either field trips onsite or offsite or both, opportunities at schools with science and engineering, and more insight into careers and what people actually do, with the hope of inspiring students toward careers in STEM. – Partner interviews*
>
> *I know that they're putting it more at the forefront. Kids are more interested in being a scientist or an engineer, or looking at math through a different lens, where you can apply it to different careers out there. – MPS leader interviews*
>
> *Being part of STEM Pathways has helped me to think more about the connections between the content I am teaching. It has also helped me link the learning in the classroom with the work many professionals do for their career. – Teacher survey*

Finding: MPS leaders and teachers recognize that the importance of partners' efforts to foster student learning by showing them the connections between what is learned in class and STEM applications in the real world.

> *The use of decimals at STARBASE allowed students to better see the importance of measuring into the hundredths and tenths; it improved their interest and understanding when we studied decimals in math. – Teacher survey*

> *I think it goes back to real life engagement and activities… so many things to learn, how science fits in with the real world. Students are making those connections to core academics and fascinating things you do with little bits of knowledge, accessing new knowledge. – MPS leader interviews*

In the small-group interviews, students talked about using science, technology and engineering in STEM Pathways programs and named topics, such as pollination, electricity, and animals as specific examples of topics covered in STEM Pathways and at school. Students also discussed using specific math concepts (e.g., measurement, area, mean, and volume) both in STEM Pathways programs and at school.

> *We were learning about surface area and finding the area of a 3D shape, and that really helped here at school. – Small-group interviews with students*

Comments from MPS leaders, teachers, and partners on ways to improve STEM Pathways programming can be found in the **Opportunities for growth** section at the end of the report.

Research question 3.

How well does the collaboration function, and how can it be strengthened?

Overall, MPS leaders, teachers, and partners viewed the collaboration very positively. Examples of factors that contributed to success include: support and communication with teachers by STEM Pathways representatives throughout the year; soliciting of teachers for feedback and ideas for improvement; support of MPS curriculum; and sense of value of collaboration, commitment to work together, and shared goals by STEM Pathways partners. All responding MPS leaders and teachers expressed their wish to continue collaborating with the STEM Pathways partners and for STEM Pathways programming to continue in their schools. A few suggestions for program improvements from MPS leaders, teachers, and partners can be found in the **Opportunities for growth** section.

Research question 4.

How effective is professional development, and what are its future needs?

STEM Pathways partners reported that the opportunity to network, learn about other informal education organizations and their programs, and learn about best practices in STEM education was beneficial, especially for educators at partner organizations.

Finding: Partners appreciate the networking opportunity with other informal education organizations, discussing common goals, sharing successes and challenges, and brainstorming new ideas.

> *I really enjoy and value being able to be part of a network of my peers. Being able to, even if we're not always talking about STEM Pathways, but being able to network with other directors of education of informal science institutions in the cities… [it] has been really valuable to discuss challenges and discuss our successes, and look for commonalities in our goals and ways to strengthen each other. – Partner interviews*
>
> *Informal organizations tend to operate in isolation, even in competition with each other. Through STEM Pathways we were able to develop a common thread between organizations that don't seem to have common relationships on the surface. – Partner interviews*
>
> *For me and my staff, working with other people doing similar work is very exciting and energizing. – Partner interviews*

Finding: Partners have gained knowledge through learning about how other informal education organizations operate and what their programming offers students.

> *It has been an amazing awareness building experience as far as what other informal education organizations are doing. I learned a lot about different structures of different kinds of field trips. Just the difference in the way we offer our programming and design our field trips, understanding funding and how it works, understanding other barriers for organizations and schools, starting to see how a partnership like this looks in the schools and how it works for teachers. – Partner interviews*
>
> *It has given us opportunities to hear new ideas. Colleagues are always bouncing ideas off each other. It is great to get fresh perspectives on ways to approach instruction in science and engineering. We get a fresh look at things when we talk to partners about things we cover that set off little light bulbs about what we might offer; new approaches to doing things that we would not have thought of before. – Partner interviews*
>
> *I think the opportunity to work with the variety of different organizations. I think there was always this… in the past, with museums working together, there was this skepticism and competitive nature, I think that thinking has changed and evolved, and there is room to work with other institutions to get new ideas and find different ways to collaborate now. – Partner interviews*
>
> *All of our instructors have a greater knowledge about the other partner programs, concepts, and strategies, and therefore we can continue to reference those experiences with any student who comes through the program. – Partner interviews*

A few suggestions from MPS leaders, teachers, and partners regarding improvements in professional development can be found in the **Opportunities for growth** section.

Research question 5.

What are the core components of the program model and conditions for replication?

Interviewees from partner organizations identified the following key conditions for successful implementation of STEM Pathways:

- Total buy-in and commitment from all partners, the school district, schools, and teachers.
- Strong leadership and direction from the steering committee.
- Endorsement and advocacy on the part of the district to principals and teachers at participating schools.
- Small-group work (e.g., fourth- and fifth-grade cohorts, implementation team, steering committee).
- Collaboration—meaningful input from every partner involved.
- Ensuring that each partner consistently implements agreed upon programmatic components (e.g., in referencing the STEM Pathways Portfolio).
- Sufficient funding.

Through its planning process during this past year, the STEM Pathways steering committee has identified unique and important assets that STEM education providers contribute to the STEM learning ecosystem. These assets are particularly relevant for effective collaboration between organizations as well as partnership with schools. These assets include:

- Effective instructional practices for actively engaging young people in STEM learning.
- Examples of authentic real-world applications of STEM.
- Exposure to a broad array of STEM careers and the broad utility of STEM skills in the workplace.
- Development of key aspects of positive student STEM identity, such as: awareness, interest, engagement and confidence.
- Meaningful connections between different STEM learning experiences offered by STEM education providers and in school that build on each other over time.

The pilot project also helped the steering committee to identify important **practices** for collaboration effectiveness and success that are central to STEM Pathways, including:

- Collaborative learning that promotes professional growth across programs and organizations.
- Clear and consistent messaging that communicates shared vision and goals to audiences and stakeholders.
- Shared instructional practices grounded in research and experience that reinforce desired outcomes across programs and over time.
- Information-driven decision-making that enhances STEM programs individually and the collaboration as a whole.
- Independent leadership that serves as a support and catalyst to enable collaborative process and achieve collective impact on behalf of all partners, stakeholders, and the community.

Outcomes

The evaluation assessed short-term outcomes associated with change in student perceptions about STEM learning and opportunities, student school outcomes related to STEM Pathways long-term impacts, and overall systems change efforts.

Student surveys and small-group interviews, a teacher survey, MPS leader interviews, and student academic achievement data were used to address the following questions.

Research question 6.

Does the STEM Pathways model enhance the short- and long-term outcomes of populations underrepresented in STEM?

Research question 7.

How well does the model work for specific underserved populations, and in what context?

Student survey

Evaluators used the student survey to assess changes over time in student awareness, interest, and confidence in STEM. A summary of the overall pattern of results across the two years of STEM Pathways implementation and results by topic area and student characteristics are presented. Figure 15 compares the results for each item in Cohort 2 to those in Cohort 1 in the fall and spring of fourth grade. Figure 16 shows the results for each item in Cohort 1 for those students who completed the survey all three times during the fourth and fifth grades. Characteristics of students participating in the survey and included in the analysis are presented in Figures 13 and 14. Comprehensive results can be found in the full report, *STEM Pathways Student Survey Results for the 2015-16 School Year* (Mueller & Gozali-Lee, 2016).

Student demographic profiles

Demographic profiles of Cohort 1 and 2 students in fourth grade (who completed the survey in both the fall and spring of fourth grade) are presented in Figure 13. These profiles are shown side-by-side because we will be comparing the survey results of these two cohorts in fourth grade. Note that the two profiles are very similar on the characteristics examined. In each cohort, the number of females and males is evenly divided, the distribution by race/ethnicity is very similar, those eligible for free/reduced-price lunch is just over three-quarters, those who are ELL is somewhat over one-third, and those receiving special

education services is about one-tenth. The lack of differences in demographic characteristics suggests that any differences found in survey results between the two cohorts is unlikely to be due to differences on these characteristics.

13. Characteristics of fourth grade students who completed the student survey in both the fall and spring: 2015-16 and 2014-15 school years

		Fourth graders	
		Cohort 2 2015-16	Cohort 1 2014-15
Student characteristics		(N=345)	(N=353)
Gender	Female	50%	49%
	Male	50%	51%
Race/ethnicity	American Indian	2%	2%
	African American	34%	31%
	Asian	5%	7%
	Hispanic	33%	35%
	White	26%	25%
Free/reduced-price lunch	Eligible	77%	78%
	Not eligible	23%	22%
English Language Learner (ELL) status	ELL	36%	39%
	Not ELL	64%	61%
Special education	Yes	11%	9%
	No	89%	91%

Figure 14 shows the demographic profile of Cohort 1 students who completed the student survey all three times (fall 2014, spring 2015, and spring 2016). Note that the number of these students (255) is almost 100 fewer than the number who completed the fall 2014 and spring 2015 surveys in fourth grade (353, as shown in Figure 13). This smaller group of students from Cohort 1 are likely less mobile than the larger, original group of students since they completed the survey all three times, indicating that they continued to attend STEM Pathways schools over a two-year period. Compared to the fourth-grade group in Figure 13, this smaller group is somewhat less likely to be African American, eligible for free/reduced-price lunch, and ELL.

14. Characteristics of fifth graders (Cohort 1) who completed the student survey in fall 2014, spring 2015, and spring 2016

Student characteristics		Cohort 1 (N=255)
Gender	Female	50%
	Male	50%
Race/ethnicity	American Indian	1%
	African American	24%
	Asian	8%
	Hispanic	38%
	White	28%
Free/reduced-price lunch	Eligible	71%
	Not eligible	29%
English Language Learner (ELL) status	ELL	33%
	Not ELL	67%
Special education	Yes	9%
	No	91%

Overall pattern of results

The comparison between the fourth-grade survey results of Cohort 2 in 2015-16 and Cohort 1 in 2014-15 indicates that overall Cohort 2 had stronger results. For example, statistically significant improvement (i.e., greater agreement with survey items from fall to spring) occurred for 9 of the 16 survey items in Cohort 2 compared with 6 of 16 for Cohort 1. For four of the five survey topic areas, Cohort 2 had larger increases in agreement than Cohort 1, higher percentages agreeing with the items at the end of the school year, or both. These results may be related to the STEM Pathways program being more fully implemented in the second year than in the first year.

For Cohort 1, survey results were stronger overall at the end of their fifth-grade year (spring 2016) than they were after the end of their fourth-grade year. That is, the percentages agreeing with the survey items at the end of fifth grade were either higher or about the same as they were at the end of fourth grade. Two items that did not have statistically significant increases in agreement at the end of fourth grade (knowing about STEM-related activities outside of school and liking to learn technology) did have significant increases by the end of fifth grade. One item that had a significant decrease in agreement after the first year (being really good at STEM) had a significant increase in agreement the second year.

Results by content area

The following section summarizes the results by content areas: awareness and relevance of STEM, STEM interest and confidence in STEM abilities, interest in STEM subjects, application of STEM to problem solving, and careers using STEM.

Awareness and relevance of STEM

Students' awareness of STEM and belief in its relevance increased in both cohorts. From fall to spring, Cohort 2 fourth graders had a significant increase in their view of the importance of STEM knowledge to their futures, their awareness of STEM in the world around them, and their knowledge of STEM-related out-of-school activities. In Cohort 1, agreement with the first two items also increased significantly in the fourth-grade year and continued to increase slightly in the fifth-grade year. Agreement with the third item (their knowledge of STEM-related out-of-school activities) increased significantly in fifth grade and was a significant increase over the two-year assessment period. Agreement with a fourth item in this topic area (frequently doing STEM-related out-of-school activities) did not change significantly in either cohort over time.

STEM interest and confidence in STEM abilities

Agreement with two of the four items in this topic area increased significantly from fall to spring among Cohort 2 fourth graders. These two items concerned liking to learn STEM and being really good at STEM. In Cohort 1, agreement with liking to learn STEM increased significantly in fourth grade but agreement with being really good at STEM decreased significantly. However, agreement with this latter item increased significantly in fifth grade so that the level of agreement at the end of fifth grade was nearly the same as at the beginning of fourth grade. Agreement with wanting to do more STEM-related activities and thinking one would be good at a job that uses STEM did not change significantly in either cohort over time.

Interest in STEM subjects

Students were asked if they liked learning each of the four STEM subjects. The percentage of fourth graders in Cohort 2 and Cohort 1 who liked learning engineering increased sharply from fall to spring. In Cohort 1, the increase in agreement with liking to learn engineering at the end of fourth grade was maintained at the end of fifth grade. Relatively high percentages of fourth graders in both cohorts agreed that they liked learning the other three STEM subjects (science, technology, and math) in both the fall and the spring. In Cohort 2, agreement with liking science decreased a small (but statistically significant) amount from fall to spring. In Cohort 1, the percentage agreeing that they liked learning

technology increased significantly from the beginning of fourth grade to the end of fifth grade.

Application of STEM to problem solving

Agreement of Cohort 2 fourth graders with the two items on applying STEM to problem solving increased significantly from fall to spring. These two items concerned using technology to solve problems and thinking like an engineer to design solutions to problems. Among fourth graders in Cohort 1, there was a significant increase in agreement with the engineering item but not with the technology item. The increase in the engineering item was maintained through fifth grade.

Careers using STEM

In both cohorts, fourth graders' agreement increased significantly for the item concerning knowing about many jobs that use STEM. In Cohort 1, this agreement continued to increase in fifth grade. Agreement with two other career-related items did not change significantly in fourth grade in either cohort, one thinking about being good at a job that uses STEM (mentioned above) and another about wanting to have a job that uses STEM. Slightly over half of fourth graders agreed with these items. The level of agreement with these items did not change over the two school years in Cohort 1.

15. STEM Pathways Student Survey: Fourth graders (Cohort 2 in 2015-16 and Cohort 1 in 2014-15)

Percentage of students answering "agree a lot or mostly agree" [a]

Item	School year	Number	Fall	Spring	Signif. Test
STEM awareness and relevance					
STEM knowledge is very important to my future.	2015-16	334	64%	76%	*
	2014-15	343	67%	75%	*
I notice STEM in the world around me every day.	2015-16	335	52%	65%	*
	2014-15	349	52%	61%	*
I know about many STEM-related activities that happen outside of school.	2015-16	334	40%	53%	*
	2014-15	345	43%	45%	
I frequently do STEM-related activities outside of school.	2015-16	337	47%	44%	
	2014-15	347	41%	40%	
STEM interest and confidence					
I like learning STEM.	2015-16	337	69%	78%	*
	2014-15	346	73%	78%	*
I would like to do more STEM-related activities.	2015-16	335	62%	67%	
	2014-15	348	67%	68%	
I am really good at STEM.	2015-16	338	54%	63%	*
	2014-15	343	60%	48%	*
I would be good at a job that uses STEM.	2015-16	335	55%	58%	
	2014-15	340	54%	54%	
Interest in STEM subjects					
I like learning math.	2015-16	336	72%	77%	
	2014-15	344	72%	74%	
I like learning science.	2015-16	338	83%	78%	*
	2014-15	345	81%	83%	
I like learning engineering.	2015-16	339	56%	76%	*
	2014-15	339	57%	81%	*
I like learning technology.	2015-16	336	76%	80%	
	2014-15	344	79%	85%	
How much do you like studying science? (percentage answering "quite a bit" or "very much" [b]	2015-16	333	83%	77%	*

15. STEM Pathways Student Survey: Fourth graders (Cohort 2 in 2015-16 and Cohort 1 in 2014-15) (continued)

Percentage of students answering "agree a lot or mostly agree" [a]

Item	School year	Number	Fall	Spring	Signif. Test
Application of STEM to problem-solving					
I use technology to solve problems.	2015-16	340	53%	64%	*
	2014-15	344	55%	54%	
I think like an engineer to design solutions to problems.	2015-16	334	45%	61%	*
	2014-15	339	50%	58%	*
Careers using STEM					
STEM knowledge is very important to my future.	2015-16	334	64%	76%	*
	2014-15	343	67%	75%	*
I know about many jobs that use STEM.	2015-16	325	50%	68%	*
	2014-15	334	57%	67%	*
I would be good at a job that uses STEM.	2015-16	335	55%	58%	
	2014-15	340	54%	54%	
When I get older, I would like to have a job that uses STEM.	2015-16	333	50%	55%	
	2014-15	343	55%	53%	

[a] Response options for the survey items are: don't agree, agree a little, mostly agree, agree a lot, and don't know.

[b] Response options for the survey items are: very little, some, quite a bit, and very much, quite a bit.

** Statistically significant (p<.05) using the McNemar Test, two-sided.*

16. STEM Pathways Student Survey: Cohort 1, fourth and fifth grades

Item	Number	Percentage of students answering "agree a lot or mostly agree" [a] 1. Fall 2014	Signif. test 1 vs. 2	2. Spring 2015	Signif. test 2 vs. 3	30 Spring 2016	Signif. test 1 vs. 3
STEM awareness and relevance							
STEM knowledge is very important to my future.	246	66%	*	77%		81%	*
I notice STEM in the world around me every day.	252	52%	*	61%		65%	*
I know about many STEM-related activities that happen outside of school.	250	40%		44%	*	55%	*
I frequently do STEM-related activities outside of school.	252	40%		41%		39%	
STEM interest and confidence.							
I like learning STEM.	252	75%		77%		79%	
I would like to do more STEM-related activities.	251	68%		67%		63%	
I am really good at STEM.	249	59%	*	46%	*	55%	
I would be good at a job that uses STEM.	246	54%		53%		53%	

16. STEM Pathways Student Survey: Cohort 1, fourth and fifth grades (continued)

Item	Number	Percentage of students answering "agree a lot or mostly agree" [a] 1. Fall 2014	Signif. test 1 vs. 2	2. Spring 2015	Signif. test 2 vs. 3	30 Spring 2016	Signif. test 1 vs. 3
Interest in STEM subjects							
I like learning math.	249	73%		75%		75%	
I like learning science.	251	80%		82%		78%	
I like learning engineering.	244	56%	*	82%		79%	*
I like learning technology.	246	79%		85%		86%	*
Application of STEM to problem-solving							
I use technology to solve problems.	249	56%		53%		60%	
I think like an engineer to design solutions to problems.	246	50%		57%		59%	*
Careers using STEM							
STEM knowledge is very important to my future.	246	66%	*	77%		81%	*
I know about many jobs that use STEM.	237	61%		69%		74%	*
I would be good at a job that uses STEM.	246	54%		53%		53%	
When I get older, I would like to have a job that uses STEM.	247	53%		53%		57%	

[a] *Response options for the survey items are: don't agree, agree a little, mostly agree, agree a lot, and don't know.*

**Statistically significant (p<.05) using McNemar Test, two-sided.*

Results by student characteristics

Overall results of the student survey do not indicate advantages for underrepresented students. The survey results were examined for differences by student demographic characteristics (gender, free/reduced-price lunch eligibility, race/ethnicity, and ELL status). For many of the survey items, there were few or no differences in level of agreement by student characteristics in spring 2016. However, several patterns of note emerged from the analysis (Figures A2-A4).

In both cohorts in spring 2016, ELL students were less likely than non-ELL students to agree that they: were really good at STEM, would be good at a job that uses STEM, and knew about many STEM jobs. In Cohort 1, students of color were less likely than white students to agree that they: would be good at a job that uses STEM, would like a job that uses STEM when they get older, and knew about many STEM jobs. These differences by ELL status and race/ethnicity in spring 2016 sometimes reflected baseline differences between the groups, and sometimes were due to differences in the change that occurred in agreement with the items between the groups from baseline to spring 2016.

In Cohort 2, there were differences on a number of items between those eligible and ineligible for free/reduced-price lunch in spring 2016. Those eligible for free/reduced-price lunch were less likely than those ineligible to agree that they would be good at a job that uses STEM and that they knew about many STEM jobs. In addition, those eligible for free/reduced-price lunch were less likely than those ineligible to agree that: STEM knowledge is very important to their future, they notice STEM in the world around them, and they know about many out-of-school STEM-related activities. Finally, those eligible for free/reduced-price lunch were less likely than those ineligible to agree that they like learning engineering and that they think like an engineer to design solutions to problems. Despite these differences, Cohort 2 students eligible for free/reduced-price lunch increased their agreement with most of these items significantly from fall to spring of fourth grade. However, the increase in their agreement was either smaller than that of ineligible classmates, or they had lower agreement in the fall (baseline) than these classmates, or some of both.

Small-group interviews with students

Students in the small-group interviews also reported that they are more confident in their STEM knowledge and are more interested in STEM careers because of STEM Pathways. In general, STEM Pathways contributes to positive feelings about STEM.

Confidence in STEM

> *I feel smarter because it kind of helped me know what to do and explain more. – Small-group interviews with students*
>
> *I feel a bit more confident in myself in science. – Small-group interviews with students*
>
> *We had tests about science that were not really going OK until we got to STEM Pathways, and they started helping us so we got better grades. – Small-group interviews with students*

Interest in STEM careers

> *Whenever I went to any of these field trips, I always wanted to be a scientist or engineer person. – Small-group interviews with students*
>
> *I wanna do STEM for my job! – Small-group interviews with students*
>
> *At first I was like, 'No, I don't want to be a scientist in my career,' and now I'm starting to think about it because after all the things we did, it's very interesting to work with and learn about. – Small-group interviews with students*

Positive feelings about STEM

> *No one liked technology before, but once you get in fifth grade and you do these field trips, you actually start to understand it. – Small-group interviews with students*
>
> *I used to think science was not fun. Now I really like science because of STEM Pathways. – Small-group interviews with students*
>
> *I like engineering now because you get to invent and experiment. – Small-group interviews with students*

MPS leader interviews and teacher survey

MPS leaders and teachers indicated that STEM Pathways increases student enthusiasm for, knowledge of, and skills in STEM and provides exposure to STEM careers. MPS leaders recognized that STEM Pathways targets lower-income schools and focuses on closing the opportunity gap for these students.

Finding: STEM Pathways has increased students' enthusiasm for STEM, science and math in school. MPS leaders said that students are excited about the new knowledge and more engaged in school.

> *Students are highly engaged with activities, with different experiences… Student love for science – that passionate engagement – has been high at events and during science class at school. – MPS leader interviews*

> *I think for the students, they're just much more enthusiastic about science and math because they can talk about the real life experiences that they had and it's not just a lesson in a book or some problem on the page that they need to solve. Because the teachers make those explicit connections, I think students are a little more enthusiastic on learning science and math. – MPS leader interviews*
>
> *They love those field trips. When they come back, they're able to tell you what they learned, that they want a classroom like at STARBASE, or as an example, when they went to Bakken, they asked why we don't have more of that in our science classes. It's got them more excited and a little more curious. – MPS leader interviews*
>
> *I think it goes back to real-life engagement and activities… so many things to learn, how science fits in with the real world. Students are making those connections to core academics and fascinating things you do with little bits of knowledge, accessing new knowledge. – MPS leader interviews*

Finding: STEM Pathways provides learning opportunities to students who might not have access to the STEM activities outside of school.

> *The students in these six schools have benefitted. The opportunity to go to museums and educational organizations that are related to science…I don't think every kid gets that experience [on their own]… I think [this] is probably the most important piece. – MPS leader interviews*
>
> *The trips are such a key piece, especially with so many students in poverty – they don't have the opportunity to visit these places, but now they want to. – MPS leader interviews*
>
> *They have the opportunity to go to places they wouldn't normally go. They have the opportunity to experience and learn some things in a more 'real world' way. – MPS leader interviews*
>
> *This program is providing opportunities that wouldn't be there for students if not for STEM Pathways. It's opening a whole new world for our students; who knows who will be sparked and inspired to continue down this road. – MPS leader interviews*

Finding: STEM Pathways helps increase student knowledge in STEM concepts.

> *Students are learning that academic language, that vocabulary, and they can then use [it] at school. I haven't seen as much growth in that area as I'd like, but it's something I'd like to focus on. – MPS leader interviews*
>
> *Well, definitely it allowed our students to be comfortable with the knowledge and subjects that STEM entails. They've created strong connections between students and STEM subjects that they could go into deeper. It's a highlight for all five classrooms [from our school] involved. – MPS leader interviews*

As mentioned earlier, MPS leaders said that STEM Pathways helps student learning by connecting classroom learning to the real world applications of STEM and by increasing student awareness of STEM-related careers.

Similarly, all teachers in the survey were positive about the impacts of STEM Pathways on their students; 80 percent strongly agreed and 20 percent agreed that the program has had a positive impact on their students (Figure A1). In their open-ended responses, teachers most frequently pointed to increased student engagement and interest in learning STEM (50%) because of the program. Teachers also said that they have seen an improvement in student skill and knowledge in STEM concepts (36%), as their students have been able to directly apply and build upon classroom learning during the field trips. Twenty-nine percent of teachers spoke about their students' increased awareness of the STEM applications in the real world and the resources in the community related to STEM. Teachers also mentioned increased exposure to new learning opportunities, engagement in cooperative group work, and improved confidence (14% each).

Examples of teacher comments:

> *We have seen a big increase in excitement/engagement with our core instruction, and students got a great deal out of the field trips that we took this year.*
>
> *My student scholars have much more confidence in the STEM areas.*
>
> *Students gain new understanding of STEM concepts and their application through the field trips. This exposure is not only powerful because it diversifies their learning environments and methods for learning, it also connects them to locations and resources within their own community.*
>
> *I think the Zoo hit on things we really couldn't by exposing kids to realistic habitats. STARBASE used technology that we don't have and was excellent at demonstrating the scientific method.*
>
> *Students work in cooperative groupings to improve their learning in STEM activities. The field trips that we did enhanced the science, math, and engineering activities we were doing on a daily basis.*
>
> *All of the field trips were very beneficial for student engagement and learning.*
>
> *Students are aware of STEM activities in their community. Several have said that they would like to return to the Works and/or The Bakken with their families.*

All teachers in the survey said that participating in STEM Pathways increased their students' interest in STEM learning and STEM subjects, and 95 percent of teachers said that participating in STEM Pathways increased their students' interest in STEM careers (Figure A1).

In an open-ended question, teachers were asked how parents have reacted to their child's involvement in STEM Pathways. One-third of teachers said that parents were very impressed by STEM Pathways and the new opportunities it gave their children. Another quarter of teachers said that parents mentioned how enthusiastic and engaged their children were with the STEM Pathways experiences. A few teachers wished for more parent involvement and support during the field trips.

Examples of teacher comments:

> *Parents are generally very excited to hear their student scholar sharing their experiences while at home or making connections from the Pathways visits.*
>
> *Parents and families are excited and supportive of STEM Pathways. The field trips are highlights for them and they are excited to make the connection between STEM education and the current need for STEM careers.*
>
> *Parents love that students can participate in STEM exploration. They [also] do this in science class, and GEMS and GISE.*
>
> *Parents that have attended field trips have been very excited about our partnership.*
>
> *Parents who attended STARBASE were impressed. Perhaps we need more family engagement.*
>
> *Parents seem excited that their children have this opportunity. I would love to see more parent involvement (chaperoning, completing experiments with children) with STEM Pathways.*

Student academic achievement

To assess the STEM Pathways potential effects on student academic achievement, treatment and comparison group students in each of the three cohorts are compared on the following measures:

- **Spring 2016 MCA-III math, science, and reading tests.** Results are reported by levels of proficiency (does not meet standards, partially meets standards, meets standards, and exceeds standards) and average (mean) scale score. Students are considered proficient if they meet or exceed standards. Only fifth graders take the science tests.

- **One-year growth in MCA-III math, science, and reading tests.** Growth, as determined by the Minnesota Department of Education, is reported in three categories: high, medium, and low growth. "High growth" is progress at a pace that will increase a student's proficiency with reference to the standards over the one-year period. "Medium growth" will keep the student at about the same level of proficiency one-year later. "Low growth" is progress at a pace that will reduce the student's proficiency over the one-year period. The one-year period is from spring 2015 to spring 2016. Only fifth graders take the science tests.

- **School attendance during the 2015-16 school year.** Attendance is measured by the percentage of days attended during the whole school year.

We consider MCA-III tests to be long-term indicators of potential effects of the program. Significant program effects may be unlikely in the short term, but could emerge after multiple years of program exposure. Data were also examined for underrepresented groups, which include students from low-income families, racial/ethnic minorities, and females.

Overall, there was no evidence found at this point for an academic achievement advantage among students who participated in STEM Pathways. Results indicated that differences between the treatment and comparison groups in spring 2016 MCA-III performance and one-year MCA-III growth tended to be small and not statistically significant in almost all instances. Although the differences were small, they generally favored the comparison group over the treatment group. This pattern occurred in all three cohorts for the subjects assessed (math, reading, and science). Only one difference was statistically significant: one-year growth in math was higher for comparison group fourth graders than treatment group fourth graders in 2015-16. Some of the differences in academic achievement in favor of the comparison groups over the treatment groups were stronger and statistically significant for some demographic groups. School attendance rates in 2015-16 were the same or almost the same in the treatment and comparison groups in all three cohorts.

A full description of results and the statistical techniques used in analyzing the student academic data is presented in another report: *STEM Pathways Student Academic Achievement Results Through The 2015-16 School Year* (Mueller & Gozali-Lee, 2016).

Research question 8.

What impacts does the model have on informal STEM education organizations?

STEM Pathways partners believe in the power of collaboration to build visible interconnections between the variety of STEM learning experiences that students will have over time, and that this will have a positive and lasting impact on student engagement and learning in STEM. Further, by working together, STEM Pathways partners believe that informal STEM education organizations can be more effective at meeting their individual goals for STEM education. Partners mentioned additional benefits of being part of a collaboration, including: increasing the visibility and credibility of participating STEM education organizations; creating common language and shared messages across organizations; participating in shared research and evaluation to support information-driven continuous improvement of programs; and enabling closer partnerships with schools and districts. Partners were excited about working together to increase attention around STEM careers and STEM skills—such as creativity, teamwork, and perseverance. One partner appreciated the educational materials, such as the career resources; another partner saw the collaborative work on writing grants and fundraising as a positive benefit of working together.

Finding: Partners believe that by having connections to other organizations, their own organization will increase its ability to reinforce STEM concepts and make a lasting impact on student STEM learning by being strongly connected to the greater whole.

> *The nature of a lot of informal science education is stand-alone field trips. Students come here one time for hours and we can do everything in our power to make it a really powerful experience, but ultimately when you have this touch point, you can reach a few students in a lasting way. The lasting impact of the experience will be pretty minimal, but when we have something like STEM Pathways where they are going to continue to revisit some of the same topics in different ways, hopefully that makes the experiences they had here much more valuable because it's part of something bigger that continues to be reinforced. – Partner interviews*
>
> *I am a strong believer that no one organization will have the silver bullet that will solve the STEM education challenge, so it has been satisfying because it's envisioning the contributing of multiple experiences from multiple places together and how they make a difference. And to see how the work they do contributes to the whole. It gives a greater sense of purpose. – Partner interviews*

Finding: Being a network has increased the visibility and credibility of STEM organizations and may have the potential to attract more funders, especially given recent interest in collaboration in the funder community.

> *It is a unique type of partnership that garners some additional visibility from the community. One thing that all organizations have a challenge with is growing capacity, growing visibility, and this type of project gives it a new spin, a new twist to how we can excite people about the work that we are doing in the community and in schools. – Partner interviews*
>
> *That value of collaboration and creating that ecosystem of STEM providers and then you're taking advantage of the credibility around that. – Partner interviews*
>
> *The collaboration was a very important attraction to funders as well. It enabled us to get significant funding from Boston Scientific and from Department of Defense for the study, project direction and other components. That was a specific result of the concept of STEM Pathways. PENTAIR provided funding as well. Hopefully this attracts more funding as we go forward. – Partner interviews*

Finding: Collaboration has led to the development of a common language around standards and learning targets.

> *I think it's allowed our programming to go much farther because there is this overlap with the 5th grade cohort, where we have this overlap of shared language and shared terminology. – Partner interviews*

Finding: There is enthusiasm among partners for working together to increase attention around STEM careers and positive STEM attitudes and skills.

> *What has been exciting is to see teammates come together and rally around STEM careers. That has been a big connection that we see in all of our partners and the work we have done. That has made our curriculum more focused on that. We always incorporated STEM careers, but it is more systematic, specific ways to approach it. It is exciting to see those changes in programming curriculum. – Partner interviews*
>
> *I think the biggest thing in the past year, the biggest value, has been in the area of how we address careers. We have always had careers as an underlying theme, and based on our involvement in STEM Pathways, we have grown to include a focused effort to address career skills and the soft skills of STEM – teamwork, problem solving, perseverance. – Partner interviews*

Finding: One partner also appreciated gaining access to educational materials, particularly those related to STEM careers.

> *There is added value in ancillary materials, especially around career videos. – Partner interviews*

Finding: The partnership has given partner organizations the ability to conduct research and evaluation that may not be possible for individual organizations. Collaborative evaluation has led to access to useful, meaningful data, that allow organizations to make information-based program improvements.

> *One of those things is related to evaluation, because if you can imagine an even larger group of collaborators who have agreed on important outcomes and then, after that, have found or developed measurements that they agree should show progress toward those outcomes, then that is consistent with the idea that it is not just one experience that will be the magic key, but rather a collection of them. Most education nonprofits do not have the resources to invest in evaluation on a large scale on their own, especially longitudinal[ly]. It increases everyone's capacity to access to useful, meaningful data. – Partner interviews*
>
> *{What] we learned about the evaluation of year one of implementation was eye-opening. The connection between the importance of students' emotions, like confidence, enjoyment – these things that should be addressed more; even though students thought [organization name] was fun, we did not really address those aspects. As a teacher [STEM Pathways educator], it just changed the way I started the day. We talked more about enjoyment, rewarding aspects, trying to connect the fun of being at [organization name] with STEM. – Partner interviews*
>
> *The evaluation component of STEM pathways that revealed information we wouldn't have uncovered in any other way. We took the results of the first-year student survey to heart and immediately developed a whole new additional set of strategies and tools here at our organization to boost student confidence in STEM. – Partner interviews*

Finding: Besides aiding research and evaluation, the partnership has led to partners working together to write grants and do fundraising.

> *There is the research, grant writing and fundraising development work that comes with this initiative. That may be something that is worth calling out. – Partner interviews*

Finding: Being in the partnership allows partners to have the opportunity to work more closely with the MPS teachers and learn how STEM Pathways lessons fit into the curriculum sequence in MPS schools.

> *MPS has their learning targets/objectives and it's incredibly valuable for providers to know how the district thinks of standards and how they map their curriculum throughout the school year, and the intent of the sequence that they have created. They might have an idea about STEM integration and can figure out how to fit our things through the school year for students. Understanding their system, their language – because sometimes it's a barrier for us. – Partner interviews*
>
> *Collaboration, not only with STEM Partners and colleagues at [organization name], but also collaborating with teachers and principals, has made the program what it is. It has been really fun to be in the middle of the ecosystem and learn more about all of the moving parts and how they fit together. – Partner interviews*
>
> *We have learned a lot about how STEM is addressed in MPS and the roles of teachers and specialists, which is very valuable. – Partner interviews*

Research question 9.

What impacts does the model have on classroom teachers?

Involvement in STEM Pathways has provided many benefits to classroom teachers, according to MPS leaders and teachers. STEM Pathways provides teaching materials and supports and inspires teachers to present the STEM curriculum to students in a way that motivates and excites them about STEM.

Finding: STEM Pathways has enhanced STEM teaching by helping teachers make connections between STEM Pathways lessons and their classroom lessons.

> *They have more authentic opportunities to engage in STEM. They can connect the math and science to their field trips and in moving forward with their curriculum. – MPS leader interviews*
>
> *I think it opens teachers' eyes to opportunities that they can be making, connections that they might not make for their students. – MPS leader interviews*
>
> *For one, they are more mindful of looking and making those connections of "wow, this is something that identifies as part of STEM," and being able to point that out to students. STEM is showing a high increase and need, it's our future. – MPS leader interviews*

Finding: STEM Pathways helps teachers integrate STEM into other areas of the curriculum.

> *It helps their passion around science and the importance of science and integrated coursework. How do we integrate science and technology into areas like language arts and math? That's the really big piece I've seen. – MPS leader interviews*
>
> *We've had a strong science focus. But I think teachers have gone more in-depth in terms of making connections to science. For example, I was in the classroom a couple of weeks ago, and they made a connection with the bees and going to the Bell Museum and what U of M scientists are doing with the bees. I thought it was great that they were bringing that up even though it wasn't the focus of the lesson. The kids were able to bring it back to that. I think that if anything it's made teachers more aware of how [we are] embedding STEM into our lessons. – MPS leader interviews*

Finding: Students' positive response to STEM Pathways experiences has influenced teachers' attitudes about STEM teaching.

> *I think the activities, lessons, journals have helped to connect with students [who were] not reached in more traditional approaches [and are a] benefit for teachers. …STEM Pathways allows better connections to students. – MPS leader interviews*
>
> *From my perspective, seeing the kids respond so positively, it influences [the teachers'] attitude and their feeling about STEM. If you think about STEM from a teacher's perspective, it can be pretty challenging. It requires content knowledge in multiple areas. In elementary schools, teachers often don't have science expertise or math expertise necessarily. They're more generalist educators. So when they see the students engage at that level, it causes them to get more excited and more interested and more connected. – MPS leader interviews*

Finding: STEM Pathways increases teacher awareness of professional development opportunities.

> *It helps increase teacher awareness of their own lack of knowledge around STEM integration, or ways to integrate STEM within their classrooms – then they can reach out for more professional development. – MPS leader interviews*
>
> *Some teachers … have an opportunity to extend their own learning …, which is huge for teachers. One teacher … was amazed by the resources available. – MPS leader interviews*

All teachers said that participating in STEM Pathways had a positive impact on them as a teacher, with 55 percent strongly agreeing that it has done so (Figure A1). In open-ended responses, teachers frequently responded that the STEM Pathways experience encouraged them to think about making real world connections with their curriculum and that it provides them with easy avenues to making those connections (40%). Twenty-seven percent of respondents spoke about how STEM Pathways has introduced them to new teaching methods and skills that they are able to use in the classroom. Additionally, teachers spoke about having access to new resources or generally enjoying teaching STEM subjects (20% each).

Examples of teacher comments:

> *Having the opportunity to use another means of educating and connecting real-world knowledge with my student scholars is ALWAYS a positive addition to me, as I continue to develop as an educator. Each STEM site had excellent hands-on learning where I got to directly interact with my students, yet also allowed me the time to observe their active learning.*
>
> *I was able to learn about activities that motivate and expose my students to STEM, as well as have specific resources and materials to discuss future paths in STEM careers.*
>
> *Being part of STEM Pathways has helped me to think more about the connections between the content I am teaching. It has also helped me link the learning in the classroom with the work many professionals do for their career.*
>
> *It has made me conscious about helping students make real-world connections with the curriculum.*

Research question 10.

What are the implications for the field of informal science education?

MPS leaders and partners identified valuable contributions that STEM Pathways has made to STEM education, including the benefits of increasing student interest and knowledge in STEM by connecting their learning to real world applications of STEM. MPS leaders also felt that STEM Pathways has enhanced schools' ability in delivering STEM education. To partners, STEM Pathways is a model for how informal STEM education organizations can work together to achieve common goals.

Finding: STEM Pathways demonstrates the opportunity and potential for informal STEM programs to provide students with valuable exposure to real-life applications of STEM, particularly STEM-related careers.

> *It helps students see what their future can be, especially for girls, and gets them to think about careers in math and science. I think they can see the possibility. They see themselves as scientists and mathematicians. – MPS leader interviews*
>
> *I think you can't put a number or value on it; it's so high. The more kids can see real-life applications to what they're learning in school – the idea of the experiential learning, learning about STEM, these careers that learn these skills – it's invaluable. – MPS leader interviews*
>
> *It's that career connection and the chance to see real-world education of the integration that STEM brings forward. – MPS leader interviews*
>
> *I think I've said it—it creates an awareness with students what STEM means, the careers ... It helps students understand the level of study, what needs to go into becoming a biologist or engineer. It reinforces the work that we're doing here, and helps when students realize [as] they think back to STEM Pathways and how it applies and how they see themselves in the real world. They can apply what they've learned ... – MPS leader interviews*

Finding: STEM Pathways raises awareness of the contributions informal STEM education programs can make in increasing student interest and engagement in STEM learning.

> *STEM Pathways has helped draw attention to the important factors of student success that go beyond test scores. Informal organizations are good at things that build engagement and interest, connect to the real world. STEM Pathways has helped raise that to a higher level in terms of valuing that. – Partner interview*
>
> *I think that if we are looking at partnerships between formal and informal, it is a really big deal for schools or districts that are trying to advance STEM education curriculum… It has the potential to advance the understanding of what makes high-quality STEM education in both worlds, both bringing something unique. – Partner interview*

Finding: STEM Pathways demonstrates the potential of informal STEM education programs to enhance the ability of schools to provide effective STEM education for students, which is a benefit to students, schools, and teachers.

> *STEM Pathways continues to put value on STEM topics for all students, and then it provides evidence – you can say you're a STEM focused school, but we can say why we're a STEM focused school: students have access to pathways and experiences. We have evidence to add to the vocabulary. – MPS leader interviews*
>
> *I think one of the challenges that both the district and the partner organizations share, along with almost everybody else in the United States, is that STEM is a very new paradigm. The idea of bringing engineering and technology, what I call the applied sciences to academic levels on par with science and math, is a learning curve and a retraining curve for the people, whether it's a formal classroom teacher or whether it's informal educators, to actually deliver STEM education that is not just STEM in name. I think the conversations between the district and the partner organizations have been a learning tool for both of us as to how to best do that. Particularly since the partner organizations are so different. And then you still need to try and have some of these common strategies and language. I think those have been really useful conversations for everyone. – MPS leader interviews*
>
> *It's huge. It builds the awareness. It's twofold. As much as the students are benefitting, the teachers are totally benefitting as well. It's not until you experience something that you think "how can I bring this more into my lessons, or my morning meeting, or a basic math lesson to bring it up to where it can embed STEM into it, not just the math parts?" That's the piece that's got them excited. – MPS leader interviews*

Finding: STEM Pathways exemplifies how informal education organizations can work together to achieve common goals.

> *It is a valuable model of how organizations can work together and accomplish more as a whole than as individual organizations. – Partner interview*
>
> *I think it is the shared goal of having an impact on students. The biggest takeaway is that we really want to have a positive impact on these students and, by working together, we can. – Partner interview*

Opportunities for growth

MPS leader perspectives

Citing the benefits and successes, all leaders said they would like STEM Pathways to continue, and most would like STEM Pathways to expand to other grades and schools.

MPS leaders also discussed the importance of more coordination between teachers and partner organizations, as teachers could incorporate more about the field trip lessons in their classrooms. One leader suggested teachers and partners co-teaching during the field trips. Another suggested providing opportunities to differentiate instruction to accommodate different types of student learners. Leaders also recommended even more communication with teachers ahead of time regarding lessons and expectations.

Finding: MPS leaders would like STEM Pathways to expand to other grades and schools.

> *I think the benefits far outweigh the challenges. I would really like to see it expanded and I would really like to see it go [to] younger grades. – MPS leader interviews*
>
> *I would absolutely love to see it continue. I would also like to work beyond the initial grant that allows us to either expand to other community partners to offer more opportunities, or increase the reach to schools and students. It was written in the grant that it was pilot exploration for the community partners, and I think we've done a good job. We just want all of our students to get it. – MPS leader interviews*
>
> *Yes, but I would like to see if we could expand it, particularly for our lowest socioeconomic schools that won't be going on any field trips unless we're able to find them funding and resources. I think it's a great opportunity for us to connect with some of our partners in the community. It's also an opportunity for our students to get out of their school building and do learning in another setting, which tends to be very engaging. I think it's a great program. I just wish it were bigger. – MPS leader interviews*
>
> *I definitely would see collaborative planning as beneficial for several sites – getting teachers not necessarily doing the same thing, but working toward the same goal, even if the path looks different. Making connections, maybe doing field trips with other [schools], so students are seeing other students their same age doing the same thing. – MPS leader interviews*

Finding: Leaders suggested bringing more partners into the schools or spreading out the partners in order to serve more schools in the district.

> *Instead of having a few schools having multiple opportunities, I'd rather have all of our schools go on one. I know that doesn't work very well with the way that it's set up right now, but I would rather spread it out and have a group of 10 schools work with The Bakken, and a group of 10 schools work with the Bell, and so on, so that every school would at least have an opportunity to do something outside of their school day that was planned and ready to go for them. – MPS leader interviews*

> *We could spread out and not go to all community partners – have schools go to three partners, say, instead of all of them. Capacity-wise, I know that STARBASE can't handle all of our classrooms. We can bring other community partners into the work we've been doing, too: Leonardo's Basement, Juxtaposition, the Science Museum. Those are things we've discussed that could work. – MPS leader interviews*

Finding: MPS leaders recommended creating clearer expectations for teachers through comprehensive and collaborative planning and better programming coordination between teachers and partner organizations. One of the comments seems to refer to the scheduling or transportation issues in the first implementation year, which caused classrooms of fifth graders in two schools to not participate in the full STEM Pathways field trip experiences. In the second year, all students received all 29 hours of STEM Pathways programming.

> *I always think the first challenge is the communication between partners – time to plan, time for teachers to get a deep understanding of what they [students] learn so they can support at school. – MPS leader interviews*
>
> *I think having some type of structured meeting with teachers where we have all the partners together so we can talk about what the year will look like, what is our goal, what's upcoming, so teachers can then backfill. We get to the Bell, but maybe we don't know what we're working on until a week or two before. It would be helpful to map out the year, intended learnings for when they [students] come out, standards they're connected to. Maybe it's happening and I'm missing it. But alignment is key. It's also important to hold schools accountable for their part, too – not just field trips or the extended curriculum. Being clear upfront that we need responses within a specific time period, when we need surveys in order to get continued funding, that kind of thing. Engagement with teachers would be helpful. – MPS leader interviews*
>
> *Sometimes the field trips make the teachers feel off the hook. Sometimes the teachers are supervising more and not engaged in the curriculum at the fieldtrips. I think more about, "How can it be a co-teaching experience when you're on the field trip?" That may be something that may help. – MPS leader interviews*

Finding: One leader recommended providing opportunities to differentiate instruction to accommodate different types of learners.

> *I would think about differentiation in activities, and what students come with, to make sure we're meeting the needs of all students, helping all students be successful. It's hard for teachers, but what we know now that students are coming in with all sorts of different strengths and needs, differentiation is important so they can all feel as successful as their peers. – MPS leader interviews*

Teacher perspectives

All teachers said that they would like their school to continue participating in the project (89% strongly agreed; 11% percent agreed; Figure A1). When asked to describe ways in which STEM Pathways could provide better support for teachers, 36 percent of respondents

spoke about wanting more opportunities for professional development, including on how to conceptualize STEM as an integrated discipline and how to incorporate the STEM Pathways resources into classroom learning more effectively. Eighteen percent of respondents stated that they wanted better access to the available resources or additional resources, including math and life science pages in the Student Portfolio.

When asked to provide suggestions for how to make the STEM Pathways resources more valuable or engaging to students, 40 percent of respondents pointed out an area in which the resources were not working well. These teachers said the game of STEM was too involved and difficult, and one said that keeping a STEM journal makes STEM appear to be a specific unit of study, rather than an approach to learning. Thirty percent of respondents gave suggestions for additions to the materials; some ideas included providing Spanish translations, additional ways to recognize students for making progress, and having more STEM professionals come to speak to classes about their careers.

Student interview findings

While the overall results from the student small-group interviews are positive, the results also pointed to areas for program improvement. These include:

- Students have varied understandings of STEM Pathways. Further, Students recognize primarily surface-level connections between STEM Pathways partners. Thus, it might be useful for STEM Pathways to reinforce consistent and targeted key messages for students and teachers about STEM Pathways and its goals, including interconnected concepts among partner programs.

- Students recognize that their STEM experiences often do not incorporate much math, and sometimes struggle to make connections between STEM Pathways and math. For programs that do not already incorporate math in a significant way, STEM Pathways may want to explore opportunities to incorporate math while at the same time being explicit when math is being used.

- Students recognized they still have a lot to learn about STEM. Further, the challenges they have learning STEM create mixed feelings related to their confidence in their abilities to do STEM. Thus, continued—and perhaps even increased—emphasis on helping students to develop attitudes and skills that build confidence may be important. This may include, for example, learning from mistakes, working on a team, and persevering through challenges.

Partner perspectives

Partners had several ideas for strengthening STEM Pathways, including more opportunities to grow professionally. Partners also aspire to work collaboratively to develop best practices for STEM learning in informal settings, share outcomes and measurements, and to become STEM expert providers.

Finding: Partners want more training, including training about the Next Generation Science Standards (NGSS); to work together with teachers to implement the training workshops; to continue to learn from each other by meeting longer and delving deeper on information sharing; and to use the evaluation results to continue developing new and improved ways of programming.

> *We have talked a lot about mentoring staff and providing additional teacher workshop trainings. I think there is some potential there, but I am not sure what that is at this time. – Partner interviews*
>
> *One of the areas I think about is Next Generation Science Standards – as we get closer to the year where our own science standards are under review [and] if Minnesota adopts these [Next Generation Science Standards], all of the STEM Pathways organizations could benefit from greater training of those standards and what they look like when implemented, so when classrooms will implement them they might have a model to look to with our organizations. It would be a great area to learn about in the future so we are ready to go when they are implemented. – Partner interviews*
>
> *One missing piece is the classroom teachers. To me that would be a beautiful next chapter for this project; being able to have classroom teachers take trainings from our STEM partners and possibly our STEM partners continuing to get opportunities to go to workshops focused on STEM. Maybe more of a collaboration and plan it out together to help each other. – Partner interviews*
>
> *I have said a few times how great it was to have the meetings we have had. All of those meetings could go longer, deeper. We could do more expertise sharing, language barrier breaking. There is such a wealth of knowledge and passion. I wish we could do more of it and learn from each other. – Partner interviews*
>
> *If the project moves forward to contributing to a STEM ecosystem, there are many opportunities for professional growth such as tapping into the resources and taking the next round of data from this evaluation and collectively utilizing that information to grow in new ways. The needs vary from organization [to organization]. Having a bank of options for professional growth would be an interest to us. I'd like them based on the findings of the STEM Pathways [evaluation] in identifying gaps in areas of focus combined with research in the field. That's the biggest priority for us. – Partner interviews*

Finding: Developing shared outcomes and metrics for STEM education is another opportunity for STEM Pathways partners'growth.

> *Shared measurement and metrics going forward is what I am excited about. Developing shared best practices of STEM education and creating professional development and networking opportunities around that, too. – Partner interviews*
>
> *One of the most promising [future directions or opportunities] has to do with the idea of shared outcomes for student learning and growth and interest. Related to that, the way to measure it. How can we continue to expand on what we have done so far, working around shared outcomes and systems? – Partner interviews*

Finding: One partner mentioned that STEM Pathways should develop, implement, disseminate formal training for STEM providers and be an expert in the field.

> *I feel strongly that STEM Pathways could develop and implement more formal training for partner staff around STEM and integrated STEM education. I am talking about developing and disseminating STEM education for the community and schools. We are putting ourselves out there as STEM expert providers. STEM Pathways has a responsibility to ensure there is quality. – Partner interviews*

Challenges and additional opportunity for growth

Limited funding and partner capacity to provide programming to more schools were challenges most often mentioned by MPS leaders and partners. STEM Pathways partnership was still in its second implementation year of the pilot project, and efforts to address these challenges are underway.

Limited funding

> *For our site, the funding is definitely a challenge. With the number of field trips, bussing gets expensive, especially when you have a student demographic where 80% qualify for free and reduced lunch. That is an expense that we're asking of families, and we appreciate it even when they only give a little, but it's an expense for us and for them. – MPS leader interviews*
>
> *Funding. We have had to tell the schools that we cannot offer it to all of these students for no cost anymore. I have had two schools who have had to opt out because they cannot afford it for the 2016-2017 [school] year, and that is even cutting the cost in half, which does not even cover our costs for the program. This is really expensive, so how can we work individually or together to secure funding. – Partner interviews*
>
> *We all, at the beginning, agreed to find ways and resources within our own organizations to really start this partnership. We are really at this crossroads where we would all like to continue, but where is the funding coming from? Where are we going to find the resources? We have had to make some changes this year because of that. A lot of us have shifted from providing a free program to providing a discounted program. – Partner interviews*

Partner capacity to offer programming

> *I think that the [capacity] size is one challenge. These partner organizations are relatively small. Their capacity to deliver programming even if we had the funding would have to be very different. – MPS leader interviews*
>
> *To be honest my concern about the program has always been that it's in six of our schools and I need it in 44. So it's not very equitable. Whoever ends up in one of these schools has access to this and if they don't end up in this school, they don't. …I realize there's a financial component, but I would prefer that we were a STEM Pathways district as opposed to a set of STEM Pathways schools. – MPS leader interviews*
>
> *I think the other big question is the capacity. What is our capacity? And defining that if we want to expand beyond Minneapolis and if we want to bring on other partners as STEM Pathways partners. I think some deep discussions need to be had, and we need to figure out what we can do on an annual basis and what the ultimate goal is. – Partner interviews*
>
> *The way that this program could support is through funding. We just need resources. And to do that, someone to really be able to have the time and ownership to lead and manage the program. Right now, it's an add-on to a lot of people's jobs, and we've been able to make it happen, but the time allowed to do it can be challenging to find. – Partner interviews*

Partners have been proactively searching for more funding by applying for grants. To increase capacity to serve more students and schools, one partner suggested adding more partners into the collaborative, which was also suggested by MPS leaders. Another partner said that roles and duties in project implementation and distribution of funding should be clarified.

> *We just applied for this Bush Foundation grant, and if we get it, it will allow us to look at the evaluation we have received and the bigger goals; it will give us that foundation we need to move forward. We have been trying to get this strategic planning with big goals, and some solid funding would give us the opportunity to solidify where we are and start looking for these bigger goals for creating an ecosystem. – Partner interviews*
>
> *If we get to the point of discussing scaling it up, offering it to the whole school district or multiple districts, I think that will offer a pretty huge challenge. I would like to hear from other projects like this about how they scale it up and the ecosystem idea where it is not necessarily always the same partners. It might be a bunch of different partners and schools are able to pick and choose or partners can come and go, but ultimately we are all supporting the same goal. I think that is a really interesting idea. – Partner interviews*
>
> *Just to ensure that when there is funding opportunities going forward, that there is … equitable distribution of those funds amongst partner organizations, and that if there are specific goals or needs of different partner organizations, that those goals and needs are very clearly articulated. – Partner interviews*

Additional comments

Following are additional comments from all responding teachers.

> *Excellent program with great resources.*
>
> *You give us great opportunities. Our science kits in MPS are pretty weak in fifth grade.*
>
> *I am retiring this year and I have enjoyed working at [school] with STEM Pathways. I feel strongly that students learn best when they are actively engaged. STEM activities are terrific to get kids learning in fun ways. We couldn't do it without the support from the STEM Pathways staff!*
>
> *I really believe it is a worthwhile endeavor, and it's great to feel like the content we are teaching is being supported and reinforced when we head out to different field trips.*
>
> *This has been a great program for [school] students and teachers. One aspect that has made it so amazing is that costs have been greatly subsidized. Many of the field trips and visits would not be possible without this funding. Any way to maintain or even increase the amount of funding designated to subsidizing costs for schools would help make this accessible to us and our students.*

Partners' comments most often restated their appreciation for commitment of all the organizations involved in the project.

> *I think it is a fabulous program. We just need to be able to identify ways that we can really support this program – support the organizations that are delivering these programs. That is how we will all have a greater impact on the students we serve.*
>
> *I am so thankful. I appreciate the in-kind donation of time and expertise from all of the partners. A lot have gone above and beyond what was being paid for.*

Looking forward

Having completed the three-year pilot project, partners continue to focus on planning and action for the next phase, building from the successes and lessons learned from the STEM Pathways pilot project and research from the field. There is strong consensus among partners regarding the value and potential impact of collaboration.

STEM Pathways partners share a vision for providing programming that raises STEM awareness, interest, enthusiasm and confidence and pursuit of STEM careers. Further, partners recognize the importance of and are committed to fostering a collaborative systems approach to inspire the next generation of STEM-literate decision-makers and problem solvers. The goal of STEM Pathways is to ensure that all young people have opportunities to engage in high-quality STEM learning experiences—over time and in a variety of settings—that lead them to develop the STEM mindset necessary to become the creative, STEM-skilled thinkers and innovators of the future. Core activities of the next stage of STEM Pathways include:

- Supporting and expanding a robust network and community of practice of informal STEM educators.
- Facilitating access to a system of high-quality and interconnected STEM learning experiences for youth provided by informal STEM education organizations, in collaboration with schools and districts and alignment with and support of core curriculum and standards.
- Promoting cross-organizational leadership to create and prioritize a culture of collaboration that builds authentic connections between organizations, people and programs; that articulates shared vision and goals; and that utilizes shared measurement to evaluate progress.
- Building evaluation capacity of the collaboration and partner organizations, including development of a shared measurement system, to encourage the use of evaluation findings to inform decision-making and program enhancements. To this end, STEM Pathways is particularly interested in measures that relate to STEM interest, mindset (confidence, perseverance, creativity, team work), and careers.
- Building effective funding and sustainability strategies.

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Appendix

A1. Teacher perspectives of STEM Pathways

	N	Strongly Agree	Agree	Disagree	Strongly Disagree
Participating in STEM Pathways had a positive impact on my school.	20	80%	20%	0%	0%
Participating in STEM Pathways had a positive impact on me as a teacher.	20	55%	45%	0%	0%
Participating in STEM Pathways had a positive impact on my students.	20	80%	20%	0%	0%
I made connections for my students between the different STEM Pathways learning experiences.	19	47%	42%	11%	0%
I made connections for my students between the STEM Pathways experiences and classroom learning.	19	37%	63%	0%	0%
STEM Pathways supports the Minneapolis Public School district's curriculum in meaningful ways.	19	47%	53%	0%	0%
STEM Pathways supports Minnesota's academic standards in meaningful ways.	19	58%	42%	0%	0%
Participating in STEM Pathways increased my students' interest in STEM learning.	19	79%	21%	0%	0%
Participating in STEM Pathways increased my students' interest in STEM careers.	19	63%	32%	5%	0%
Participating in STEM Pathways improved my students' learning in STEM subjects.	19	58%	42%	0%	0%
My students made connections between the different STEM Pathways learning experiences.	19	42%	53%	5%	0%
Overall, the STEM Pathways partner experiences were engaging for my students.	19	79%	21%	0%	0%
I would like my school to participate in STEM Pathways again next year.	19	89%	11%	0%	0%

A2. STEM Pathways student survey fourth grade (Cohort 2) results by student characteristics, 2015-16: Statistically significant results (p<.05) by survey item

Student characteristics	Significant difference between groups in percentage who "agree a lot" or "mostly agree" with survey item in Spring 2016 [a,b]				Significant change within group in percentage who "agree a lot" or "mostly agree" with survey item [a,c]		
					Group	Fall 2015	Spring 2016
STEM knowledge is very important to my future.							
Gender					Female (n=166)	64%	74%
					Male (n=168)	63%	78%
Free/reduced-price lunch	Eligible (n=255)	73%	Ineligible (n=79)	85%	Eligible (n=255)	63%	73%
					Ineligible (n=79)	66%	85%
Race/ethnicity					Of color (n=247)	63%	75%
					White (N=87)	67%	79%
ELL status					ELL (n=121)	58%	73%
					Non-ELL (n=213)	67%	78%
I notice STEM in the world around me every day.							
Gender					Male (n=166)	50%	68%
Free/reduced-price lunch	Eligible (n=255)	62%	Ineligible (n=80)	78%	Eligible (n=255)	49%	62%
					Ineligible (n=80)	61%	78%
Race/ethnicity					Of color (n=247)	51%	65%
ELL status	ELL (n=122)	55%	Non-ELL (n=213)	71%	Non-ELL (n=213)	56%	71%
I know about many STEM-related activities that happen outside of school.							
Gender					Female (n=166)	36%	51%
					Male (n=168)	43%	54%
Free/reduced-price lunch	Eligible (n=255)	49%	Ineligible (n=79)	63%	Eligible (n=255)	37%	49%
					Ineligible (n=79)	47%	63%
Race/ethnicity					Of color (n=246)	37%	51%
ELL status					Non-ELL (n=212)	42%	56%

A2. STEM Pathways student survey fourth grade (Cohort 2) results by student characteristics, 2015-16: Statistically significant results (p<.05) by survey item (continued)

Student characteristics	Significant difference between groups in percentage who "agree a lot" or "mostly agree" with survey item in Spring 2016 [a,b]				Significant change within group in percentage who "agree a lot" or "mostly agree" with survey item [a,c]		
					Group	Fall 2015	Spring 2016
I like learning STEM.							
Gender					Female (n=169)	70%	80%
Free/reduced-price lunch					Ineligible (n=80)	68%	84%
Race/ethnicity					Of color (n=249)	68%	78%
ELL status					ELL (n=123)	63%	78%
I am really good at STEM.							
Free/reduced-price lunch					Ineligible (n=79)	49%	72%
Race/ethnicity					White (n=88)	56%	69%
ELL status	ELL (n=122)	54%	Non-ELL (n=216)	68%	Non-ELL (n=216)	56%	68%
I would be good at a job that uses STEM.							
Free/reduced-price lunch	Eligible (n=256)	54%	Ineligible (n=79)	68%			
ELL status	ELL (n=122)	50%	Non-ELL (n=213)	62%			
I like learning math.							
Gender					Male (n=170)	65%	75%
ELL status					ELL (n=124)	69%	80%
I like learning science.							
ELL status					Non-ELL (n=214)	85%	78%
I like learning engineering.							
Gender					Female (n=168)	54%	73%
					Male (n=171)	58%	78%
Free/reduced-price lunch	Eligible (n=259)	72%	Ineligible (n=80)	88%	Eligible (n=259)	54%	72%
					Ineligible (n=80)	65%	88%
Race/ethnicity					Of color (n=251)	53%	73%
					White (n=88)	65%	82%
ELL status					ELL (n=123)	47%	70%
					Non-ELL (n=216)	62%	79%

A2. STEM Pathways student survey fourth grade (Cohort 2) results by student characteristics, 2015-16: Statistically significant results (p<.05) by survey item (continued)

Student characteristics	Significant difference between groups in percentage who "agree a lot" or "mostly agree" with survey item in Spring 2016 [a,b]				Significant change within group in percentage who "agree a lot" or "mostly agree" with survey item [a,c]		
					Group	Fall 2015	Spring 2016
I like learning technology.							
Free/reduced-price lunch	Eligible (n=258)	78%	Ineligible (n=78)	88%			
I use technology to solve problems.							
Gender					Female (n=170)	47%	63%
Free/reduced-price lunch					Eligible (n=260)	54%	64%
					Ineligible (n=80)	49%	65%
Race/ethnicity					Of color (n=252)	52%	64%
ELL status					ELL (n=124)	51%	65%
					Non-ELL (n=216)	54%	64%
I think like an engineer to design solutions to problems.							
Gender					Female (n=168)	43%	58%
					Male (n=166)	47%	64%
Free/reduced-price lunch	Eligible (n=256)	56%	Ineligible (n=78)	77%	Eligible (n=256)	43%	56%
					Ineligible (n=78)	51%	77%
Race/ethnicity					Of color (n=246)	46%	59%
					White (n=88)	42%	65%
ELL status					Ell (n=122)	43%	57%
					Non-ELL (n=212)	46%	63%
I know about many jobs that use STEM.							
Gender					Female (n=163)	50%	64%
					Male (n=162)	51%	73%
Free/reduced-price lunch	Eligible (n=245)	64%	Ineligible (n=80)	83%	Eligible (n=245)	47%	64%
					Ineligible (n=80)	61%	83%
Race/ethnicity					Of color (n=237)	45%	66%
ELL status	ELL (n=116)	61%	Non-ELL (n=209)	72%	ELL (n=116)	38%	61%
					Non-ELL (n=209)	57%	72%

A2. STEM Pathways student survey fourth grade (Cohort 2) results by student characteristics, 2015-16: Statistically significant results (p<.05) by survey item (continued)

Student characteristics	Significant difference between groups in percentage who "agree a lot" or "mostly agree" with survey item in Spring 2016 [a,b]				Significant change within group in percentage who "agree a lot" or "mostly agree" with survey item [a,c]		
					Group	Fall 2015	Spring 2016
How much do you like studying science? Percent responding quite a bit/very much: [d]							
ELL status	ELL (n=121)	84%	Non-ELL (n=212)	73%	Non-ELL (n=212)	81%	73%

[a] Response options for the survey items are: don't agree, agree a little, mostly agree, agree a lot, and don't know.

[b] Statistically significant difference (p<.05) using Fisher's Exact Test, two-sided.

[c] Statistically significant change (p<.05) using McNemar Test, two-sided.

[d] Response options for the survey items are: very little, some, quite a bit, and very much, quite a bit.

A3. STEM Pathways Student Survey: Cohort 1, fourth and fifth grades

Item	Number	Percentage of students answering "agree a lot or mostly agree" [a]					
		1. Fall 2014	Signif. test 1 vs. 2	2. Spring 2015	Signif. test 2 vs. 3	30 Spring 2016	Signif. test 1 vs. 3
STEM awareness and relevance							
STEM knowledge is very important to my future.	246	66%	*	77%		81%	*
I notice STEM in the world around me every day.	252	52%	*	61%		65%	*
I know about many STEM-related activities that happen outside of school.	250	40%		44%	*	55%	*
I frequently do STEM-related activities outside of school.	252	40%		41%		39%	
STEM interest and confidence.							
I like learning STEM.	252	75%		77%		79%	
I would like to do more STEM-related activities.	251	68%		67%		63%	
I am really good at STEM.	249	59%	*	46%	*	55%	
I would be good at a job that uses STEM.	246	54%		53%		53%	

A3. STEM Pathways Student Survey: Cohort 1, fourth and fifth grades (continued)

Item	Number	Percentage of students answering "agree a lot or mostly agree" [a] 1. Fall 2014	Signif. test 1 vs. 2	2. Spring 2015	Signif. test 2 vs. 3	30 Spring 2016	Signif. test 1 vs. 3
Interest in STEM subjects							
I like learning math.	249	73%		75%		75%	
I like learning science.	251	80%		82%		78%	
I like learning engineering.	244	56%	*	82%		79%	*
I like learning technology.	246	79%		85%		86%	*
Application of STEM to problem-solving							
I use technology to solve problems.	249	56%		53%		60%	
I think like an engineer to design solutions to problems.	246	50%		57%		59%	*
Careers using STEM							
STEM knowledge is very important to my future.	246	66%	*	77%		81%	*
I know about many jobs that use STEM.	237	61%		69%		74%	*
I would be good at a job that uses STEM.	246	54%		53%		53%	
When I get older, I would like to have a job that uses STEM.	247	53%		53%		57%	

[a] Response options for the survey items are: don't agree, agree a little, mostly agree, agree a lot, and don't know.

*Statistically significant ($p<.05$) using McNemar Test, two-sided.

A4. STEM Pathways student survey Cohort 1 results by student characteristics, Fall 2014 to Spring 2016: Statistically significant results (p<.05) by survey item

Student characteristics	Significant difference between groups in percentage who "agree a lot" or "mostly agree" with survey item in Spring 2016 [a,b]				Significant change within group in percentage who "agree a lot" or "mostly agree" with survey item [a,c]		
					Group	Fall 2014	Spring 2016
STEM knowledge is very important to my future.							
Gender					Female (n=124)	62%	83%
Free/reduced-price lunch					Eligible (n=177)	63%	82%
Race/ethnicity					Of color (n=179)	67%	80%
					White (N=67)	63%	84%
ELL status					ELL (n=81)	59%	77%
					Non-ELL (n=165)	69%	83%
I notice STEM in the world around me every day.							
Gender					Female (n=126)	52%	65%
					Male (n=126)	52%	65%
Free/reduced-price lunch					Eligible (n=180)	51%	64%
Race/ethnicity					Of color (n=181)	52%	67%
ELL status					ELL (n=82) p=.05	48%	61%
					Non-ELL (n=170)	54%	67%
I know about many STEM-related activities that happen outside of school.							
Gender					Female (n=124)	34%	54%
Free/reduced-price lunch					Eligible (n=178)	40%	55%
Race/ethnicity					White (n=70)	33%	60%
ELL status					Non-ELL (n=167)	40%	59%
I am really good at STEM.							
ELL status	ELL (n=83)	42%	Non-ELL (n=166)	62%			
I would be good at a job that uses STEM.							
Race/ethnicity	Of color (n=175)	49%	White (n=71)	63%			
ELL status	ELL (n=81)	41%	Non-ELL (n=165)	59%			
I like learning math.							
Free/reduced-price lunch	Eligible (n=176)	80%	Ineligible (n=73)	63%			

A4. STEM Pathways student survey Cohort 1 results by student characteristics, Fall 2014 to Spring 2016: Statistically significant results (p<.05) by survey item (continued)

Student characteristics	Significant difference between groups in percentage who "agree a lot" or "mostly agree" with survey item in Spring 2016 [a,b]				Significant change within group in percentage who "agree a lot" or "mostly agree" with survey item [a,c]		
					Group	Fall 2014	Spring 2016
I like learning engineering.							
Gender					Female (n=123)	46%	75%
					Male (n=121)	66%	83%
Free/reduced-price lunch					Eligible (n=172)	55%	79%
					Ineligible (n=72)	57%	78%
Race/ethnicity					Of color (n=176)	57%	78%
					White (n=68)	53%	79%
ELL status					ELL (n=79)	48%	78%
					Non-ELL (n=165)	59%	79%
I like learning technology.							
Free/reduced-price lunch					Eligible (n=174)	79%	87%
I know about many jobs that use STEM.							
Gender					Female (n=122)	55%	73%
Free/reduced-price lunch					Eligible (n=166)	59%	72%
					Ineligible (n=71)	66%	79%
Race/ethnicity	Of color (n=167)	69%	White (n=70)	86%	Of color (n=167)	57%	69%
					White (n=70)	70%	86%
ELL status	ELL (n=76)	64%	Non-ELL (n=161)	79%	Non-ELL (n=161)	64%	79%
When I get older, I would like to have a job that uses STEM.							
Free/reduced-price lunch					Ineligible (n=72)	49%	65%
Race/ethnicity	Of color (n=176)	52%	White (n=71)	69%	White (n=71)	49%	69%
ELL status					Non-ELL (n=166)	50%	61%

[a] Response options for the survey items are: don't agree, agree a little, mostly agree, agree a lot, and don't know.

[b] Statistically significant difference (p<.05) using Fisher's Exact Test, two-sided.

[c] Statistically significant change (p<.05) using McNemar Test, two-sided.