



2014-2015 STEM Pathways Evaluation

*First-year Results of an Informal STEM Education Partnership,
in Conjunction with Minneapolis Public Schools and
Minnesota Department of Education*

D E C E M B E R 2 0 1 5

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Summary

STEM Pathways aims to increase youths' long-term interest, learning and achievement in STEM through a deliberate and interconnected system of STEM learning opportunities. STEM Pathways is a partnership of Minneapolis Public Schools (MPS), the Minnesota Department of Education (MDE), The Bakken, The Bell Museum of Natural History, Minnesota Zoo, STARBASE Minnesota, and The Works that tests a model for collaboration that could be expanded and replicated across more grade levels, schools, organizations, and communities.

As part of a three-year project, STEM Pathways partner organizations began the first year in 2013-2014 with an intensive collaboration process to learn about each other's program and make concept and theme connections, develop shared tools and strategies, and plan for project implementation. Partner organization refers to informal STEM education organizations, working in conjunction with the Minnesota Department Education and Minneapolis Public Schools. STEM Pathways began offering activities to fourth- and fifth-grade students at six MPS elementary schools: Bryn Mawr, Emerson, Jefferson, Keewaydin, Loring, and Pillsbury in 2014-2015. STEM Pathways continues to provide programs to fourth- and fifth-graders in those schools in 2015-2016.

Evaluation

A core component of STEM Pathways is the inclusion of an ongoing evaluation that can be used to inform programming. STEM Pathways participates in a rigorous, independent evaluation conducted by Wilder Research. Evaluators assess the implementation and outcomes of the project, using student survey and academic data and interviews with MPS leaders and STEM Pathways partner representatives. This report reflects evaluation findings in 2014-2015.

Student survey results

In fall 2014 and spring 2015, a survey was administered to fourth- and fifth-grade students at the six STEM Pathways schools in MPS. The survey assessed students' STEM awareness, attitudes, interests, and activities. Changes in students' responses in these areas from fall to spring may be associated with participation in STEM Pathways. A total of 705 students completed the survey in both the fall and spring for a response rate of 85 percent. Results are organized by areas that showed promising findings and areas that could be improved.

Promising results

STEM interest and application

Interest in engineering (“I like learning engineering”) increased overall from fall to spring. This increase occurred primarily among fourth-graders and appeared to be due to increased knowledge or understanding of what engineering is as “don’t know” responses from fourth-graders went down sharply from fall to spring while “agree a lot” responses went up very strongly. Perhaps related to this, agreement with the statement, “I think like an engineer to design solutions to problems,” increased among fourth-graders from fall to spring. The interest in engineering of all demographic groups examined (gender, eligibility for free or reduced-price lunch - FRL, English Language Learner - ELL status, and race/ethnicity –white students, students of color) increased from fall to spring as well.

Interest in STEM as a whole (“I like learning STEM”) also increased among fourth-graders from fall to spring. This increase occurred especially among boys and ELL students.

Overall, interest in other STEM subjects (math, science, and technology) did not change significantly from fall to spring. These results might still be viewed as favorable because over three-quarters of the students already liked learning these subjects at the time of the baseline survey in the fall.

STEM relevance and awareness

Students’ agreement that STEM knowledge is important to their futures increased from fall to spring. This increase occurred across grades and across almost all student demographic groups examined.

Overall, students’ awareness of STEM (“I notice STEM in the world around me every day”) also increased from fall to spring. This increase primarily occurred among fourth-graders and among students of color.

Knowledge of STEM careers

Knowledge of STEM jobs (“I know about many jobs that use STEM”) increased from fall to spring in both fourth and fifth grades. This increase occurred in most of the student demographic groups examined.

Possible opportunities for growth

Confidence in STEM abilities

Confidence in STEM abilities (“I am really good at STEM”) decreased from fall to spring. Fourth-graders had a bigger decrease than fifth-graders, with more fourth-graders being less sure of their STEM abilities in the spring. Student demographic groups with decreases in their STEM confidence levels were girls, low-income students, ELL and non-ELL students, and students of color.

Despite the decrease in agreement with the statement, “I am really good at STEM,” agreement with the statement, “I would be good at a job that uses STEM,” did not change significantly from fall to spring. Females, low-income students, and students of color tended to be less confident that they would be good at a STEM-related job compared to their demographic counterparts.

Participation in STEM activities outside of school

The proportion of students engaging in frequent STEM-related activities outside of school did not change significantly from fall to spring in either fourth or fifth grade.

Interest in STEM careers

Similarly, there was little change from fall to spring in students’ interest in having a job that uses STEM when they are older, with slightly over half agreeing with this item at both time points. Higher income students were more likely to have an interest in such a job.

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 their spring 2015 Minnesota Comprehensive Assessments, Series III (MCA-III) math, reading, and science scores. A statistical method was used to “equalize” the two groups at baseline on factors that could influence achievement (i.e., student demographics and prior achievement). Results show no differences in academic performance between the treatment and comparison groups, with the exception of a slight advantage in reading for comparison group students in fourth grade. When differences in academic performance between treatment and comparison groups were examined within student demographic categories, no strong patterns of differences emerged. Differences were generally small within gender, income, ELL, and race/ethnicity categories.

Results of Minneapolis Public Schools leader interviews

Wilder interviewed MPS leaders to get their views on STEM Pathways effectiveness, alignment with Minnesota standards and MPS learning targets, collaboration, and benefits to students, teachers, and the district. Nine MPS leaders participated, including five principals of the six STEM Pathways schools. Leaders viewed their collaboration with STEM Pathways organizations positively. Several benefits to teachers, students, and the district were mentioned, including the following:

- Provides students with good experiences in science and math
- Expands student access to STEM learning activities, increases their enthusiasm and engagement in STEM learning, and promotes career exploration
- Increases ability within schools to integrate science and literacy requirements
- Provides modeling for teachers, inspires them, and increases their interest in STEM topics—giving them new ideas for ways to incorporate STEM education into their classroom
- Connects and aligns informal education opportunities to state standards and MPS learning targets
- Increases resources available to schools and the district and helps them use these resources more strategically
- Strengthens relationships with the MPS district, including individual STEM Pathways schools and STEM Pathways partner organizations, resulting in better alignment of programming

Results of STEM Pathways partner representative interviews

Twelve representatives from the STEM Pathways partner organizations, including steering committee and implementation team members, were also interviewed by Wilder Research. Representatives were asked their views on the STEM Pathways collaborative, the program's implementation and effectiveness, including impacts on their organization, program delivery, and staff development.

Representatives of the STEM Pathways partner informal STEM education organizations indicated several successes from the first year of implementation including:

- Full implementation of each informal STEM education partner's programming for all the fourth- and fifth-grade classes at the six STEM Pathways schools
- Enthusiasm and commitment on the part of all partner organizations

- Increased familiarity with, knowledge, and appreciation of what other partner organizations do and how their work complements the work of other informal STEM education organizations
- Sharing of educational approaches between partner organizations, leading to new ideas and improved curriculum and instruction
- Stronger alignment with and reinforcement of state standards and increased knowledge, on the part of the partner organizations, of MPS learning targets
- Buy-in from leadership and teachers at MPS
- Attention to and support for the Next Generation Science Standards

Issues to consider

Student survey results indicated fourth-grade students made gains in their STEM interest, awareness, and knowledge. Their gains tend to be higher than those of fifth-grade students. However, as the year progressed from fall to spring, their confidence in STEM abilities decreased. As of fall 2015, STEM Pathways partner organizations are considering ways to incorporate conversations with students into programming that could impact student confidence in STEM. Further, responsive interviews are planned for January and February 2016 in order to hear directly from students about how they perceive STEM.

STEM Pathways' potential effects on student academic achievement were examined using MCA tests, which are considered 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.

STEM Pathways partners and MPS leaders felt that STEM Pathways was successfully implemented, especially considering that it was the first year of implementation. Partners and leaders are hopeful for stronger project implementation over time. Both MPS leaders and STEM Pathways partners also pointed out some opportunities for project implementation efforts, including stronger and more consistent implementation of common project concepts, tools, and strategies across organizations; greater involvement of all partners; better communication and schedule coordination with the schools and the school district; involving teachers in STEM Pathways professional development meetings; and increasing funding for the project.

Looking forward

STEM Pathways partners continue to strengthen their partnership and deliver programming to fourth- and fifth-grade students in the same six MPS schools. Fourth-

grade students from 2014-2015 who are enrolled in one of the STEM Pathways schools in 2015-2016 as fifth-graders continue to receive STEM learning experiences from STARBASE and two new partners (Minnesota Zoo and Bell Museum). Another cohort of fourth-grade students in these schools also start participating in STEM Pathways, receiving programming from The Bakken, The Works Museum, and STARBASE. Wilder Research will continue to follow these cohorts of students in 2015-2016 and into later years, assessing the long-term impacts of the project, if funding permits.

As STEM Pathways is well into the third year of the project, partners are focusing on strategic planning to determine the next phase of the project. Through this process, STEM Pathways partners will consider:

- How to facilitate and support sustainability of access to a system of high-quality and interconnected informal STEM education for youth in collaboration with schools and districts
- Articulating and strengthening of the local STEM learning ecosystem
- Continuing to promote 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 toward goals
- Continuing to support and even expand the network of informal STEM educators that STEM Pathways has created
- Strategies for sustainability

Introduction

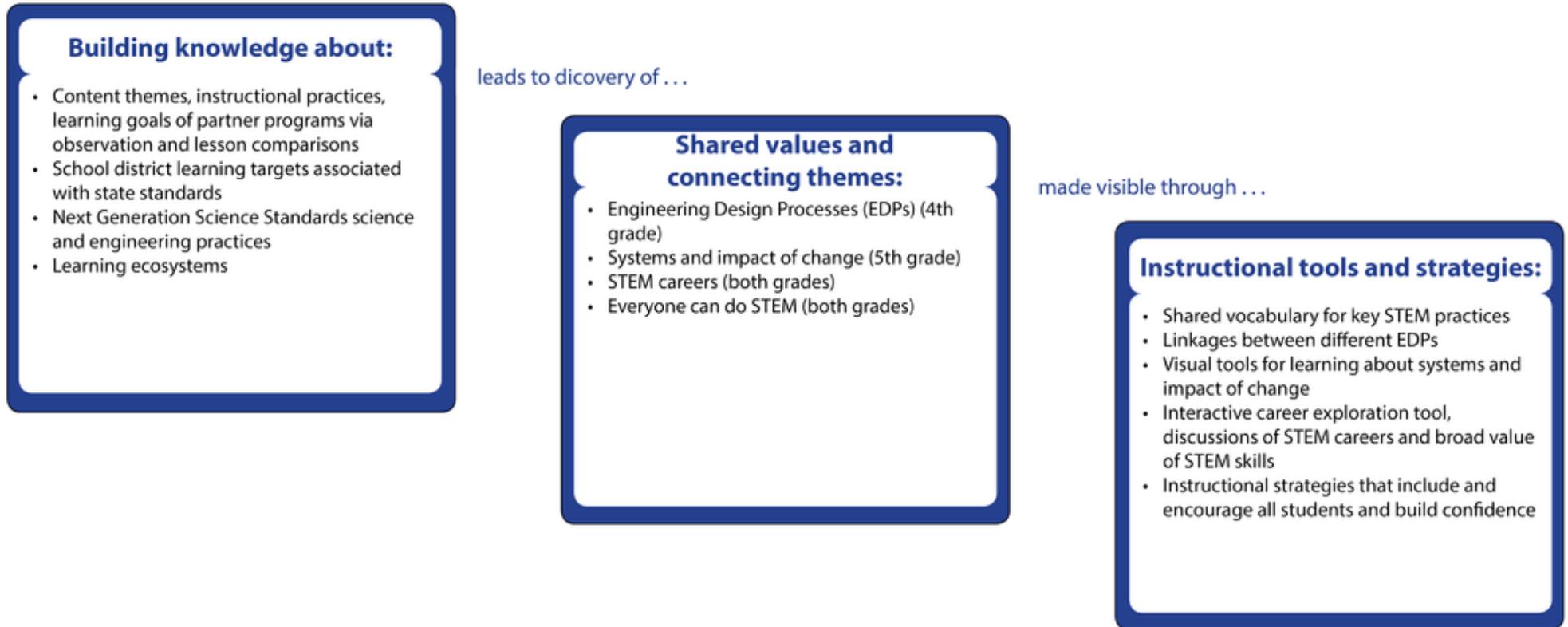
STEM Pathways aims to increase youths' long-term interest, learning and achievement in STEM through a deliberate and interconnected system of STEM learning opportunities. STEM Pathways is a partnership of Minneapolis Public Schools (MPS), the Minnesota Department of Education (MDE), The Bakken, The Bell Museum of Natural History, Minnesota Zoo, STARBASE Minnesota, and The Works that tests a model for collaboration that could be expanded and replicated across more grade levels, schools, organizations, and communities.

The partnership was formed in spring 2013 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

During the first year of the project (2013-2014), STEM Pathways partner organizations developed and used a collaboration process 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 develop common tools, strategies, and messages that would help students experience long-term and interconnected STEM learning and build their confidence (Figure 1). The collaborative efforts of sharing goals, strategies, and tools among partner organizations to build interconnected learning experiences for students is a major shift in the culture of informal STEM education organizations that traditionally work in isolation from one another. Partners met regularly through a series of working meetings. A summary of the working meeting topics is described on pages 10-12.

STEM Pathways collaboration process



Source: *STEM Pathways*

STEM Pathways worked with the Minneapolis Public Schools' Teaching and Learning director and STEM coordinators to select the schools and grade levels where informal STEM learning opportunities were most needed. School principals and teachers received extensive information about and expressed their willingness to participate in STEM Pathways prior to launching the project.

In the second year (2014-2015), STEM Pathways began offering activities to fourth- and fifth-grade students at six elementary schools: Bryn Mawr, Emerson, Jefferson, Keewaydin, Loring, and Pillsbury.

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

Funding

STEM Pathways received funding from the Department of Defense (DoD) STARBASE, Boston Scientific and in-kind contributions from the partner organizations, Minneapolis Public Schools, and Minnesota Department of Education. Funding from DoD STARBASE and Boston Scientific supported the evaluation of the project and the project director position. Recently, STEM Pathways also received additional funding from Pentair. Partner organizations dedicated substantial amounts of staff time to the implementation efforts and subsidized the program fees.

Content of the report

This evaluation report focuses on first-year implementation of STEM Pathways and short-term project outcomes during the 2014-15 school year.

The report is organized into the following sections:

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

Partnership efforts

Planning year (2013-2014)

The STEM Pathways steering committee which consists of key representatives from informal STEM organizations, MDE, and MPS met regularly throughout the planning year. Additionally, working meetings were held for STEM Pathways educators and steering committee members to learn about each other's organization and make connections. Implementation team and grade-level workgroups were created to plan and coordinate the activities for fourth- and fifth-grade students.

Below is a short summary of four working meeting topics in 2013-2014 (note that there were multiple topics covered at each of the meetings). These meetings were each held at four different partner organizations and each attended by about 25 STEM educators and leaders and MPS leaders and teachers.

- *Engineering Design Process*. STEM Pathways educators and leaders and STEM educators from Minneapolis Public Schools explored the various Engineering Design Processes (EDPs) used by the partner organizations, identified the common concepts and language across the EDPs and opportunities to make connections between them.
- *Next Generation Science Standards (NGSS)*. In this professional development session, the MDE STEM Specialist and the MPS Elementary STEM Coordinator engaged partners in lessons designed to focus on developing science and engineering practices.
- *STEM Pathways logo development*. Sample logos were developed by STEM educators and meeting attendees voted on the final logo. Attendees discussed how the logo can be used to brand STEM Pathways and be used by each partner organization and how the logo represents the messages STEM Pathways wants to convey to teachers, students, and families.
- *Learning targets in the MPS science curriculum*. The MPS Elementary STEM Coordinator led discussions about how MPS uses student-centered learning targets with individual science and engineering lessons to build student mastery of science standards. STEM Pathways partners discussed how the same approach is being used or could be used in their programming.
- *Writing in science*. STEM Pathways partners explored research-based practices for engaging students in writing in meaningful ways for practicing and developing science and engineering skills.

First implementation year (2014-2015)

In 2014-2015, the STEM Pathways steering committee and educators continued to meet and refine the project efforts. A summary of working meeting topics and task force efforts in the second year of STEM Pathways (first implementation year) follows.

- *Development of STEM Pathways Portfolio.* The Portfolio is designed as a tool to help students reflect on their STEM experiences, showcase their STEM-related activities, and track their progress in STEM. It consists of a STEM Passport, a place to record participation in each of the STEM Pathways programs; reflection pages, where students can record information and thoughts after STEM partner experiences; additional STEM activities that can be completed in class or at home; the Game of STEM, where classroom teachers recognize students' progress and accomplishments in STEM that allows students to "level up" in STEM. The Portfolio is designed for use by teachers and students. STEM Pathways educators are encouraged to reference the Portfolio and how it can be used during their programming.
- *Development of STEM Pathways Career Interactive.* Students can explore a wide range of STEM careers designed to build off the momentum of the partner experiences back at school. For example, for careers related to their experiences with Minnesota Zoo and the Bell Museum, students can view videos of an entomologist, a neurobiologist, or a frog scientist describing their work. For careers related to their experiences at The Bakken, STARBASE, or the Works, students can view videos of a solar car engineer, a wind researcher, a renewable energy engineer or a robot engineer. The videos are produced by Twin Cities Public Television, Dragon Fly TV.
- *MPS learning targets follow-up.* STEM educators practiced developing learning targets specific to their programs and explored how each program's unique set of learning targets, in combination with ones specific to MPS curriculum, support student mastery of standards.
- *STEM learning ecosystems.* STEM educators explored the concept of natural ecosystems, and possible changes and implications of those changes to the ecosystems, and then applied these concepts to imagine a local STEM learning ecosystem including its components and resources to thrive.
- *Implementation team best practice sharing: STEM integration, storytelling, and live animals.* Instructors from three partner organizations shared key practices from their programs. STARBASE Minnesota presented their approach to integrating the STEM subjects (science, technology, engineering and math) and how this informs the curriculum review process that they use to make program improvements. The Bakken

shared storytelling techniques that they use to engage students in invention and scientific discovery. The Minnesota Zoo shared their approach to using live animals in their programs and how they use this opportunity to inspire empathy for and connection to the natural world. Following these presentations, attendees discussed what they learned from each other and points of connection between STEM Pathways programs.

- *Defining STEM Pathways values and key messages.* Implementation team and steering committee members gathered to revisit core assumptions of STEM Pathways collaboration and the values that drive its work. Partners affirmed values related to educational experiences that: integrate science, technology, engineering and math, rather than treat them as isolated topics; promote the value of STEM education for all, not just those who will enter the traditional STEM workforce; help students develop positive STEM confidence and competency beliefs; and are interconnected and reinforcing so that students take part in a web of STEM experiences that share concepts and themes over time.

Additionally, STEM Pathways partner representatives presented the work of STEM Pathways at the following professional development conferences:

- 5th Annual Minnesota STEM Network Conference, April 2014*
- University of Minnesota Pre-K-12 Network Conference, February 2015
- National Science Teachers Association (NSTA) National Conference, March 2015
- Minnesota STEM Network and Ignite Afterschool Joint Conference, April 2015

* *This presentation happened in the first (planning) year of the project*

Research methods

In consultation with STEM Pathways steering committee, Wilder Research developed an evaluation plan for the first project implementation year with the potential for extending it as funding permits. 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 in 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

First-year evaluation efforts were guided by the following research questions, organized into the implementation and outcome components of the evaluation:

Implementation questions

The implementation component of the evaluation is an important mechanism for understanding project efforts that seem effective and for providing feedback useful in 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 evaluation year, outcome measurement focuses 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?
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 implementation and outcome components of 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 2015, 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; two representatives each from The Bakken Museum, Minnesota Zoo, and Minneapolis Public Schools; and one representative each from The Works Museum and The Bell Museum of Natural History.

Minneapolis Public Schools leader interviews

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

Wilder Research also conducted one-to-one phone interviews with MPS leaders in spring 2015, including five of the six school principals, GEMS & GISE coordinator, STEM

curriculum integration specialist, the director of elementary education, and the director of Teaching and Learning. The survey asked MPS leaders about the implementation and accomplishments of STEM Pathways as well as suggestions for changes or improvements for STEM Pathways in the future.

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

In fall 2014 and spring 2015, a survey was administered to fourth- and fifth-grade students at the six STEM Pathways schools in MPS. The survey was administered to students as a group in their classrooms by Wilder Research staff in both fall (September 2014) and spring (May-June 2015). 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 students who completed all or most of the survey in fall and spring in the STEM Pathways schools. Of 829 eligible fourth- and fifth-graders from the six STEM Pathways schools, 705 completed all or most of the survey in both the fall and spring for a response rate of 85 percent.

Academic achievement data
(Questions 6 and 7)

This first year evaluation report 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 initial project period is important in that ultimately, this project is intended to assist with systems change efforts that 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 will also be included as a student outcome measure in the evaluation in future years. It seemed too early to include it as an outcome measure during the first year of project implementation. This is because attendance was measured throughout the year as the project was being implemented, and consequently, it is not an end-of-year measure that would have a greater chance of being impacted by project programming.

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 project.

Student survey

Data are analyzed for the same 16 closed-ended survey items included in the fall and spring student survey, permitting analysis of changes in students' responses to the items from the beginning to the end of the 2014-15 school year. Of the 705 students who completed all or most of the survey in both the fall and spring, 353 were fourth graders and 352 were fifth graders. Response options to the survey items were: "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.

Statistical tests (McNemar Test, two-sided) were conducted to determine whether change from fall to spring 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.

Differences in survey results were examined by grade and by student demographic characteristics: gender, eligibility for free- or reduced-price lunch (an indicator of students' family income), ELL status, and race/ethnicity (white students and students of color).

Student academic achievement

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

The six "treatment" schools participating in STEM Pathways include four K-5 schools, one K-8 school, and one 3-8 school. The schools are:

- K-5 schools: Bryn Mawr, Emerson, Loring, and Pillsbury
- K-8 school: Jefferson
- 3-8 school: Keewaydin

The evaluation includes cohorts of fourth- and fifth-grade students in these schools in 2014-2015. Another cohort of fourth-grade students will be added in 2015-16 and the evaluation will continue to follow these students over time, as funding permits. Figure 1 shows the study cohort groups.

1. STEM Pathways cohort groups

	2014-2015	2015-2016	2016-2017
Cohort 1	4 th grade	5 th grade	6 th grade
Cohort 2	5 th grade	6 th grade	7 th grade
Cohort 3	---	4 th grade	5 th grade

Note: STEM Pathways was implemented in 2014-2015. Evaluation can potentially follow the students who 'graduate' from Pathways into the later grades (6th, 7th and 8th grades and high school), assessing their long-term academic outcomes.

School performance of the STEM Pathways cohort students (treatment) were compared with those of same-grade students from non-Pathways schools (comparison). The evaluation uses a statistical technique (propensity score analysis) to “equate” 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 (third- and fourth-grade MCA-III math scores for fourth- and fifth-grade students, respectively) 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 on student achievement measures: MCA math, reading, and science scores. Differences in student achievement between the treatment and comparison groups were examined overall for fourth- and fifth-graders, and within demographic subgroups. A detailed description of the statistical techniques used in analyzing the student academic data is presented in another report, *STEM Pathways Student Academic Achievement Results for the 2014-15 School Year* (Mueller, 2015).

Overall strengths and limitations of methodology

Strengths

The study data were collected from multiple perspectives, including STEM Pathways partners, MPS leaders, 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, student demographics and academic achievement data for treatment and comparison students were provided to the study by MPS Research, Evaluation, and Assessment department (REA).

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 them to STEM Pathways because other STEM experiences students may have had in and out of school during the same period could have contributed to the changes as well. 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.

A classroom teacher survey was not collected during 2014-2015. However, the STEM Pathways project coordinator and STEM Pathways staff met with classroom teachers at the end of the school year to get their feedback about the project. Information provided by the teachers was used to help in planning for the second year of project implementation. In 2015-2016, a classroom teacher survey will be conducted by the evaluator.

Minnesota Comprehensive Assessments (MCA-III) were used to assess student academic outcomes in math, science, and reading proficiency. MCA tests are the academic achievement measures administered to students statewide each spring, and serve as accountability measurement tools in Minnesota for the federal No Child Left Behind law. We consider MCA tests 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 evaluation plans were approved by REA. Data collection instruments and consent procedures used in the course of this evaluation were also reviewed by REA prior to their implementation.

Implementation

In 2014-2015, STEM Pathways' goals for implementation include:

- Giving students access to multiple in and out-of-school STEM Pathways partner programs
- Offering connected experiences across partner programs
- Offering high quality, relevant STEM experiences for Pathways students

Research question 1.

How successfully is the STEM Pathways model being implemented?

During the 2014-2015, fourth- and fifth-grade students received almost 30 programming hours from STEM Pathways partners. 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 really works and how it relates to them, specifically around the practices and process of science and engineering and STEM careers. Fourth grade programs are offered by the following organizations.

The Works Museum

Program hours: 3-hour fieldtrip

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 fieldtrip

On the first visit to the school, Bakken educators invite all fourth-graders in the school to explore what it means to “Wonder, Try, Discover, and Share” – important habits of every scientist and engineer. A key goal of this presentation is for all students to see themselves as scientists and engineers. On the second visit, a Bakken educator works with fourth-grade

students in each classroom to guide them in applying “Wonder, Try, Discover, and Share” as they re-invent the battery. As scientists and engineers, students practice supporting their claims with evidence and learn the importance of taking risks and making mistakes in the process of discovery.

Following the assembly and the classroom visit, students travel to The Bakken Museum to participate in a hands-on workshop and a guided exhibit tour. In the Magnets and Electromagnets workshop, students discover properties of magnets by recreating historical experiments and explore magnetic force and field and the relationship between magnetism and electricity. During the guided tour, students 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. Students 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 of and impact of change on systems. Fifth grade programs are offered by the following organizations.

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 the habitats as a result of

changes in the ecosystems. Students gain deeper understanding of ecosystem dynamics and greater appreciation for the important roles everyone can play in the system.

Bell Museum of Natural History

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

The fifth grade curriculum (a core MPS 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 the microscopes, forceps, and dissections to make observations of the anatomy of bees and flowers. Students learn about the 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 attend 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.

In addition to connecting themes, STEM Pathways programs use shared instructional tools and messaging, which include vocabulary cards that help students and teachers recognize specific content connections between programs. For example, “conflict cards” are used to help the fifth-grade cohort students understand the impacts of a change on systems. After introducing the concept of systems, these conflict cards challenge students to determine what would happen when a conflict occurs in a system. STEM Pathways also provides tools that teachers and students can use at school or home, such as the *STEM Pathways Career Interactive* mentioned earlier.

STEM Pathways Instructional Tools



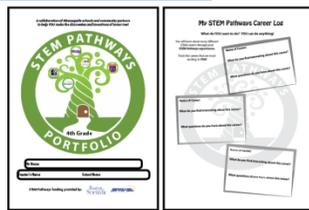
Vocabulary Cards - Common vocabulary is utilized by partner organizations, including vocabulary cards with visuals to support the learning needs of English language learners.



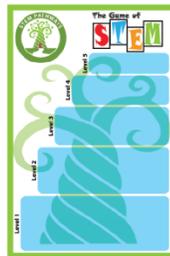
Conflict Cards - Used in the fifth-grade programs, each conflict card introduces a change to a system that students have been studying. Students are then challenged to determine what would happen when that change occurs.



Career Interactive - A web-based interactive tool that allows teachers and students to explore STEM careers via kid-friendly videos.



Student Portfolio - All students receive a STEM Pathways portfolio to track their STEM Pathways, classroom, and out-of-school STEM experiences throughout the school year. Reflection questions and pages to track interesting STEM careers are also included.



Game of STEM - A game board included in student portfolios and a classroom poster used by teachers to recognize each student's STEM learning. Students “level up” as they do more and more STEM.

Source: *STEM Pathways*

Perspectives from partners, MPS leaders, and students

The following section provides results from interviews with STEM partner organizations and MPS Leaders. Interviewee responses are organized by research questions. Detailed interview results are also presented in two separate reports: *Results from Spring 2015 Interviews with STEM Pathways Partners* (Streich and Bartholomay, 2015) and *Results from Spring 2015 Interviews with Minneapolis Public Schools Leaders* (Streich and Bartholomay, 2015). Results of an open-ended question in the spring student survey are also included.

Overall, STEM Pathways partners and MPS leaders felt that STEM Pathways was successfully implemented, with all the partners implementing a total of almost 30 programming hours at the six STEM Pathways schools. Although still at an early stage of implementation, partners and leaders mentioned seeing the connections among partners' work in using common vocabulary, crosscutting concepts, practices, and core ideas. Partners and MPS leaders mentioned that STEM Pathways programming aligns with the state standards and increasingly supports the district curriculum. MPS leaders mentioned the benefits of the project for the students' STEM learning. Comments from partners and MPS leaders follow.

Successes

A major accomplishment of the first operational year was the implementation of each partner's programming for all the fourth and fifth grade classes at the six Pathways schools

Just the fact that, in its first year of trying to provide 30 hours of programming in fourth and fifth grade at six schools, that to a large degree it happened, I think is a big success.
– Steering committee member, STEM Pathways partner interviews

Connections among partners' work and with MPS

Finding: Most partner organizations refer to other partner organizations when working with students.

I very intentionally will reference STARBASE and the MN Zoo, what their programs are about, the scientific process that they have participated in and how that flows through all three of our programs. – Implementation team member, STEM Pathways partner interviews

Finding: Relationships between the MPS district, including individual Pathways schools, and STEM Pathways partner organizations have been strengthened resulting in better alignment of programming.

...I definitely think that the organizations working together and with the district is a huge success. I think [the] communication, sharing of goals and ideas, and education is a huge success. I think having common language, vocabulary and having those connections between organizations so that students can pick up on that is a really big deal. – MPS leader interviews

Finding: Partners began to use common vocabulary, crosscutting concepts, practices, and core ideas.

*The idea of systems and interdependence in systems, as well as impact of change on systems, is the big crosscutting concept that we're trying to have woven through this whole fifth grade experience. A lot of that is introduced by us. I don't know that we did a super good job this year, but I think next year, now that we've been through this once, my instructors, when they introduce this kind of stuff, will be able to say - you're going to see more systems or think about when you encounter systems and will know what to talk to them about moving forward. We've talked a lot about it and are working on how to do a good job of pulling that stuff through.
– Implementation team member, STEM Pathways partner interviews*

In the spring survey, students were asked to name one experience or learning that was similar between two different STEM Pathways programs. Students described many similarities in their STEM learning experiences across STEM Pathways programs. Their most frequent answers included learning about science, STEM in general, and about animals or nature. They also mentioned other learning not related to STEM, such as learning is fun and they can build anything (Figure A3).

Alignment with state standards, NGSS, and supports of MPS curriculum

Finding: The partners felt that STEM Pathways programming from each site is strongly aligned with state standards and expressed improved knowledge of and alignment with MPS learning targets.

- The partner organizations were working to align their programming with the state standards before their involvement with STEM Pathways, and have now become more familiar with how the district defines them and how they are implemented by teachers within the district. Working with each other, with the district, and with teachers helped the informal education organizations to make even greater connections to the standards.

... right now at [Partner Organization] all of our programs are aligned to the state standards, but we hadn't done any work to specifically align them to the learning targets in Minneapolis. That was something that we started to look at this year. – Steering committee member, STEM Pathways partner interviews

Finding: MPS leaders felt that STEM Pathways supports some aspect of the MPS curriculum.

[STEM Pathways partners] know what those standards are for the fifth grade, and when our students go on a field trip [at the partner site] they will highlight those things or they'll make sure they're using some of the same vocabulary the teacher might be using in labs or lessons here. – MPS leader interviews

Talking with the teachers, they feel it really supports the MPS curriculum 100%. – MPS leader interviews

Our curriculum is aligned to the state standards that teachers are charged with teaching each year. Insofar as the things I've looked at, some of the written materials and what I saw at STARBASE, there's also an alignment there with those same standards. – MPS leader interviews

Finding: The partners have kept in mind the Next Generation Science Standards (NGSS) as they have been developing their programming. It is understood that these standards are important and may be adopted by Minnesota in the near future.

As soon as we started going down the road in developing the curriculum and talking about how we were going to present the material, we were already looking at the NGSS at the same time. – Implementation team member, STEM Pathways partner interviews

Connections with students' STEM learning at school

Finding: There is growing enthusiasm and engagement in STEM learning from students as a result of STEM Pathways field trips. Students are making connections between their STEM Pathways experiences and what they are learning in school.

What our students have shared is that they think being a scientist is cool, being a scientist is fun, and building stuff is fun. I remember distinctly sitting with a few students saying 'I need to learn this, I need to learn this because this is what we practiced when we were at STARBASE. We practiced this in math, so I need to figure this out.' So they're making these connections and to me that's what it is. If a student walks away learning something and seeing the value and its purpose and how it connects to their future, it was a successful day. – MPS leader interviews

Opportunities for improvement

MPS leaders and partners mentioned some challenges they experienced in the first year of the project. These challenges included partners are at different points in their

understanding and implementation of the model, lack of communication or coordination with schools, and scheduling issues. At the same time, interviewees felt hopeful that the project is making improvement on these areas.

Understanding of the model

Finding: Partners varied in their understanding and implementation of shared vocabulary, crosscutting concepts, practices and core ideas.

I feel like we talked about it a lot, but I don't know that we ever came to any consensus about what that shared vocabulary was going to be. So I don't feel like that's done. It's sort of a work in progress, but I do feel like it's important. –Steering committee member, STEM Pathways partner interviews

I'm still a little vague on what that means... We have core ideas that we're trying to emphasize. Whether they're crosscutting concepts I'm not exactly sure. – Steering committee member, STEM Pathways partner interviews

Finding: The STEM Pathways Portfolio was developed for classroom teachers to use in the classroom to support student STEM learning. Some partners said that teachers have given positive feedback on the Portfolio as a useful tool. Referencing to the STEM Pathways Portfolio varied across organizations, with some organizations referencing it more regularly than others. Similarly, discussion of careers or promoting the Career Interactive website varied across partner organizations.

I have absolutely no idea how it worked...I've heard, just through meetings, talking with [instructor] who's the main liaison between the teachers and the [informal educators], that they liked it and it was useful, but I haven't spent much time thinking about it. – Implementation team member, STEM Pathways partner interviews

...but we don't have a ton of time to focus on career stuff. As I mentioned before we only have 45 minutes of hands-on time with the kids. – Implementation team member, STEM Pathways partner interviews

Communication or coordination

Finding: Communication between teachers and informal education sites prior to the field trip visits varied for each partner organization. Often teachers didn't know what they were going into when they went on a STEM Pathways field trip. However, several principals felt that, after this year, teachers will be able to plan better to fit the learning from each site into their curriculum and learning sequence.

The first year was a little tricky with teachers for navigating. Now they can see for next year how they will connect it. Connecting has happened after, next year [it] could happen more before. – MPS leader interviews

Teachers weren't sure about what would be happening at the Bell Museum coming up. – MPS leader interviews

Finding: Scheduling between the schools and the partner organizations presented logistical challenges for some organizations.

That can be pretty tricky because we weren't able to schedule until later in our scheduling process. Picking dates that are available for teachers and their classes was a big challenge. – Implementation team member, STEM Pathways partner interviews

Research question 2.

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

Drawing from their experiences during the first year of implementation, both STEM Pathways partners and MPS leaders felt more time for planning and reaching consensus on what they want to accomplish is important for successful implementation. Partners and MPS leaders also indicated that scheduling activities and coordinating with teachers or schools earlier and communicating costs, availability of funding, and what each organization is able to contribute are needed. Involving teachers and parents was mentioned by MPS leaders and more involvement from steering committee was mentioned by partners. MPS leaders suggested getting feedback from teachers about the project. Although a teacher survey was not collected in 2014-2015, the project coordinator and STEM Pathways staff met with some of the teachers informally to get their feedback about what worked well and what needed enhancement or improvement.

More time for planning and reaching consensus on goals

- Partners recommended agreeing on shared vocabulary, crosscutting concepts, practices, and core ideas to strategically implement across organizations. They also recommended agreeing on the development and use of new programmatic tools. They specifically mentioned: scheduling a meeting to go over the STEM Pathways Portfolio with representatives from each partner organization, developing shared goals as informal educators, and providing more opportunities for informal educators to meet.

Having more time to get to know the other organizations and to talk about what we were trying to accomplish and how we were going to assist each other would probably be the best thing that we could do. – Steering committee member, STEM Pathways partner interviews

- Develop concrete goals to accomplish and utilize project management strategies to document progress.

I think that one of the things that makes it hard to speak authoritatively about whether or not we're fulfilling goals, whether or not work is being successful, is that it's not always clear throughout the process, what precisely the STEM Pathways are delivering or committing to deliver and on what time line. I gave the group some feedback, specifically around the need for a more robust planning process and then some really consistent project management to back up whatever commitments are being made to make sure they're actually getting built and implemented – MPS leader interviews

Schedule early and establish communication

- Partners recommended addressing scheduling challenges. They recommended doing so by scheduling visits to partner organizations far in advance, developing and adhering to an appropriate sequence for visits to partner organizations for students, and identifying one person to coordinate scheduling logistics with the partner organizations and schools.

The suggestions I have... the further out we can plan these things...often these things are a month, month and a half in advance, but I would love to know now about next year's schedule. I've got programs and my staff have got programs scheduled throughout June already. And sort of arbitrarily dropping in or doing a number of Doodle polls to try and find something...it's all just kind of ineffective and right now we should be looking at our schedules for next year and trying to get people to either commit to times and holding those times so we can get more people participating or something like that. – Steering committee member, STEM Pathways partner interviews

For the fourth grade cohort, I definitely think that summer planning and cohort meetings are absolutely necessary because the program takes off so quickly in the fall. I think teachers report back to Minneapolis schools on August 17th and I feel like we need to have our plan in place, what we're going to do, by the end of August. And then for fifth grade, again, early fall planning would be fine, but just kicking things off earlier as a cohort. – Implementation team member, STEM Pathways partner interviews

- Hold an initial kick-off meeting that includes not only the partner organizations, but teachers as well. – MPS leader interviews
- Increase communication between teachers and informal education sites earlier in the year and prior to the field trip visits for a more coordinated effort to improve student learning. – MPS leader interviews

Communicate costs and funding

- Interviewees recommended addressing funding challenges. Their specific recommendations included increasing funding to facilitate greater participation from

partners who do not have capacity, having each organization commit monetarily to the project, and providing transparency regarding what each organization is willing and able to do for the project.

I think in order to make something like this result in more meaningful change and benefit, all the partners and Minneapolis schools need to inform us of and commit to what they are willing and not willing to do. So we know what we're dealing with. So we know what we're working with and can be more planful around that. Who are the decision-makers, who are the developers, who are the implementers, and what is each and every person willing and able to do and how often. – Steering committee member, STEM Pathways partner interviews

- Communicate costs related to program participation to principals earlier in the year so they can plan for STEM Pathways in their budget. –MPS leader interviews
- Secure funding for buses and site visits. – MPS leader interviews

Involve teachers and parents

- Offer training for the teachers before the school year starts and have a time for them to learn from each other about how they incorporate aspects of the field trips into their classroom.

One idea I guess I have is to maybe have all the teachers of STEM Pathways schools talk about ways that they incorporate these things in their classroom so that we're not all trying to do separate things. Sharing some of those ideas. – MPS leader interviews

- Provide an opportunity for teachers to give feedback on the experiences at each organization.

Teachers could give some feedback if there was an exit slip to give feedback on what went really well this year, what would be another opportunity for learning or what might be some ways to make those connections for growth. They could provide more on that. – MPS leader interviews

- Involve/provide opportunities for parents. Provide a list of possible STEM activities for parents to do with their children in the community. – MPS leader interviews

Increase steering committee members involvement

- Interviewees recommended increasing the capacity, empowerment, accountability, and engagement of the steering committee to match that of the implementation team.

Everyone is trying really hard to provide input when it is asked for. But it's still kind of they are only involved, when they're asked to be involved as opposed to taking initiative. – Steering committee member, STEM Pathways partner interviews

Research question 3.

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

MPS leaders felt that the collaboration among STEM Pathways partner organizations has improved the coordination of STEM experiences for fourth- and fifth-grade students in the schools. MPS leaders appreciated how STEM Pathways partner organizations supported teachers and communicated with them before and after the field trips or visits. Also, as mentioned earlier, MPS leaders felt that STEM Pathways support the district's curriculum.

Successes

Better coordination and alignment of STEM programming in the schools

Finding: Some MPS leaders felt that participating in STEM Pathways strengthened their relationships with the partner organizations and made them more meaningful.

STEM Pathways allows for a clear balance between the fourth and fifth grade of who's going where and then making it more meaningful... It's connected to what they're doing and [it's] connected to [what they're doing] during different times of the year. – MPS leader interviews

I think the work we do with them is more coordinated and aligned. – MPS leader interviews

Finding: MPS leaders appreciated how STEM Pathways partner organizations supported teachers and communicated with them before and after the field trips or visits.

The Bakken is helpful because they co-plan with the teachers. [The] staff reached out to teachers. A lot of connecting and planning [happened] leading up to the future... The Bakken and STARBASE staff have really reached out and have worked a lot with the science department. So much work happened behind the scenes. – MPS leader interviews

Strong collaborative work

Finding: Partners share common goals and value their collaborative work.

And I think having this shared belief and common understanding and goals and this collective brain power is just really critical to our work and success. – Steering committee member, STEM Pathways partner interviews

Strengths of the collaboration are all of us getting together and talking and developing these consistent themes and simplifying our messages and getting down to some core messages that we're trying to get across. I think that's valuable. – Steering committee member, STEM Pathways partner interviews

Challenges

Varying levels of partner involvement

Finding: STEM Pathways partners viewed their collaboration positively. However, partner organizations had varying levels of engagement in the project. Some partner organizations were more able than others to contribute time and resources to STEM Pathways.

...everyone is excited about it and has bought in but there's not a super good balance of how much work different organizations put in toward making stuff happen. And so that can create a strange dynamic. And I can imagine down the line, if other organizations aren't able to feel sort of like as big of a player that things could start to fall apart. – Implementation team member, STEM Pathways partner interviews

The organizations that don't have any funding currently, it's hard for us to fully commit and do what we want to do to make this a really great collaboration without having any resources behind it. –Steering committee member, STEM Pathways partner interviews

Research question 4.

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

Professional development for STEM Pathways partner educators

Partners described that they received training about MPS learning targets, state standards and curriculum, a writing in science session about science notebooks, and presentations from each partner organization about their programming. They appreciated the sharing of knowledge among the partners.

Finding: Sharing knowledge and identifying commonalities between, as well as unique talents of, each organization was a beneficial component of the collaboration.

We get to know more about each other, but we also get to observe and experience other teaching styles – other methods of delivering science and engineering concepts. It's always good to see other people in action. Good educators doing their thing in their environment, because it always challenges you. Everybody can get complacent in their teaching style and their delivery methods. It's inspiring to see other people and it kind of kicks you in the butt and gets you thinking about different ways to present. – Implementation team member, STEM Pathways partner interviews

For future professional development, partners gave the following recommendations:

- Provide professional development for MPS teachers regarding content knowledge and ideas for implementation.

- Provide training for informal educators on how to work with English language learners (ELL). Provide an opportunity to learn from other informal educators' techniques when working with ELL students.
- Focus and target the professional development offered so that it is relevant to those who attend. Have more single purpose meetings—make sure there are clear goals for what needs to be achieved and then follow-up.
- Provide professional development for the partner organizations to learn about STEM integration and how MPS defines it.

Professional development for classroom teachers

Similarly, MPS leaders felt that classroom teachers would benefit from the professional development with STEM Pathways.

Finding: Some MPS leaders would like to have professional development offerings for teachers who have classrooms involved in STEM Pathways. Others referred to the teachers' involvement in STEM Pathways as a form of professional development and felt that teachers were able to benefit from attending STEM Pathways field trips with their students.

I definitely want PD [Professional Development] for our teachers that are implementing... So understanding the programming and how to then integrate that into your lessons in your classroom. – MPS District leader

If we had one or two teachers get some more intensive professional development that they could bring back to their colleagues or some kind of model where teachers could develop their craft a little more with the subject matter. That could follow-up with collaboration they're already doing and build capacity for them to do some of this learning throughout the day. – MPS Principal

Wonder if there's an opportunity for schools and partners to get together for a half day of learning or planning around the experiences they're going to have. Set aside some planning time. Teachers are always asking for that. – MPS Principal

I know that the teachers who have gone on these experiences have learned a lot more about science, technology, engineering, and math. Their own content knowledge is much stronger and that always helps when they're teaching. – MPS Principal

MPS leaders recommended creating a Professional Learning Community (PLC) around STEM.

Research question 5.

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

The discussion that follows addresses a portion of this research question regarding the conditions necessary or desirable for successful implementation or replication, but does not identify the core components of the program's model. Interviewees identified the following key conditions for successful implementation of STEM Pathways:

- Total buy-in from all partners, the school district, and teachers.

...buy-in by everybody, but I think teachers are really important. – Implementation team member, STEM Pathways partner interviews

Without someone like [MPS STEM Integrationist] committed to the project it would be really hard to make this happen, so that's really critical. – Steering committee member, STEM Pathways partner interviews

I would also say that it's equally incredible that the partner organizations, most of whom have never worked together before or have needed to work together before, have come together on this collective work toward this common purpose and all have done so without any monetary benefit. That's been pretty amazing because it's no small amount of work and no small investment.

– Steering committee member, STEM Pathways partner interviews

- Strong leadership and direction from the steering committee.

I would say commitment of participating partners, maintaining the focus of the goals and the deliverables of the Pathways project and having a funding stream that enabled someone to spearhead this as part of a main priority or to facilitate the process.

– Steering committee member, STEM Pathways partner interviews

- Understanding from teachers about what STEM Pathways is and what the field trips involve.

One of the things that went well, and maybe there was some hesitation at first about how it's all going to work, but really having the classroom teachers understand what the project is... just connecting with them and helping them understand what STEM Pathways is really early on in the year. – Implementation team member, STEM Pathways partner interviews

- Endorsement and advocacy on the part of the district to principals and teachers at participating schools.

There has to be a strong connection with the expectations of Minneapolis Public Schools and this project. If a teacher in the classroom has just received a portfolio, for example, from the STEM Pathways liaison and they're left to wonder if this is supported by Minneapolis schools, does this count towards anything, does this align or is this an extra add-on. That's not good. That needs to be clearer and that needs to be more transparent and promoted. So there has to be advocacy there on the part of Minneapolis schools for any parts of these pieces that we're trying to accomplish. – Steering committee member, STEM Pathways partner interviews

- Small group work (e.g., fourth and fifth grade cohorts, implementation team, steering committee) was described as one of the ways the project was able to get things accomplished despite challenges with time and capacity.

I thought our groups getting together, our small work groups, was very useful. Getting to know the other participants was very helpful... Having more time to get to know the other organizations and to talk about what we were trying to accomplish and how we were going to assist each other would probably be the best thing that we could do. – Steering committee member, STEM Pathways partner interviews

- Collaboration—meaningful input from every partner involved.

I think that it will be important that there will be equal representation from all of the organizations in decision-making. – Steering committee member, STEM Pathways partner interviews

- Consistency of activities—ensuring that each partner consistently implements agreed upon programmatic components (e.g., in referencing the STEM Pathways Portfolio).

*I think greater consistency of activities, stronger leadership [or] direction on the part of the steering committee... We couldn't rely on just shared messages from the partners because we knew that wasn't happening consistently. And the portfolios weren't being implemented consistently.
– Steering committee member, STEM Pathways partner interviews*

- Funding.

*So I think the biggest gap is funding to the participating organizations. Support funding.
– Implementation team member, STEM Pathways partner interviews*

Outcomes

The first year 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 outcomes, and overall systems change efforts.

Student surveys in fall and spring, 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 activities?

Research question 7.

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

Student survey

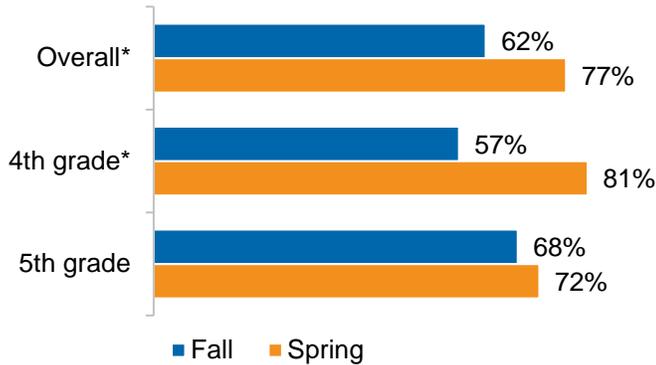
Results for the 16 close-ended survey items included in both the fall and spring surveys are summarized below. The closed-ended items were a series of statements with the response options: agree a lot, mostly agree, agree a little, don't agree, and don't know. Those who agreed a lot or agreed mostly were considered to be in agreement with an item. Results are summarized here by content areas with promising results and opportunities for growth in student learning. Results in detail can be found in the full report, *STEM Pathways Student Survey Results for the 2014-15 School Year* (Mueller, 2015).

Promising results

STEM interest and application

Interest in engineering (“I like learning engineering”) increased overall from fall to spring (agreement with the statement increased from 62% to 77%). This increase occurred primarily among fourth-graders (agreement increased from 57% to 81%; Figure 2). The increase appeared to be due to increased knowledge or understanding of what engineering is as “don't know” responses from fourth-graders went down sharply from fall to spring (24% to 7%) while “agree a lot” responses went up very strongly (38% to 58%). The share of fifth-graders who indicated having interest in engineering did not change significantly from fall to spring, with a quite high percentage of the students agreeing with the statement at both times (68% in fall and 72% in spring, Figure 2).

2. I like learning engineering: Overall results

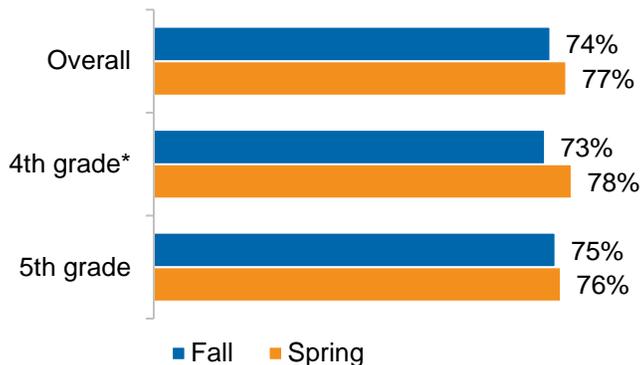


*The change in the percentage of students responding “agree a lot” or “mostly agree” to the item from fall to spring was statistically significant ($p < .05$).

Perhaps related to this, agreement with the statement, “I think like an engineer to design solutions to problems,” increased among fourth-graders from fall to spring (from 50% to 58%). Boys showed more interest in engineering than girls, but the interest of both groups increased from fall to spring. The interest in engineering of all other demographic groups examined increased from fall to spring as well.

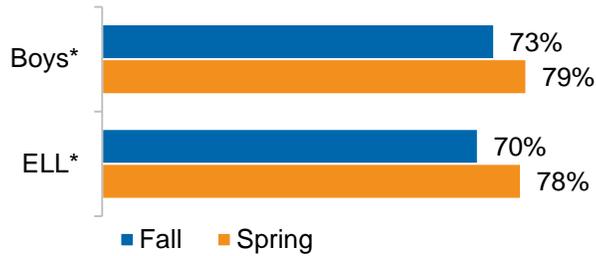
Interest in STEM as a whole (“I like learning STEM”) increased among fourth-graders from fall to spring (agreement with the statement increased from 73% to 78%; Figure 3). This increase occurred especially among boys (from 73% to 79%) and ELL students (from 70% to 78%; Figure 4).

3. I like learning STEM: Overall results



*The change in the percentage of students responding “agree a lot” or “mostly agree” to the item from fall to spring was statistically significant ($p < .05$).

4. I like learning STEM: Boys and ELL students



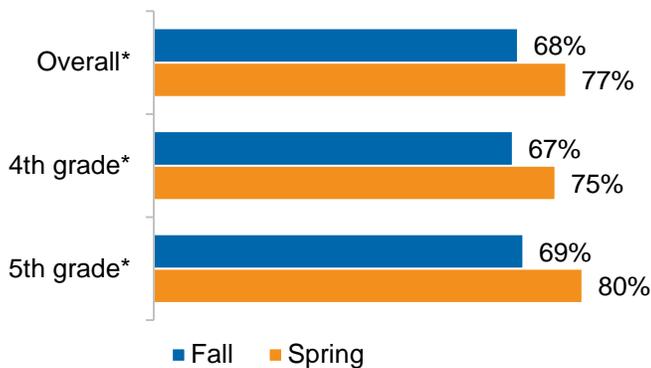
*The change in the percentage of students responding “agree a lot” or “mostly agree” to the item from fall to spring was statistically significant ($p < .05$).

Overall, interest in other STEM subjects (math, science, and technology) did not change significantly from fall to spring. These results might still be viewed as favorable because over three-quarters of the students already liked learning these subjects at the time of the baseline survey in the fall. Despite the lack of change overall, interest in both science and technology increased among boys from fall to spring.

STEM relevance and awareness

Students’ agreement that STEM knowledge is important to their futures increased from fall to spring (from 68% to 77% in agreement; Figure 5). This increase occurred across grades and across almost all student demographic groups examined.

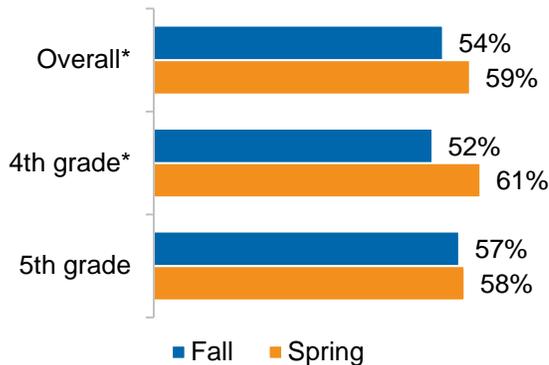
5. STEM knowledge is very important to my future: Overall results



*The change in the percentage of students responding “agree a lot” or “mostly agree” to the item from fall to spring was statistically significant ($p < .05$).

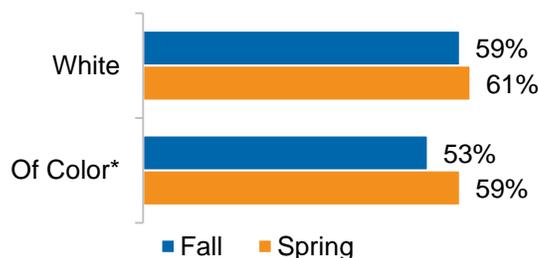
Overall, students' awareness of STEM ("I notice STEM in the world around me every day") also increased from fall to spring (from 54% to 59% agreeing with the statement). This increase primarily occurred among fourth graders (from 52% to 61% agreeing with the statement; Figure 6) and among students of color (Figure 7).

6. I notice STEM in the world around me every day: Overall results



*The change in the percentage of students responding "agree a lot" or "mostly agree" to the item from fall to spring was statistically significant ($p < .05$).

7. I notice STEM in the world around me every day: White students vs. students of color



*The change in the percentage of students responding "agree a lot" or "mostly agree" to the item from fall to spring was statistically significant ($p < .05$).

Knowledge of STEM careers

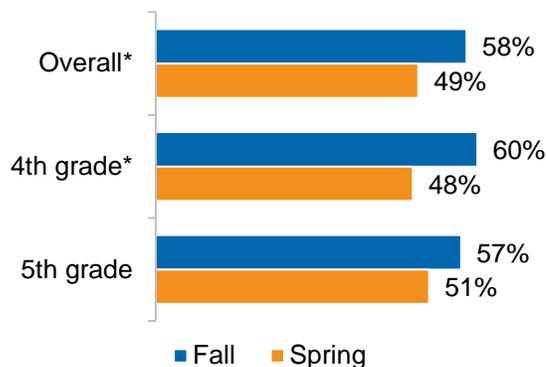
Knowledge of STEM jobs ("I know about many jobs that use STEM") increased from fall to spring in both fourth and fifth grades (from 59% to 68% agreeing with the statement). This increase occurred in most of the student demographic groups examined.

Challenges and possible opportunities for growth

Confidence in STEM abilities

Confidence in STEM abilities (“I am really good at STEM”) decreased from fall to spring (from 58% to 49% agreeing with the statement). Fourth-graders had a bigger decrease than fifth-graders, with more fourth-graders being less sure of their STEM abilities in the spring (i.e., more responding “don’t know” to the survey item, 17% in fall to 29% in spring). Student demographic groups with decreases in their STEM confidence levels were girls, low-income students, ELL and non-ELL students, and students of color (Figures 8 and 9)

8. I am really good at STEM: Overall results



*The change in the percentage of students responding “agree a lot” or “mostly agree” to the item from fall to spring was statistically significant ($p < .05$).

9. I am really good at STEM: High- vs. low-income students



*The change in the percentage of students responding “agree a lot” or “mostly agree” to the item from fall to spring was statistically significant ($p < .05$).

Despite the decrease in agreement with the statement, “I am really good at STEM,” agreement with the statement, “I would be good at a job that uses STEM,” did not change significantly from fall to spring (slightly over 50% agreed at both time points). Girls, low-income students, and students of color tended to be less confident that they would be good at a STEM-related job compared to their demographic counterparts.

Participation in STEM activities outside of school

The proportion of students engaging in frequent STEM-related activities outside of school did not change significantly from fall to spring in either fourth or fifth grade. Overall, 39 percent of the students in the fall survey agreed that they frequently did STEM-related activities outside of school and 36 percent in the spring survey agreed they frequently did such activities in the spring. The proportion of ELL students participating frequently in such activities declined from fall to spring (from 45% to 32%). Figure A2 shows the student responses to the open-ended question about the STEM-related activities they did outside of the school day in the spring student survey.

Slightly fewer than half of the students in both the fall and spring agreed that they knew about many STEM-related activities outside of school. The only demographic group to have an increase in agreement with this item from fall to spring was white students.

Over 60 percent of the students in both fall and spring agreed that they would like to do more STEM-related activities.

Application of technology

Applying technology to problem-solving (“I use technology to solve problems”) did not change from fall to spring with 56 percent of all the students agreeing with this item at both time points.

Interest in STEM careers

There was little change from fall to spring in students’ interest in having a job that uses STEM when they are older, with slightly over half agreeing with this item at both time points. Higher income students were more likely to have an interest in such a job.

MPS leader interviews

In their interviews, MPS leaders indicated that STEM Pathways strengthens student STEM skills and provides exposure to STEM careers. MPS leaders recognized that STEM Pathways targeted lower-income schools and focused on closing the opportunity gap for these students.

Finding: STEM Pathways expands student access to STEM learning activities and promotes career exploration.

Yeah, I think motivation in middle school especially. I guess even in the upper elementary grades. Sometimes kids will say, 'Why do I need to learn this?' And now there are very practical and obvious things we can point to. Well if you want to have a job in technology, make a video game, or do any of those things you need those skills. And I know a lot of the field trip experiences show those career pathways. – MPS leader interviews

Finding: STEM Pathways sets up students for success by strengthening skills around science, technology, engineering, and math. It also helps students make connections between STEM and everyday things.

Being able to say, 'building a bridge is really cool' or 'building a skyscraper' or 'being a scientist that is able to help with finding a cure for something.' Or, as a mathematician, I know all these pieces, but if I want to expand it I can become an architect or if I want to become a chemist or any of those things. So it's really about the kids starting to have these connections made for them. It's not just in a white lab coat wearing goggles or a mathematician writing problems. It's really showing the kids, by learning this, this is the bridge that helps you get to that next point. – MPS leader interviews

Finding: STEM Pathways will increase the likelihood that students will take more STEM classes in later grades and will pursue careers in STEM.

So I believe when we get students excited about science, technology, engineering, and math in the early years, we're going to be a lot more likely to see them pursuing that rigorous coursework down the road. And maybe eventually careers in those fields. And so I think we're doing them a great service in terms of sparking their interest. Helping them compete down the road in the job market and globally. So I think that's probably the bigger value of it. – MPS leader interviews

Finding: STEM Pathways provides students with good experiences in science and math.

It's just a really positive experience for kids. I'm hoping that it will have an impact on students' achievement. We are just kind of getting scores in and it's always hard to figure out, kind of, what is it that helped our test scores, was it a field trip, was it a project that they did? It's hard to say, but I think having positive experiences in science and math is always a good thing and will help student learning. – MPS leader interviews

Finding: STEM Pathways provides experiences for students who may not be exposed to STEM related activities outside of school.

Bottom line they get the experience and the exposure that as a school with students that are 95% in poverty, 20% in shelters, they're not getting the opportunities to go to places like this and this may be one of their only opportunities. – MPS leader interviews

Student academic achievement

STEM Pathways potential effects on student academic achievement were examined using the spring 2015 Minnesota Comprehensive Assessments, Series III (MCA-III). We consider MCA 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 group which includes students from low income families, racial/ethnic minorities, and females.

Overall results

A series of statistical analyses were carried out to determine whether MCA math, reading and science (available for fifth grade only) scores differed significantly between the treatment and comparison groups. Findings are reported in Figure 10, with fourth and fifth grade findings shown separately. Average (mean) scale scores were reported for each MCA test by group as well as the percentage that reached the proficiency level on the test (i.e., met or exceeded grade-level standards).

For the most part, there was little difference in MCA scores between the treatment and comparison groups. In fourth grade, average scale scores and proficiency percentages were slightly higher in the comparison group than the treatment group. These differences were not statistically significant for math scores and proficiency percentages, but they were significant for reading scores and proficiency percentages. In fifth grade, the average scale scores for math, reading, and science were almost identical for the treatment and comparison groups (one-point difference or no difference). Proficiency percentages were also very similar across the groups for math, reading, and science (one-two percentage point differences). None of the differences between groups for fifth-graders were statistically significant. Note that half or fewer of the students were proficient on each of the tests across grades and study groups (ranging from 28% to 50%). Among fifth-graders, 28 and 30 percent, respectively, were proficient in science in the treatment and comparison groups.

10. Achievement tests (MCA-III) results in spring 2015: Treatment and comparison groups

		Group	
4 th Grade		Treatment (N=355)	Comparison (N=1,067)
Math	Scale score mean ^a	446	448
	Percent proficient ^b	45%	50%
Reading	Scale score mean ^{a, c}	441	444
	Percent proficient ^{b, c}	31%	37%
5 th Grade		Treatment (N=331)	Comparison (N=1,059)
Math	Scale score mean ^d	543	543
	Percent proficient ^b	36%	37%
Reading	Scale score mean ^d	544	545
	Percent proficient ^b	40%	39%
Science	Scale score mean ^d	539	540
	Percent proficient ^b	28%	30%

^a In 4th grade, scale scores range from 409 to 499 in math and 411-490 in reading.

^b Percent meeting or exceeding standards.

^c The difference between the treatment and comparison group is statistically significant ($p < .05$).

^d In 5th grade, scale scores range from 515 to 586 in math, 517-591 in reading, and 501-599 in science. MCA science is only administered to fifth grade students.

Additional comparisons within student demographic categories

Potential treatment-comparison group differences on the 2015 MCA tests were examined separately within the following demographic categories: female, male, eligible for free or reduced-price lunch, ineligible for free or reduced-price lunch, ELL, non-ELL, Asian, black, Hispanic, and white. (There were too few students to conduct the analyses within the American Indian group). No strong patterns of differences emerged within any of these demographic categories. Overall, differences tended to be small and most often slightly in favor of the comparison group (i.e., slightly higher average MCA scale scores). A weak but consistent pattern of MCA score differences in favor of the comparison group was found among white students and students ineligible for free or reduced-price lunch (higher-income students). Differences in favor of the comparison group, although usually small, were consistent across grades four and five and across type of test for these two demographic groups.

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 for the 2014-15 school year* (Mueller, 2015).

Research question 8.

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

STEM Pathways partners felt that they have become more familiar with what other partner organizations do and can appreciate their similarities and differences. Many partners commented on having the realization of a rich STEM community in the Twin Cities and that this has helped them feel supported in what they do. Leaders at the partner organizations felt impassioned by the staff at the other organizations and enjoyed getting to know them, particularly through presentations from participating organizations on their programming. Many organizations said they realized that they are not a stand-alone organization, but rather, what they have to offer complements the work of the other partners.

Finding: Familiarity with, knowledge of, and appreciation for what other partner organizations do and how their work complements the work of other informal STEM education organizations has increased substantially.

I've gotten to know these other informal educators and I've enjoyed working with them. I've gotten to know them better. It's a nice thing. I know the roles of the different informal education programs better, what their focuses are. – Implementation team member, STEM Pathways partner interviews

This past year working with these other institutions and realizing that it is genuinely trying to be cooperative. It's really helped me to realize what our place in the whole Twin Cities/Minnesota region is, what our niche is, what our role is in the community, and how these other organizations are different. So that if a school came to me or a teacher came to me and said, 'oh, we'd really like to do a program on the human body and electricity' or something, I could say, we could do something like that, but you should really go to The Bakken. Or, in another case, you might want to go to the Minnesota Zoo. I have a better idea of how we're cooperative and can be cooperative rather than being in direct competition. – Steering committee member, STEM Pathways partner interviews

Research question 9.

What impacts does the model have on classroom teachers?

MPS leaders indicated that involvement in STEM Pathways provided benefits to classroom teachers, including providing modeling for teachers and supporting them in presenting STEM curriculum and career options to students

Finding: STEM Pathways provides modeling for teachers, inspires them, and increases their interest in STEM topics. It gives them new ideas for ways to incorporate STEM education into their classroom.

I think it's helped them...I'm thinking mostly about our science teachers. Science is often times a subject in elementary grades that you do when you have time to do it, because there's so much you have to do in terms of literacy and math. This has been a chance for teachers to really dig into science and feel the importance of that content and have the tools and resources to really teach it in depth. And I think this has really helped that. I'm thinking, specifically about some of the vocabulary that is used in all of these experiences and then also back in the classroom. I think that's been really great. I've seen teachers talk about those field trip experiences in the lessons that they're doing in the labs that they're doing back here. So that's been very helpful. ...Last year we departmentalized so there was just one fourth grade teacher who taught all the science, and I think she got very good at this. She knew exactly what she needed to teach them, and I think that was very helpful with all those experiences. – MPS leader interviews

Finding: Principals feel that teachers felt supported by STEM Pathways and that it helped alleviate some of the pressure around planning and organizing meaningful experiences for students.

Just understanding what standards are being addressed by each partner helps us to coordinate student learning, but also helps teachers as they're doing their planning to be very purposeful ... there's an opportunity for these preliminary and post-activities and tying it in a meaningful way. – MPS leader interviews

I think having that support. It's not a 'here, do this' program, but the teachers are getting the support. There's follow-up, they're meeting and having check-ins with the coordinators. I think that's important and a positive thing that gives them the support they need and also keeps them on the right track. – MPS leader interviews

Finding: STEM Pathways assists and empowers teachers to make connections to the MPS curriculum and broadens their ability to present STEM curriculum, including providing stronger foundations for students in math and science to support their knowledge in engineering, and present STEM career options to students and career options to students.

I think the professional development they get by going [on the field trips] with their students, but also the ones who participate in the planning group around the STEM Pathways, I think will feel more connected to the work at MPS and will help us build our institutional knowledge around what quality STEM instruction looks like for elementary age students. – MPS leader interviews

I think it also gives teachers a sense of empowerment, to the extent that they are planning and leading around STEM Pathways programming, not just experiencing something that's been designed by other people for their benefit without any of their input. – MPS leader interviews

It's an opportunity for our students and our teachers and our 4th and 5th grade to have beginning exposure to STEM and to build that catalyst that will get them even more interested to seek further information, seek further in professional development and being able to integrate it into classroom. So I think the largest piece is making those connections across the standards and bringing them in for STEM for what we know about our 21st century learners. The importance of having a strong science foundation, a strong math foundation, so that all of those come together and continue to support that engineering piece. And what we know is that anything that's hands-on for our students, such as STARBASE and really hits that engineering goal, our kids did exceptionally well in terms of their participation and their behavior. It showed the gaps in what they may or may not know overall in those areas, but it was a piece that when the kids come back they were like, 'can we have our classroom like this?' It's beginning to contribute to building that, so that is one of the kind of overall goals. ... Building a knowledge base around those key disciplines, looking at how you integrate/make those connections so that our kids are ready to be 21st century learners. – MPS leader interviews

Research question 10.

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

MPS leaders had positive views on the implications that STEM Pathways might have for STEM education, including in increasing students' interest in science and preparing them for the 21st Century skills.

It's really the catalyst to get our students to think about what it means to be a 21st century learner and a citizen of the 21st century. – MPS leader interviews

I think it's a model that other organizations in different areas of Minnesota or across the nation could really adopt and look at. I think it has a lot of potential in [conveying] what we want STEM education to look like. – MPS leader interviews

Especially with MCAs, a lot of the focus is on reading and math, and science kind of gets put to the side. So I think something like this, the STEM Pathways program, keeps the sciences, especially the sciences, alive—doing it in the classroom and beyond. Earlier I said I've seen a lot more science going on in fourth and fifth [grade] classrooms this year than I have in the past. – MPS leader interviews

Partners felt that the STEM Pathways model can be used as an example of strong collaboration among informal education organizations that can support and improve student learning at school.

Finding: STEM Pathways can serve as an example and model for other informal organizations and other communities.

I would say we're setting ourselves up as a model for other communities throughout the country. Hopefully it will have the results that we hope will come out of it. We've kind of become the icon, the hallmark, the leader of the pack and could maybe get programs like this started in other locations. – Implementation team member, STEM Pathways partner interviews

If we can show that we can have a great impact on student learning by combining our efforts and helping students see the connections between these different experiences, I think that has a tremendous impact on other institutions in different communities who are looking to broaden their impact as well. – Steering committee member, STEM Pathways partner interviews

I also think every community and every school district is different so it needs to be a model that can be tweaked to meet the specific needs of the community where it's being implemented. – Steering committee member, STEM Pathways partner interviews

Finding: STEM Pathways provides a strong example for how informal science education can support and improve classroom learning.

The potential for this type of work is to show that there are actual ways to collaborate and to do integrated science education that brings in the humanities, the reading, the social studies that schools say that they want, what education says is needed. This is something that can do that in a small way, but as a much better example of how it could be done than what currently exists. So an implication could be if it worked it could have broad impact on what we do and could be a case example for what other people do in the future. – Steering committee member, STEM Pathways partner interviews

Looking forward

STEM Pathways partners continue to strengthen their partnership and deliver programming to fourth- and fifth-grade students in the same six MPS schools. Fourth-grade students from 2014-2015 who are enrolled in one of the STEM Pathways schools in 2015-2016 as fifth-graders continue to receive STEM learning experiences from STARBASE and two new partners (Minnesota Zoo and Bell Museum). Another cohort of fourth-grade students in these schools also start participating in STEM Pathways, receiving programming from The Bakken, the Works Museum, and STARBASE.

As STEM Pathways is well into the third year of the project, partners are focusing on strategic planning to determine the next phase of the project. Through this process, STEM Pathways partners will consider:

- How to facilitate and support sustainability of access to a system of high-quality and interconnected informal STEM education for youth in collaboration with schools and districts.
- Articulating and strengthening of the local STEM learning ecosystem.
- Continuing to promote 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 toward goals.
- Continuing to support and even expand the network of informal STEM educators that STEM Pathways has created.
- Strategies for sustainability.

References

Mueller, D. (2015). STEM Pathways Student Survey Results for the 2014-15 School Year. Saint Paul, MN: Wilder Research.

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Appendix

Student open-ended responses

Figures A1 – A4 present the results of the open-ended questions from spring student survey. The responses to these open-ended questions were coded according to a unique coding scheme for each question. Each student’s response was assigned up to five codes. The number and proportion of students with the responses are presented for fourth- and fifth-graders separately and for all respondents combined. Some students did not provide any answers to the open-ended questions.

Student most frequently described non-structured activities when describing the STEM-related activities they did outside of the school day. One in five students mentioned activities related to fixing or building things, crafts, cooking or gardening (22%). They described using electronic devices, such as computers, phones, and iPads (16%); and playing or sports (10%) as STEM-related activities they did outside of the school day. They also mentioned doing math (14%) or homework (11%) (Figure A1).

A1. Please list the STEM-related activities you do outside of the school day

Examples	4 th grade (N=274)		5 th grade (N=289)		All students (N=563)	
	N	%	N	%	N	%
Nature/life sciences	7	3%	23	8%	30	5%
Fixing/building things/crafts/cooking/gardening	62	23%	62	21%	124	22%
Experimenting/testing	23	8%	16	6%	39	7%
Using/counting money	4	2%	3	1%	7	1%
Homework	24	9%	39	14%	63	11%
ST Math	7	3%	5	2%	12	2%
Video games	12	4%	9	3%	21	4%
Use computer/iPad/phone/electronics	36	13%	51	18%	87	16%
Running/playing/sports/exercise	54	20%	44	15%	98	17%
Reading	9	3%	7	2%	16	3%
Coding/programming	5	2%	5	2%	10	2%
Robotics	11	4%	8	3%	19	3%
Rockets	3	1%	4	1%	7	1%

**A1. Please list the STEM-related activities you do outside of the school day
(continued)**

Examples	4 th grade (N=274)		5 th grade (N=289)		All students (N=563)	
	N	%	N	%	N	%
Out-of-school programming						
STARBASE	9	3%	6	2%	15	3%
MN Zoo	-	-	4	1%	4	1%
The Bakken	9	3%			9	2%
The Bell Museum	-	-	1	<1%	1	<1%
The Works	7	3%	-	-	7	1%
GEMS or GISE	8	3%	31	11%	39	7%
Other After School (e.g., Math Masters, Math Squad)	4	2%	10	4%	14	3%
Restated field, without example						
Science (restated specific field or letter "S")	25	9%	15	5%	40	7%
Technology (restated specific field or letter "T")	20	7%	21	7%	41	7%
Engineering (restated specific field or letter "E")	17	6%	10	4%	27	5%
Math (restated specific field or letter "M")	44	16%	37	13%	81	14%
STEM (no activity is specified)			5	2%	5	1%
Other, none, and don't know						
Other-science related	1	<1%	9	3%	10	2%
Other-engineering related	-	-	4	1%	4	1%
Other-math related	6	2%	4	1%	10	2%
Other	21	8%	19	7%	40	7%
None/I don't do any	41	15%	34	11%	75	13%
Total						

Note: Students can give multiple answers and their responses received multiple codes. Some students did not provide any answers. Small numbers of responses for a category (<1% for total students) are not included in the Figure, except for Bell Museum.

Through their experiences being a scientist and engineer in a STEM Pathways program, students indicated they gained confidence in their abilities overall, gained confidence in their STEM skills, enjoyed learning about STEM topics, and became aware of STEM career options or of their interest in those careers (Figure A2).

A2. Tell us one thing you learned about yourself while being a scientist or engineer with [organizations]

	4 th grade (N=126)		5 th grade (N=100)		All students (N=226)	
	N	%	N	%	N	%
Build own character/confidence						
I can accomplish something if I improve/try hard/learn more/ don't give up	13	10%	5	5%	18	8%
I can build/make something/design something	9	7%	5	5%	14	6%
I am good at something/capable/smart	6	5%	7	7%	13	6%
I like/am good at working with others/groups	4	3%	7	7%	11	5%
Gain confidence in STEM skills						
I am good at science	7	6%	6	6%	13	6%
I am good at engineering	7	6%	6	6%	13	6%
I am good at mathematics	2	2%	2	2%	4	2%
I am good at technology	-	-	5	5%	5	2%
I am good at STEM overall	5	4%	2	2%	7	3%
I am good at building/making things/designing things	6	5%	3	3%	9	4%
Like or enjoy the learning						
I like/love/enjoy it; I thought it was fun/interesting	12	10%	2	2%	14	6%
I like/enjoyed/interested in STEM or subtopic of STEM	28	22%	13	13%	41	18%
I like learning about STEM careers	5	4%	2	2%	7	3%
I like learning about nature/animals	-	-	5	5%	5	2%
I like building/fixing/creating things	4	3%	2	2%	6	3%
I like learning/learning is fun	2	2%	3	3%	5	2%
I like to solve problems	1	1%	2	2%	3	1%

A2. Tell us one thing you learned about yourself while being a scientist or engineer with [organizations] (continued)

	4 th grade (N=126)		5 th grade (N=100)		All students (N=226)	
	N	%	N	%	N	%
Interest in STEM careers/know career options						
I can be/I like to be a [STEM career]	1	1%	7	7%	8	4%
Scientist	3	2%	3	3%	6	3%
A career that has to do with technology	1	1%	1	1%	2	1%
Engineer	13	10%	8	8%	21	9%
I can have many career options	3	2%	-	-	3	1%
Other, none, and don't know						
Other	6	5%	14	14%	20	9%
None/I don't do any/Nothing	2	2%	5	5%	7	3%

Note: Students can give multiple answers and their responses received multiple codes. The organizations listed in the fourth grade survey are The Bakken Museum, The Works Museum, or STARBASE and those listed in the fifth grade survey are The Bell Museum, Minnesota Zoo, or STARBASE. Small numbers of responses for a category (<1% for total students) are not included in Figure A2.

Students described many similarities in their STEM learning experiences across STEM Pathways programs. Their most frequent answers included learning about science, STEM, and about animals or nature. They also mentioned other learning not related to STEM, such to challenge themselves, to respect others, and that learning is fun (Figure A3).

A3. Name one thing that was similar about what you learned at [Organization] and what you learned at [Organization] ^a

	4 th grade (N=244)		5 th grade (N=248)		All students (N=492)	
	N	%	N	%	N	%
Electricity/Energy	17	7%	1	<1%	18	4%
Building	21	9%	3	1%	24	5%
Science	45	18%	38	15%	83	17%
Technology	27	11%	19	8%	46	9%
Engineering	21	9%	9	4%	30	6%
Math	3	1%	3	1%	6	1%
STEM- no specific content/topic	80	33%	62	25%	142	29%
Other similarity made (not STEM related)	25	10%	28	11%	53	11%
Other similarity made by topic/content (e.g., problems in the world; talk about human discovery; something to do with water)	12	5%	9	4%	21	4%
Robots	2	1%	2	1%	4	1%
Mars/space/rover	1	<1%	4	2%	5	1%
Problem solving	3	1%	6	2%	9	2%
How things work	2	1%	2	1%	4	1%
STEM jobs	9	4%	14	6%	23	5%
Extinction/Endangered species	-	-	6	2%	6	1%
Habitats	-	-	8	3%	8	2%
Environment	-	-	7	3%	7	1%
Animals/bees/nature	-	-	48	19%	48	10%
Survival	-	-	3	1%	3	1%
None/I don't have any	5	2%	9	4%	14	3%

Note: Students can give multiple answers and their responses received multiple codes. Small numbers of responses for a category (<1% for total students) are not included.

^a Two of the three organizations were selected randomly. For fourth-grade survey, the three organizations are The Bakken Museum, The Works Museum, and STARBASE and for the fifth grade survey, they are the Bell Museum, Minnesota Zoo, and STARBASE.

Students mentioned that their STEM Pathways experiences will help prepare them for a STEM career (57%), makes them smarter (17%), help them to know how to help others (17%), help them in school or prepare them for college (5%), and know how to care for the environment (1%) (Figure A4).

A4. What have you learned from the [organizations] that you think will help you now or in your future?

	4 th grade (N=116)		5 th grade (N=107)		All students (N=223)	
Good for jobs/learned I can be a [STEM career]/learned about being a [STEM career]	68	59%	59	55%	127	57%
Increase knowledge/makes me smarter/learned about something	23	20%	14	13%	37	17%
Ways to help others or the world/animals	11	10%	26	24%	37	17%
Helps with school/college	7	6%	4	4%	11	5%
Environmental sustainability/helps me care for environment	-	-	2	2%	2	1%
Other, none, and don't know						
Other	9	8%	5	5%	14	6%
None/I don't do any	1	<1%	4	4%	5	2%

Note: Students can give multiple answers and their responses received multiple codes. The organizations listed in the fourth grade survey are The Bakken Museum, The Works Museum, or STARBASE and those listed in the fifth grade survey are the Bell Museum, Minnesota Zoo, or STARBASE.