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STEM Pathways Small Group Interview Findings

Jeanna Wieselmann

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Purpose and Partnership

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 between five informal STEM organizations—The Bakken, Bell Museum of Natural History, Minnesota Zoo, STARBASE Minnesota, and The Works—Minneapolis Public Schools (MPS), and the Minnesota Department of Education (MDE) that tests a model for collaboration that could be expanded and replicated across more grade levels, schools, organizations and communities.

Introduction

STEM Pathways connects six schools from Minneapolis Public Schools (MPS) with a set of science, technology, engineering, and math (STEM) experiences provided by Twin Cities organizations. These organizations include The Bakken Museum, the Bell Museum of Natural History, the Minnesota Zoo, STARBASE Minnesota, and The Works Museum. By offering a cohesive set of STEM experiences to fourth- and fifth-graders, STEM Pathways aims to increase students' interest and achievement in STEM.

Previous quantitative research of STEM Pathways found that participating students experienced a decrease in confidence in their STEM abilities over the course of the school year. Although there were positive findings related to STEM interest, relevance, and awareness of STEM careers, more information was needed to understand the apparent decrease in student confidence in order to better foster student confidence in STEM.

The present study examines fifth-grade STEM Pathways participants' thoughts more closely to learn more about their perceptions of self, STEM, and the STEM Pathways partner programs. Small group interviews provided qualitative data to better understand the lived experience of fifth-graders in STEM Pathways.

Method

The purpose of the present study was to acquire in-depth qualitative knowledge about students' experience of STEM Pathways. Given previous findings, there was a need to better understand students' experiences with STEM Pathways, confidence in STEM, and perceived connections among partner programs and between STEM Pathways and school.

Design

A semi-structured interview protocol was developed in collaboration with STEM Pathways representatives (see Appendix A for complete interview protocol). The semi-structured nature of the interview provided consistency between interviews while also allowing for probing and follow-up questioning related to items of interest brought up by students.

A total of 11 interviews were conducted with groups of four students, for a total of 44 students interviewed. Two interviews were conducted at each of five STEM Pathways schools, and one interview was conducted at the remaining school. Interviews lasted an average of 22 minutes, 54 seconds, with the shortest 14 minutes, 26 seconds and the longest 29 minutes, 18 seconds. Interviews were audio recorded and took place from May 12 to May 26, 2016.

Throughout each interview, a laminated poster with the STEM Pathways logo and each of the partner program logos was used as a visual aid. The researcher recorded student responses specific to each partner program about what students remembered doing and components of each experience that made them feel like scientists or engineers. Connections between STEM Pathways partner programs were shown with a line connecting the programs and written descriptions of the connections described by students. Following each interview, a photograph of the annotated poster was taken for future reference.

Participant Selection

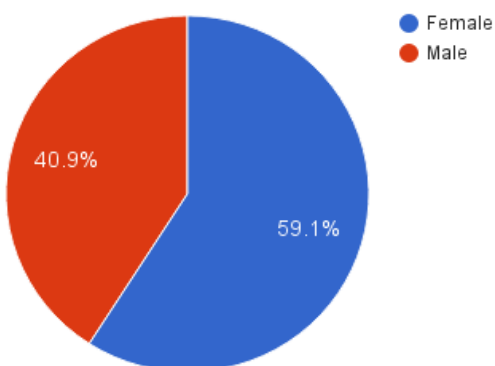
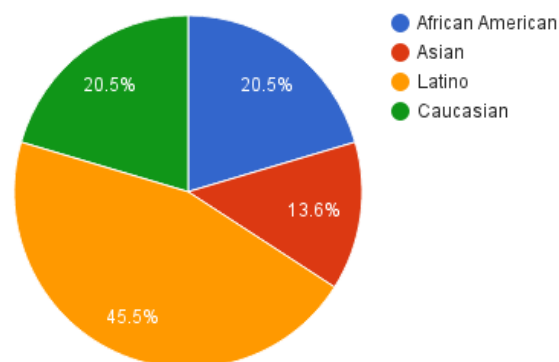
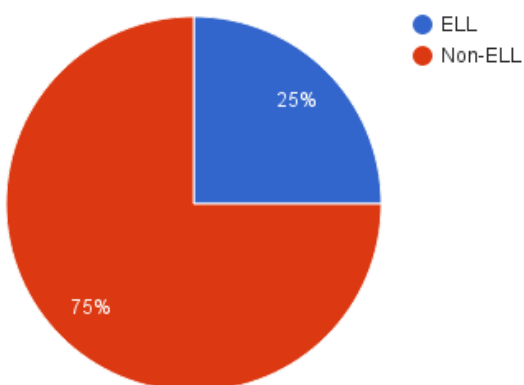
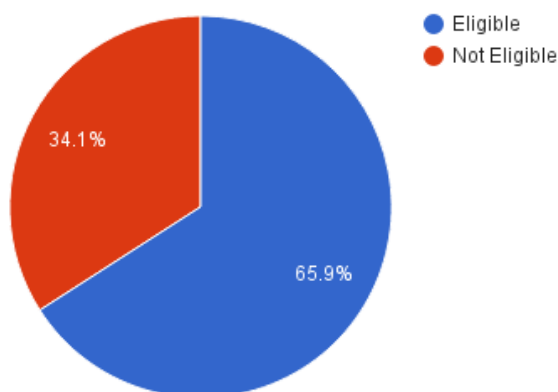
Consent forms were distributed to all fifth-grade students in the six STEM Pathways schools. Returned consent forms were collected and demographic information compiled to help ensure the students selected for interviews were representative of the student population as a whole. Based on the desire for demographic diversity, preferred interviewees were selected in advance of the interviews; if those students were absent from school, back-up interviewees were included instead.

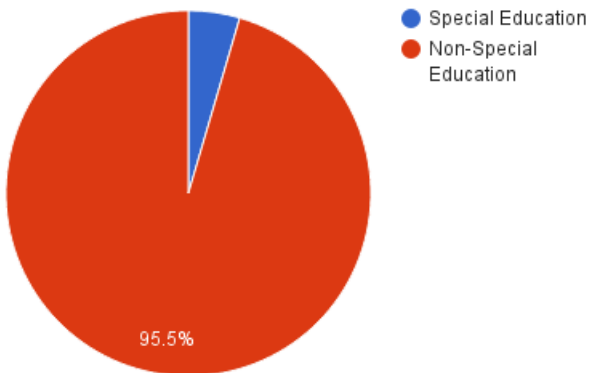
In situations where few consent forms were returned, selection was more limited based on available students. Limited student availability resulted in one small group interview, rather than two, at one of the six STEM Pathways schools.

Participant Demographics

A total of 44 participants were interviewed as part of this study. There were 26 females and 18 males. Nine African American, six Asian, 20 Latino, and nine Caucasian students participated. Eligibility for free and reduced school lunch is a common measure of

socioeconomic status, and 29 of the participants were eligible, with 15 not eligible for free and reduced school lunch. Eleven of the students were currently classified as English Language Learners (ELL), while 33 were not receiving ELL services. Out of the 44 participants, two received special education services and 42 did not. Visual representations of these demographics are shown below.

Gender**Ethnicity****English Language Learners (ELL)****Free and Reduced Lunch Eligibility**

Special Education Status

Analysis

The researcher transcribed the small group interviews within 48 hours of when each interview took place. An initial phase of open coding was completed using NVivo software. Following an examination of emergent themes, a second phase of coding was conducted in NVivo. Based on the codes and corresponding student remarks, a set of tentative assertions was made. Student quotations in support of each tentative assertion were compiled into an evidence matrix, and assertions that lacked sufficient support were eliminated from the findings.

Overview of Findings

1. Knowledge of STEM and STEM Pathways
 - a. Students have accurate knowledge of the STEM acronym.
 - b. Students have varied understandings of STEM Pathways.
 - c. STEM Pathways helps students more accurately understand STEM components.
2. Students' Experience of STEM Pathways
 - a. STEM Pathways experiences are different from and better than other field trips and classroom visits.
 - b. Students have vivid and accurate memories of STEM Pathways experiences.
 - c. Students struggle to make connections between STEM Pathways and math.
3. Feeling Like Scientists and Engineers
 - a. Hands-on activities are engaging and authentic.
 - b. Acquisition of information alone does not make students feel like scientists or engineers.
 - c. Creativity and innovation make students feel like scientists and engineers.
 - d. Teamwork is an important aspect of science and engineering.
4. Connections Among STEM Pathways Partner Programs and Between STEM Pathways and School
 - a. Students recognize primarily surface-level connections between STEM Pathways partners.
 - b. Students connect STEM Pathways to some of their other field trips.
 - c. Students see STEM Pathways reflected in specific topics of study or skills used at school.
5. Confidence in STEM
 - a. STEM Pathways experiences make students feel smarter and more confident about their content knowledge.
 - b. Students recognize they still have a lot to learn about STEM.
 - c. STEM challenges create mixed feelings related to student confidence in STEM.
6. Beliefs about STEM
 - a. STEM is relevant and important for the present and future.
 - b. STEM Pathways contributes to more positive feelings about STEM.
 - c. Students are more interested in STEM careers because of STEM Pathways.

Detailed Findings

Knowledge of STEM and STEM Pathways

Students have accurate knowledge of the STEM acronym.

When asked to describe STEM Pathways, the first response in every group of students included a statement that STEM refers to science, technology, engineering, and math. Given that an increase in STEM awareness is one of the goals of STEM Pathways, this finding shows that students are aware of STEM and its component parts.

"I didn't even know what STEM was before we started doing these."

Students have varied understandings of STEM Pathways.

In some cases, students were able to report that STEM Pathways is related to science, technology, engineering, and math but were not able to describe why the word "pathways" was included.

"I know what STEM means, it's science, technology, engineering, and math, but I don't know what pathways is."

In contrast, some students had more complete understandings of STEM Pathways, including references to their futures and the recognition that STEM Pathways relates to some of their field trips.

"STEM Pathways is a program for our school that helps us go on field trips so we can learn more about science, technology, engineering, and math and help us with those skills in life later on."

"STEM Pathways is a company that works with schools, and they let them go on field trips. They work about science, technology, engineering, and math, and they help them advance with that."

One student mentioned that STEM Pathways also helps parents learn more about STEM; upon further questioning, she shared that her parents learned about STEM when she went home and talked about her experiences through STEM Pathways.

"STEM Pathways is an educational program that lets kids and parents to learn more about science, technology, engineering, and math, and it can help kids for their future work or dreams."

STEM Pathways helps students more accurately understand STEM components.

Previous research has suggested that students often have simplistic views of STEM. For example, they may view technology as synonymous with computers. While this is the case for some students, others found that STEM Pathways helped them to refine their understanding of STEM and its component parts.

“When I first heard of engineering, I thought it was just about fixing cars because when I was little, I didn’t know much about STEM.”

“I thought that technology was the things that people use with wires, but it’s all the things that engineers build.”

Students’ Experience of STEM Pathways

STEM Pathways experiences are different from and better than other field trips and classroom visits.

Students overwhelmingly believed that STEM Pathways experiences were unique, and they named a variety of factors to justify this belief. The most common reason was that STEM Pathways experiences were more fun than other field trips or classroom visits.

“They’re way better... because it’s a fun way for me to learn.”

Many students viewed the amount they learned through STEM Pathways as different from other experiences. They felt STEM Pathways gave them more opportunities to learn about a wider variety of topics. They also appreciated their active involvement as participants rather than passive observers.

“The STEM Pathways field trips are the ones that actually really, really helped. The other ones let us learn too, but we didn’t really get to do much.”

Finally, students pointed to the unique nature of STEM Pathways activities as an important factor in why STEM Pathways experiences are different from other experiences. They specifically mentioned touch-and-see rooms, 3D printing, seeing animals up close, and programming as things they wouldn’t otherwise have the opportunity to do. These unique opportunities led to positive feelings about STEM and STEM Pathways.

“It helps you with your education, and plus you get to do things that you don’t get to do anywhere else.”

“I like STEM because it’s special. You don’t get to do that every day.”

Students have vivid and accurate memories of STEM Pathways experiences.

Students were asked to report what they remembered doing with each of the STEM Pathways partner programs, and they were probed to give responses specific to each program. They were able to recall numerous experiences related to each program and provide vivid details describing their memories. Because the researcher previously observed each partner program as part of prior research, it was clear that students’ recollections were almost always accurate. This was the case even for experiences that occurred when the students were in fourth-grade and suggests that the STEM Pathways experiences were significant and meaningful to students. (See Appendix B for program-specific details about the experiences students recalled.)

Students struggle to make connections between STEM Pathways and math.

Students were asked whether their STEM Pathways experiences made them think or feel differently about STEM, and follow-up questions probed into their thoughts and feelings toward science, technology, engineering, and math as individual components of STEM. While students were able to verbalize how STEM Pathways related to their thoughts and feelings about science, technology, and engineering with seeming ease, they struggled to make connections between STEM Pathways and math.

"We left out the M in STEM!"

"None of them really used the math, actually."

Two students were able to report very specific and brief examples of using math with partner programs, but even those students did not view math as equal to the other aspects of STEM in regard to their experiences of STEM Pathways.

"We focused more on science, technology, and engineering than on math."

The majority of students reported that their feelings about math were unchanged by their experiences in STEM Pathways, largely because they didn't recall having math-related experiences. Some students reported that they had always had positive feelings toward math, while others reported that they had negative feelings toward math both before and after their STEM Pathways experiences.

"Yeah, I never really liked math that much."

"I've always loved math, so I don't feel any different about it. Still good."

Although students struggled to recall using math in STEM Pathways partner programs, math skills were among the few specific examples students were able to identify when they were asked how their STEM Pathways experiences helped them in school. This finding is discussed in more detail in the "Connections Among STEM Pathways Partner Programs and Between STEM Pathways and School" section that follows.

Feeling Like Scientists and Engineers

Hands-on activities are engaging and authentic.

When asked to describe whether and how their STEM Pathways experiences made them feel like scientists and engineers, students reported that their hands-on experiences felt authentic and were important to feeling like scientists and engineers.

"It made us feel like real scientists because you actually get to experiment, think about what you've done, and try again like a real scientist would do."

"We got to actually do it, experience it, because we thought other people just do it for us, but we actually got to experience it."

"We made our own designs, and it felt like you were making your own thing as a scientist or engineer."

Several students contrasted their active involvement to more passive instances when they simply observe someone else doing an activity or experiment. They felt that the passive experiences did not make them feel like scientists or engineers because they were not "doing."

"When you're not doing the work, it gets really boring for someone to do it for you. You actually want to learn something... so then there are some times when you get to get up and do it yourself."

"We got to do experiments by ourselves, like in groups, instead of the teacher doing it in front of all of us."

Acquisition of information alone does not make students feel like scientists or engineers.

Although students spoke positively about the new information they acquired, if they were not doing something hands-on with that information, they did not view it as related to STEM. They believe that factual knowledge is important and useful, but STEM requires them to "do" something with that knowledge.

"Well, we didn't really do STEM there because we just learned about some things."

"No, it wasn't STEM. It was just a normal field trip where we learned."

Creativity and innovation make students feel like scientists and engineers.

Students recognized that STEM Pathways partner programs provided opportunities to be creative and think of new ideas. They viewed this as an authentic part of STEM and felt like scientists and engineers as a result.

"You can be creative, let your heart out using all your creativities to come up with stuff, and it has to do with science."

"It's just fun to start with something that you don't really know what you're making, but later on you kind of build something that you're very happy with."

For some students, their experiences with STEM Pathways led them to make realizations about themselves. By being immersed in new environments, they discovered new things about their skills and potential for future learning.

"When I went to these field trips, I never knew that I had all this stuff that I could learn, and it just gave me a whole 'nother access to my creativity."

Teamwork is an important aspect of science and engineering.

Students regularly discussed working in teams because of STEM Pathways. They mentioned teamwork as a factor that made them feel like scientists and engineers because they believe STEM does not happen in isolation. Students had overwhelmingly positive teamwork experiences and remembered their collaboration fondly.

"We all worked together."

"It feels like you're with your team, and it feels like you're being happy and going out to have fun."

Connections Among STEM Pathways Partner Programs and Between STEM Pathways and School

Students recognize primarily surface-level connections between STEM Pathways partners.

Students were questioned about similarities and connections they saw between STEM Pathways partner programs. The most common response was that each experience involved STEM.

"I think STEM connected with all of them."

Students often broke apart science, technology, engineering, and math so they could discuss what they perceived to be the focus of each partner program. There was little consistency within or between interview groups about the focus of the partner programs. For example, some students reported that The Works Museum was mostly about science, while others mentioned engineering as the most important aspect of that experience.

The second most common connection involved content that was similar across programs. When it occurred, this type of content connection related to very specific aspects of the programs. For example, some students shared that multiple STEM Pathways programs addressed content related to electricity and energy. Every group of students reported a connection between the Bell Museum and the Minnesota Zoo because of their similar focus on animals and the environment.

"I'm trying to think hard. The Bell Museum is kind of like an environment place, so probably Minnesota Zoo and Bell Museum because we're talking about environment and animals."

Even with rigorous probing about similarities or connections, students rarely named skills or practices beyond a general recognition that they were using or doing STEM. Two students spoke about building, and one mentioned problem solving as a similarity between all of the programs.

"We got to build something at those places."

"I think all of them are kind of the same 'cause all of them have like a problem that we need to solve."

Only one student recognized that the use of an engineering design process was something that occurred across partner programs, and even he questioned whether that recollection was accurate.

"Didn't we do ask, imagine, plan, create, improve? At both?"

Students connect STEM Pathways to some of their other field trips.

Although almost all students reported that STEM Pathways experiences are unique when compared to other field trips, several students asked whether some of their other experiences were also part of STEM Pathways. In every instance, their peers within the small group interview were able to clarify and explain that the field trips were not part of STEM Pathways, but it is interesting to note that students may not always distinguish between their STEM experiences. The Children's Museum, Minnesota Valley National Wildlife Refuge, and Audubon Minnesota were all mentioned as also related to the STEM Pathways experiences.

Students see STEM Pathways reflected in specific topics of study or skills used at school.

When questioned about whether and how STEM Pathways experiences helped them with things they did in school, students most frequently named specific topics of study. For example, they mentioned pollination, electricity, and animals as topics that were found in STEM Pathways and at school. These topics were often tied to specific projects, such as conducting research or writing poems.

Interestingly, despite students' struggles to connect math to their STEM Pathways experiences, math skills were the only skills mentioned as being transferrable between STEM Pathways and school. Students discussed measurement, area, mean, and volume as things they learned through STEM Pathways and at school. Some students expressed that their STEM Pathways experiences helped them or their peers understand math content they had previously found to be quite challenging.

"We were learning about surface area and finding the area of a 3D shape, and that really helped here at school."

Although students previously mentioned that they used teamwork and creativity in STEM Pathways partner programs, they did not mention these skills or practices as being helpful to them in school. They named very specific content and skills as being useful but did not recognize the transfer of more general skills or practices.

Confidence in STEM

STEM Pathways experiences make students feel smarter and more confident about their content knowledge.

Students recalled many topics of study from STEM Pathways partner programs and accurately described many things they had learned. Their recall of information suggests that the learning experiences were effective for them in acquiring new content information. This translated to increased confidence in students' knowledge of STEM.

"I feel smarter because it kind of helped me know what to do and explain more."

"I feel a bit more confident in myself in science."

Several students spoke about performance on tests and the grades they received, noting that they were doing better in science following their STEM Pathways experiences.

"We had tests about science that were not really going OK until we got to STEM Pathways, and they started helping us so we got better grades."

Although students frequently spoke of increased confidence in their factual knowledge, only one student out of the 44 interviewed mentioned that she felt more confident in her ability to do STEM.

"I used to think that I couldn't engineer anything, but then I did STEM Pathways and learned that I can look and find out how to create things."

Students recognize they still have a lot to learn about STEM.

Although they felt smarter after STEM Pathways experiences, students also recognized that there was much more for them to learn in the future. Their new experiences through STEM Pathways made them aware of how much remains for them to learn.

"I feel like I know more. I think I need to learn more, but I also think I have a lot of information."

"I thought science was just potions and stuff, but now I know there's a lot more to learn, not just potions."

STEM challenges create mixed feelings related to student confidence in STEM.

Students viewed the challenges associated with their STEM Pathways experiences as a unique aspect of the partner programs.

"The people that were at the places we went to challenged us with different things using STEM."

"STEM Pathways helped us challenge our minds, helped us learn more."

When students were successful, they experienced feelings of pride and accomplishment. This was particularly the case when they encountered some initial challenges and had to persevere.

"It was really difficult, but we did it."

"When people build apps and all of that stuff, they have to think about it, like you have to do this, or no, this would work, no. It's very confusing, but at the end, you're proud of yourself that you actually did it."

Students perceive the challenges of STEM as authentic to the fields, but such challenges also cause frustration. Some students found it difficult to remain motivated when they faced difficult challenges.

"STEM can be so hard!"

"It sometimes just makes me want to quit. Like why do we have to do this sometimes?"

In addition to feelings of frustration, some students felt concern and anxiety about the possibility of failing when they face challenges in STEM. They worried about having the prerequisite knowledge to be successful and how their failures might have implications for others or the world around them.

"It made me kind of worried because sometimes I don't know how to do the things."

"We think we might fail and something bad will happen because of our engineering."

Beliefs about STEM

STEM is relevant and important for the present and future.

Students overwhelmingly believe STEM is relevant to their lives, both in the present and in the future. They recognize STEM as being present in the world around them and see its value in helping them understand and explain things.

"Everything here, like every single thing, everything in this whole world is all made out of science."

"Science explains things we thought not possible."

Some students spoke about how STEM Pathways changed their beliefs about the relevance of STEM. Their experiences at the partner programs helped them realize that STEM has real-world applications that affect their daily lives.

"I thought that STEM was like not that useful I guess, but ever since I learned more, I think that STEM is useful."

"I think STEM is really important in life because you use it every day."

A number of students discussed the importance of STEM in making the world a better place. They provided specific examples related to the environment, future exploration, and communication.

"Engineers think of new solutions to make the world better."

"STEM helps make the world a better place."

STEM Pathways contributes to more positive feelings about STEM.

Students revealed many positive associations with STEM as a result of STEM Pathways. They explicitly connected their positive feelings about STEM to their STEM Pathways experiences and expressed interest in having more STEM experiences in the future.

"Now I honestly think STEM is my favorite thing in school."

"STEM is less boring because we had a lot of fun at the places, and I wish we could go there again."

In addition to newfound appreciation for STEM in general, some students felt more positive about the individual areas of science, technology, and engineering. As previously mentioned, student opinions toward math remained largely unchanged following their STEM Pathways experiences.

"No one liked technology before, but once you get in fifth grade and you do these field trips, you actually start to understand it."

"I used to think science was not fun. Now I really like science because of STEM Pathways."

"I like engineering now because you get to invent and experiment."

Students are more interested in STEM careers because of STEM Pathways.

Students spoke fondly of their hands-on, authentic experiences with the STEM Pathways partner programs. They felt like engineers because of these opportunities, and this generated enthusiasm for STEM careers as a result.

"Whenever I went to any of these field trips, I always wanted to be a scientist or engineer person."

"I wanna do STEM for my job!"

"At first I was like, 'No, I don't want to be a scientist in my career,' and now I'm starting to think about it because after all the things we did, it's very interesting to work with and learn about."

Discussion

Students shared many positive feelings about their experiences through STEM Pathways, but there were also some opportunities for growth. This discussion will look more closely at four growth areas and provide some suggestions for how to achieve such growth.

First, students understand STEM Pathways at varying levels of completeness and accuracy. Some only recognize that it relates to science, technology, engineering, and math, while others understand that it provides a set of field trips with the goal of developing skills for future use. More consistent messaging about STEM Pathways could help create more consistency and accuracy in students' understandings of STEM Pathways and its purpose. The STEM Pathways steering committee may want to consider who is initially introducing STEM Pathways to students (teachers at school, program personnel, etc.), the information to be conveyed, and how to reinforce the pertinent messages on an ongoing basis throughout students' STEM Pathways experiences.

Second, students do not recognize math as being an integral part of their STEM Pathways experiences. Although they name discrete math skills as helping them with their schoolwork, they do not seem to think that math is essential to their success in their STEM Pathways experiences. Partner programs may want to consider their curricula and determine whether there are opportunities to strengthen the integration of math. Students may also fail to recognize the connections between "school math" and math applications in the real world; perhaps explicit acknowledgment of how math is a useful and necessary component of the STEM activities students are completing could help students recognize its importance. Even if the mathematics at hand is too complex for students in fourth and fifth grade, discussion how math is used could increase awareness of and appreciation for the real-world applications of math.

Third, students only recognize surface-level connections between the STEM Pathways partner programs. They make basic content connections and point to the use of STEM as the primary connections. However, they largely fail to recognize how the skills and ways of thinking may be similar between programs. The STEM Pathways steering committee and implementation team should review intended connections to determine if they are appropriately explicit, refine as necessary, and strategize ways to improve how these connections are conveyed to students. For example, if it is important that students see perseverance as key to success at each program, how can each individual program share that with students? On the other hand, if common vocabulary takes precedence, what strategies can ensure that students are recognizing the terms from one experience to the next? It seems that the typical student does not think deeply about how STEM Pathways experiences are similar or connected to each other, so more explicit messaging is needed if this is a priority. The same is true of students' connections between their STEM Pathways experiences and what they are doing in school. They see STEM Pathways reflected in very specific topics of study or skills they use at school; if the goal is to have students recognize more broad skills or ways of thinking, it may be of value to consider this more carefully.

Finally, and perhaps most importantly, there are mixed findings about students' confidence in STEM. Students almost unanimously acknowledge that their experiences through STEM Pathways make them feel smarter and help them learn. However, they recognize that they still have a lot to learn, and some report feelings of frustration and anxiety related to the challenges they face in STEM. At first glance, these findings may appear contradictory; however, it is possible to reconcile the findings to better understand previous research that showed students experience a decrease in STEM confidence. First, it is important to acknowledge that STEM fields are truly challenging; thus, students seem to have a more realistic view of STEM after their experiences in STEM Pathways. The two quotes below demonstrate how STEM Pathways experiences helped students move from a naïve belief that STEM is simple to form a more accurate representation of complex nature of STEM.

"I thought STEM was easy, but I learned there's some really hard stuff that engineers have to think about."

"I thought engineers just built things and then used them, but it actually turns out they had to do a bunch of engineering. It would take like two or four months to finish it."

The prospect of working on a single project for two to four months may be unfathomable to fifth-graders. Following their STEM experiences, students realize that STEM involves failure and multiple iterations, which is a common reality of working in STEM fields. They have a more nuanced understanding of STEM, which includes some of its challenges. It is important to provide students with accurate information and prepare them to overcome challenges if they pursue STEM in the future, so the key issue is how to simultaneously help students understand that STEM is complex and that with hard work and perseverance, they can be successful in STEM fields.

One possible way to contribute to increased confidence in STEM involves distinguishing between content knowledge and the application of that knowledge. Students easily recalled and discussed in detail the factual information they learned. They seemed to have very high confidence about their STEM content knowledge. In contrast, only one student spoke of feeling confident about her ability to *do* engineering. Although students regularly referred to the hands-on activities, it is possible that they did not realize they were actually applying their content knowledge to a practical situation. In order to translate students' increase in content knowledge to increased confidence in STEM overall, there may be a need for more opportunities to apply such knowledge and explicit messaging to make students aware of when they are doing so.

Limitations

Selection Bias

Given the need for parental consent for students to participate in this research, the pool of possible participants was limited based on the number that returned consent forms. In some classrooms, the majority of students returned signed consent forms, allowing for a more random selection of participants. In other classrooms, however, the low number of signed consent forms eliminated that possibility. Although every effort was made to interview a selection of students representative of the population as a whole, it is possible that the students who returned consent forms were different from the other students in some way.

Language

Small group interviews were conducted almost exclusively in English, and 25% of students who participated were English Language Learners. Although the researcher shared with Spanish-speaking students that they could speak Spanish if they preferred, this only happened on a few occasions. While the students seemed able to express their thoughts in English, it is possible that they would have been more comfortable if a translator were present.

Student Age

The current study focused on students in fifth grade at the time of the interviews. All but four students had experienced STEM Pathways programs as both fourth- and fifth-graders. It is possible that their thoughts and perspectives are different from those of fourth-graders who have only participated in one year of STEM Pathways programming. It is important to note that the previous research finding of a decrease in STEM confidence was especially marked among fourth-graders, so future research should consider the fourth-grade perspective as well. Any generalizations beyond the participants in the current study must be made with caution.

Position of the Researcher

The researcher is a former employee of one of the partner programs. Students were excluded from the participant pool if they had worked directly with the researcher in the past, but it is possible that some students recognized the researcher. In an effort to prevent recognition and any influence on students' results, the researcher identified herself in her current position at the University of Minnesota and wore a University of Minnesota nametag to help provide a visual distinction from the partner programs as well.

Conclusion

Fifth-grade STEM Pathways participants have very vivid, accurate, and positive recollections of their STEM Pathways experiences in general. Students speak highly of their participation in the partner programs and offer promising feedback about their interest in STEM, the perceived relevance of STEM, aspects of STEM that felt most authentic, and future aspirations related to STEM. However, there are also possibilities for program growth and development around student understanding of STEM Pathways, integration of math, connections among partner programs and between partner programs and school, and student confidence in STEM. The findings from this study can be used to guide conversation around future priorities for the STEM Pathways partner programs, both individually and in collaboration, to continue working toward greater student interest, achievement, and confidence in STEM.

Appendix A – Interview Protocol

General

- What is STEM Pathways?
- Is STEM Pathways different from other field trips or classroom visits that you have experienced?
If yes, ask: In what way?

Program experiences

Use visual aid to record student ideas as they are shared.

- This year, you participated in programs at the Bell Museum, Minnesota Zoo, and STARBASE. What did you do in those programs? ** Probe for responses about each program.
- You also participated in programs at the Bakken and the Works when you were in fourth grade last year. Do you remember what you did in those programs? If yes, ask what did you do in those programs? **Probe for responses about each program.
- Did any of the things you did in these programs make you feel more like a scientist or an engineer?
If yes, ask: What did you do that made you feel this way?
- Were there things you did or learned in STEM Pathways programs that helped you with what you were learning in school?
If yes, ask: What things were those that helped with what you were learning in school?
- Were there any similarities between what you did or learned in one STEM Pathways program and another one?
If yes, ask: What similarities were there between which programs?
- Do you think of STEM any differently now because of your experiences in STEM Pathways programs?
If yes, ask: In what way do you think of STEM differently?

Appendix B – Program-Specific Details

The Bakken Museum

- Frankenstein video
- Shocks (people hold hands and shock travels through all)
 - o Several shock mechanisms described
- Electricity
- Mind ball game
- Benjamin Franklin: kite and lightning
- Magnet on TV
- Fish that shocked and healed man's foot
- Living in the past without electricity
- Friction

Bell Museum

- Types of bees
- Pollinators – different types
- Animal dioramas
- Tasting honey
- Seeing person work with bee hives
- Foods that would not be available if bees went extinct
- Dissecting a flower
- Tools to extract honey
- Touch and see room – snakes, starfish, animal skins
- Game: people as deer and wolves
- Cockroaches
- Animal behaviors
- Habitats
- Seeing queen bee

Minnesota Zoo

- Saw many types of animals
- Endangered animals
- Bird exhibit
- Habitats
- Animal characteristics
- Food web/chain
- Bird show
- Touching stingrays
- Predators and prey
- Animal defenses
- Biomes
- Animal adaptations

STARBASE Minnesota

- Rockets
- 3D modeling and printing
 - o Rocket fins
 - o Wind turbines
- Programming/controlling robots/rovers
- Wind turbines – designing and testing
- Mars colony
- Airplanes
- Crash tests
- Creo
- Vacuum pump
- Finding volume of a place to add lights
- Moving rocks out of an area
- Survival on Mars
- PokeMars
- Finding area
- Making prototypes
- Prizes for doing homework/Clubhouse
- Energy from turbines – don't want turbines to explode
- Solar panels
- Generators
- Stealth mode
- Finding mean
- Science Court at lunch

The Works Museum

- Pizza box mazes
- Harp with sensors
- Musical living room
- Laser maze
- Blocks for building
- Marble track
- Roller coaster
- Car races
- Engineering a game
- Pulley
- K'nex
- Disco room
- Mirrors that make you look different

Appendix C – Selected Visual Aid Photos

Note: Photos have been cropped to remove school names.

