DEEPENING, SUSTAINING, BUILDING
COHERENCE AND FOSTERING STUDENT
LEARNING AND EQUITY
About this Project:

This report is the result of a collaborative project supported by the Council of Ontario Directors of Education (CODE), Technology and Learning Fund, TDSB Teaching and Learning Department-STEM K-12 and TDSB Research and Information Services lead by Research Coordinator Erhan Sinay.

TITLE: STEM Teaching and Learning in the Toronto District School Board. Research Series II: Deepening, Sustaining, Building Coherence and Fostering Student Learning and Equity.

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EXECUTIVE SUMMARY

During the 2015-16 and 2016-17 school years, the Toronto District School Board (TDSB) continued its work in Science, Technology, Engineering, Mathematics (STEM) implementation across the board. This report details lesson learned from the key program implementers of the STEM Innovation Project. The TDSB research team conducted classroom visits and interviews with school administrators, teachers, and STEM coaches participating in the STEM Innovation Project.

Figure 1: STEM

Overall, key findings include the STEM strategy making important gains with administrators, teachers, and students. Most educators viewed STEM as an important way to prepare our students for 21st century living, and improving student engagement and enthusiasm. For teachers, the main successes included increased teacher collaboration and better teaching practices that are more reflective of students’ learning. For administrators, the STEM strategy has helped improve inter-school collaboration and professional growth. For STEM coaches, the STEM strategy has helped create “mind shift” around inquiry-based learning with teachers. Figure 2 displays the key findings of this study.
Our study findings provide key lessons that can set directions and inform practices and policies in STEM education as well as implementing system-wide interventions and strategies across the schools. Below is a summary of key lessons learned from the TDSB STEM Innovation Project.

**Figure 3: STEM Year 2 Key Findings**

<table>
<thead>
<tr>
<th>KEY LESSON</th>
<th>FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Implementation</td>
<td>Most schools have had the STEM program in place for one year.</td>
</tr>
<tr>
<td>Understanding of STEM</td>
<td>Educators feel STEM is important for preparing our students for 21st century living. However, educator understanding of STEM is on a continuum, some teachers have a better understanding of STEM than others.</td>
</tr>
<tr>
<td>Involvement in STEM</td>
<td>The main ways teachers got involved in STEM was: personal interest, STEM coaches, teachers volunteering, or as part of the Model School initiative.</td>
</tr>
<tr>
<td>KEY LESSON</td>
<td>FINDINGS</td>
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<tr>
<td>Teacher Collaboration/ Planning Administrator Collaboration</td>
<td>Overall, teachers and administrators had a <strong>variety of opportunities</strong> to collaborate, co-plan, and coordinate activities; however, <strong>more consistent and equal opportunities</strong> across schools are desired.</td>
</tr>
<tr>
<td>Types of Supports Provided</td>
<td>Schools received <strong>support</strong> through funding, receiving necessary technology, training, STEM coaches, and release time. Some of the STEM coaches were <strong>overextended</strong>. Unfortunately, administrators and teachers both report not receiving any real support from STEM digital lead learners.</td>
</tr>
<tr>
<td>Additional Supports</td>
<td>The main support needed is more <strong>funding</strong>. The other main call was for more <strong>technology</strong>; this could be upgrading old technology or ensuring sufficient technology for the classrooms as well as consistent technology support for teachers.</td>
</tr>
<tr>
<td>Successes</td>
<td>One of the most commonly cited successes was <strong>increased student engagement and enthusiasm</strong> for the initiative. For administrators’ successes included <strong>professional growth</strong> among them and their staff with STEM. For teachers, the main successes were increased teacher collaboration and better assessment practices that are <strong>better reflective of student learning</strong>. For STEM coaches, the main successes were increased implementation of STEM pedagogy.</td>
</tr>
<tr>
<td>Issues/ Challenges</td>
<td>The main challenges include: <strong>lack of time</strong>, issues with <strong>teacher buy-in</strong>, lack of financial resources, lack of material resources, <strong>technology issues</strong>, and student engagement issues.</td>
</tr>
<tr>
<td>Impact</td>
<td>One area that teachers and administrators report positive impact is among <strong>student engagement</strong>, especially with students who traditionally do not respond to conventional learning practices. Other impacts include a <strong>growth mindset</strong> among students and teachers, more problem-solving, critical thinking, and collaboration. Among teachers, STEM teaching and learning has had an impact on creating more <strong>student-centered</strong> teaching practices.</td>
</tr>
<tr>
<td>KEY LESSON</td>
<td>FINDINGS</td>
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<td>------------</td>
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</tr>
<tr>
<td>Equity</td>
<td>STEM was seen as an equalizer in many regards by teachers. The use of STEM allowed for engaging students who might not fare well under conventional learning methods. This was especially true for HSP, students with special education needs, ELLs and students from low economic backgrounds to succeed. It also allowed for differentiated learning, hands-on learning, and access to technology.</td>
</tr>
<tr>
<td>Achievement</td>
<td>Overall, students who have had continued participation in STEM have shown increases in achievement and engagement and Learning Skills as reported in report cards. In schools where STEM is in its second year students demonstrated an increase in learning skills (responsibility, organization, collaboration, and self-regulation) and increased scores in reading, mathematics, and science.</td>
</tr>
<tr>
<td>Recommendations for Scaling Up</td>
<td>The most commonly cited recommendation among teachers was the need for more consistent time with knowledgeable STEM coaches who can help co-teach and co-plan especially with students with special education needs. Another ongoing recommendation was the need for technology in schools to be upgraded and ensuring there is enough technology for smooth implementation of the initiative. Teachers and administrators would like to see a scaling up of sharing information, perhaps through an online resource center, a lead teacher, or through co-planning. For the Board, teachers and administrators would like to see a clearer vision of STEM with details on how to achieve proscribed goals and accountability to ensure goals are met. Teachers would also like meaningful and ongoing professional development that progressively teach new concepts.</td>
</tr>
</tbody>
</table>
SECTION A: INTRODUCTION

The purpose of this study was to examine the second year of implementation of the Toronto District School Board’s (TDSB) Science, Technology, Engineering, Mathematics (STEM) K-12 Strategy and track outcomes for administrators, teachers, and students involved in this strategy. This was done as part of our three year developmental evaluation framework\textsuperscript{1}.

As part of the second year of implementation data was collected through interviews with system leaders on STEM, school administrators, teachers, and STEM coaches as well as classroom visits to examine perceptions of STEM, planning and implementation for the STEM initiative, collaboration efforts, supports provided, successes, issues and challenges, impact, recommendations for scaling-up, and achievement results. Schools were selected randomly using stratified random sampling among the STEM elementary pilot schools. Six elementary schools were randomly selected among the STEM pilot schools\textsuperscript{2} using the schools’ socio-economic background as measured by the TDSB Learning Opportunities Index (LOI)\textsuperscript{3}.

\textbf{Figure 4: Overview of Methods}

Overview of Second Year of Implementation

- **Interview with Lead Teachers**
- **Interviews with STEM Coaches**
- **Interviews with System Leaders and Administrators**
- **Classroom Visits**

\textsuperscript{1} Please see the details on our three year evaluation plan in Sinay, E., Jaipal-Jamani, K., Nahornick, A., & Douglin, M. (2016). STEM teaching and learning in the Toronto District School Board: Towards a strong theoretical foundation and scaling up from initial implementation of the K-12 STEM strategy. Research Series I. (Research Report No. 15/16-16 Toronto, Ontario, Canada: Toronto District School Board, p.81).

\textsuperscript{2} For details on 60 STEM pilot schools (20 elementary, 20 middle and 20 secondary school) in 2015-16 please see our report (Sinay, et, al, 2016) from: [http://www.tdsb.on.ca/Portals/research/docs/reports/TDSBSTEMStrategyResearchRpt1.pdf](http://www.tdsb.on.ca/Portals/research/docs/reports/TDSBSTEMStrategyResearchRpt1.pdf)

\textsuperscript{3} For detail information on TDSB Learning opportunities Index please visit: [http://www.tdsb.on.ca/research/research/learningopportunitiesindex.aspx](http://www.tdsb.on.ca/research/research/learningopportunitiesindex.aspx)
SECTION B: DATA ANALYSIS STRATEGY

The data in year two of the STEM K-12 strategy was collected to answer the following research questions:

1. Do the pilot STEM lead schools have the resources, professional learning, and support needed to deliver STEM programming?
2. What are teachers’ and administrators’ perceptions of STEM education? How do they perceive the viability and relevance of STEM education?
3. What STEM skills and competencies have students developed through their involvement in the STEM program?
4. What can we learn from the second year of implementation of the TDSB STEM strategy, including factors that hinder its implementation? What are the recommendations for moving forward with the implementation strategy?

The following sections will examine these research questions in detail.

Figure 5: Overview of Research Questions

<table>
<thead>
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<th>Research Question</th>
<th>Teacher Interviews</th>
<th>Administrator Interviews</th>
<th>Classroom Visit</th>
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<tbody>
<tr>
<td>Q1. Do STEM lead schools have the resources, professional learning and support</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Q2. What are teachers’ and administrators’ perceptions of STEM?</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Q3. What STEM skills and competencies have students developed?</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Q4. What can we learn from the second year of implementation?</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>
SECTION C: BACKGROUND INFORMATION

Administrators and teachers were asked background questions to provide some contextual information. Questions focused on the length of time administrators had been working in the school and the length of time teachers had been engaged in the STEM initiative and how they got involved with the initiative.

Why Schools Got Involved

Some schools got involved to remedy low EQAO scores.

“I know that our EQAO scores were abysmally low in math and seeking support from my superintendent; I know that was one of the things that came up because of the interdisciplinary nature of it all because math is in there and math, sciences, and all of that.”-Administrator

Length of Time Involved with STEM Initiative

Teachers stated though they had done STEM in some capacity before, the initiative has been in place officially from one to two years at their school.

“Well, I think some form of STEM has been done for many years. I’ve been teaching for 21 years. It’s interesting, because I look back at things and activities I’ve done over the years and I have a collection of them up there [that] I can show you later… Well, last year was when I really got pushed off the ground with the STEM coach.”-Teacher

How They Got Involved

Teachers got involved in the initiative through their STEM coach. Some got involved through their own personal interest and research.

“I don’t even know how it happened. I guess through the coach, they mentioned that there was some LEGO WeDo kits that we could get or borrow so I signed up and I just used it for our lunchtime LEGO club and the kids really loved it....”-Teacher
Summary: The findings suggest the schools under study have only recently integrated robotics into their official school schedules. In most schools the program had only been in place for a year, and was sometimes in response to low EQAO scores. In most cases schools got involved through their STEM coach or from personal interest and research.
SECTION D: PERCEPTIONS OF STEM

Administrators and teachers were asked about their understanding of the TDSB STEM strategy, why do STEM, whether there is a clear understanding of the STEM strategy among administrators and/or teachers in the school, if they wish to see the TDSB STEM strategy continued as STEM education or as STEAM (Science, Technology, Engineering, Art, and Science) education, and what the success of the STEM strategy would look like.

Understanding of STEM Strategy

Integrated STEM
Most teachers and educators viewed STEM as a strategy that is embedded in instruction and learning, not simply an add-on.

“[I] think the key is that it’s embedded in our instruction and learning of students...It’s not an add-on...”-Administrator

Hands-on Inquiry Based Learning
Most saw STEM as hands-on inquiry based learning. A form of teaching that moved from teacher directed to student centered with teacher guidance. STEM was seen as enriching students’ experiences because it is a hands-on way of learning.

“Now we’re looking at the questioning from students. Our own questioning...Exploring that question and moving along that problem as we, you know, in terms of looking at possible solutions and looking at very hands on, and that thinking of our students.”-Administrator

Technology and Science
Teachers stated some of them were immediately disinterested in STEM because they associated it strictly with technology and science.

“I wouldn’t say... there’s nobody really against it. I would say that there are people who are a little intimidated by it, shall we say, especially the technology piece.”-Teacher

Creative Problem Solving
Teachers stated it needs to be more clearly demonstrated that STEM is not just about technology and math but is a way to foster creative problem solving and critical thinking skills.

“This isn’t just [a] school where we give you something and you learn it. There’s real problems that we need to solve. But we want the kids to come up with all sorts of creative ways, to look at it and see the problems and figure out for themselves with hands-on materials.”-Teacher
Model for Capacity Building

The strategy was understood as implementing STEM in certain schools so they could act as a model for other schools. Once staff has been trained and the program is effectively working these schools would act as a model to other schools in an attempt to mainstream the program across the Board.

“Trying to proliferate learning through a STEM lens by rolling it out to certain schools first and then I think the initial idea was to use those schools to build capacity ... [and] then...model for other schools.”-Administrator

Anti-Oppression

Some thought STEM needs to be social justice oriented. STEM as solving real life social issues. Classroom observation revealed some teachers were in fact incorporating a social justice orientation to their STEM curriculum.

“I also felt that STEM should embrace looking at real issues from a lens that is... anti-oppressive. Not sure if that’s the right word to use. Sometimes we look at social justice issues and we can use STEM to answer those social justice issues.”-Administrator

Engineering Focused

Some administrators thought elementary school teachers were disinterested in STEM because of the engineering element. These teachers felt engineering is a concept to be covered in high school and beyond, not at the elementary school level.

“In a K to Grade 5 school like this one, as soon as you start talking around engineering, I think a lot of teachers switch off. They see the concept of engineering as either a high school concept or a post-secondary concept.”-Administrator

Why Implement STEM?

Prepares Learning for 21st Century Living

STEM prepares students for 21st century living. STEM jobs are viewed as better paid and therefore the initiative was seen as preparing students for a competitive workplace. Because of this reality many thought STEM needs to also be offered in high school in order for students to continue their engagement with STEM.

“[Y]ou know what 21st century STEM and technology is there, it’s front and centre. Without that, if we don’t give our kids opportunities to dabble in it we’re doing a disservice to our kids...”-Administrator
Whether there is a clear understanding of the STEM strategy among administrators and teachers

**STEM Learning on a Continuum**
Administrators found that teachers are engaged with the STEM strategy; however, on a continuum, whereby some teachers were more comfortable than others. It was a learning process and administrators saw teachers’ understanding of STEM progress throughout the year. This was attributed to teachers learning from each other, STEM coaches, and professional development. Never the less, this was not the case in all schools. Some administrators thought teachers at their school did not have a good understanding of the STEM strategy. They felt teachers did not know how to incorporate STEM into their daily practices. However, to further develop the implementation of the strategy administrators helped in many ways, including in some cases making a physical space at their school where teachers can go and experiment with new ideas.

“I would say we’re probably, maybe 50/50 in this building in terms of who’s… fully understand[ing] it.” -Teacher

**Wish to see STEM continued as STEM or STEAM education?**
Administrators thought STEAM was important and should be incorporated into everyday learning.

“That is a no brainer. I would like to see STEAM, because I believe that everything, “EVERYTHING” is so important. That balance needs to exist and my greatest fear is that we go from one end to the other end.” -Teacher

**What success of the STEM strategy would look like?**

**Collaboration**
Administrators believed that for STEM to be successful, their schools need opportunities to collaborate with other schools and share information.

“So sharing the knowledge among schools, making it part of the agenda for example when we have our LTMs, principals come together, making that part of the learning. The learning should not only be the students learning, but the teachers definitely need to gain that understanding, so that they can work with the students implementing it. But also administrators and superintendents at the system level. In order to run a school and have staff excited about the learning, we have to help facilitate that, we have to be leaders in terms of educating them.” -Administrator
Cross-curricular Teaching
Administrators spoke to the importance of cross-curricular teaching. Teachers cannot plan curriculum in silos because it will not allow for reaching all the set expectations. STEM allows for incorporating cross-curricular teaching. Classroom observations revealed many teachers were utilizing a transdisciplinary approach in delivering curriculum.

“[I] think success, the science curriculum,..., it’s making the connections that the math and science can be addressed and approached by integrating projects together. I think when our teachers start to realize that I don’t have a science period and I don’t have a math period, I may have a STEM period where I’m combining those two then we’ve hit success because now they learn to plan cross-curricular.”—Administrator

Engaged Students
Success for many was measured by increase in student engagement in the learning process.

“I think STEM is when students, ...are successful in learning I think it’s when they’re engaged. They’re questioning, and when there’s that, you know, student voice.”—Administrator

Changing Pedagogy
Another cited success was change in pedagogy that encouraged student creativity and problem solving as opposed to rote learning strategies. Classroom observations revealed teachers drew on teaching methods that emphasize problem solving, inquiry based, and hands-on learning.

[My understanding of the TDSB STEM Strategy is I think if you’re looking at the global ...picture, we’re behind in maths and sciences. ... I think a big part of the problem is our... rote learning strategies [which]... take... away the empowerment of children to demonstrate their creativity and to want to solve problems.”—Teacher
Summary: Administrators and teachers were asked about their understanding of the TDSB STEM strategy. Overall, most viewed STEM as very important to prepare our students for 21st century living. STEM is viewed as a strategy that is embedded in instruction and learning that enriches student’s experiences because it is a hands-on way of learning, and allows for cross-curricular teaching, creativity, problem-solving, collaboration and changes in pedagogy. It is important to note, that educator understanding of STEM is on a continuum, some teachers are more comfortable with STEM than others. Educators were also asked if they would like STEM continued as STEM or STEAM education, and many feel it is important to change to STEAM and be incorporated into everyday learning.
Administrators and teachers were asked how they got involved in STEM. Administrators were asked how they prepared to bring STEM teaching and learning to their school and the process they underwent to select teachers to participate in STEM.

Selection Process to Participate in STEM

Personal Interest
Few administrators stated they got involved in the strategy because they already had personal interests in STEM and when the opportunity arose from the Board they were excited about implementing the strategy.

“You know what, for me, I have a personal kind of passion. I read about some of the research a few years ago...And so when my superintendent actually ... sent us an email over the summer...I happened to be checking email over the summer and I responded to his email saying that I am interested. From there, he selected I believe two pilot schools...And yeah that’s how we started.”-Administrator

STEM Coaches
STEM coaches were credited for playing an important role in implementing the strategy.

“In order for me to bring something to my staff and kind of see the importance of it I’ve [got to] have a good understanding of it. I’ve got to find as much information that I can...so I have a good understanding of where we want [to be] as a starting point. So sitting down with [STEM coach] our STEM coach and telling me ...about STEM. I need to know more about STEM. What it’s all about? What it looks like, what it sounds like, what it feels like?”-Administrator

Teachers Volunteered
Some teachers got involved by self-volunteering when they were made aware of the opportunity.

“From what I understand our school was selected to be a STEM school and through that, we got access to the coach. And then it was put out to us through the principal like who wanted to work with the coach and I volunteered”-Teacher

Model Schools
Model Schools got involved because they were approached with the STEM initiative as part of the Model School initiative.

 “[W]e became a model school...part of the STEM initiative which came with model schools.”-Administrator
Preparation to bring STEM teaching and learning

Lead Teacher
Some administrators stated they implemented the strategy with a lead teacher or a few teachers and then slowly expanded it to the rest of the school.

“As you know, you need to have someone on staff who is going to lead it. They don’t have to know everything about that but someone who is interested in getting to lead it.”—Administrator

Provided Release Time
Administrators aided in the preparation of the teachers for STEM by providing release time.

“What we’ve done, is when we plan our units, and teachers [request] release time to plan the units. I specifically talk to them about incorporating STEM and ways to do it.”—Administrator

Co-learning
Both teachers and administrators got familiarized with STEM and then shared knowledge with fellow staff to prepare for implementation. Administrators and teachers learned together, sharing knowledge.

“So the first year we really focused the grades 6, 7 and 8. That was the huge focus, and then from there they were able to collaborate with some of the junior teachers and primary. And now, it’s become school wide.”—Administrator

Limited Time to Prepare
Some administrators admitted they did not have adequate time for preparation because when it was announced that their school would be part of the strategy the school year had already commenced. Additionally, some STEM coaches reported inadequate time to prepare and collaborate with teachers.
Summary: Administrators and teachers were asked how they got involved in STEM, and how they prepared for STEM teaching and learning. The main ways teachers got involved in STEM was: personal interest, STEM coaches, teachers volunteering or as part of the Model School initiative. The main ways administrators and teachers prepared for STEM teaching and learning was through: lead teachers, providing release time, and co-learning. There was a concern that in some cases there was limited time to prepare for the STEM initiative.
SECTION F: TEACHER COLLABORATION/ PLANNING, ADMINISTRATOR COLLABORATION

Administrators and teachers were asked if they had opportunities to collaborate, co-plan and coordinate activities related to STEM education, opportunities for collaborative inquiry, whether any STEM related professional learning communities had formed at the school, and whether they had opportunities for collaboration/ learning with other schools.

Learning Hub for Administrators

Some administrators were part of a learning hub with fellow administrators from their family of schools which helped their understanding of the STEM initiative.

“A: ...creating a learning hub amongst my colleagues...
Interviewer – When you say other colleagues, do you mean other principals?

A – Other principals from my family of school.”-Administrator

Co-planning

Teachers engaged in co-planning. A lot of this co-planning was done on personal time. Co-planning was uneven. For example, in terms of co-planning some teachers felt there was a divide between the primary/junior and middle school teachers in their school. They suggested allowing teachers of certain groups of grades the time needed to plan together to encourage collaboration for professional development.

“We have planning time every month; I think we have two half day planning time. We have been having them...to collaborate.”-Teacher

Release Time

Administrators provided release time when it was possible and had allocated part of the school budget for planning time. Teachers felt they would be able to plan more if administrators gave time. However, some teachers felt the process should not be too formal or taxing because this might deter teachers from becoming involved, for example if they had to provide official lesson plans after the planning sessions.

“Various grades have had opportunities to co-plan. But that’s just the starting point. And often times, they need more than that half day. If I’ve been able to, I’ve provided it to them...”-Administrator

Professional Learning Committees (PLC)

Some schools had professional learning teams. These PLCs met to discuss specific topical areas related to STEM and combine lesson planning resources. Not all schools had a PLC for STEM however. In these cases sharing informally occurred.
“[W]e have professional learning teams and they meet not only within the instructional day they meet 4 times, 4 half-days, 2 per each reporting period, but they also meet on their own time.”-Administrator

**STEM Coaches**
Teachers were given time to co-plan with coaches. The STEM coach was a good resource for facilitating co-teaching and planning.

“Every time he’s here, he’s working with a class and teachers have opportunities to sign up, talk to him, and plan beforehand. So he’s been involved with the planning, creating things with the students.”-Teacher

**Co-learning with Students**
Teachers admitted they learned from the students, particularly the technology components.

“Oh absolutely *laughter* they take a lot of the things, like a lot of the programs and they go to the next level or ‘I’ve found this’ and I’m like ‘show me how.’ For example, I had an activity where I was messing around with [a screencast client?] to try to capture images for my presentation and the kids have said ‘you know, this is a tool that you might use, I’m having a little trouble with it.’ So one of the children goes home and says ‘let me look at this,’ so he goes home, works on it that night, and is like ‘okay, here’s how you do it.’ So he was showing me, like you know, he got excited, you just point them in the direction and say ‘these are some of the apps that I think could be useful to us or helpful’ and I think kids are more tech savvy than us, their brains are ready for it.”-Teacher
Summary: Administrators and teachers were asked about opportunities to collaborate and co-plan with the STEM initiative, and about providing teachers with release time. Teachers reported that co-planning was done mostly on their own time. As such, the amount of co-planning was uneven. Other collaboration took place through professional learning committees, STEM coaches and co-learning with students. Overall, teachers and administrators had a variety of opportunities to collaborate, co-plan, and coordinate activities; however, more consistent and equal opportunities across schools are desired.
SECTION G: TYPES OF SUPPORTS PROVIDED TO ASSIST WITH STEM TEACHING AND LEARNING

This section looks at several types of supports provided to assist with STEM including support from: System/ Central Leadership, School Administrator, STEM Learning Coach, Digital Lead Leaners, External Sources, and Learning Networks.

Support from System/ Central Leadership

Funding
The biggest type of support administrators received was funding. Pilot schools received STEM specific funding. Some administrators drew on a collaborative approach for funding distribution with teachers. Through dialogue with teachers, administrators made decisions regarding how the funds were to be spent which they found builds a collective sense of ownership of the school.

“Fortunately, we have a supportive community, we’re part of the pilot, so, you know, we do have funds. And when I look at the budget, a good portion of the budget goes towards it because that’s what right now we’re focusing on.” -Administrator

Knowledge Resources
Teachers were given technology training by the Board. Administrators noted that other forms of support supplied by the Board included lists of resources to help with who to connect with and how to take the initiative outside the school boundaries. For example, connections to STEM related competitions.

“[M]y tech learning this year has gone through the roof, just because of the way that they structured things and the opportunities that they gave us to work on things. I think that has been great...” -Teacher

Release Time
Getting a pilot school designation from the Board gave schools additional resources and additional release time.

“And this year, you know, I reached out to him [STEM coach] because I wanted to help the family of school grow and he provided us half day release PD for our family of school to be able to provide professional development to every school.” -Administrator
Support from School Administrator

**Release Time**
Administrators supported teachers by giving release time for them to co-plan.

“For their planning I try to give them common planning time so all the grade 3s and 4s would work together and have some planning time to do that.” - Administrator

**Professional Development (PD)**
Administrators supported STEM by promoting PD opportunities and budgeting funds for PD. Teachers attended conferences and workshops. Administrators were seen by teachers as being supportive of the initiative and they were good at letting staff know about useful training opportunities.

“And then there’s been a lot of system-wide PDs that I have sent teachers to. I try to send as many teachers as I can. The more, the merrier.” - Administrator

**Providing Time for Knowledge Transfer**
Administrators provided time for teachers to come back from their professional development and relay knowledge to other teachers.

“They need to come back and share it. The nice part...it’s a 2 edge sword, you have to send them but you also have to provide them opportunities for when they come back to impart the knowledge or the expertise or the neat things that they had [learned] because you never know how that little piece of information may spur an interest of somebody else wanting to be a part of it.” - Administrator

**Time to Work with STEM Coach**
Some administrators designated planning periods with the STEM coach.

“A lot of it that has come from [administrator], our principal, because he’s super on Board with STEM, and training, ... making the time and providing release for teachers to engage in that.” - Teacher

**Budgeting for STEM**
Administrators allocated money for equipment and time to plan.

“We committed [monies]... out of the budget to support in-class instruction during the instructional day. ...each teacher gets 4 half-days to plan with their PLTs during the instructional day. That’s a commitment I have made to them to say it’s important for you to plan. Without planning, program is not going to make a difference.” - Administrator
Advocating for STEM
Some administrators integrated STEM into their school improvement plan to foreground the prominence they give to the initiative.

“When you work with staff, the number one thing is you have to make it part of your school improvement plan. So when I work with the staff, at the beginning of the year, and sometimes we look at the year before, the school improvement plan, STEM becomes part of it.”—Administrator

Support from Family of Schools
Some administrators were part of a learning hub for principals within their family of schools. Administrators invited fellow principals to see their classrooms to understand how they were integrating the STEM strategy.

“I think it’s one thing to help your school grow, but it’s another to help the system grow...And just really helping them understand like, a starting point, some possible starting points, some challenges...”—Administrator

Support from STEM Learning Coach
STEM coaches were the most commonly cited type of support teachers received. This aligns with findings from our report on “An Exploratory Study of Differential Effects of Coaching on system-wide STEM Implementation”4 whereby most administrators and teachers felt the STEM Learning Coach model was an effective approach for professional learning. Eighty percent (80%) of administrators and 73% of teachers reported that they thought the STEM Learning Coach model was a very effective or moderately effective model. The remaining teachers who thought the STEM Learning Coach model was slightly effective or not at all effective felt it could be more effective if they hired more coaches who were consistent and had greater knowledge. These were echoed in the current findings.

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Co-plan and Co-teach
The STEM coaches were heralded as being responsible for co-planning and co-teaching. They helped teachers surpass initial fears of the STEM strategy. Some schools had started to co-plan with the STEM coach and some had not begun using their STEM coaches. All the schools expressed interest in working with the STEM coach if they were not already doing so. It is important to note, some of the STEM coaches were seen as overextended. The experiences with STEM coaches were uneven.

“It’s been very instrumental having the STEM coach helping us drive and becoming and increasing our awareness of understanding what STEM is all about....I think that if we didn’t have the STEM coach we wouldn’t be as far as we are today...”-Administrator

Resource for Ideas
STEM coaches were credited for getting additional resources and were knowledgeable about grants, PD opportunities, and competitions that teachers could access and participate.

“[STEM coach] really provided me, was a great resource for ideas. I would come to him with an idea and he would help me structure it into you know a lesson or unit...he actually helped me develop the base model for the airplane launcher. So having his expertise, he has a lot more expertise in the actual use of the robotics. So having him as a source, a resource to go to really helped me with... figuring things out.”-Teacher

Support from Digital Lead Leaners (DLL)
Some administrators revealed they did not receive any meaningful support from the STEM digital lead learners. Some teachers admitted they had no contact with the STEM DLL, partially because the role was not needed because they had a STEM coach at their location.

“We have one STEM DLL for our FOS [Family of School]. And our school hasn’t been involved with her in any way...– Partially because... with [STEM coach] here...We don’t really need that access.”-Teacher

Support from External Sources
Teachers also received opportunities to train with external institutions; for example, the University of Toronto.

“Yeah so she was part of the initiative and I had to apply to her to get the LEGO WeDo kits and I also went to U of T and TDSB LEGO workshop on Scratch....”-Teacher
Summary: This section looked at the types of supports that were provided to assist with STEM teaching and learning. The biggest type of support administrators received from the system/central leadership was funding. Other supports given by the system/central leadership included being provided with the required technologies to implement the strategy and training and release time. Supports were also received from the school administrator which included: release time for teachers to co-plan, STEM professional development, time to discuss STEM learning, time to work with STEM coaches, budgeting for STEM, and advocating for STEM. STEM coaches also supported teachers through: co-planning and co-teaching and providing resources. It is important to note that some of the STEM coaches were overextended. Unfortunately, administrators and teachers both report not receiving any real support from STEM digital lead learners, possibly because they had STEM coaches at their schools. Support was also received externally, such as through training with the University of Toronto.
SECTION H: ADDITIONAL SUPPORTS, RESOURCES, PROFESSIONAL LEARNING OPPORTUNITIES NEEDED

This section details additional supports, resources, professional learning opportunities administrators and teachers feel are necessary for the success of STEM.

Financial Resources
Administrators advocated most for more financial resources. Some requested knowledge on the optimal ways to spend the resources they were given.

“I would say more continue to put money and resources both people resources in place to help support teachers.”—Administrator

Technology
There was a call for more access to technology. There was also a request to upgrade existing technology in the schools in order to successfully implement the new initiatives. This was corroborated by classroom observations that indicted some classrooms had antiquated equipment. In fact, many classrooms relied on students bringing their own devices to school.

Teacher Understanding
Administrators advocated for additional help (i.e., networking sessions) for teachers. They want support in showing teachers how to integrate inquiry based learning into their lessons and in familiarizing teachers with different technologies.

“For us, one of things we looked [at] recent PD sessions [for] every staff here was in terms of Google Apps…. And so having that communication and setting up like a classroom for discussion and sharing and I think that’s important….Some teachers haven’t used Google Apps….For them, it was important…how to set up a classroom, how to even set up a forum….”—Administrator

Professional Learning
To better develop their skills, teachers advocated for meaningful workshops that were consistent.

“I found a lot of things that I went to also this year are [that] they’re all geared towards ‘intro to’. …. Now I want to figure out how to do this in a more expansive way, you don’t have that support and the workshops are a one off hour. I went to a full day for Scratch and it was still let’s whip through all of this because there’s so much. But if it was every 2 months, we’re going to meet back with the same. ….”—Teacher
Co-teaching and Co-planning
Administrators wanted more support to help teachers embed STEM/robotics into their programs. They needed more support with co-planning and co-teaching. Teachers asked for more coaching, workshop, time to meet other teachers for knowledge transfer. They wanted detailed training. They also wanted more direction on how to incorporate STEM into the curriculum.

“So showing me how to plan it or to incorporate it, or blend it into my program better. It would have been helpful along the way or [at] the beginning.”-Teacher

School Expansion
Teachers advocated for more support to expand the initiative throughout the school and to get more teachers involved.

“[O]ne of the things I’ve been trying to do is... is trying to proliferate [the] use of STEM in my own school as well.”-Administrator

Modelling
Teachers asked for opportunities to see STEM modelled in different classrooms.

“It would be great to have both... like kindergarten workshops and kindergarten co-teaching. Even if there are open classrooms to be able to go in and visit and see like what a STEM classroom... Like what a STEM activity looks like.”-Teacher

Planning
Teachers and administrators need support to create long term plans of how STEM is to be implemented and what are the year to year goals that need to be achieved for successful implementation.

“I think...having a long range vision is important of course as an administrator and as a teacher too. What can we achieve this year and next year? What’s part of their long range plans?”-Administrator

Technology Support
Teachers need knowledge support to navigate new technologies. This support needs to be consistent.

“But if you have a bad experience then it’s hard and I think that’s why the back end support [is needed] when you hear they’re cutting this and they’re cutting techs and they’re cutting supports for coaches...you think...how are you going to support the teachers when they call and they need help? ...Who do you call? I can read about it in a book and I can go on the website
and [see] all the STEM stuff, but if it’s not support that can come and work with my teachers then who’s [going to] do it?“-Administrator

**Summary:** This section detailed the additional supports, resources, and professional learning opportunities administrators and teachers felt were necessary for the success of STEM. The main support needed is more funding. Administrators advocated for more money to help support teachers. The other main call was for more access to technology; this could be upgrading old technology or ensuring there is sufficient technology for the classrooms. Other additional supports included: more support for teachers on STEM and inquiry-based learning through more co-teaching, co-planning, coaching, and networking, and more meaningful professional development that digs deeper, expanding STEM throughout the school, more opportunities to see STEM taught in other classrooms, long term plans for STEM, and consistent technology support for teachers.
SECTION I: SUCCESSES EXPERIENCED DURING STEM TEACHING AND LEARNING

This section looks at successes experienced during STEM Teaching and Learning including student engagement, teacher engagement, and school engagement.

Student Engagement

Access to Technology
An example of a success was students being given access to important technology through STEM. This will aid in their future learning.

“So what I feel most proud about is I feel like the trickledown effect that I’m giving the students and my students are giving the school is that we are giving them that base in technology at a younger age, so that when they get there, they’ll have more tools to succeed.”—Teacher

Student Enthusiasm
One of the most commonly cited successes was student engagement and enthusiasm for the initiative.

“The enthusiasm of the students has been really tremendous. When the kids are really interested in a real problem or work with peers. It really minimizes trouble because they are so engaged.”—Administrator

Engaging Different Students
STEM resonated with students who are traditionally disengaged from normative teaching styles. STEM was credited with making students more open to try new things and to continue learning even if they do not understand the material from the onset.

“That is why it is important that we all do STEM because it could be an entry point for a number of students. That’s what I have seen. For instance, one kid in particular, if he is involved in a STEM activity, creating and building anything, he is there, absolutely no problem. But [if] you ha[nd] him...a pencil and paper alone, absolutely no interest.”—Administrator

Destigmatizing Different Learners
STEM destigmatized students in the Home School Program (HSP). During STEM activities, other students wanted to work with students in the HSP; whereas, previously they would distance themselves from them. Classroom observations confirmed STEM projects allowed HSP students to integrate with the wider class.

“[M]y whole HSP program changed because of STEM. It’s just ... I feel that it’s a lot more successful. It’s [a] successful program that...destigmatized our HSP program as well. I have kids
coming up to me now from the regular classes saying “Can I be in your class? I want to do what you’re doing. Can I be in HSP?”-Teacher

**Co-learning**
Co-learning among students was another cited success.

“You see the collaborative learning, the critical thinking, the cooperation of the kids.”-Teacher

**Student Voice**
The initiative gave students a ‘voice’ in their learning process, as well as more confidence discussing classroom work.

“Student voice, huge, because they talk about their designs, they share opinions about what to do, they try it out if it’s not working.”-Administrator

**Levelling the Playing Field**
The initiative was seen as levelling the playing field for students of lower socio-economic backgrounds who might not have access to technology at home. The initiative also leveled the playing field for ELL students who might face language barriers in traditional learning settings. However, hands-on learning allows them to draw on other skills.

“I know the focus of this interview is robotics but I’d say technology in general. To me that levels the learning playing field. But with robotics, 100%. And in fact some of our participants in these clubs are children who [have] special needs. And the gains that they make from it in terms of their learning, in terms of their self-esteem, in terms of working with a team, in terms of sharing and what not are huge.”-Administrator

**Initiatives and Partnerships**
Administrators cited students winning competitions as a success of the initiative. Additional successes were establishing partnerships with other initiatives including the engineer in residence program.

“We’ve taken part in several initiatives, like the I-cubed. ... Initiatives like that, the engineer in residence has been amazing [with] program partnership. ... And so they helped problem solve and incorporate that into the lessons and actually have an engineer working with the students.”-Administrator

**Student Leadership**
Through STEM, students are taking a leadership role in their learning process.

“Instilling students to be leaders in the building within the technology area and dabbling with that and showing, and working with our little ones, our older kids working with our little ones to
help move the technology along or understand the technology, that’s very powerful stuff.”

Administrator Engagement

Professional Growth
Other successes cited by administrators included professional growth among them and their staff in their understanding of STEM.

“I think for me, there’s that professional growth from not just the teachers but myself.... I think we’ve grown in that journey in terms of our understanding of STEM and accepting of that... was just not... another new initiative by the Board.”

Administrator

Budgeting STEM
Another cited success among administrators was centering STEM into their school budgets and school improvement plans to ensure effective implementation.

“...[I]ncorporating, integrating part of the teaching, part of my budget planning this year, this school year, part of my school improvement plan, part of our professional learning [to STEM].”

Administrator

Teacher Engagement

Teacher Collaboration
Another success of STEM was increased collaboration among teachers. Teachers were also collaborating with other teachers from across the Board. Teachers have become more engaged through this process. The program has also been credited for increases in co-teaching and co-planning. This has been true even among teachers who did not traditionally engage in these practices. Classroom observations revealed many teachers were engaging in co-teaching.

“The grade 1 teachers are working with various schools in the system with the [STEM] coach to create a unit and then they’re going to share that information at the school level as well as continue at the family of schools level.”

Administrator

New Assessment Practices
Teachers stated they are formulating more comprehensive assessment practices that better reflect student learning. STEM requires integrating conventional learning styles resulting in changes in evaluation practices.

“I’m also just more proud [of] the way I’ve been able to, like I said, get away from the paper-pencil more confidently and feel like my assessment is valid, because I’ve become better at assessing students by moving away from that paper-pencil and more about the process and
what I’m hearing and the dialogue, so you can actually give the kids a chance to make that mistake and fix it and you can see the learning.” -Teacher

School Engagement

School Integration
Another cited success was the integration of STEM in the school and classroom, normalizing STEM.

“I see it in our classrooms, on the walls...”-Administrator

External Collaboration
Another cited success was the connection to other initiatives and partnerships with outside organizations, including the University of Toronto.

“We got to go to U of T and I got to go learn Scratch and share with a colleague. Opportunities definitely open up using STEM and professional learning.”-Teacher

Parent Engagement
Another area of success was parental exposure to the initiative. The initiative energized the parent community.
Summary: This section looked at successes experienced during STEM teaching and learning. Overall, there were many successes to be proud of especially related to student engagement, teacher engagement, and school engagement. One of the most commonly cited successes was increased student engagement and enthusiasm for the initiative. For administrators, successes included professional growth in STEM for them and their staff. For teachers, the main successes were increased teacher collaboration and more comprehensive assessment practices that are better reflective of student learning.
SECTION J: ISSUES/CHALLENGES IN PLANNING & IMPLEMENTATION OF STEM

Administrators and teachers were asked to discuss issues and challenges experienced in planning and implementing STEM. This section will look at issues and challenges experienced during the planning and implementation of STEM Teaching and Learning including: lack of time, teacher buy-in, lack of financial resources, lack of material resources, computer technology, and student engagement.

Lack of Financial Resources

One of the most commonly cited issues for administrators was lack of money. Administrators stated they had to carefully budget their resources.

“...we never have enough money to do the things we want.”—Administrator

Lack of Time

One of the most commonly cited issues was lack of time. This issue was raised during the Partial Implementation Phase outlined in the first report. The recurrence of this issue demonstrates that it has not been fully addressed.

Lack of Time to Co-plan

Both administrators and teachers thought teachers need more time to co-plan.

“The challenges become many teachers; many grade teams want the planning, right? I start off by saying “You’re going to get a half day each.” For example, the kindergarten team, right from kindergarten, we had the three teachers. But then, I also released the ECEs to co-plan with them. And so, they worked with the librarian, they created their unit. Various grades have had opportunities to co-plan. But that’s just the starting point. And often times, they need more than that half day.”—Administrator

Lack of Time for Knowledge Transfer

Administrators need more time to visit other schools to see how they are implementing the strategy.

“My colleagues, we never find enough time to sit and say what are you doing for STEM? Or hey you know what we’re doing this in Grade 3 have you thought about STEM? No I’m too busy doing the other 50,000 things I do as an administrator. It’s finding time to dialogue with my colleagues and share best stories or best practices which is hard to do.”—Administrator
Lack of Time to Meet Curriculum Expectations

Teachers were not able to balance STEM with other expectations. The challenge was making time to incorporate it in addition to completing the required curriculum with the students.

“All I said I was a little hesitant with HSP because I thought, I am teaching three different grades basically; three or four different grade levels at one time so I was like, “Ughh it is going to be so hard.” And then I only had them for such a short time; I only had them for three periods and then I had to teach them all this curriculum, reading, writing, media and math. In my head I was like, “This is going to take up so much time,” this STEM.”-Teacher

Lack of Time for Training

There was not enough training for teachers to overcome these issues, which they felt can only be solved with time designated for training.

“We’re getting there, like we all know we’re a STEM school and we know what the goals are. But having a full understanding of it, it’s going to take a little more time to get everybody trained and really understanding what to do with it.”-Teacher

Lack of Time in the Timetable

Teachers did not have space in their timetables to collaborate with other teachers. Teachers who taught HSP thought more time in the timetable was needed for these students to work on STEM projects because of their different needs.

“[O]ur time table at our school is hard to manage...because we’re K to 8. But we kind of use an elementary time table model so it’s been hard to. Our admin has tried as much as possible to try at least [to] get myself and the teachers I work [with] time to co-plan but it’s kind of hard.”-Teacher

Lack of STEM Coach

Administrators and teachers advocated for more access to the STEM coach. These STEM coaches were overextended because they were also responsible for other schools.

“Each school doesn’t get enough time with the STEM coach. That’s my biggest criticism...”-Teacher

Lack of Professional Development (PD)

Another issue was finding opportunities for professional learning training for teachers. Some administrators thought there was not enough training for teachers and that much of the PD provided was just a one off. There needs to be meaningful PD that is related to what teachers do on a day-to-day basis. Teachers thought some of these challenges can be solved with progressive PD, where they can work on bettering their skill sets.
“The worst thing is to send a teacher to a day of PD and they walk away with nothing that they want to come back [with] or excited about. It needs to be something that’s meaningful, relevant to what they do on a day-to-day basis.”—Administrator

**Computer Technology Issues**

From a technical standpoint, another issue was difficulties with the computers. For example, teachers had difficulties uploading programs onto computers because of barriers like passwords and firewalls. These types of barriers can act as a deterrent for further engagement. Technology needs to be upgraded to support the STEM initiative.

“We did a lot of hand holding and crying in frustration with loading the programming on the technology where there were so many bloody passwords and firewalls and all this other stuff that our teachers go why am I even wasting my time to load the software to run the robot? Or they get it loaded and then they say oh you need an administrative password so you had to have somebody come in from the Board to load it.”—Administrator

**STEM Integration**

For administrators one challenge was making sure STEM becomes integrated into the school as opposed to being a project based add-on.

“The hardest part for me is … I’ll look … at a unit or the curriculum and be like ‘…I want to do this. How do I make it fit with this?’”—Teacher

**Lack of Comfort**

Teachers do not feel comfortable; they are not adequately versed in STEM. They thought it might be too difficult to incorporate. It takes time to shift teachers’ mindsets. The initiative needs to be implemented in a manageable way. This will ensure the initiative is not overwhelming for teachers. The initiative needs to be focused and well planned in order to be implemented in an organized manner.

“The problem with STEM is…it’s science, technology, engineering and math, as soon as you say that, you automatically have some teachers who don’t feel comfortable in those, in those specific areas. There is a barrier there already to their own professional development, right?”—Teacher

**Union Employees**

Some administrators had difficulties working with union employees. Due to the recent collective action, administrators felt they were not able to introduce new initiatives because it would be perceived as adding to teachers’ workload.
“So people are still looking at how much I am doing. What more am I to do? Before the action it wasn’t that widespread. Don’t get me wrong. I have nothing against the action but this is what it has done. When you go to a teacher, you have got to be so careful because the first thing they say is that you are adding to what they are doing. Some people will find themselves in a place where it is highly unionized and the unions thing is that you are not to be doing all these things.”—Administrator

**Board Restructuring**

The recent Board restructuring for some meant that they would need time to build new relationships. However, they did recognize this also allowed the opportunity to meet new people and learn from them.

“And I think that with the Board being reshuffled again that doesn’t help it either because we’re with a new group of people now that we have to start to build a new relationship with and connections.”—Administrator

**Teacher Buy-in**

It was hard to get some teachers involved with the initiative. They had difficulty connecting STEM to what they were already doing in the classroom. It is interesting to note that despite findings in Report I (Sinay, et al., 2017) whereby over 90% of teachers and administrators doing STEM strongly believed in the value of STEM there remains a discrepancy when it comes to actual implementation.

“I find that the biggest road block is...to get other people [to] buy in...[and]...to see the benefit.... It looks like playing. Or too tech heavy and ... especially for teachers who want to teach through social justice lens, which... which is a big push a lot of teachers want to use. That connection between social justice and STEM is really hard to make for a lot of people.”—Teacher

**Lack of Knowledge**

Some teachers felt both at the school and Board level it was not made clear that STEM is not only about math, technology, and engineering, rather it is about fostering creativity, problem solving, and critical thinking skills. Teachers felt a clearer understanding needs to be outlined. One remedy was to have STEM coaches come into the classroom and co-plan and co-teach to get the teachers comfortable with the initiative, modelling STEM lessons. Teachers need to be made aware of inquiry-based learning and how to implement it. ‘Lunch and Learns’ do not work because teachers do not attend.

“... I’m not judging anyone’s teaching, I’m just saying in terms of understanding how to bring this sort of pedagogy together, tie things together, and to realize it’s not more, it’s less. Like if you have a good understanding of how it works, you realize how much time you save yourself, because you’re double dipping in so many areas. It saves a lot of time and I think, especially
for... you know, there are some of those teachers who are sort of in that in between phase, where they weren’t around for the change from thematic; they came in during the curriculum crunch. Well, all of the sudden this is new language to them, a new idea, new ideology. So I think those are the ones that are having a little more trouble adjusting to it.”-Teacher

**Lack of Material Resources**

Teachers are not able to implement all their ideas because they lack the material resources. This includes robotics kits and computers. Classroom observations corroborated this fact. Many classrooms did not have robotics kits. Classrooms with the kits did not have an adequate amount. Also, equipment was unequally distributed throughout different schools. Classroom observations revealed some classrooms and schools were better equipped than others. These issues were raised during the Partial Implementation Phrase outlined in Report 1 (Sinay, et al., 2017. This illustrates that these concerns have not been adequately addressed.

“The biggest challenge is always the resources. When you start doing STEM, you start thinking of crazy ideas to do and getting the resources to do that.”-Teacher

**Issues with Program Uploads**

Another concern was the practical issue of being unable to upload programs onto the computers without administrator’s permission. Every time a new program was uploaded, permission passwords were required from administrators, all of which took time. A suggestion was made that prior to commencing the initiative all the computers should be updated and all the programs loaded. Since a lot of this initiative is technology based, equipment needs to function. When they do not function there needs to be formal written set of protocols for troubleshooting for teachers.

“And then the other thing too is that if you ever want to install anything on a computer you need an administrative password so to put these programs that you need for coding and what not on these computers, there’s just a lot of things that don’t link up overly well and because of that there’s been some hiccups…”-Teacher

**Lack of Inter-school Coordination**

Schools were working on STEM in isolation from other schools. This did not allow for knowledge transfer or resource sharing. There was a need for more comprehensive guidance. There was a lack of knowledge about how to be connected to appropriate learning resources. A suggestion was made to distribute a comprehensive list of who to call in addition to the STEM coaches for trouble shooting assistance.

“I would love to visit other people that are doing STEM initiatives. And that’s another thing is being able, myself, an opportunity to go visit sites to pick their brains and sit like this and say ok what are you doing for STEM?”-Administrator
Student Engagement

STEM does not engage all students. Some students prefer and thrive better under traditional teaching methods. There are also students with special education needs who are not responsive to this teaching style. Classroom observations revealed that although STEM engaged the majority of students including HSP students, they did not engage all students in the same manner.

“The other issue is that for as much as we get excited about STEM, there are some kids who prefer a rote learning style and that’s been interesting. I have a couple of children in my [special education] class who… I try to get them engaged in it and … a couple of them, they haven’t even done it, they’re just like ‘nope’ it’s a refusal, ‘I don’t want to do it, I want you to tell me…’ There are still other learning styles, so you have to find a way to balance that out. I was kind of shocked by that, I thought everybody’s going to love this, but it’s not always true.” -Teacher

Figure 13: Main Challenges Implementing STEM

Main Challenges

- Lack of STEM coaches
- Lack of Time (to plan, share, train and meet curriculum expectations)
- Teacher Buy-In
- Lack of Materials (robotics kits, support for technology...)
- Student Engagement Issues

Summary: This section looked at issues and challenges experienced during the planning and implementation of STEM teaching and learning which included: more and consistent time with STEM coaches, lack of time for planning and in-class STEM, issues with teacher buy-in due to lack of knowledge, feelings of potentially not completing the required curriculum, lack of financial resources, lack of material resources, computer technology, and student engagement.
SECTION K: IMPACTS

Administrators and teachers were asked to discuss impacts of using STEM. This section looks at the different areas of impact experienced during STEM Teaching and Learning including, student engagement, teacher engagement, and changes in teacher practice.

Student Engagement

Administrators and teachers spoke to the increase in student engagement. Student engagement especially increased among students who traditionally do not respond to conventional learning practices. This was partly due to the investigative approach to learning as opposed to traditional academic approaches.

“The largest impact in my students’ learning has... really been how...engaged they are. I don’t think there’s a single student in my class over the last few years in different cohorts, where they haven’t been fully into it.” - Teacher

Change in Mindset

Teachers noted that there was a shift in students’ ideas about learning. Some students no longer viewed failing as bad. Rather, when they failed, STEM taught them to find a solution to remedy their errors, it is through this process where learning takes place.

“It’s this whole idea like ‘Yeah, yeah. It’s ok to fail.’ because when something goes wrong, that’s when you get to think about how to make it better and that’s where you[‘re] learning comes from...Doing the engineering design and building process through a STEM activity really models the benefit of the failure to the students instead of saying, ‘I can’t do this. I’m terrible at this. I - like I can’t do this.” - Teacher

Collaborative Learning

Students undertook co-student learning and teaching. There was more collaboration among students, even among students who typically had problems working with their peers.

“When you have a class that has...STEM, you have a class that... they collaborate more, they talk more, they are not afraid to share their ideas, because they understand it’s a process. So the kids who are usually quiet and are saying ‘I don’t want to say anything because I don’t want to be wrong or be teased,’ now it just becomes, ‘Well, what about this...this [and]...this?’ The brainstorming, the trying out ideas, I find that that has been one of the biggest positives; it’s just the change in the dynamic of the classroom.” - Teacher
Problem Solving and Critical Thinking Skills
Students were hands-on and STEM helped them with problem solving and critical thinking skills.

“So it’s hands on and it speaks through their learning style. It’s not that academic its more investigative and that sense of innovation I guess everybody really goes [for]. Nothing is right or wrong, but that kind of environment is very conducive to kids feeling good about themselves and being able to express more or participate more willingly or feel good about their learning, you know?”-Administrator

21st Century Learning
According to teachers, the initiative provided students with the skills needed for 21st century employment.

“I can’t say they can do their times tables better, but I think that they’re learning from a character’s perspective like 21st century learning skills, the collaboration perspective, all those things...”-Teacher

Teacher Engagement

Change in Mindset
Administrators saw a shift of perception and integration of STEM among teachers. It created a culture of learning. In some schools, the initiative changed teachers’ mindset about STEM.

“I think that a lot of our teachers have had to change their mind shift and their focus about how they plan.”-Administrator

Integration of STEM
Some teachers integrated STEM into their daily teaching practices in the process of changing their teaching practices. Teachers planned long-term projects as opposed to single units that are often unrelated.

“I think the key was really a shift from just creating units and projects to everyday learning. And I think that’s the key and that’s my learning at least for me...that they’re actually doing STEM on an ongoing basis.”-Administrator

Collaborative Learning
Teachers also learned from students. This demonstrated a change in teaching and learning practices.

“I was walking around and going “That’s amazing!” “How did you do that?” They were teaching me. And so that’s changed because I used to feel like I was the expert, and I’m not anymore, which is a good thing.”-Teacher
**Inquiry-based Learning**
Teachers were changing their teaching practices to incorporate inquiry-based learning.

“Like I said, I am more conscious and... trying to be more... base it on inquiry-based learning, problem solving, especially, not even just teaching the skill but just teaching the kids that they are able to problem solve.” - Teacher

**Transdisciplinary Focus**
Teachers also cited that the initiative changed their teaching practices to a more transdisciplinary model. For example, teachers spoke of how they changed teaching math from strand specific teaching to a transdisciplinary focus. A transdisciplinary model was used among many teachers during classroom observations. The initiative also changed the way teachers planned. They now focused on long term projects as opposed to smaller separate units that are unrelated.

“I’ve moved away from strand specific teaching of math and teach my math as all kind of strands in one now... So it’s definitely change[d] the way I see my own instruction.” - Teacher

**Change in Assessment Process**
The assessment process for teachers shifted from traditional pencil and paper approach of looking at the final results to evaluating the entire learning process.

“My assessment has been up so much more on process, on what I observe, and the dialogue and the conversation. I mean, it’s not... the paper-pencil, my kids I know are not going to do well. So when I have the opportunity to observe them in this and talking about it and just taking my notes, I’ve learned so much more about my kids through this. So it’s been a nice direction.” - Teacher

**Learning New Technologies**
As a result of STEM, teachers were more willing to continue to learn new technologies and incorporate it into their classrooms.

“I think I’m going to keep pushing myself in terms of learning different technologies that I can bring to the table, because I think that the kids get excited when they see something new.” - Teacher
**Summary:** This section looked at different areas of impact experienced during STEM Teaching and Learning. One area that teachers and administrators report positive impact is among student engagement, especially with students who traditionally do not respond to conventional learning practices. Other impacts include a growth mindset among students, more problem-solving, critical thinking and collaboration. Among teachers, STEM Teaching and Learning has had an impact on integrating STEM into daily practice, incorporating more inquiry-based learning, creating a more transdisciplinary focus in teaching and changes in assessment to be more reflective of student learning.
SECTION L: EQUITY AND STEM EDUCATION

Administrators and teachers were asked to discuss perceived benefits of using STEM with different types of learners, in particular students with special education needs or students in the Home School Program (HSP). This section will look at issues of equity in STEM education, including: 1) leveling the playing field for students with special education needs and students in the Home School Program, 2) differentiated learning, 3) assistive technology for students with special education needs and students in the Home School Program, 4) destigmatizing learners, 5) leveling the playing field for English Language Learners (ELL), 6) minimizing gender barriers, and 7) socio-economic equalizers.

Leveling the Playing field for Students with Special Education Needs (SEN) and Students in the Home School Program (HSP)

Teachers and administrators saw STEM as an equalizer. STEM engaged students who typically do not learn well under conventional learning methods. This was particularly true for students in the HSP and students with special education needs. STEM connected with different learning styles. STEM was not only test-based but rather learning through discussion. Teachers thought that through STEM, students could work on problems from their abilities standpoint.

“Because they are not being put on the spot. It’s not, ‘Here’s a test. Answer the questions.’ You know? Its discussion...it’s an area where maybe they can shine more because they can have input, because they can connect something and make connections and talk in a very natural, authentic way. It’s not set up as a test... from that perspective. Also big ideas, you know... they can come at any point. They can come in depending on their abilities.”-Administrator

Differentiated Learning

STEM allowed students regardless of skill level in the HSP class to work on the same project. STEM allowed for adjusting course content according to students’ skill level or for engaging in different ways.

“And the other aspect is I can take a project like boat building and easily differentiate that across grade levels from Kindergarten to grade 8...by making it more complex...I’ll give the example with just the boat building and measurement. So they have to build a boat, design and build a boat. Kids at the grade 4 level HSP math, they build their boats using...rectangular shapes. If they’re grade 5 and 6 level, they get into... building shapes with triangles, triangular shapes. Grade 7, they start doing trapezoids, which follows, those expectations in the curriculum. They’re all doing the same task, but the parameters around that task are differentiated depending on what their skill level [is].”-Teacher
Assistive Technology for Students with Special Education Needs and Students in the Home School Program

STEM introduced technologies into the classroom that assisted students with special education needs and students in the Home School Program with their learning process.

“The thing with STEM, there’s an assistive technology piece with STEM and the technology lends itself to help support our kids with learning strategies that can help make them successful.”- Administrator

Destigmatizing Learners

STEM helped destigmatize SEN and HSP learners. When other students saw these students engage in STEM activities they wanted to join. This increased the confidence of students who learn differently.

“My whole HSP program changed because of STEM. It’s just … I feel that it’s a lot more successful. It’s a successful program in destigmatizing our HSP program as well. I have kids coming up to me now from the regular classes saying “Can I be in your class? I want to do what you’re doing. Can I be in HSP?”-Teacher

Leveling the Playing Field for ELLs

STEM engaged ELL students more effectively because they did not face the same language barriers due to the hands-on nature of the learning compared to typical learning methods.

“I see it also with my ELL kids. They’re new to the country and they come in. Language may be a barrier sometimes, but tools are universal. And so it’s really been an opportunity over the past few years [where] I’ve seen some kids really shine. Otherwise, they’re actively seeking out the shadows, you know, to sort of hide and digest because they’ve only been with us for a few weeks or months. But all of a sudden almost when we’re in the shop, it’s a very level playing field and they excel, which is really nice.”-Teacher

Minimizing Gender Barriers

STEM was seen as minimizing gender barriers. Since the projects were not overtly math or science, female students did not shy away. In addition, male students did not automatically have more confidence on the subject matter. Everyone was seen as being on the same level. However, in some cases when male and female students worked in pairs on the computer, male students tended to dominate computer time. Some teachers actively tried to remedy these occurrences.

“One thing in Grade 1, Kindergarten is the same, the equity, the gender equity that’s there because...girls and the boys don’t think, ‘I’m going to do this because it’s math oriented, it’s science oriented.’ They’re both in it at the same time and some people are stronger. Some
people are weaker, but they’re working together, and nobody is saying “I’m better at math, I’m good at math or I’m not good at math”, which you kind of get that perception, self-perception, grows as the kids get older. It’s just not there, when you’re doing these STEM projects. Everybody’s equal.”-Teacher

**Socio-economic Equalizer**

Economically, STEM was also seen as an equalizer. It allowed students from low economic backgrounds access to technology that they might not have at home.

“...I think our kids through the STEM initiative have more opportunities to dabble with technology then some of the schools I’ve visited that are in well-to-do areas. They have very little technology to work with.”-Administrator

**Summary:** This section looked at issues of equity in STEM education. STEM was seen as an equalizer in many regards by teachers and administrators. The use of STEM allowed for engaging students who might not fare well under conventional learning methods. This was especially true for students in the HSP, students with special education needs, ELLs, and students from low economic backgrounds to succeed. It also allowed for differentiated learning, hands-on learning, and access to technology. Additionally, STEM also helped destigmatize SEN and HSP learners. When other students saw these students engage in STEM activities, they wanted to join, reducing social and learning distance.
SECTION M: RECOMMENDATIONS FOR SCALING UP STEM WITHIN THE SCHOOL AND THE SYSTEM

Administrators and teachers were asked to make recommendations that would aid in the scaling up of STEM within the school and at the system-wide level. Questions focused on included: 1) recommendations for the coaching model, 2) support for teaching STEM, technology integration, and professional learning. The recommendations reported in this section include: 1) recommendations for the Coaching Model, 2) recommendations for teacher engagement, 3) recommendations for professional learning, 4) recommendations for resources and technology, and 5) recommendations for the Board.

Recommendations for Coaching Model

Access to STEM coaches
Administrators recommended having more STEM coaches available. The most common recommendation among teachers was the need for more time with STEM coaches. STEM coaches need to be at the school or the school needs a teacher who can take on the STEM coach role.

“If you have a [STEM] coach, and you say you are now the [STEM] coach of 50 schools, you’re giv[en] a little bit of nothing…. If you really want change, you have to make it so that the [STEM] coach is at least in a school half day per week on a regular basis.”-Administrator

Consistent Access to the STEM Coach
Consistency of STEM coaches at a school was important.

“So, it would be nice to have more consistent access to a [STEM] coach. “-Teacher

STEM Coaches Need to Help Co-teach and Co-plan
STEM coaches need to help set up the program, co-teach, and co-plan with the teachers. They need to help integrate STEM into the curriculum, day-to-day practices, specifically into the literacy and social justice components. Some teachers preferred having STEM coaches co-teach in the classroom versus attending workshops because they preferred not leaving their classrooms. STEM coaches should co-teach in the classes so they can provide classroom specific STEM coaching which is not possible in workshops. Having STEM coaches come to the classroom and model STEM practices will get more teachers involved.

“I think if you want people to buy into STEM particularly, you need [STEM] coaches who are not just a STEM coach, but someone who really knows how to integrate STEM into everything else. Specifically the literacy and social justice piece because that’s…where I see a lot of the... diverges between the STEM and all of that.”-Teacher
STEM Coaches Need to be versed in the Special Education Needs Curriculum

Administrators recommended having STEM coaches with knowledge working with students with special education needs.

“And, I really think every [STEM] coach should also have a very strong understanding in special [education] because that’s where the piece is lacking.” - Administrator

Recommendations for Teacher Engagement

Resource Sharing Networks

Administrators believed STEM can be scaled up if there is a sharing of information. Teachers also recommended a space for sharing information and collaborative learning. They recommended sharing materials through an online resource center.

“I wasn’t thinking of just one particular person, I was more or less thinking of like a hub. If this is going to be a centre of STEM, then there should be some given things that people sit down and... (pause) you [have to] know what your destination is before you get...on the train. So you’re going to have to be able to sit down with people who...whether these are consultants or coordinators.... It all comes... there’s a curriculum right. We need to look at this and create a pathway for getting us there.” - Administrator

Teachers Need to Feel Comfortable with STEM

If introduced slowly and in small increments, teachers will be more comfortable with STEM. Administrators thought it was pivotal to encourage teacher buy-in. There is a need for a bottom-up approach. If teachers are not enthusiastic about the initiative, it will be difficult to implement. Engagement can only be built if teachers receive the required support. Administrators felt the strategy should be introduced progressively. It is important to start small and with teachers who are eager and then expand. It should be manageable for teachers and teacher buy-in is needed to sustain the initiative.

“If you’re saying to staff that you will or must do this, you may have, it may work, but I can tell you that you will not sustain it because it will be short term. The only reason staff will do this is because you’re telling them, not because they want to do it. If you want to sustain change and see long term benefit, then it has to be bottom-up with support from the top.” - Administrator

STEM Needs to be Integrated into Day-to-day Planning

Growth is possible with proper expertise. STEM needs to be woven into the day-to-day planning. If viewed as an add-on, teachers will not prioritize STEM.
Time for Planning
Administrators and teachers recommended ensuring time is given for long-term advanced planning. The second most commonly cited recommendation was the need for release time to collaborate with other teachers and make connections to other grades. Teachers need to develop curriculum together. They need time to learn. Planning is important for successful implementation of the program. Teachers stated that they needed time support from administrators.

“...It’s kind of ironic that we got all this collaboration that we’re trying to do with the kids. We need more [time and] collaboration.”-Teacher

STEM Teacher Lead
Every school should have a teacher who is a STEM lead who can provide support for other teachers.

“Like one of the things I proposed to the principal for next year is because we’re losing our STEM coach, I would like to make sure that we keep it going, I would like to...for example, take on, in the morning, sort of...the role of like...help[ing] to facilitate...STEM, like work with teachers to help develop curriculum and I think that’s the hardest part -... need[ing] to get that curriculum developed and it takes [time]...it’s not something that you can do on the spot. You need to start in June, start preparing, so that when you get going into the year, it’s ready to roll. But in order for it to be a good program, two heads are better than one, and I think that’s one of the things also that sometimes you lack, having that time to work together as teachers.... But in terms of what I need, I think I’m pretty good. What I want mostly is at the school level, in terms of what can we do to, you know, time to work together, time to plan together, that’s the most precious thing.”-Teacher

Collaboration with Family of Schools
Recommendations were made for working more collaboratively with others within the Family of Schools to see how other schools were integrating STEM. This would allow for developing best practices.

“I think they need more exposure. Opportunities to work with others maybe within the family of schools, to go places and see what they are doing versus what other people are doing because that is how you build schema about your craft and what you do.”-Administrator
Recommendations for the Board

Clear STEM Vision
If STEM is to be scaled up, the Board needs to have a clear vision that is adequately translated to staff. There needs to be a coherent goal and pathway to this goal outlined.

Program Evaluation
The Board needs to use monitoring and evaluation results for sustainability and scaling up.

“I think accountability is huge...I think...you coming in and asking what’s going on, that’s important for the department to really get a sense of ... what are schools doing and how can we use that information to share with others schools.”-Administrator

Recommendations for Professional Learning

Professional Learning Communities for Teachers
For teachers, scaling up can be accomplished through learning communities where they can share their experiences. Teachers need opportunities to collaborate with other teachers and their family of schools. They need opportunities to visit other schools to see how STEM is modelled.

“I think...[the] community thing will work, the Professional Learning Community, getting us to talk with each other, maybe even presenting during staff meetings.”-Teacher

Meaningful Ongoing Professional Development
Another recommendation was meaningful professional development. An ongoing professional development model would allow teachers to consolidate knowledge for professional growth. For example, learn one day, then have a month to put into practice what they learned, then return to discuss and share what they would do differently, and then return and implement the changes.

Professional Learning and Technology
Along with the technology, professional development (PD) should be provided to ensure resources are used in the most optimal manner. More PD will give teachers confidence to engage with STEM principles.

“I think in the end, we do need the PD that goes along with that cart to use it to a 100% of its capacity. I don’t want to start taking things for the sake of taking. It has to be meaningful and explicit. Yeah...I don’t want it to be exploring, but there needs to be a purpose for it.”-Teacher
Professional Development for Administrators

Administrators advocated for more PD for them to learn how they can integrate STEM into schools.

“I think...more PD for administrators...would really help...a lot of administrators may require a better understanding behind the pedagogy and then how to integrate [STEM] into their school.”-Administrator

Partner School Model

Administrators recommended adopting a partner school model whereby schools that have integrated STEM can be a model for a school that has not integrated STEM.

“I just went to another school...to see that too. I was blown away and it wasn’t a STEM school. It was great to see them kind of really incorporate that piece. I think it’s fantastic. That’s when I know words getting out [about STEM]. I know that teaching and learning is doing a great job. I think the plan in place is fantastic. I think how do we continue now that we’ve got a lot of schools on board? What about ...other schools that want to be on board...but is kind of like timid. And so, maybe partnering up just like a student. I was meeting with a family...waiting for me outside and one of the first things I said to them, ‘Don’t worry we’re going to have a partner... We’re going to have a buddy...Like having a bud.’”-Administrator

Continued Teacher Assessment

Teachers also recommended continued workshops that progressively assess teachers’ Professional Learning.

Recommendations for Resources and Technology

Need for More Technology

Administrators cited the need for more financial resources. Technology in schools needs to be upgraded in order for STEM to be smoothly implemented. Teachers also recommended more equipment so students can work in smaller groups which will allow them to be more focused.

“When the system bogs down and my teachers are doing some neat stuff with technology with their kids and it doesn’t work, what happens is we lose interest. We get frustrated and we don’t want to do it again and the kids lose interest and [become] frustrate[ed]. But when it does work, guess what? It’s a great thing [because] our kids suddenly want more.”-Administrator

Need for Grade Appropriate Material Resources

Teachers advocated for appropriate grade level material. Full day Kindergarten teachers felt left out of the initiative and want Kindergarten targeted STEM training.
“When I looked at it (the STEM cart) first, there were saws, and... I brought in tools when we had a community helper unit where we brought in real tools. But, I think for a lot of it, you want to be as open as possible with the kids. I didn’t know how to go about it with that for the Kindergarten kids...if the materials were catered more at a Kindergarten level, maybe you wouldn’t have felt as overwhelmed.” – Teacher

**Need for More Staff**
More staff needed to incorporate STEM into the Special Education Needs curriculum.

“Unfortunately, we are short staffed here but having two adults for sure because I think they are needier because of language skills and reading, even reading the codes and things like that and reading the instructions...” – Teacher

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**Figure 16: Recommendations for Scaling Up STEM**

Recommendations for Scaling up STEM

- **Coaching Model**
  - Consistent access to coaches
  - More time with coaches
  - Help with co-planning/ co-teaching

- **Board**
  - Clear vision of STEM
  - Continued evaluation of STEM program

- **Professional Learning**
  - Ongoing and meaningful professional development that progressively teach new concepts

- **Resources & Technology**
  - Technology in schools need to be upgraded
  - Ensure enough technology for initiative
**Summary:** This section focused on recommendations for scaling up STEM within the school and the system. The most commonly cited recommendation among teachers was the need for more consistent time with knowledgeable STEM coaches who can help co-teach and co-plan especially with students with special education needs. Teachers and administrators would like to see a scaling up of sharing information, perhaps through an online resource center, a lead teacher, or through co-planning. For the Board, teachers and administrators would like to see a clearer vision of STEM with details on how to achieve the goals and accountability to ensure goals are being met. Teachers would also like meaningful and ongoing professional development that progressively teach new concepts. Another ongoing recommendation was that technology in schools needs to be upgraded and ensuring there is enough technology so the initiative can be smoothly implemented.
SECTION N: ACHIEVEMENT AND ENGAGEMENT FINDINGS

This section details achievement and engagement findings based on learning skills reported in students’ report cards. Learning skills and work habits are evaluated by teachers in Report Cards based on teachers’ professional judgement throughout the year. Student cohorts engaged in STEM pedagogy over time derived from information provided by the STEM Coaches. Following are the findings on the Student Learning skills and work habits.

Learning Skills and Work Habits

**Overall** – A longer period of STEM implementation led to higher levels in elementary school learning skills. Specifically, in all cases, 2 years of involvement in STEM consistently led to the highest results. Although the improvement is not vast, a higher proportion of students in STEM schools developed stronger learning skills than compared to students in non-STEM schools and the overall student population at the TDSB. Results were statistically significant (p<0.05) across all learning skills and work habits. Overall, results were most pronounced in: Responsibility, Organization, and Self-Regulation.

**Responsibility** – Seventy-five percent (75%) of the overall TDSB elementary school students received Excellent or Good for the area of “responsibility”. Seventy-five percent (75%) of non-STEM students at STEM schools also received Excellent or Good, and a slightly higher (78%) of STEM students received Excellent or Good. In schools where students engaged STEM pedagogy for two years, a higher proportion (85%) of students received a rating of Excellent or Good.

**Organization** – Similarly, when it comes to “organization” skill, 74% of TDSB elementary school students overall and non-STEM students at STEM schools received Excellent or Good. STEM students were slightly more likely (76%) to receive Excellent or Good. In schools where students engaged in STEM pedagogy for two years, the proportion of students receiving Excellent or Good increased to 85%.

**Independent Work** – Seventy-two percent (72%) of the overall TDSB elementary school students and non-STEM students in STEM schools received Excellent or Good on “independent work” skill. In comparison, STEM students were slightly more likely (73%) to receive Excellent or Good. In schools where students engaged in STEM pedagogy for two years, this number increased to 77%.

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5 EQAO Standardized test results were not used due to low numbers as well as unavailability of the EQAO data in the 2014-15 school year due to labour disruptions.
Collaboration – Eighty-two percent (82%) of the overall TDSB elementary school students received Excellent or Good on “collaboration” skill. Similarly, 83% of STEM and non-STEM students in STEM schools received Excellent or Good, while 86% of students in schools in their second year engaging in the STEM pedagogy received Excellent or Good.

Initiative – Seventy-five percent (75%) of the overall TDSB elementary school students and non-STEM students at STEM schools received Excellent or Good in “initiative” skill. A slightly higher proportion (76%) of STEM students received Excellent or Good, while 81% of students from schools in their second year engaging in the STEM pedagogy received this rating of Excellent or Good.

Self-Regulation – Seventy-one percent (71%) of the overall TDSB elementary school students and non-STEM students at STEM schools received a rating of Excellent or Good on “self-regulation” skill. A slightly higher proportion (74%) of STEM students were more likely to receive Excellent or Good. In schools where students engaged in STEM pedagogy for two years, 83% received Excellent or Good.
Figure 17: Learning Skills - Elementary

*Significant differences (p<0.05) were found across STEM status groups in our two year cohort study.
Subject Achievement

**Overall** – Similar to improvement in learning skills previously discussed, the amount of time students spend within a STEM program has a positive association with report card achievement across all subject areas. In general, students in schools that were not engaged in STEM pedagogy had the lower elementary school report card achievement with the fewest proportion of students achieving Level 3 or 4 across subject areas. Results were significant (p<0.05) in reading, mathematics, and science.

**Reading** – Seventy-four percent (74%) of the overall TDSB elementary school student population achieved Level 3 or 4 in reading and a similar 72% of non-STEM students in STEM schools received Level 3 or 4. In comparison, STEM students fared better with 76% receiving Level 3 or 4. In addition, a higher proportion of students in schools where students engaged in the STEM pedagogy for two years achieved Level 3 or 4 in their reading (85%).

**Writing** – Sixty-seven percent (67%) of the overall TDSB elementary school student population achieved Level 3 or 4 in writing. Sixty-six percent (66%) of non-STEM students in STEM schools received Level 3 or 4. Similar to reading achievement, a higher proportion (71%) of STEM students and a slightly higher proportion of students (72%) in schools where students engaged in the STEM pedagogy for two years achieved Level 3 or 4 in writing.

**Overall Mathematics** – Seventy-seven percent (77%) of the overall TDSB elementary school student population and non-STEM students in STEM schools achieved Level 3 or 4 in overall mathematics. This same high level of scores was achieved by a slightly higher proportion (80%) of STEM students and 83% of students in schools where students engaged in the STEM pedagogy for two years.

**Science** – Seventy-nine percent (79%) of the overall TDSB elementary school student population achieved Level 3 or 4 in science. A slightly lower proportion (77%) of non-STEM students in STEM schools achieved either Level 3 or 4. In contrast, 80% of STEM students and 84% of students in schools where students engaged in the STEM pedagogy for two years achieved Level 3 or 4 in science.
Summary: This section detailed achievement and engagement findings on learning skills reported in report cards. Overall, a higher proportion of students who have had continued participation in STEM demonstrated greater scholastic achievement and engagement. Furthermore, in schools where STEM is in its second year of implementation, students demonstrated an increase in learning skills (responsibility, organization, collaboration, and self-regulation), while also having increased scores in reading, mathematics, and science.
SECTION O: CONCLUSION AND RECOMMENDATIONS

In Year 2, the STEM strategy allowed us to learn more about the second year of implementation of the TDSB STEM strategy, including factors which hindered its implementation. The following is a summary of the conclusions and recommendations along with a summary of what we can learn.

What can we learn from the second year of implementation of the TDSB STEM strategy, including the factors that hinder its implementation?

Overall, the findings demonstrate that the STEM strategy is making important gains with administrators, teachers, and students. Most educators feel strongly that STEM is a very important way to prepare our students for 21st century living and a positive means to help prepare students with the skills and competencies they need. Most educators felt STEM has improved student engagement and enthusiasm for learning. STEM was seen as an equalizer in many regards by teachers. The use of STEM allowed for engaging students who might not fare well under conventional learning methods, as it allowed for differentiated learning, hands-on learning, and access to technology.

The STEM strategy has also had impactful changes for teachers including increased teacher collaboration and better teaching practices that are more reflective of students’ learning. For administrators, the STEM strategy has helped improve inter-school collaboration and professional growth.

Nonetheless, even with such important gains, there have been some factors that have hindered the STEM strategy including overextended STEM coaches, lack of time for preparation, issues with teacher buy-in, lack of financial resources, lack of material resources, technology issues and student engagement issues.
Following is a summary of the results from the second year of implementation:

1. **Do pilot STEM lead schools have the resources, professional learning, and support they need to deliver STEM programming?**

The results show STEM pilot schools received a variety of resources, professional learning and support to deliver STEM programming; however, educators would like to see more consistent and equal opportunities across schools.

Educators reported receiving support through funding, technology, training, release time, and STEM coaches. However, some of the STEM coaches were seen as overextended. As such, some educators report not receiving consistent time with equally knowledgeable STEM coaches. Administrators and teachers both report not receiving any real support from STEM digital lead learners.

Educators would also like more funding to better support STEM initiatives. As part of this, educators report a call to action for technology for their teaching. In some cases, educators reported having outdated technology or insufficient technology. Additionally, there was a call for ongoing point of care technology support for teachers.
2. **What are teachers’ and administrators’ perceptions of STEM education? How do they perceive the viability and relevance of STEM education?**

Teachers and administrators were asked about their perceptions of STEM education. Overwhelmingly, educators feel strongly that STEM is a **very important** way to prepare our students for 21st century living by enhancing the skills and competencies they need.

STEM is viewed as a strategy that is embedded in instruction and learning which enriches students’ experiences because it is a **hands-on way of learning**, and allows for cross-curricular teaching, creativity, problem-solving, collaboration, and changes in pedagogy.

It is important to note that educator understanding of STEM is on a **continuum** where some teachers have a better understanding of STEM than others.

Educators were also asked if they would like STEM continued as STEM (Science, Technology, Engineering and Mathematics Education) or STEAM (Science, Technology, Engineering, Arts and Mathematics education), and many felt that it was important for STEM education to be revised to incorporate the Arts and be incorporated into the curriculum as **STEAM**.
3. **What STEM skills and competencies have students developed through their involvement in the STEM program?**

Educators report students developing a variety of skills and competencies through their involvement in the STEM program. Educators report changes towards *growth mindset* among students, more problem-solving, critical thinking, and collaboration.

Another area that teachers and administrators report a positive impact is in student *engagement*, especially with students who traditionally do not respond to conventional learning practices.

Additionally, students who have had continued participation in STEM have showed increases in *achievement and engagement* reported in report cards. In schools where STEM is in its second-year, students demonstrated an increase in learning skills (responsibility, organization, collaboration, and self-regulation) and increased scores in *reading*, *mathematics*, and *science*. 
4. What can we learn from the second year of implementation of the TDSB STEM strategy, including factors that hinder its implementation? What are the recommendations for moving forward with the implementation strategy?

Overall, there are many lessons that can be learned from the second year of the TDSB STEM strategy. The main lessons gained from the STEM initiative are:

**LESSON 1:** Students have been reported to have increased engagement and enthusiasm for learning through STEM.

**LESSON 2:** Educators are receiving a variety of supports to help with the implementation of STEM.

**LESSON 3:** Educators teaching practices have become more student-centered and reflective of students’ learning needs through the STEM initiative.

**LESSON 4:** Administrators have grown professionally and created professional learning networks for STEM.

**LESSON 5:** Students who have continued participation in STEM have showed greater achievement in reading, mathematics, science, and learning skills as demonstrated in report cards.
The main challenges that are hindering implementation include:

- **Insufficient STEM coaches**: STEM coaches are seen as overextended, as not equally knowledgeable.
- **Lack of time**: to co-plan, for knowledge transfer, to meet curriculum expectation and for training.
- **Teacher buy-in**: difficulty for some teachers to change their practices and connect STEM to what they are doing every day in their classroom.
- **Lack of financial resources**: money for technology, support, release-time, and co-planning time.
- **Lack of material resources**: lack of robotics kits, insufficient or out-of-date technology.
- **Technology Issues**: computer technology issues, such as firewalls, and installation problems.
- **Student Engagement Issues**: teachers report not all students are engaging with STEM.
For moving forward, following are a few recommendations:

- **Recommendation 1:**
  - Need for more **consistent time with knowledgeable STEM coaches** who can help co-teach and co-plan especially with students with special education needs.

- **Recommendation 2:**
  - **Technology** in schools needs to be upgraded and ensure there is enough technology so the initiative can be smoothly implemented.

- **Recommendation 3:**
  - Scaling up of **sharing information**, perhaps through an online resource centre, a lead teacher, or through co-planning.

- **Recommendation 4:**
  - Educators would like to see a **clearer vision of STEM** with details on how to carry out the goals and accountability to ensure goals are met.

- **Recommendation 5:**
  - Teachers would like meaningful and **ongoing professional development** that progressively teach new concepts.
As discussed in this report, the STEM Innovation Project has made tangible gains in teaching and learning. Both students and teachers are emboldened and invigorated by the approach and it helped to provide avenues for students of all academic abilities to connect with their classmates, their school and most importantly, their own learning.

With additional opportunities for professional development, more teachers can be brought into the pedagogical approach and STEM can expand to more classrooms and schools. STEM has been shown to scale up best when it is the teachers leading the charge themselves. With that said, when administrators give release time and provide the resources required for STEM related professional learning communities and teacher co-learning and teaching, STEM has been shown to grow within their schools.

Students who take part in STEM show higher academic achievement. Not only are students enjoying higher report card achievement, and learning skills they are also having fun. In the midst of enjoying their learning process they are becoming more and more engaged doing STEM and across other subject areas additionally. As denoted within these interviews, and across other STEM research report series such as in robotics and coding⁷, STEM helps to develop students’ global competencies in creativity, collaboration and problem solving while engaging them in the deep learning process that is crucial in improving students’ as lifelong learners.

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⁷ Global Competencies and Deeper Learning with Digital Technologies Research Series are in press and can be retrieved from: http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx