FOSTERING GLOBAL COMPETENCIES AND DEEPER LEARNING WITH DIGITAL TECHNOLOGIES

RESEARCH SERIES:

COMPELLING RESEARCH FINDINGS
Conference Presentations

• AERA: American Educational Research Association - Austin, Texas, 2017
• EARLI: European Association for Research on Learning and Instruction - Tampere, Finland, 2017
• CSSE: Canadian Society for the Study of Education, Toronto, Canada, 2017
• Ministry of Education: 21st Century Teaching and Learning Roundtable, Toronto, 2017

Erhan Sinay | Research Coordinator
Research & Information Services
Toronto District School Board
STEAM (Sciences, Technology, Engineering, Arts, Mathematics) Mission
To introduce STEAM – a trans-disciplinary approach to inquiry and problem-based learning – across the TDSB to foster collaboration, creativity and innovation to prepare students to participate in a rapidly changing, technological and interconnected world.

TDSB’s STEAM Vision
- Providing STEAM education for all students.
- Moving away from teaching subjects in silos and linking real world issues to classroom teaching and learning.
- Promoting problem-based learning and STEAM skills to allow students to stay current, explore, inquire and actively engage in relevant issues of the world around them.
- Encouraging scientific discovery and technological innovation to shape how future citizens work collaboratively to provide creative and viable solutions to today’s and tomorrow’s real-life problems.

TDSB’s Commitments

<table>
<thead>
<tr>
<th>Investing in STEAM Instructional Leadership</th>
<th>Providing Purposeful and Targeted STEAM Resources</th>
<th>Supporting Student Choice</th>
<th>Building Strong and Effective Community Partnerships</th>
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</thead>
<tbody>
<tr>
<td>• Collaborate among different disciplines to deliver relevant STEAM programming</td>
<td>• Provide STEAM resources to facilitate planning, development and implementation of STEAM programming</td>
<td>• Encourage opportunities for students to collaborate, innovate and create</td>
<td>• Build STEAM-related connections with post-secondary institutions</td>
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<td>• Creating a community of learners, including the school Principal</td>
<td>• Provide targeted professional learning supports</td>
<td>• Engage students through relevant and contextualized problem-based learning</td>
<td>• Offer career exploration in STEAM related fields with mentorship and co-op opportunities with business and community partners</td>
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<td>• Building capacity by investing in teacher leaders at the school and system levels</td>
<td>• Create STEAM inquiry cards to align connections with various disciplines</td>
<td>• Support use of technology and engineering design for students to build prototypes of solutions</td>
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Fostering Global Competencies and Deep Learning Through STEM Education and High-Quality, Effective Professional Learning


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"I’ve moved away from strand specific teaching of math and teach my math as all kinds of strands in one now... So it’s definitely changed the way I see my own instruction.” - TDSB Teacher*

Levels of STEM Integration

- **Disciplinary**: Students learn concepts and skills separately in each discipline.
- **Multidisciplinary**: Students learn concepts and skills separately in each discipline but in reference to a common theme.
- **Interdisciplinary**: Students learn concepts and skills from two or more disciplines that are tightly linked to deepen knowledge and skills.
- **Trans-disciplinary**: By undertaking real world problems or projects, students apply knowledge and skills from two or more disciplines and help to shape the learning experience.

*For more details please see full reports in: Technology and Innovation Research in TDSB: http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx

Heuristic Research Framework in Relation to TDSB K-12 STEM Strategy Program Implementation

Key Research Questions

Phase I
STEM Theoretical Foundation

STEM education attributes
High-Quality professional learning
Review of STEM implementation & teaching and learning practices
Educators’ & students’ attitudes, beliefs, opinions, knowledge, practices and self-efficacy
Teachers’ and students’ development of STEM skills and practices

Phase II
Going Deeper
Research Evidence: Informing Second Year Implementation
Change in Teacher practice and Engagement
Focus on Teaching and Learning with Robotics and Coding
Improvement in Student Engagement, belonging, global competencies and academic outcomes

Phase III
Scaling Up
Research Evidence: Informing Third Year Implementation
Revising STEM goals and action plans
Deepening teaching and learning with technology
STEM Pedagogy focusing on early years, global competencies, numeracy, equity and inclusive learning

Research to drive action
System-wide feedback loop and modification

TDSB K-12 STEM Strategy Process Map

2014-2015
2015-2016
2016-2017

Longitudinal mixed method, pre- and post-randomized control group research designs with peer review opportunities
Quantitative & Qualitative Data Gathering
Surveys, classroom observations, interviews, classroom visits, document analysis
Data Analysis & formation of interrelated themes
Rearrangement of themes & comparison of emergent theory with existing theory

Change in Teacher practice and Engagement
Improve Student Engagement, belonging, global competencies and academic outcomes

Improvement in Student Engagement, belonging, global competencies and academic outcomes

An Exploratory Study of Differential Effects of Coaching on System-Wide STEM Implementation
Teaching and Learning with Coding: Differentiated Effects on Teachers’ Technological Pedagogical Content Knowledge (TPACK) and Students’ Learning Outcomes
Educational Coherence: Learning from System-Wide STEM Implementation

Fostering Global Competencies and Deep Learning through Integration of Robotics and Technology into the Classroom

TDSB Digital Lead Learners as System-Wide Change Agents Promoting Global Competencies and Deep Learning Across the Board

Fostering Deeper Learning and Global Competencies through STEM Pedagogy in the TDSB

For more details please see full reports in: Technology and Innovation Research in TDSB:
http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx

Source: Sinay, et al., 2016, p. 81
During 2015-2016 and 2016-17, the Toronto District School Board (TDSB) continued its work in STEM implementation in selected TDSB schools.

**Length of Implementation**
Most schools have had the STEM program in place for one year.

**Understanding of STEM**
STEM learning is on a continuum. There is a range of understanding of STEM.

**Involvement in STEM**
Involvement in STEM.

**Educator Collaboration**
Interviews with Lead Teachers

**Personal Interest**
Interviews with Administrators

**STEM Coach**
Interviews with STEM Coaches

**Volunteers**
Classroom Visits

**STEM Pilot Schools/Centres**

**Lessons Learned**
- Funding
- Technology
- Resources
- Release Time
- STEM Teachers
- Knowledge transfer (co-teach/plan)

**Needed**
- More & New Technology
- Inquiry-based learning PD
- More co-teaching
- More co-learning

**Supports Provided**
- Additional Supports
- Funding
- More co-teaching
- Inquiry-based learning PD
- More co-learning
Overall, the results show the STEM strategy is making important gains with administrators, teachers, and students. Most educators viewed STEM as a very important way to prepare our students for 21st century living, and improve student engagement and enthusiasm. Using the recommendations for moving forward, hopefully the STEM Innovation Project will continue to make great gains in the future.

Key Findings
For the Second Year of Implementation of the STEM Innovation Project

**Educators**
- Teaching more reflective of students’ needs
- More collaboration

**Administrators**
- Improved inter-school collaboration
- Professional growth

**Students**
- Increased engagement
- Increased enthusiasm
- Improved achievement in learning skills, math, science and reading

21st century global competencies
- Resources
- Achievement: scaling up
- STEM coaches
- Second Year of Implementation
- Training
- Engagement
- Supports
- Equity and STEM
- perceptions of STEM
- Professional learning
- Administrator collaboration

These research series are in progress and key findings will be published on the TDSB Research website. For more details please see full report in Technology an Innovation Research in TDSB: http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx

Increased Achievement in:
- Reading
- Math
- Science

**Lessons Learned**
- Consistent access to coaches
- More time with coaches
- Ongoing progressive professional development
- Clearer vision of STEM
- Continued evaluation of STEM
- Upgrade technology
- Ensure sufficient technology

**Challenges**
- Lack of STEM coaches
- Lack of time
- Teacher buy-in
- Lack of materials
- Student engagement issues

**Impact**
- STEM into daily practice
- More inquiry-based learning
- Assessment reflective of student learning

**Equity**
- Engaged many different kinds of students
- Hands-on learning
- Access to technology
- Allowed for differentiated learning

**Increased Engagement**
- Growth Mindset
- Improved Global Competencies

**Moving Forward...**
- Consistent access to coaches
- More time with coaches
- Ongoing progressive professional development
- Clearer vision of STEM
- Continued evaluation of STEM
- Upgrade technology
- Ensure sufficient technology
In 2015-2016, a mixed method, pre and post survey design, study on robotics and technology in the classroom was conducted as part of the TDSB STEM strategy. It included the following:

- **Teacher Survey**
  - Pre-and post survey before and after professional learning

- **Student Survey**
  - Pre and post survey before and after teachers’ attend professional learning and integrate robotics into the classroom

- **Student Achievement**
  - Analyzing student achievement by examining EQAO and Report Card results after robotics integration

- **Challenges & Barriers**
  - Teachers and administrators were interviewed to discuss barriers and challenges or robotics initiative

Reporting on:

- **Teacher Technology Integration**
- **Teacher Engagement**
- **Student Engagement**
- **Improvement in TDSB Global Competencies**
- **Student Achievement**
- **Challenges & Barriers**

*For more details please see full reports in: Technology and Innovation Research in TDSB: [http://www.tdsb.on.ca/research/research/Publications/TechnologyandInnovationinEducation.aspx](http://www.tdsb.on.ca/research/research/Publications/TechnologyandInnovationinEducation.aspx)*
Overall, the results suggest professional learning in robotics and teaching with robotics leads to: **reduced barriers** teachers feel towards teaching with robotics and with technology in general **increased student engagement** and **increased global competencies** among students.

### Key Findings

- **Reduced barriers** teachers feel towards teaching with robotics and technology in general
- **Increased student engagement**, self-esteem, and perseverance
- **Increased teacher engagement** (higher levels of teacher emotional and social engagement)
- **Increased global competencies** with collaboration, inquiry/problem-based learning, creativity, and innovation
- **Improved Student Achievement, Engagement, Global Competencies, and Digital Fluencies**
- **Lack of teacher buy-in** and barriers in terms of available resources

### Barriers & Recommendations for Future Implementation

#### Resources

**Recommendations:**
- Develop long-term plan for robotics/blending
- Maximize resource use

#### Buy-in

**Recommendations:**
- Ongoing professional development on technology/robotics
- Opportunities to visit other classrooms

**Recommendations:**
- Workshops at the beginning of the year on technology/robotics

### Teacher Confidence

Using Technology

*For more details please see full reports in Technology an Innovation Research in TDSB: http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx*
In 2015-2016, a study on teacher engagement was conducted with 227 educators, 167 STEM educators, and 60 non-STEM educators in the TDSB as part of the STEM strategy.

STEM Teacher Engagement Survey Examined:

Majority of educators are always cognitively and emotionally engaged in teaching

STEM educators had statistically significant emotional engagement compared to non-STEM teacher and find teaching exciting and fun

STEM educators’ engagement with colleagues was statistically higher than non-STEM educators

More than half of educators are always sympathetic and socially engaged with students

The results show a disconnect between educator’s expectations of leadership and their actual experience

Educators support technology in the classroom, but some may feel uncomfortable using it

Use of some digital tools were minimal (social media and video-conferencing)

Overall, the results have shown that engagement involves much more than just learning and teaching and includes many dimensions. A major finding from the study shows a statistically significant increase in engagement for STEM teachers compared to non-STEM teachers in many areas of engagement.

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Compelling Research Evidence: Impact on Teachers

Teacher Engagement

COGNITIVE ENGAGEMENT

I try my hardest to perform well while teaching.
While teaching, I really "throw" myself into my work.
While teaching I pay a lot of attention to my work.
While teaching, I work with intensity.

Overall

Significant difference between groups \( p < 0.05 \)

EMOTIONAL ENGAGEMENT

I am excited about teaching.
I feel happy while teaching.
I love teaching.
I find teaching fun.

Overall

Significant difference between groups \( p < 0.05 \)

SOCIAL ENGAGEMENT: COLLEAGUES

At school, I connect well with my colleagues.
At school, I am committed to helping my colleagues.
At school, I value the relationships I build with my colleagues.
At school, I care about the problems of my colleagues.

Overall

Significant difference between groups \( p < 0.05 \)

TEACHING WITH TECHNOLOGY

I feel at ease learning about technologies for teaching and learning.
I feel comfortable about my ability to work with technologies for teaching and learning.
I feel comfortable about my ability to teach students to work with technologies.
I feel confident that I have the skills necessary to use technologies for instruction.
I feel confident that I can successfully teach relevant subject content with appropriate use of technology.
I feel confident that I can regularly incorporate technology into my lessons, when appropriate, to support student learning.

Overall

Significant difference between groups \( p < 0.05 \)

Technology Usage

NON-STEM

STEM

Significant difference between groups \( p < 0.05 \)

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Compelling Research Evidence: Impact on Teachers

STEM/Global Competencies/Deep Learning

Teacher Practices: STEM activities implemented (% of Teachers)
- Hands-on activities: 90%
- Experiments: 67%
- Computer technology: 64%

STEM Program Benefits
- Providing STEM teaching and learning resources
- Supporting teaching with STEM resource kits and monographs
- Providing professional learning focused on hands-on learning experiences
- Co-planning with teachers and assisting with classroom lessons and programs

Digital Fluency

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<tr>
<th>TEACHING WITH TECHNOLOGY</th>
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<tr>
<td>I feel confident that I can regularly incorporate technology into my lessons, when appropriate, to support student learning.</td>
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</tbody>
</table>

Overall
- Strongly Agree: 68%
- Agree: 59%
- Somewhat Agree: 65%
- Neither Agree nor Disagree: 68%
- Somewhat Disagree: 59%
- Disagree: 68%
- Strongly Disagree: 80%

Digital Fluency

<table>
<thead>
<tr>
<th>NON-STEM</th>
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<tbody>
<tr>
<td>Strongly Disagree / Disagree / Neither agree nor disagree / Strongly Agree / Agree</td>
</tr>
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</table>

Overall
- Strongly Agree: 86%
- Agree: 77%
- Somewhat Agree: 78%
- Neither Agree nor Disagree: 79%
- Somewhat Disagree: 77%
- Disagree: 78%
- Strongly Disagree: 85%

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Compelling Research Evidence: Impact on PL on Teachers’ STEM-TPACK

Students substitute tools, including technologies, to complete tasks (e.g., student submitting an assignment in a Word document rather than handing it in on paper).

Students use technologies to augment their learning and improve how they are doing tasks (e.g., students use the text-to-speech function on a word processor to help the writing process).

Students modify their learning and task completion using technology (e.g., students place their essay on an online discussion board to seek feedback from classmates).

Students use technology to completely redefine their learning and task completion (e.g., students submit a short documentary using Windows Movie Maker instead of an essay).

SAMR Model

Pre-Survey
Post-Survey

I can teach lessons that appropriately incorporate robotics, inquiry based teaching approaches, and technologies across different subject areas.

I feel confident that I have the skills necessary to use robotics for classroom instruction.

Students substitute tools, including technologies, to complete tasks (e.g., student submitting an assignment in a Word document rather than handing it in on paper).

Students use technologies to augment their learning and improve how they are doing tasks (e.g., students use the text-to-speech function on a word processor to help the writing process).

Students modify their learning and task completion using technology (e.g., students place their essay on an online discussion board to seek feedback from classmates).

Students use technology to completely redefine their learning and task completion (e.g., students submit a short documentary using Windows Movie Maker instead of an essay).

SAMR Model

Pre-Survey
Post-Survey

I am able to design learning experiences that develop students' collaboration, creativity, and innovation skills by appropriately incorporating robotics, inquiry based teaching approaches, and technologies in my classroom.

I feel confident that I can engage my students to participate in technology-based projects.

I am able to design learning experiences that provide opportunities for authentic conversations by appropriately incorporating robotics, inquiry based teaching approaches, and technologies in my classroom.

I feel confident that I can help students when they have difficulty with robotics.

I can use strategies that combine content, technologies and inquiry based teaching approaches in my classroom that I learned about in STEM professional learning.

I feel confident about teaching students using the LEGO WeDo/ EV3?

Technology Pedagogical Content Knowledge

Pre-Survey
Post-Survey

Significant difference between groups (P < 0.001) (P < 0.05)

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Teacher Technology Integration

Key Finding

Pre-Survey
Post-Survey

Overall Findings

Increased knowledge of robotics and coding for teaching and learning

Increased confidence in choosing pedagogical approach to best research their students

Improved confidence in ability to help students when they have difficulty with robotics.

Increased understanding and connecting robotics to other technologies.

I feel confident that I have the skills necessary to use robotics for classroom instruction.

I feel confident that I can engage my students to participate in technology-based projects.

I feel confident that I can help students when they have difficulty with robotics.

I feel confident about teaching students using the LEGO WeDo/ EV3?

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Compelling Research Evidence: Impact on Leadership and Coherence

How would you rate each of the following as related to the organizational support you receive in your school environment? (Administrators)

<table>
<thead>
<tr>
<th>Response</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Significance</th>
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<tbody>
<tr>
<td>Our school provides high quality professional learning needed to foster STEM teaching and learning in my school.</td>
<td>4.26</td>
<td>(0)</td>
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<tr>
<td>Our school/district leaders are willing to listen attentively to teachers’ thoughts.</td>
<td>4.64</td>
<td>(0)</td>
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<tr>
<td>Our school shares collective goals and values regarding how the STEM program can help boost student achievement.</td>
<td>4.59</td>
<td>(0)</td>
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<tr>
<td>Our school nurtures a culture of trust and risk-taking.</td>
<td>4.59</td>
<td>(0)</td>
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<tr>
<td>Overall</td>
<td>4.49</td>
<td>(0)</td>
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</table>

Significant difference between groups (p < 0.05)

**Significant Difference between Elementary and Secondary schools**

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Compelling Research Evidence: Impact on Students’ Global Competencies and Deep Learning

Student Skill Growth

Collaboration
Communication
Computational Skills
Confidence
Creativity
Innovative Thinking
Inquiry-based Learning
Perseverance
Problem-based learning
Other

Pre-Survey
Post-Survey

I work well with others to accomplish the task.
I am able to follow instructions given by other students.

Inquiry/Problem-solving based learning

I ask questions so I can better understand the problem.
I try out different possibilities so I can solve the problem and answer the question.

Significant difference between groups (P < 0.001) (P < 0.05)

Increased Student Engagement

Increased Student Perseverance

Increased Self-Esteem

Overall Student Engagement Findings

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### Compelling Research Evidence: Impact on Students’ Global Competencies and Deep Learning

#### Teacher Practices: Inquiry-based learning (Elementary)

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<th>Strongly Agree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
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<tr>
<td>Overall</td>
<td>35% (115)</td>
<td>26%</td>
<td>10%</td>
<td>5%</td>
<td>4%</td>
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<td>Teacher Practices:</td>
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<td>Creativity</td>
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#### Teacher Practices: Problem-based learning (Elementary)

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<th>Strongly Agree</th>
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<th>Somewhat Agree</th>
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<tr>
<td>Overall</td>
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#### Teacher Practices: Creativity (Elementary)

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#### Teacher Practices: Collaboration (Elementary)

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TDSB Digital Lead Learners as System-Wide Change Agents
Promoting Global Competencies
and Deep Learning Across the Board

Background
In 2015-16 and 2016-17 school years, the Toronto District School Board conducted a study with Digital Lead Learners (DLLs) and STEM DLLs to better learn how to support the learning and growth of DLLs.

Impact of PD
On STEM DLLs and STEM pedagogy

Needed Support
For DLLs and STEM DLLs.

Challenges
Experienced by DLLs and STEM DLLs

Methodology
STEM DLLs completed a pre-survey, attended professional development and completed a post-survey. DLL’s completed a post-survey only.

Pre-Survey
STEM DLLs completed pre-survey

PD
STEM DLLs attended professional development

Post-Survey
STEM DLLs and DLLs completed post-survey
Guide to Key DLL Study Findings

Key STEM DLL Findings

41% INCREASE in teacher understanding of STEM after attending PD

34% INCREASE in knowledge of STEM pedagogy after attending PD

34% INCREASE in student learning after attending PD

30% INCREASE in teaching efficacy after attending PD

Key DLL Findings

96% agreed or strongly agreed to have TPACK knowledge

69% agreed or strongly agreed there is unequal access of technology

MORE TECH
DLLs need more hardware and software

CONTINUE DLL
DLLs would like the program to continue

*Source: http://tpack.org; The image is adapted and modified for the TDSB by the permission of the authors Mishra & Koehler, 2006, p. 1025; Reproduced by permission of the publisher.
Compelling Research Evidence: Impact on Student Achievement

These research series are in progress and key findings will be published on the TDSB Research website.

For more details please see full reports in: Technology an Innovation Research in TDSB: http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx

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**Report Card Achievement - Elementary**

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<tr>
<td></td>
<td>80%</td>
<td>76%</td>
<td>72%</td>
<td>74%</td>
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<tr>
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<td>72%</td>
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<td>83%</td>
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<td><strong>Science</strong></td>
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<td>84%</td>
<td>80%</td>
<td>77%</td>
<td>79%</td>
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*Significant differences (p<0.05) were found across STEM status groups in our two year cohort study.*

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**Learning Skills - Elementary**

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

Question/Comments
• Please feel free to email the TDSB Research Team:
• Erhan.Sinay@tdsb.on.ca

For more details on findings please see full reports in:
Technology and Innovation Research in TDSB
http://www.tdsb.on.ca/research/Research/Publications/TechnologyandInnovationinEducation.aspx