SEPTEMBER 30, 2016

TRANSFORMING LEARNING EVERYWHERE

A STUDY OF THE SECOND YEAR OF IMPLEMENTATION

education | YORK UNIVERSITÉ UNIVERSITY

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Executive Summary

This report provides a comprehensive description, analysis and assessment of the Hamilton-Wentworth District School Board (HWDSB) initiative, *Transforming Learning Everywhere* (TLE). TLE is a 5-year project with the ambitious goal of transforming learning environments across the district by integrating new instructional practices with innovative technology use, including 1:1 iPad distribution.

TLE is still in the initial phases of implementation, with full implementation planned for the 2017-18 school year. This report provides an analysis of TLE during the 2015-16 school year. The focus of our research was a family of 7 TLE pilot schools which were in the second full year of 1:1 implementation of iPads in grades four through eight. The research was carried out over the second half of the school year; its goals were to examine the impact of TLE on transforming teaching practices, enhancing student engagement, and improving student learning and 21st century skill development.

TLE rationale

Transforming Learning Everywhere has as its goal the design and creation of innovative learning environments for developing student knowledge, skills, and life-long learning dispositions essential for learners to succeed in the 21st century, and to help students meet the challenges of the rapidly changing environments outside of school in the domains of communication, work, and citizenship.

TLE is based on the principle that, while technology tools can accelerate and support student learning, it is effective pedagogy – transformative teaching together with rich support for learning – that is the cornerstone of the initiative. To this end, the TLE initiative has advanced a strategic plan to bring together technology tools with innovative inquiry-based learning (IBL) practices to support deep learning engagement, self-directed student learning, and fluency with new media tools and 21st century literacies.

TLE logic model

We developed a logic model to guide our research based on the district's theory of action and implementation plans for the TLE initiative. The model focusses on the relationship between TLE inputs (funding; technology distribution; professional development for iPad use and new inquiry-based pedagogies; and evidence-based feedback), short and intermediate term mediating outcomes such as teacher buy-in and student engagement, and longer-term goals. These longer-term goals include creating a professional culture supporting TLE; supporting teacher desire to change pedagogy in accordance with TLE aims and purposes; having teachers acquire new instructional competences for inquiry-based learning and digital tool use; and generating evidence of improved student engagement and learning. The logic model gave us a comprehensive frame to assess TLE's plan of action, and address these inputs and desired outputs, as well as draw conclusions and make strategic recommendations.

Research questions

In this report, we consider if, how, and to what extent TLE's particular implementation of inquiry-based learning (IBL) and infusion of technology through its 1:1 iPad distribution were effective in enacting TLE's goals. Our specific research questions, informed by our TLE logic

model and its theory of action, are outlined below. They are organized by their domains of action: the school system level, the teacher level, and the student level.

System level: What policies and TLE inputs have been put in place to implement and scale TLE, and to support professional development and a professional culture supportive of TLE aims and practices? How have these efforts been translated to the teacher and student domains? And how have key TLE actors created or sustained change, and promoted a culture where actors at all levels of the board can begin to take ownership of the initiative and maintain momentum as TLE is scaled?

Teacher level: To what extent have teachers embraced TLE and transformed their pedagogy, becoming facilitators of student learning, and in particular, how are they promoting deep learning through the adoption of inquiry-based teaching? The teacher level of analysis includes factors like formal and informal professional development, the impact of technology tools, and teacher dispositions and perspectives surrounding new inquiry-based pedagogies and iPad and technology use.

Student level: What kinds of learning tasks were instantiated and what roles did 1:1 device use play in advancing TLE goals? What strategies were being used to assess student learning? What is the evidence for transformed learning environments, student engagement, and achievement in teacher and student interviews and student work samples?

Situating TLE in context of the literature

Transforming Learning Everywhere is based on the view that inquiry-based learning (IBL), supported by one-to-one technology distribution, is the most effective pedagogical approach to facilitating students' development of 21st century skills and deep learning dispositions (e.g., life-long learning, critical thinking, authentic knowledge-building, digital literacies and communications competences, experiences of self-efficacy).

In chapter 2, we review the existing literature, educational theory and empirical research relating to TLE aims, values, and practices: particularly, the literature on IBL and one-to-one technology use in schools. On the basis of our review, we concluded that the TLE vision and rationale are supported by the research and policy literature, as well as by policy directives and professional learning resources published by the Ontario Ministry of Education.

According to the research, IBL can improve learning outcomes for students. Further, recent literature also suggests that IBL methods and outcomes can be further enhanced by innovative uses of technology; combining IBL with technology can significantly redefine and transform educational purposes and practices, particularly in relation to new literacies and digital media competences.

Pervasive research and emerging policy frameworks in and outside of Ontario indicate that TLE is not only on firm theoretical ground, but forward-looking. In our review of the literature, we found that the integration of IBL with one-to-one iPad use offers significant opportunities to increase student engagement and the development of 21st century literacies and learning.

However, we signal in this chapter (and elsewhere in the report) that IBL methods and practices must be implemented in ways that stay true to the principles of the method; the gains of IBL pedagogies can only be leveraged when IBL in all its phases is optimally implemented in classrooms. The extant research strongly indicates that administrators and teachers will not be able to realize TLE's aims simply by equipping their students with iPads: meaningful inquiry-

based learning must be enacted in order to maximize the opportunities of 1:1 technology distribution.

Research methodology

A multi-dimensional case study approach was used to capture the detail, nuance, and context of how the TLE initiative was implemented in the 7 North schools we studied, and how and why teaching and learning were impacted.

Structured, open-ended interviews were conducted with 14 randomly selected teachers, 5 key informants in leadership roles for TLE at the school and system level, and focus groups were held with students from the classes of the teachers interviewed. For both teachers and students, the questions asked addressed the use and impact of IBL and iPads tool use on teaching, learning, student engagement, and 21st century skills development. Key informants were asked about the processes and outcomes of TLE implementation, and school district documents were consulted to source data on TLE's theory of action and implementation plans. Data from district surveys of students and teachers were also used to assess the degree of IBL adoption and iPad utilization in the classroom, teacher perspectives on IBL and iPad applications to learning, and their impacts on students.

Student work sample sets from grade 4 through grade 8 classes were examined and assessed on the extent to which students fully engaged in deep inquiry learning and demonstrated 21st century learning skills. The assessment process had two elements: a holistic quantitative rating of student samples (grade 4-8) using an established rubric for assessing 21st century learning; and a detailed qualitative analysis that was undertaken of a subset of that work. The qualitative analysis used, as sources for its assessment criteria, the HWDSB document *Transforming Learning Everywhere*, as well as key documents from the Ontario Ministry of Education, including *Achieving Excellence: A Renewed Vision for Education in Ontario* and documents from the Ministry's *Capacity Building Series* on inquiry-based learning. In addition, we evaluated tasks and technology applications by utilizing the well-known SAMR (Substitution, Augmentation, Modification, Redefinition) model, and cross-referenced these findings with work by Michael Fullan on inquiry pedagogies and innovative technology use supportive of deep learning and the demonstration of 21st century competences.

The holistic quantitative analysis focused on three sample sets (from grades 4, 7, and 8). Samples of student work were selected from those schools where at least three or more projects on the same topic were available for coding *and* where the projects were relatively substantive, requiring a minimum of one week to complete. The sets of student works were rated using criteria developed by SRI International (http://www.itlresearch.com/research-a-reports/2011-itl-research-design-and-methods) to specifically assess student work product for evidence of 21st century learning competences.

Putting TLE into practice

In this chapter, we examine how HWDSB has mobilized resources and strategically acted, administratively and organizationally, to put TLE into practice, and to further refine key TLE aims during the 2015-2016 school year.

Working from the intended activities laid out in the TLE action plan, we investigated (1) professional support for teachers, (2) professional support for administrators, (3) digital hardware and software provisioned to classrooms, (4) technical support for schools and teachers, (5) evidenced-based feedback on implementation collected within the district, and (6)

funding from the board and the Council of Ontario Directors of Education (CODE). To assess TLE actions and outputs at the system level, we focused on three key drivers of organizational change – competency drivers, organization drivers, and leadership drivers.

Competency drivers consist of the formal and informal professional learning opportunities and supports provided to (and by) administrators and teachers.

With regard to competency drivers, we identified a variety of formal professional learning opportunities, as well as a very healthy climate for informal, ad hoc collegial sharing (where teachers shared best practices, inquiry-ideas, methods, new apps, and so on). The forms of formal or organized professional development identified in our report are, in the literature, generally regarded as "best practices" for teacher development, and include PA day events; school-organized professional learning activities; lunch-and-learn sessions; formal or informal collaboration with external partners; and/or discussions at staff meetings and other knowledge-sharing opportunities. Embedded mentoring and coaching are also identified as promising practices. While teachers indicated that they do not generally utilize or contribute to the internal Yammer social messaging system, some pursued informal professional development using Twitter and other social media tools.

While teachers reported a generally favorable climate in their schools surrounding TLE in terms of culture and administrative enthusiasm for the initiative, they also frequently indicated in interviews and their survey responses that more formal and intensive professional development focusing directly on integrated IBL and iPad uses were necessary to further advance and refine teaching practices.

Organization drivers are defined as the organizational and administrative components necessary to generate a culture and community that supports organizational change across the system. In the report, we examine TLE's technological systems and infrastructure, E-BEST's (the board's research department) role in TLE, and provide a brief overview of HWSDB fiscal support for TLE and what the board is doing to fund and further scale TLE.

With regard to the organization drivers, we found that the board has made a financial commitment to TLE significantly above and beyond the funding received from CODE. For the 2015-2016 school year, technical infrastructure and tech support had improved over the previous year, and the technology infrastructure is, for the most part, now sound. Teachers generally reported good to excellent network connectivity and technology support, but there were occasional wireless network latency and bandwidth issues and sometimes a significant wait time for onsite technology support.

Finally, while we see the value of E-BEST in providing both research and critical feedback on TLE, we found that many opportunities for mobilizing research to improve and refine and scale TLE may be lost when E-BEST is constrained by formal research protocols. Because E-BEST considers their monitoring of TLE to be a research activity as opposed to a program improvement undertaking, informed consent is required. For various reasons consent is always difficult to obtain, which results in poor response rates, hindering research scope and validity. We suggest that E-BEST find ways to rearticulate research aims in terms of program improvement, with a more direct focus on refining TLE aims and actions as the initiative scales up across the district.

Leadership drivers refer to the strategic actions taken by key TLE actors to transform systems, create and sustain change, and promote a culture where actors at all levels in the board can

begin to take ownership for the initiative and maintain momentum as TLE is scaled across the board.

With regard to leadership drivers, we identified organizational structures and key actors that work to promote and refine TLE aims. A senior level steering committee manages the initiative, and monthly organizational leadership meetings are held for administrators. While these meetings may or may not focus directly on TLE, meetings often have a TLE component where administrators are able to share their own experiences with, and findings about, TLE, and TLE is sometimes used as a lens through which to discuss other policy and administrative objectives. We found that TLE is increasingly becoming an embedded and accepted feature of the pilot schools in our study. Moreover, there is evidence of longer-term strategic planning to scale up TLE throughout the district, and circulate TLE values, models, and practices. In order to scale TLE, the leadership agenda must encourage deep and sustainable change in actor practices and dispositions in the face of competing priorities and demands; the values and principles of TLE need be solidified in pilot schools (through continued professional development focusing on interweaving IBL and iPad tool use) as the initiative is extended to other HWSBD schools; and, finally, the TLE initiative needs to ensure schools and families of schools take ownership of initiative values, processes and practices.

Overall, TLE looks to be well positioned for scaling up across the board, especially given the fact that HWSDB now has feedback available about its initial rollout problems and shortcomings (vis-à-vis the pilot schools and projects). However the scaling of TLE must also be accompanied by continued formal and informal professional development with a focus on refining inquiry-based learning and promulgating innovative uses of technology throughout the inquiry learning cycle, including the use of formative assessment as and for learning.

Inquiry learning in the classroom: Impacts and outcomes

We utilized data from multiple interview sources (teachers, administrators, TLE support, and student focus groups) as well as teacher and student district surveys to inform our research questions surrounding the implementation of inquiry-based learning in 1:1 pilot school contexts, addressing the possible effects and outcomes in classroom practice.

In assessing the adoption of IBL, we wanted to look at whether IBL was being implemented in ways that reflected or remained true to IBL best practices described in the literature. In examining the fidelity of implementation we aimed to determine not only if IBL was being utilized, but to what extent it was being adopted in optimal forms of practice – forms that might realize the potential of IBL to engage students, transform educational experience, and maximize learning outcomes and experiences of self-efficacy.

We defined optimal IBL practice based on the Ministry of Education's Capacity Building Series documents on IBL for educators. In these, IBL is described as a student-directed inquiry process that is both teacher-supported and informed by phases of provocation (stimulating curiosity, or sense of wonder); conceptualization (student question-posing, hypothesis formulation, connecting research to "big ideas" in the curriculum); the selection of appropriate research resources and technology tools; the marshaling of evidence through planning, investigation, experimentation and interpretation; collaborative sharing of student-constructed knowledge; and critical reflection on inquiry processes and products of learning. IBL can also provide rich opportunities for creative student agency and collaboration, interdisciplinary learning and the construction of authentic knowledge for real-world audiences

Fidelity of implementation: Among the teachers we interviewed, the fidelity of implementation of IBL pedagogy varied. According to teachers, the time devoted to IBL in any form ranged from 33% to 50% of class time; students, alternately, reported the proportion of time dedicated to IBL as being between 5% and 40%.

Teachers found mathematics to be a hard "fit" for IBL; the majority of IBL projects were enacted in science, history, and social studies classes, as well as the arts. In many cases, teacher were able to connect IBL to "big ideas" in the curriculum that also intersected with concerns and controversies in the real-world (such as ecology and global warming), and there was some evidence of student agency in investigating their own research questions.

Teachers frequently mobilized videos, visual texts, newspaper articles to stimulate interest or wonder, and then followed up with class discussion and support for developing research questions. We found that teachers varied greatly in the degree of guidance and the latitude they gave students to formulate questions and pursue self-directed research trajectories. Some teachers allowed more room for students to personalize research, to make wider connections, and to extend their learning. However, many of the projects were highly constrained by teachers in advance, and in teacher interviews we found that the expectations for some projects (both in terms of activities and work product) were predetermined and managed to such an extent that they would not qualify as IBL.

When conducting formative assessment, some teachers made use of innovative forms of "success criteria" in the form of rubrics and checklists that enabled students to plan, monitor and self-assess their learning and work products as they moved through the IBL process. In some cases, success criteria were co-developed with students, which we found to be a valuable enactment of IBL, giving students agency in determining and reflecting upon the standards for success and good work.

Teacher assessment typically shifted away from a primary focus on student work products to a more process-oriented examination of student thinking as well as their learning and work processes. Educators made more use of observational evidence in both formative and summative assessment, and the amount of formative assessment they undertook increased. Only in a minority of cases did student presentations have any audience beyond the teacher and classmates, but students clearly valued these opportunities when they arose and were highly motivated by them. Community action stemming from inquiries was very rare.

Students' IBL research was principally conducted using iPads connected to vetted online resources, Hub-based sources, and, in several cases, governmental and institutional sites. Research activity was frequently directed to teacher-provided links (although in many instances latitude was allowed for more self-directed research navigation).

iPads proved very useful for including ELL populations and students with special needs in IBL project work, as the iPad-based assistive technologies such as translation "read aloud" and speech-to-text functions enabled students and teachers to overcome language and literacy barriers. This enabled a wider range of students, including those who may have formerly been excluded and even stigmatized by peers, to participate in whole-class learning processes, and had a notable impact on their levels of engagement.

There was strong evidence of peer collaboration and knowledge-sharing in students' IBL work. Teachers reported that both individual and group inquiry-projects were supported by different

forms of informal collaboration, and in some cases collaboration was made a formal and integral part of IBL phases.

We found that culminating projects (a key element of the IBL cycle) were nearly always presented to the class. Culminating presentations or showcases provided opportunities for peer assessment as well as teacher assessment and critique, and for students to assume a teaching role when presenting their works and sharing findings and knowledge with others. Teachers reported that the affordances of the technology (iPads, projectors, network connectivity, Google Drive, blogs, and apps that permitted shared document access and editing) made collaborative work and knowledge sharing much easier and more productive.

For culminating projects, we found that students were typically permitted to choose the forms (tools, modalities, and media) through which to design their work artefacts and present their learning. Students demonstrated a strong preference for using digital, multimedia tools. (e.g., Explain Everything, iMovie, multimodal slide shows).

The changes in student outcomes reported for IBL work were several and significant:

- *Student engagement*: Teachers and students reported substantially higher levels of student engagement in IBL relative to most other forms of learning. This held true for both high-performing students and students who typically struggle. Many teachers stated that this higher degree of engagement fostered student agency, initiative-taking, and a greater willingness to persist through challenges.
- *Deeper learning:* Teachers reported that students learned more deeply when involved in IBL projects, and that IBL provided opportunities for students to demonstrate more sophisticated competences and learning than through traditional forms of instruction.
- *Planning, research skills, and self-regulation:* While student research, planning and self-monitoring skills were observed by most teachers to improve with IBL, some reported that these skills were still underdeveloped in a substantial proportion of their students.
- *Analytical skills, critical thinking, and inference making*: Most teachers reported that there was little evidence of enhanced analytical skills or critical thinking (including drawing inferences and original hypothesis development) in students as a result of the IBL method of learning. (As we discuss below in our analysis of student work, this may be the result of teachers' over-regulating the IBL experience by tightly managing both IBL processes and outcomes through defined research templates with fixed sets of expectations.)

While there is a great deal of teacher support and even enthusiasm for adopting IBL, several enthusiastic teachers reported that they were to some extent still struggling with implementing IBL in a manner that would realize its full potential. The teachers' sense of their own competence in utilizing IBL was not always strong; a substantial minority of teachers surveyed had some reservations about their levels of mastery, and there were some concerns expressed about how well IBL served to cover off the full range of curriculum expectations in the topics it was used to address.

A small minority of teachers expressed sharper reservations about IBL, or a reluctance to implement IBL fully, which suggests that TLE aims and values have not been unanimously embraced by all educators. We address this issue in the recommendations section.

IBL situates student interest, agency, and self-direction at the centre of the learning experience, and teachers reported mixed degrees of anxiety and enthusiasm about "letting go" of their traditional teacher roles as curriculum authority and director of learning, and letting students

co-determining their own course of inquiry and learning. While some teachers signaled their concern about this pedagogical shift, many teachers found the opportunities it presented to be exciting and promising, and saw significant benefits of students doing so.

An iPad for every student: Impacts and outcomes

Here we examine the applications and impacts of 1:1 iPad use, including iPad use in both IBL and non-IBL instructional contexts. (As we consider how iPads were used in these classrooms, it should be kept in mind that at the time of our data collection, the grade 4-8 teachers at the seven North schools we studied had nearly two years of teaching experience in classrooms with 1:1 iPads).

Our findings indicate that teachers employed iPads for diverse aims and in a range of educational processes and learning tasks. On one hand, teachers often utilized iPads to uphold conventional instructional forms (frequently as a substitute for print media) or mobilized the iPad to augment traditional practices, with modest degrees of transformation in pedagogy, process, task design, and student knowledge demonstration resulting. But it was also true that most teachers – to varying degrees and extents – were leveraging the affordances of the iPad and associated technologies, including Google Drive and presentation hardware like Apple TV, to promote new kinds of learning tasks, and support novel and meaningful forms of knowledge construction and sharing, through such practices as peer presentation or blog publication.

Not surprisingly, given the 1:1 iPad distribution, most teachers and students reported that much of daily class time involved some kind of iPad use across a wide range of teaching, learning, and communicative tasks, from direct instruction and practicing basic skills to collaborative problem solving and pursuing research inquiries in groups or individually. The iPad was "the platform of choice" for most of the student research carried out in science and social studies.

Common uses of the iPad included:

- *Research*: iPads were employed in accessing and navigating research and multimedia sites, including external research sites, vetted resources (provided by way of teacher links), and videos, models and simulations. One-to-one device distribution made spontaneous pursuit of inquiry questions feasible (while eliminating arguments over access to limited technology tools for research or other tasks).
- *Writing*: Most student writing activities were conducted using the iPad and the suites of provided apps supportive of traditional writing tasks and multimodal production (combining written text, images, graphics, and audio).
- *Digital games*: Educational games and gamified drill and quiz apps were used with some degree of frequency by teachers, usually to practice basic literacy and numeracy skills. Some teachers reported more sophisticated uses of games and simulations, including using Minecraft for construction-driven learning.
- *Mathematics*: Many teachers utilized iPads to model and practice numeracy skills and math principles, and some teachers utilized math drills, quizzes and games, as well as virtual manipulatives. In some cases, teachers leveraged the affordances of the iPad and tools such as Explain Everything to create shared spaces for modeling and sharing student problem solving in real time, and as a platform for students to share their rationales when solving equations or other problems.
- *Project work*: Students utilized iPads to demonstrate learning (for IBL and other purposes), using diverse apps, as well as combinations of apps, to demonstrate knowledge and learning through multimodal digital artifacts.

- *Interdisciplinary work, art, and design:* iPads were sometimes used as a creative and dynamic medium for artwork and music composition, as well as to facilitate multimodal artefact creation in interdisciplinary work for demonstrations of knowledge.

Further, as iPads provided a wide spectrum of multimodal resources, they were found by teachers to better accommodate students who favoured learning styles where traditional print literacy did not dominate or in some cases even play a significant role. Significantly, iPads were also used to bridge language boundaries for ELL students as well as support special needs students in overcoming textual and linguistic learning barriers through these multimodal and multimedia functionalities.

For most students, the preferred apps for demonstrating learning and knowledge were those that supported multimodal expression, allowing the integration of text, visual elements (images, maps, infographics, video) and audio voice-over and/or music. These iPad apps were mobilized to design and create many types of products and documents, including slide shows (sometimes converted to PDF or movie formats), eBooks, Explain Everything multimedia documents, iMovie video projects and trailers, as well as animations and virtual models.

Pedagogical shifts and roles: Teachers indicated that the extensive use of iPads encouraged or induced a general shift away from more traditional forms of direct instruction due to the new affordances and capabilities they brought into the classroom. The iPads were seen to support and facilitate more student-directed, collaborative and project-based learning, including IBL, and teachers indicated that they were assuming new roles as co-learners and moving away from traditional roles as directors of learning and conduits of expert knowledge. And teachers were likely to see students assuming new roles as knowledge-makers, and sometimes as teachers (e.g., when presenting culminating works and findings to peers).

Engagement and agency: Teachers and students both indicated that iPads increased student engagement, especially when students were involved in creating learning demonstrations using multimodal tools and apps. When iPads were in play, students also were more likely to persist when confronted with obstacles, and were also seen to display greater autonomy and agency, taking initiative or directing their own learning.

Formative assessment: iPads (both on their own and in combination with IBL) had an impact on assessment, particularly formative assessment, with teachers using iPads and related tools such as Google Drive and commenting features in apps to provide more timely feedback and formative assessment to support learning processes. Some teachers found the Sesame Snap app was instrumental in this process; it was used for taking observational notes or video, and developing assessment checklists and rubrics which could then be easily shared out to students, revised when needed, and readily applied to uploaded student work.

Collaboration and sharing: The sharing of student learning with peers, which is an important element of both IBL and other pedagogies, was facilitated by iPads (in conjunction with other classroom technology tools). Teachers frequently indicated that students would share work in progress for discussion or present final projects. Moreover, iPads were seen to facilitate collaboration, work-sharing, cross-commenting, ad hoc research, and real-time modeling of ideas or processes.

Digital literacies and research: Teachers reported a gradual increase in students being able to research, develop good "search questions", and navigate websites, and evaluate the reliability of

information and sources of information. Some teachers reported, however, than they had several students who needed ongoing structure for and guidance in these practices.

iPad use frequently had a major impact on teachers' own pedagogical perspectives and their reported professional growth. Among all the teachers we interviewed, ongoing professional development was seen as key to the successful integration of iPads into classroom practice, and most of the teachers signaled the need for continued, ongoing formal and informal professional development and support to scale up their own TLE-fostered practices. We found evidence of a great deal of informal and improvised professional sharing among most of the teachers, especially the enthusiastic ones who were eager to maximize the potential of iPads and IBL in student learning. Several teachers reported that iPads – in conjunction with new pedagogies – had significantly enhanced their capacity to provide richer and deeper learning opportunities for their students, with some signaling that the technology (or TLE more generally) was enabling them to become the teachers they wanted to be.

Descriptions and analysis of student work

We conducted an in-depth analysis of student work samples from the six TLE schools where we conducted student and teacher interviews, looking at whether and how student project work samples reflected or enacted TLE objectives, and how the TLE action plan inputs may have generated the desired student outcomes. Specifically, we examine if, how, and to what extent the student work samples provided evidence of effective inquiry-based learning practices, and to what extent the affordances of technology and 1:1 iPad distribution were effective in supporting deep learning and the acquisition of 21st century competences.

In the first part of this examination of student work, we undertook a qualitative assessment of student work samples using, as criteria, principles of IBL as laid out in TLE and Ontario Ministry of Education documents. In addition, we made use of the well-known SAMR model for classifying the degree of innovation observed in student work, cross-referencing this simple heuristic model with Michael Fullan's writings on deep learning, new pedagogies, and new technology tools. In the second part, we undertook a holistic quantitative analysis of three sample sets from three TLE pilot schools using a research rubric.

We begin with a discussion of the quantitative analysis first, as the qualitative discussion provides insight into the results of the quantitative analysis.

Qualitative Analysis of student work

In this section we briefly distil observations from our analysis of the student work samples, and on that basis highlight possible areas of focus for refining TLE goals and better supporting IBL practices and innovative tool use.

Our analysis of student work samples, together with notes provided by teachers, indicates that TLE aims for enhanced student learning were most likely to be enacted when and where: 1) teacher-provided task templates did not predetermine student learning or solicit propositional statements, short answers, or the conventional reproduction of static facts; 2) dynamic digital media tools were applied to support *all* of the different phases of the IBL cycle, including formative assessment; 3) students assumed authentic roles, using authentic media tools, as producers of knowledge, demonstrating learning through the creation of dynamic products for real-world audiences; 4) digital research, knowledge production, and the application of communications literacies were exercised within tasks that were driven by student concerns, and related to the extended world (and its issues and controversies) outside of the classroom.

In several cases, student sample sets did not display evidence of these features or processes, particularly in the grade 7 and 8 samples, where IBL methods and project work seemed largely constrained by templates and traditional knowledge reproduction (restating facts found on research websites, in some cases, in copy and paste form).

Evidence for IBL fidelity of implementation: What was absent in many samples was evidence of student agency in the initial work planning processes, in refining inquiry questions, or in extending and deepening the scope of related research beyond the provided templates. We suggest that students could have more directly involved in the initial planning phase, and invited to notice, wonder, and ask questions that might have shaped and reshaped the research questions through the ongoing process. We reference in this regard TLE documents and the Ministry of Ontario *Capacity Series* on IBL, which encourage student agency in the initial planning stages and, further throughout the entirety of the inquiry-learning cycle.

For 7th and 8th grade samples, we did not see evidence of students being enabled to co-generate knowledge in ways that enact deep, interdisciplinary learning in which new knowledge is connected to the world in meaningful ways.

In the 4th and 5th grade samples, we saw more evidence of IBL in action, and of innovative tool use as well. For example, the "Poetronica", "Government Letter", and "Wildlife Habitat" projects displayed greater evidence of student involvement, with students able to create knowledge in ways that engaged research competencies. Interdisciplinary learning occurred in these projects, with new knowledge being extended or holistically connected in meaningful ways. Across all of the grades, however, our work analysis findings signal a need for refinement of IBL practices.

Application of technology: While the use of digital tools for research and knowledge demonstration was present in almost every sample, not all of the sample tasks modeled transformative uses of technology to support new pedagogies. Again, pre-given templates appeared to determine outcomes and constrain the use of technologies to locate information and apply it in dynamic ways. In the 7th and 8th grade samples, there was too frequent evidence of copy and paste, and little evidence of knowledge synthesis or connection to real world issues and big ideas (except in perfunctory ways). In these cases, iPads were used to simply duplicate traditional learning tasks in digital or online contexts, with little or no significant transformation of curricular forms and classroom practices.

At the same time, we do see evidence in some student work of emerging iPad use where teachers are using the technology to substantially modify and even transform how teaching and learning takes place. Here we see evidence of innovative teaching and learning in the contexts of IBL, formative assessment, digital literary acquisition, and multimodal communications practices supportive of deep learning and 21st century competences.

The most pedagogically transformative uses of technology were present in 4th and 5th grade sample sets, where teachers were integrating multiple tools to support deep learning *throughout* the IBL process as a whole. Teachers used videos to stimulate curiosity and wonder, employed interactive virtual walls to model techniques and support real-time collaborative learning, and utilized interactive polling tools to encourage discussion on topics.

This use of multiple media tools throughput the inquiry process (in 4th and 5th grade samples) also facilitated more dynamic culminating projects. In these projects students were more likely to engage in real-world problem solving and designing knowledge for real-world audiences (e.g.,

iMovie products and letters posted to public-facing blogs). At the same time the projects showed evidence of interdisciplinary learning.

Innovative formative supports and assessment methods were also employed in the grade 4 and 5 samples. In one project, well-defined "success criteria" were used to formatively encourage, rather than delimit, student agency and the creative application of learning. In this case, success criteria drew student attention to opportunities and possibilities for creative production and knowledge design. In another project, formative feedback was conducted as an "ongoing conversation" with students (using Google Doc comments). In still another project, forms of student self-assessment were nested into the final digital Explain Everything document, requiring students to document evidence of learning and critically reflect on the learning process.

The 4th and 5th grade samples also evidenced a greater degree of student critical reflection on IBL processes and products of learning, and in these cases (based on teacher task descriptions) students were more likely to take collaborative roles sharing and teaching one another using digital presentation media.

Holistic quantitative analysis of student work

There is not space in this summary to present the details of our methodology for this analysis, or the limitations of our sample, but some brief context is needed. Samples of student work were selected from schools where at least three or more projects on the same topic were available for coding *and* where the projects were relatively substantive, requiring a minimum of one week to complete. The sample sets we obtained represent project work from grades 4, 7, and 8.

Sample sets were rated using a student work product assessment rubric developed by SRI International that was specifically designed to evaluate evidence of 21st century learning competences. The SRI International rating scales provide four dimensions for assessing student learning as evidenced in their work: knowledge building, applied ICT use, real-world problem solving and innovation, and communication skills. The SRI International rating scales were selected for this report as they consist of dimensions that closely align with TLE objectives for student innovative digital tool (ICT) use, deep learning tasks, and learner-centred pedagogies like IBL. The rating scheme scoring ranges from 1 to 4, where a score of 1 indicates that the student work demonstrates no evidence of the skill to a high of 4, which indicates a very high skill level is evident.

Our analysis of the sample sets indicated that the mean scores on each of the dimensions were above the mid-point of the scale in most cases (rating between 2 and 3 on the scale, across all four dimensions noted above). None of the samples scored on the high end of the scale on any dimension (the 3 or 4 rating on the SRI scale), a score which would indicate a high level of skill or competency on that dimension. It was evident that there was room for significant improvement across all of the four dimensions of the scale. However in comparison to an international group of students these scores were above average; SRI International reported that in their *Microsoft Partners in Learning* international study, over 50% of student work samples were scored 1 on every dimension (and student work samples in our study scored, on average, higher than that).

Summary and recommendations

Here we structure our findings in accordance with the TLE logic model articulated earlier, organizing our summary statements and conclusions around our anchoring research questions across three category levels: board, teacher, and student.

Board level findings: Our literature review, interviews with key actors and TLE leadership staff, and analyses of the TLE action plan and related TLE policy documents indicate that the HWSBD has developed an initiative that is supported by the research and literature, including Ministry documents and directives. Extensive research within and outside of Ontario and Canada suggests that IBL, supported by 1:1 technology tools, provides an excellent footing for supporting 21st century literacies and competences. There is of course the need to ensure that 1) there is fidelity of implementation when IBL is put into practice, and 2) technology tools are used in innovative ways that encourage deep learning and are not use to merely reproduce traditional instructional forms.

The board has made significant progress in rolling out TLE beyond the initial pilot schools and plans to continue expanding it in 2016-17 to include all grade 9 classrooms with 1:1 iPads, shared kits of iPads for all grade 6 classrooms, and 1:1 iPads for grade 10s in two secondary schools. We estimate that this expansion will result in about 24% of students having their own iPad. The board has also made a significant financial commitment to TLE and plans to increase total funding from $540,000 in 20115-16 to $990,000 next year, while the CODE grant is projected to decrease slightly from $758,000 to $745,000 year over year.

Based on our findings, we conclude that professional learning must continue to be supported for current and new teachers. There already exists a vibrant informal professional learning community supporting TLE within several of our schools, and so we urge the board to find some means of sustaining and enriching formal professional learning events and policies while, simultaneously, recognizing and energizing small-scale informal professional learning communities among its teachers both within and across schools.

We also offer a number of suggestions for the scaling and further roll out of the TLE initiative. Here, drawing on the work of Fullan and Donnely, we provide empirically-grounded models and strategies for implementing and sustaining large scale system shifts. In particular, one suggestion is to encourage local clusters of schools that can take up ownership of the initiative, circulate its aims and values, and lead implementation. In addition, recommendations regarding E-BEST for retooling its research policies and practices to have a more direct and effective impact are provided.

Teacher level findings: Despite the concerns teachers expressed about their changing role we found evidence that they were, in fact, beginning to promote deep learning opportunities, particularly through inquiry-based methods and innovative uses of iPad technology. Our key findings at this level follow:

- The strongest evidence for IBL implementation in student work was found in the 4th and 5th grade student work samples where teachers integrated the innovative use of multiple digital tools throughout all stages of the inquiry-based learning process, and forged new learning contexts and collaborative partnerships.
- We found encouraging evidence of a shift to formative assessment practices, where teachers are providing feedback and co-developing success criteria with students (in some cases) and using technology tools to support assessment as and for learning.

- Whole-class sharing and peer assessment of student work is being conducted in most classrooms – a key feature of IBL that supports critical reflection on the process of learning.
- We see a need for considerable advancement in certain dimensions of the IBL implementation as currently found in the typical TLE 1:1 classroom. These include providing greater opportunities for student agency in the initial IBL planning processes, and in the refining of inquiry questions and the extending and deepening of related research beyond teacher-created templates; enabling students to create authentic products, and engage real-world problems; and providing real-world audiences for culminating student work.

Student level findings: Teachers reported high levels of student engagement when iPads, especially in conjunction with IBL practices, were integrated into the learning process. The key findings at this level are as follows:

- Student engagement was noted to be higher in general during both IBL and iPad use, and was very robust when students were using iPad tools to learn from or create multimodal artefacts and multimedia documents integrating written text, voiceovers, music, images and/or video. Engagement was similarly strong when students were demonstrating learning through the production of iMovie films and trailers, or when they were creating animations and simulations (Minecraft), or music created with iPad apps. Students gravitated to these kinds of multimedia applications to demonstrate knowledge or design culminating projects.
- Strong student engagement with new media was not limited to high-performing students. The assistive affordances of technology tools and the availability of leveled resources led more students to engage and participate (including special needs students and English-language learners).
- Dynamic collaborative opportunities were facilitated with the iPads (and associated technology tools), supporting group work, knowledge sharing, ad hoc collaboration, and the presentation and showcasing of final works. Students welcomed taking the role of the expert and demonstrated both a capacity and willingness to share knowledge with peers and teachers.
- Teachers reported that students, when working with iPads, were more likely to persist in the face of challenges and demonstrate initiative, displaying greater autonomy and agency in relation to research and learning challenges. However, some students require more scaffolding and support for their self-monitoring and metacognition, and guidance in work planning.

We note, however, that the kinds of significant transformations that TLE is seeking to instantiate do not occur overnight, and challenges are to be expected, particularly in the short term, when 1:1 technology tools and pedagogies like IBL are first being engaged. Their applications can seem counter-intuitive to teachers accustomed to assuming conventional teaching roles and employing traditional teaching practices. That said, we find that a vital TLE culture is emerging in these schools, supported by many enthusiastic principals and teachers who have already taken ownership of TLE, and are beginning to transform teaching and learning in ways that are significantly advancing the program's desired outcomes.

Our recommendations

Professional learning recommendations

- Continue to support teacher development in the pilot schools at the same time as supporting teachers in the schools that newly join the project.
- Provide support for new teachers assigned to TLE schools.

- Create conditions in schools to support a variety of formal and informal professional learning opportunities including coaching, peer mentoring, lesson observation, "lunch and learn," professional learning communities using social media (e.g., Yammer) and other similar kinds of opportunities.
- Address the formative and summative assessment of digital artefacts and presentations more fully in professional learning activities.
- Conduct an annual professional learning needs assessment and plan programming accordingly.
- Develop an FAQ that answers teacher questions on topics such as use of IBL in mathematics, student question formulation, multimedia project assessment, and how IBL relates to and can directly support EQAO preparation to aid in fostering a shared of understanding of IBL and assessment strategies across all TLE schools .
- Produce exemplary demonstration videos of IBL in action, particularly in mathematics, and make them available in the Hub.
- Provide the opportunity for "learning walks" within and across schools participating in TLE to observe teaching and learning strategies and student products

Scaling TLE recommendations

- Make public the plan and rationale for expanding to other schools and grades.
- Provide financial projections on how TLE can become district-wide within a five-year timeframe.
- Seek additional funding above and beyond current levels to make TLE a demonstration initiative that can provide leadership for the province in development of 21st century learning.
- Encourage and provide mechanisms for clusters of schools to share and support each other.
- If home use is reinstated, provide support and training to parents so that they can better monitor and regulate their child's iPad use.
- Host a "celebration of learning" (in families of schools) for students, teachers, and community as an opportunity to showcase teaching and learning strategies and student exemplars.

Hardware, infrastructure, and support recommendations

- Consider supplying keyboards iPads or moving to laptops for intermediate/senior grades.
- Review the policy on students taking home iPads and develop policies based on taking them home being a privilege that is first earned, but can be revoked for misuse.
- Develop a district strategy for educating parents in the value of iPads in their children's education, and the standards of care and rules for use they should apply when their children bring them home.
- Address the network latency issues reported in some schools.
- Provide solutions for classrooms that do not have sufficient outlets for charging iPads.
- Consider giving new teachers and those in new schools the option of receiving iPad kits during their first year rather than a full class set.

TLE evaluation recommendations

- Continue to refine and extend E-BEST research practices to more directly interface with and support professional learning to enable teachers to become active researchers and

collaborators/contributors; encourage teachers to build this into their professional growth plans.
- Collect data from principals, teachers, students, and parents as a program accountability/improvement initiative that does not require informed consent, rather than considering it a research undertaking that does require consent.
- Make public internal analyses or reports on project outcomes to increase accountability.
- Provide references to internal analyses or reports in the annual reporting to the board to increase credibility.

Future Technology Learning Fund (TLF) recommendations

- Develop guidelines and common instruments/protocols for boards to help them conduct internal TLF research and reporting to CODE; in doing so provide boards with a menu of choices from conducting very rudimentary research where resources are limited to more fully fledged undertakings.
- To establish uniformity in methodology for future research supported by the Ministry of Education/CODE, encourage the clear articulation of program theories of action and related logic models.
- Support arms-length evaluations (in collaboration with board research departments) of TLF projects that are reaching the stage of implementation maturity.
- Develop a readily accessible database to share internal board-initiated and CODE-sponsored research on TLF.
- Encourage boards to place teacher education candidates from Ontario faculties of education in TLF schools for their practicum experience to better prepare them for teaching and learning with technology.

This research was supported by the Council of Ontario Directors of Education (CODE), however the opinions expressed are solely those of the authors and not necessarily those of CODE.

Table of Contents

Chapter 1: Introduction

Transforming Learning Everywhere (TLE) is a five-year initiative of the Hamilton-Wentworth District School Board (HWDSB) aimed at developing student knowledge, skills, and characteristics essential to succeed in the 21st century. This report contains a description and analysis of the implementation of TLE during the 2015-16 school year and its impact on teacher practices and student learning and engagement.

The TLE initiative is partially supported by the Ontario Ministry of Education's Technology Learning Fund which was established to help schools realize the vision set out in the Ministry's strategic document *Achieving Excellence: A Renewed Vision for Education in Ontario* (Ontario Ministry of Education, 2014). The vision described in this document calls for the transformation of teaching and learning in ways that will ensure students are prepared for a more competitive, globally connected, and technologically engaged world by providing them with what are seen as essential 21st century learning competencies. TLE is the district school board's action plan for accomplishing this vision.

Launched in the 2014-15 school year, TLE adopted inquiry-based learning –supported by technology – as its primary pedagogical strategy for achieving the desired transformation. Former director John Malloy, in the document *Transforming Learning Everywhere* (2014), committed the board to "creating a personalized, collaborative inquiry based learning environment for each student" (p. 1) that encourages students to ask questions, search for answers, apply their learning in multiple situations, and communicate their learning to others. This was to be accomplished by "changing learning conditions, environments and opportunities, for every student enabled by 1:1 technology" (p. 8). TLE was envisaged not as a technology project but rather as an opportunity to transform pedagogical practices, to invite students to engage in rich learning tasks, and to enable students to drive the learning environment, using technology to leverage these desired outcomes.

Four major beliefs are cited in the same document that provide the underlying rationale for the TLE initiative:

- We envision a personalized, collaborative inquiry-based learning environment where students own their learning and teachers support student learning in many ways.

- We believe that effective instruction improves student achievement and well-being. Effective instruction is situated in today's physical and digital world.

- We believe that educators play a crucial role in creating learning conditions where our students improve their ability to think, create, communicate and enhance their sense of well-being.

- We believe technology accelerates the ability for educators and students to learn deeply and differently, never forgetting that the focus is our students, effective instruction and the learning, not the tools. (p. 5).

The board emphasizes the point that student learning facilitated by digital tools and resources should not be constrained to a once a week session in a computer lab. Additionally, the sharing

of 30 devices across numerous classrooms is not considered to be adequate to support effective pedagogy. Thus a goal of TLE is to put learning devices in the hands of every teacher and student as an effective way to create personalized, collaborative, inquiry-based learning environments. They intend to accomplish this goal by September 2019 subject to continued Board approval.

In sum, the theory of action for TLE put forward by the HWDSB contends that by supporting teachers in transforming teaching and learning through professional development and by providing access to technology and digital resources in widespread use in the broader world, students will become more engaged in their learning, develop critical 21st century learning skills and competences, and enhance their achievement.

Implementation of TLE

The HWDSB has an extensive implementation program for TLE that includes timelines for communication with stakeholders and strategies for monitoring and measuring the success of the *Transforming Learning Everywhere* model in schools. The five-year plan follows the National Implementation Research Network's (2009) five stages of implementation. Each year of the action plan is aligned to a stage of change as follows:

2013-2014 Exploration

2014-2015 Exploration and Installation

2015-2016 Initial Implementation

2016-2017 Partial Implementation

2017-2018 Full Implementation

At the time of writing, HWDSB is completing the Initial Implementation phase. Characteristics of this stage for TLE are awareness building, preparation for change, training, and small scale piloting of strategies resulting in introductory use of the evidence informed strategy. A critical expectation for TLE from 2014-2016 was to increase the awareness and understanding of the vision for senior administration as well as increase the awareness for teachers and other staff. Four projects were the focus of TLE from 2014 - 2016 as part of the initial implementation:

1. **North Digital Project.** This is based in a family of seven elementary schools in the northern area of the district (Adelaide Hoodless, A.M. Cunningham, Cathy Weaver, Dr. Davey, Memorial City, Prince of Wales, and Queen Victoria) referred to as the "7 North" where all students and teachers in grades 4 to 8 have been supplied with their own Apple iPad, software, and support. *The focus of this report is on the North Digital Project.*
2. **Nora Frances Henderson Secondary School Project.** Henderson is a newer school of about 900 students. Students and teachers in this school also received their own iPad.
3. **Mountain Secondary School Project.** Mountain is a smaller school where all students have an Individualized Education Plan. All students and teachers in this school also received their own iPad.
4. **New Pedagogies for Deep Learning Project.** This project involved 24 schools in the western part of the district that are part of an international network of schools focusing on developing students' character, citizenship, collaboration, communication, creativity, and critical thinking (see http://npdl.global).

Research is being carried out by the board to gauge the success of and provide feedback to participants in this initial implementation phase, and to help new projects benefit fully from the experiences of the initial four projects as TLE scales up across the board. Data are being collected by the internal research department, known as E-BEST, annually from a variety of sources including key leaders, teachers, students, and parents. The board is also analyzing spending on these projects and anticipates making changes to implementation as data become available.

Research model

In order to understand whether the TLE program is having the intended impact, and if so, why, how, and to what extent, we developed a logic model for the program shown in Figure 1 on the next page. This logic model was used to guide the research presented in this report. A logic model provides a simple diagrammatic representation of the program's plan of action and highlights its causal structure, indicating the inputs, outputs and intended outcomes (impacts) of the program. Logic models are used to guide program evaluations when one wants to know whether specific actions led to, or caused, particular outcomes of a program rather than simply knowing if certain outcomes were attained. Evaluations based on logic models are typically referred to as program-theory or causal-model evaluations (Petrosino, 2000). Program-theory evaluations can be used to either guide the development of a program (i.e., for formative purposes) or to determine how well a program worked (i.e., for summative purposes); this type of program evaluation does not prescribe a particular methodology—either qualitative, quantitative, or a combination of methodologies may be employed (Rogers, Petrosino, Huebner, & Hacsi, 2000).

The theory of action depicted by the logic model in Figure 1 below shows that TLE in its initial implementation phase is based on the proposition that:

1. Funding from the Technology Learning Fund,
2. Provision of digital hardware and software technology to teachers and students,
3. Technical support and professional development on inquiry-based learning and iPad use, and
4. Evidenced-based feedback

will lead to:

1. Educators seeing the potential of TLE
2. Increased desire by teachers to change their pedagogy
3. Teachers acquiring skills to critically reflect on their pedagogy and how an inquiry approach to learning may be implemented
4. Teachers exhibiting commitment to the basics of TLE by employing iPads in the classroom and experimenting with inquiry-based learning
5. Students becoming increasingly engaged in their learning.

Similarly, the medium and long term outcomes are expected as the project becomes fully implemented by 2018-19 and beyond as depicted in the figure in the rightmost two columns.

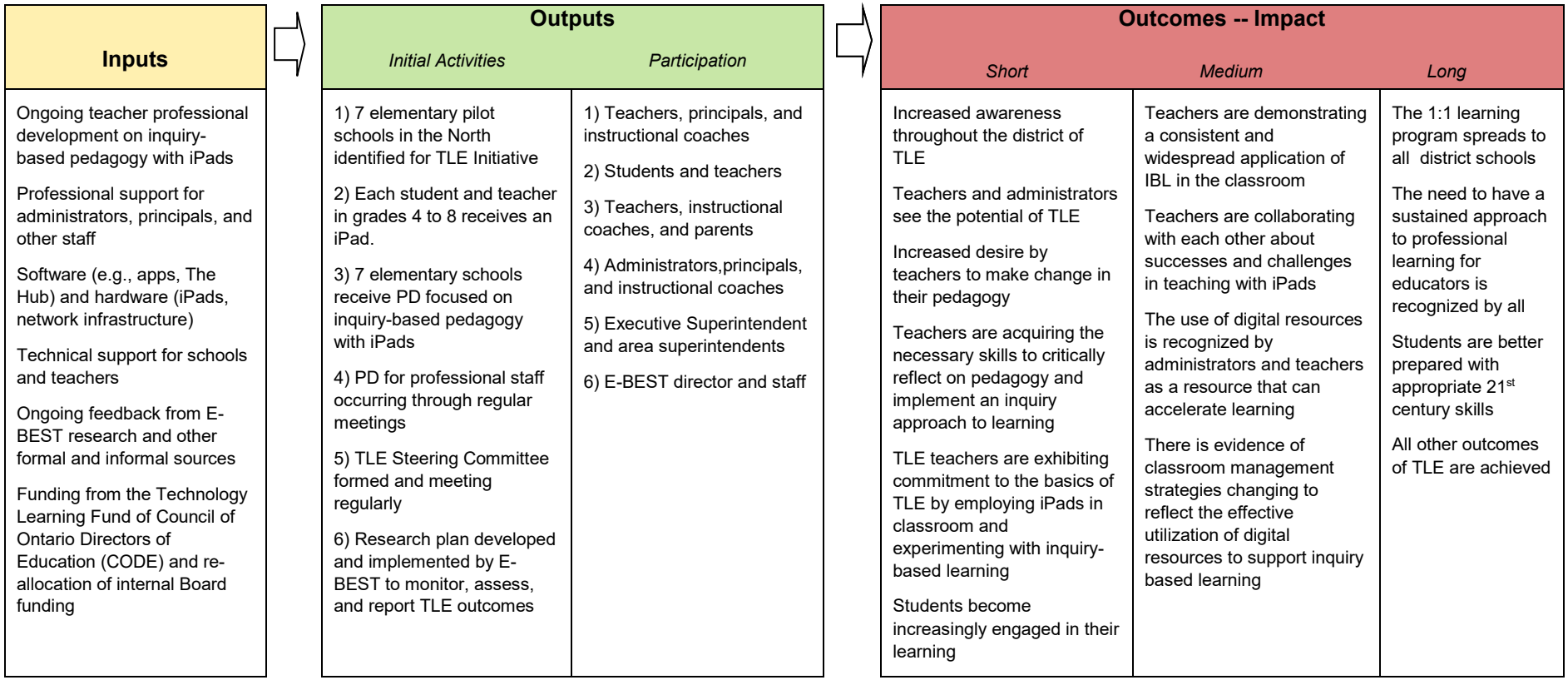
Because TLE is only at the initial implementation phase, we will be investigating the causal link between the four general categories of inputs and the short term outcomes as mediated by the output activities carried out by participants listed in the figure. The short term outcomes deal with matters related to the board, teachers, and students. Therefore, our research questions given below are formulated around these three actors.

Research questions

At the board level we chose to focus on policies and plans developed to implement TLE and what practices have been put into place to bring about transformation and to scale it up across the board. At the teacher level, we investigated to what extent have teachers have shifted roles toward becoming facilitators of students taking more responsibility for their learning, and how teachers are promoting deep learning, in particular through inquiry-based methods. Also of interest was the nature of both the informal and formal professional learning occurring and what impact this is having on classroom practice and student learning. At the student level we wanted to understand what kinds of learning tasks were occurring and what role the 1-to-1 technology played in supporting these tasks. Moreover, we sought to find out what measures are being used to assess student learning and what evidence is there of transformed learning environments, engagement, and achievement.

As mentioned above our research will be limited to the 7 North Elementary pilot schools where TLE was in the second year of rollout in grades 4 to 8 as resources were not available to include the other three TLE pilot projects in this study. Before describing the methodology used for this research, we first provide a short review of the theoretical context in which TLE is situated.

Figure 1: TLE Program Logic Model for Elementary Schools



Assumptions underlying the TLE model:

1) With appropriate supports, teachers are willing to change their pedagogy to align with the district's TLE vision.

2) The financial commitment will be there to fund the purchase of digital resources to expand the TLE program.

3) There will be the support needed from all stakeholders to expand the TLE program.

4) The district will provide the necessary professional learning to support teachers with pedagogical change and the inquiry based learning approach.

External Factors impacting TLE implemention:

1) Labour issues can disrupt plans.

2) Providing equity of opportunity – determining what schools come on board next with a 1:1 approach.

3) Competing fiscal needs (building repairs, new schools etc.

4) Any potential Ministry of Education reduction in TLF funding.

Chapter 2: Situating TLE in Context of Literature

A fundamental tenet of *Transforming Learning Everywhere* is that inquiry-based learning (IBL), supported by one-to-one technology, is the most appropriate pedagogical approach to support students' development of 21st century skills and competences. Therefore, in this section, we provide a brief overview of the literature that supports this position, beginning with a discussion of inquiry-based learning (IBL) with an emphasis on the Ontario context, followed by an overview of one-to-one technology research.

What is inquiry-based learning?

IBL places curiosity, critical thinking, and student action at the centre of educational experience. Students are presented with a provocation or challenge by the teacher and are solicited to wonder, notice, describe and ask. In doing so, teachers create dynamic contexts for stimulating intellectual curiosity, and students in turn are invited to develop and refine research questions and, with the guidance of the teacher, connect their own questions, interests, and ideas to the 'big ideas' of the curriculum. Inquiry is anchored in meaningful contexts where student learning is linked to vital issues, bound up with their own interests, and connected to 'big ideas' in the curriculum and the surrounding social world.

Through the inquiry process, students develop hypotheses and refine research questions (through a recursive process of inquiry, sharing, and dialogue) and make increasingly sophisticated predictions with regard to knowledge-building, scientific inquiry, and project design (Pedaste, Mäeots, Siiman, De Jong, Van Riesen, Kamp, & Tsourlidaki, 2015; Fullan & Langworthy, 2014; Ontario Ministry of Education, 2013, Capacity Building Series Nos. #13, #24).

In IBL, increasingly sophisticated research practices are supported and modeled by teachers, where students gather information from a variety of first-hand resources, critically interweaving new information and knowledge with previously acquired knowledge. IBL applies and integrates 'higher-order' thinking capacities as students perceive patterns, describe and classify, plan and test hypotheses, imagine solutions and narrate stories, and refine inquiry-based conclusions (which may be then challenged by other students, teachers or visiting experts, by way of classroom dialogue and/or formative assessment interventions) (Ontario Ministry of Education, 2013, Capacity Building Series; Fullan & Langworthy, 2014).

During the inquiry process, teachers guide learning with modeling and formative assessments, and frequent classroom dialogue plays a key role in critically evaluating student progress as students teach one another (establishing a rich and reciprocal community of learners). Teachers may intervene with 'just-in-time' direct instruction of skills and background knowledge, so as to renew attention and build momentum, while helping students negotiate obstacles, new terminologies, and domain-specific discourses (Gee, 2004; Ontario Ministry of Education, 2103, Capacity Building Series). At the same time, students may also be involved in developing assessment criteria for their own individual and/or collaborative project work, giving them agency to reflect upon their own learning, and to monitor progress and critically anticipate possible learning outcomes and achievements where excellence can be demonstrated.

IBL methods frequently culminate in substantial projects or dynamic applications of learning. In the IBL model presented by the province (Ontario Ministry of Education, 2013, Capacity Building Series) students may pursue collaborative projects, present and celebrate their

research and/or creative artifacts, and communicate their research findings and creations to peers, teachers and, in some cases, local communities and the outside world (through classroom websites, blogs, social media, community events and conferences, or other forms of social engagement) (Fullan & Langworthy, 2014).

Integral to the recursive nature of the inquiry-learning process, students may then pose new, more sophisticated research questions for investigation, apply or transfer their knowledge to new situations and challenges, or identify wider avenues for social action, agency, and cultural participation. However, no single IBL process is complete until students critically reflect upon what they have done or created, how they have learned, and where the inquiry process itself might be refined and transferred to the next challenge or iteration of inquiry. This reflective element of IBL supports metacognitive capacities, enabling students to both learn deeply and, simultaneously, understand how they learn best (Pedaste, et al., 2015; Bruce & Casey, 2012; Ontario Ministry of Education, 2103, Capacity Building Series).

Empirical rationale for IBL

Over the past decades, educational research has consistently shown active, inquiry-based learning to be more effective than "traditional" instructional approaches, specifically when students are supported with appropriate modeling, scaffolding, and ongoing formative feedback (Lazonder & Harmsen, 2016; Friesen, Scott, Snyder, Mourshed, & Chijioke, 2013; Furtak, Seidel, Iverson, & Briggs, 2012; Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014; Prince & Felder, 2006). Formal research on inquiry-based learning has a long history, going back to the 1960s, with early research syntheses indicating advantages of IBL over expository teaching and more direct (lecture-based) forms of instruction (Bittinger, 1968; Hermann, 1969). Meta-analyses performed in the 1980s continued to indicate advantages of IBL approaches in the sciences (Lazonder & Harmsen, 2016) and, in the mid-1990s, the National Research Council (NRC) established IBL as a pedagogical cornerstone of science education in the United States (NRC, 1996).

In direct response to this National Research Council policy directive, Furtak et al. (2012) conducted a meta-analysis to identify "gold standard" IBL studies appearing in the wake of the NRC's revised National Science Education Standards. While the reviewed literature suggested that inquiry-based learning can be more effective than direct instruction, the results were limited in generalizability due to the small number of studies included. In their own meta-analysis of 72 IBL studies, Lazonder & Harmsen (2016) assert that there is convincing evidence that inquiry-based methods can be more effective than expository methods of traditional instruction (where exposition is typically characterized by teacher explication of predetermined bodies of content and predefined knowledge). However, in clarifying the opportunities and achievement benefits of IBL, recent meta-analyses underscore the importance of guidance and modeling to maximize the impact of IBL pedagogies (Furtak et al., 2012; Lazonder & Harmsen, 2016; Friesen et al., 2013).

Building upon this view of IBL, a recent review of literature by Friesen and Scott (2013) concludes that inquiry-based approaches to learning "positively impact students' ability to understand core concepts and procedures" (p. 25). Self-directed inquiry-based learning, where students are authentically situated at the centre of intellectual and creative processes, is also seen to ignite student interest, deepen critical and imaginative engagement, and support student agency and self-efficacy (Friesen & Scott, 2013; Ryan & Deci, 2000; Ketelhut & Dede, 2006; Dede, 2014; Ontario Ministry of Education, 2103; Egan, 2010; Fullan & Langworthy, 2014). Friesen et

al., (2013) further report that approaches to inquiry learning that integrate interactive instruction and modeling, authentic technologies and intellectual work, real-world role-taking in research and creative practices, and ongoing formative assessment can dramatically improve academic achievement.

IBL and new technologies

In considering the acquisition of 21st century literacies, Richardson (2013) and Christensen, Horn, & Johnson (2008) forcefully reject the view that simply integrating new technologies into schools in order enhance traditional instructional practices will transform learning in significant ways, or address the rapidly changing literacy needs of students. Chris Dede (2014) and Fullan and Langworthy (2104) similarly argue that 21st century educational transformation is not simply a matter of technology, it is also a pedagogical challenge, and that "technology used without powerful teaching strategies (and deep learning tasks) does not get us very far" (p. 30).

According to Dede (2014) and Fullan and Langworthy (2014), IBL can dynamically connect with new media to significantly redefine and transform educational purposes and practices. As Fullan and Langworthy (2014) state:

> Technology, strategically integrated with the other core components of the new pedagogies, unleashes deep learning. When pedagogy and deep learning capacities are clearly defined and developed, digital tools and resources enable the: 1) discovery and mastery of new content knowledge; 2) collaborative, connected learning; 3) low-cost creation and iteration of new knowledge; 4) use of new knowledge with authentic audiences for "real" purposes; and 5) enhancement of teachers' ability to put students in control of the learning process, accelerating learner autonomy. (p. 33)

Here, the conjunction of new media and new pedagogies is seen to support not only deep learning, but students' mastery of the very processes of learning itself, ultimately abetting the transfer of those processes to meet the workplace demands that students will face in their future lives, outside of schools. At the same time, conjoining innovative pedagogies with technologies directly links learning with current media tools and informal learning opportunities found outside of schools, in still-emerging networked spaces where students may already be engaged in creative media practices (Ito, Gutiérrez, Livingstone, Penuel, Rhodes, & Salen, 2012). What is more, all of the researchers cited above suggest that these transformed pedagogical and technology practices might address one of the most pressing challenges confronting education in the 21st century: the problem of student disengagement.

One-to-one technologies

Research on one-to-one technology use in schools – whether desktop computer, laptop, tablet or iPad – tends to focus on technology as a "treatment," and little detail is given in most studies on how the technology is actually used by students and teachers and why or how particular results were attained. Nevertheless, the literature is instructive in a broader sense to help our understanding of what to expect when students have access to their own devices throughout the school day.

The two senior authors of this report conducted pioneering research some 20 years ago on the impact of laptops on student writing at an Ontario school where each student had their own device. In this longitudinal study, Owston and Wideman (1997) followed the development of several writing competences in a class of students as they progressed from grade 3 to the end of grade 6. Compared to a class in a nearby school (in a higher income neighbourhood) which was

only equipped with a small set of desktop computers in their room, the 1:1 laptop-using students significantly surpassed their peers in mechanics, paragraphing, and overall writing fluency by the end of grade 6 (after starting out somewhat lower in writing competency).

At the beginning of Owston and Wideman's study (in the 1993-94 school year), very few schools were experimenting with one-to-one technology, primarily because of the cost of the devices; moreover, very few studies had, or were being conducted at the time. As costs decreased and Internet access became more common, more schools began implementing one-to-one programs and more studies were undertaken. Several US states implemented laptop programs, the largest of which was the Maine Learning Technology Initiative (Maine, 2016), and the One Laptop Per Child initiative (http://one.laptop.org/) endeavored to provide ubiquitous access to low cost devices to schools in developing countries. The New South Wales Department of Education and Training (2009) carried out a review of the impact of one-to-one computing that synthesized findings of studies carried out in the early to mid 2000s. Three major findings emerged from this review: First was that there is "*potential* [this author's emphasis] for a transformation of the learning environment to improve student learning outcomes" (p. 19). Among the potential student benefits were improved writing quality, increased engagement in learning, more collaborative work, and greater project-based learning. Second, it was found that successful implementation takes time and effort as teachers transform their teaching practices to adapt to the new learning environments. Third, it was reported that that the integration of new technologies into the curriculum cannot be guaranteed by merely equipping classrooms with devices: ongoing professional learning and supportive leadership are essential.

Findings from the most recent synthesis of one-to-one technology by Zheng, Warschauer, Lin, & Chang (2016) support the New South Wales findings but add more specific detail with respect to learning benefits. The authors conducted a meta-analysis of ten studies carried out between 2001 and 2015 and found statistically significant, yet small, effects of laptops on student achievement in English, writing, mathematics, and science. The effect of laptops on reading, the fifth subject area analyzed, was not significant. The authors also analyzed a larger pool of 96 studies for evidence of the effect of laptops on development of essential skills as defined by the Partnership for 21st Century (P21, 2010): Learning and Innovation, Information, Media and Technology, and Life and Career. They found that evidence was weak overall for 21st century skill development, although slightly stronger for the first two areas.

Although iPads differ from laptops in their technical features, software available, ease of use, and cost, we have not located any empirical research evidence suggesting that outcomes of student learning with iPads in one-to-one settings, measured using traditional classroom assessment tools, differs significantly from laptop outcomes. Typically, studies of iPad usage in K12 classrooms report greater student motivation, interest, and engagement, as well as the perception by teachers that students are learning more effectively than without one-to-one technology (e.g., Burden, Hopkins, Male, Martin & Trala, 2012; Beauchamp & Hillier, 2014); these findings are similar to the one-to-one laptop studies cited above.

Conclusions about context

Based on the literature reviewed above, TLE appears to be based on a theoretically sound rationale, supported by empirical research studies as well as diverse and increasingly pervasive theories and policy frameworks. IBL, if implemented in ways that are faithful to the principles cited in the literature, can enhance and/or transform learning experiences for students (whether or not technology is factored into the equation). However, coupling IBL with

networked, one-to-one iPad usage increases the likelihood of improving student engagement and the development of 21st century literacies, skills, and competences. Nevertheless, the desired outcomes of TLE are unlikely to be attained unless the TLE initiative is implemented in ways that result in significant transformations in pedagogical practices: that is, practices facilitated by innovative one-to-one technology use that move beyond traditional teaching methods to support self-directed student inquiry and deep learning (Fullan & Langworthy, 2014; Dede, 2014). Teachers will not be able to enact these changes merely by equipping their students with iPads and duplicating traditional practices in digital formats. Here, educators must be supported with appropriate professional learning opportunities to model and help them understand how they can introduce IBL and new digital media into their classrooms. At the same time, teachers must be supported by school board policies and forms effective leadership that can encourage teachers to enact the changes called for in the TLE proposal.

In the next chapter, we report on the methodology employed in this study to understand how HWDSB has implemented TLE and the impact that the program is having on students and teachers.

Chapter 3: Research Methods

Introduction

In our choice of research methods, we were guided by the key principals and objectives of case study research. This approach to inquiry addresses both descriptive and explanatory questions, and the rich data it generates makes possible a detailed, nuanced, and well-contextualized understanding of how and why a program works in a particular setting (Yin, 2006). In the present study it has been used to illuminate the relationships between the TLE initiative's inputs, intermediate and mediating outputs, and program outcomes as expressed in the program's logic model. Our evaluation procedures and data sources were chosen to provide the data needed to assess the degree of alignment of the "espoused" theory of action of TLE with the "theory-in-use" – what actually happened in the school district and the classroom (Patton, 1990).

School sites studied

The seven schools selected for study were each in their second full year of providing one iPad to every student in grades four through eight, and were part of the initial pilot for TLE. This sampling made it possible for us to study those school sites where the TLE program was most fully implemented to date both in terms of technology adoption and uptake of IBL, giving us the best available window on the intermediate-term impacts and outcomes of the initiative. Our inclusion of all of the elementary school sites at this stage of TLE implementation as sub-cases ensures that our evaluation findings are not unduly biased by the unique or idiosyncratic experiences of any particular site or sites, and allowed us to uncover commonalities in process and impact across all of these schools.

Table 1 below shows some of the key social, socioeconomic, and educational characteristics of the families living in the catchment areas of the seven schools.

Table 1: Family characteristics in studied school catchment areas

Variable	Description	Average across 7 schools	Range across 7 schools
1. Median Income	Median household income in dollars	$44,792.66	$34,015.07 to $61,930.18
2. Unemployment	Unemployment rate (percentage)	14%	10% to 20%
3. Lone Parent Families	Percentage of families that are led by a single parent	45%	35% to 50%
4. Mother Tongue other than English/French	Percentage of individuals with no knowledge of English/French	3%	1% to 7%
5. Recent Immigration (2012-2015)	Percentage of population that has recently immigrated (2012-2015)	1%	0% to 2%
6. Home Ownership (Renters)	Percentage of rented dwellings	46%	21% to 76%
7. Low Education	Percentage of household Population 25 to 64 Years with no certificate, diploma, or degree	24%	15% to 38%
8. Low Income	Percentage of households that have an annual income of less than $30,000	35%	21% to 46%

These socioeconomic attributes show many, but not all of the defining characteristics common to inner-city schools in large metropolitan areas: low average incomes, a high percentage of single-parent families, high unemployment levels, a high proportion of residents with low educational levels, and relatively low home ownership rates. Relative to similar catchment areas in a city like Toronto, however, the neighborhoods appear to have a very low percentage of recent immigrants.

Data sources and research procedures

Our data collection methods and sources were chosen to provide converging lines of evidence that "triangulate" in order to make our findings as robust as possible (Patton, 1990). The major sources of data were teacher and key informant interviews, student focus groups, teacher and student surveys, publicly-available policy and planning documents, and student work products and artefacts. As discussed earlier, our data collection was integrated with that undertaken by the school district as part of their own ongoing research and monitoring of TLE as well as learning and teaching in the district, and this had a significant impact on the extent and types of data we were able to collect. Data were collected during the second half of the school year. The data collection sources and methods we used, and any effects of that collaboration on our procedures are discussed by category below. The chapter ends with a discussion of a few additional data sources we had intended to employ, but were unable to utilize, and a consideration of the impact of this on the reliability of our findings.

Teachers

Fourteen teachers from six of the seven schools were interviewed on site (in a few instances the teachers were interviewed in pairs, in accord with their wishes). (One school, the sole junior elementary site extending up only as far as grade 6, chose not to participate in the interviews.) The teachers interviewed were selected randomly using a stratified sampling procedure to ensure that two teachers from each of the five grades (grades 4-8) were part of the sample. The two remaining teachers interviewed had no specific grade teaching responsibilities: a special education teacher who worked in other teachers' classrooms and also withdrew students for special instruction; and a TLE champion/resource teacher who collaborated with and coached other teachers around IBL and iPad applications to teaching, and provided digital citizenship and research skills instruction. All but two of the teachers were in their second full year of being in classrooms with a complete set of iPads; and all but two had been teaching for seven or more years. Nearly all had spent half or more of their teaching careers at current school.

The open-ended, structured interviews, which were recorded and later transcribed, probed all aspects of these teachers' use of IBL pedagogy through the phases students' inquiry work, from project initiation to student presentations and summative evaluations. They also addressed teachers' observations of students' work practices in inquiry learning, and its impacts of student engagement, persistence, knowledge building, and 21st century skills development. Teachers' perspectives on the role, value, and affordances of iPad technology in IBL and other forms of learning, how iPads were employed in their classrooms, and their effect on student learning practices, 21st century skills development, and learning outcomes were also examined in depth. Teachers were also asked about if and how IBL and 1:1 technology infusion had augmented or transformed their pedagogical practices and professional growth. Perceptions of the educational advantages and the limitations of IBL and iPad integration were taken up, and their professional learning experiences supporting TLE goals explored.

Additional data about teacher attitudes and perspectives on IBL and iPad integration and related professional development were gathered from the 2016 version of the online survey of teachers the school district conducts on an annual basis. Only the data from the 39 respondents teaching in 1:1 classrooms in grades 4-8 in the seven schools studied were considered. The survey questions largely consisted of Likert-scaled items, with a few having open-ended answer options. (We had initially planned to conduct our own teacher survey but this was not permitted by the school board. We were allowed to submit additional questions for the district survey, and a few of those were accepted. These addressed teacher attitudes about having iPads in their classrooms; the learning purposes and formats digital tools were applied to; and professional development activities and opportunities and support for iPad use.)

Key Informants

While we were not permitted to conduct our own interviews of TLE program leaders and district and school administrators about TLE (with one exception), a few additional questions we proposed were added to the protocol for an annual interview conducted by district researchers of those deemed "key informants" on the TLE program. The five key informants interviewed included three principals from the seven schools, a senior consultant responsible for TLE implementation, and the superintendent responsible for the family of schools which included our seven sites. These open-ended semi-structured interviews were provided to us in anonymized form and we had them transcribed. The key informants were asked what they considered to be the major successes and challenges of TLE over the past year; their understanding of the theory of action for TLE; changes seen in instructional practices; strategies

used by teachers to integrate technology into their classrooms; changes in student practices, skills, and norms; and the nature and extent of professional learning activities and capacity building over the year. In order to obtain more details on the specifics of the TLE action plan and implementation policies and process, an additional telephone interview of the executive superintendent with overall responsibility for the TLE was conducted by two evaluation team members. This interview was also recorded and transcribed.

Students

A total of 44 students from 11 grade 4-8 classes in six of the schools participated in the late spring of 2016 in focus groups consisting of four classmates. While the selection of participants from the pool of available students in a class was random, that pool was usually very small due to a low rate of return of the compound permission forms the district sent to parents[1]. In these focus groups students were asked to describe the nature and extent of their experiences with inquiry learning, the various ways they used iPads in their learning, and their attitudes and opinions about both of these facets of the TLE program.

Relevant data from the district's annual online student survey that was administered in late spring 2016 was also utilized. Items were primarily Likert scaled, although a few short-answer questions were also asked (about the most frequently used iPad apps). Here again some of the additional questions the evaluation team submitted for the survey were accepted by the district's research department, specifically a set probing student attitudes and opinions about iPad use in the classroom, and another tapping the frequency with which iPads were used for various learning tasks. Because the granting of parental consent to participate was very limited, only 179 grade 4-8 students from the seven schools answered the survey, with between 30 and 40 students responding at each grade level except at grade 4, where 57 answered. The distribution of respondents across schools was fairly uneven, extending from a low of 15 at one school to a high of 58 at another.

Student work samples collected from the classes of the teachers interviewed were subject to both a narrative and a holistic rating analysis. These were obtained at the end of the school year; teachers were asked to submit samples of long-term (i.e., longer than one week) student inquiry work products or learning demonstrations such as a presentation or other artefact. Once again the low parental permission return rate constrained the number of student work samples that were collected. Samples taken from different IBL projects were subject to analysis to determine if, how, and to what extent the student work samples provided evidence of effective IBL, and to what extent the affordances of technology and 1:1 iPad distribution were effective in supporting student learning and/or the acquisition of 21st century literacy and communications competences. This analysis had two components, the first comprising a qualitative assessment of nine work samples from different inquiry projects using criteria derived primarily from Ontario Ministry of Education documents on IBL, and the second a holistic analysis of three sample sets from three of the seven schools. For the latter, a holistic student work rating scale developed by SRI international was used by a pair of trained teacher raters to assess documentary evidence of 21st century learning on four dimensions: knowledge construction, applied ICT use, real-world problem solving and innovation, and communication skills. More

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[1] This form sought parental permission for a range of student activities including focus group participation, the collection of student project work by our evaluation team, and the undertaking of the district's annual student survey and online 21st century learning skills assessment.

detailed descriptions of the student work analysis procedures and SRI International rating scale can be found in chapter 7 of this report.

Planned additional data sources

There were three additional data collection strategies sources we had planned to employ to further our understanding of the TLE implementation and its effects on teaching and learning that the school board would not allow us to utilize. We had hoped to conduct an extensive interview with each of the school principals in order to gather data needed for a thorough analysis of the role of school leadership in the TLE implementation and its impact on program success. We also intended to pursue systematic classroom observations in a sample of the classes whose teachers were interviewed, using a well-researched observational protocol developed by SRI International to directly assess (1) teacher roles in the classroom, (2) the pedagogical strategies teachers used (including instances of IBL), (3) student knowledge building, collaboration, and self-regulation, and (4) technology integration into teaching and learning. Finally, we wanted to collect all assigned learning activities over a two week period from a sample of our teacher population and utilize a third SRI International rubric to assess the extent to which each activity required students to demonstrate five different dimensions of 21st century learning in their work: (1) collaboration, (2) knowledge building, (3) use of technology for learning, (4) problem-solving and innovation, and (5) self-regulation.

The lack of these additional data, particularly the direct classroom observations, weakened the rigour of our research by making our analyses more reliant on reports about classroom practices and student learning impacts from teachers, key informants, and students that were not independently and directly corroborated. Self-reported data are prone to distortion by the *self-presentation bias* of respondents who either consciously or unconsciously shade their responses to present themselves in what they construe others will perceive to be a more favorable light. However by incorporating the analysis of student works in our design, our evaluation does provide some check on this form of bias. And it is worth noting here that research on the reliability of different forms of teacher and student self-reporting suggests that when undertaken under the right conditions and where it addresses specific behaviours it can be trustworthy. In a review of this literature, Desimone concludes that "when teachers are reporting on concrete professional development and teaching behaviors and activities, observations and surveys can elicit much the same information", provided the data are understood by respondents to be confidential and not linked to the teacher's own evaluation—as was the case in the present study (Desimone, 2009, p. 189). Extensive research on student self-reports also suggests that students are accurate and credible reporters of their educational experiences when the questions asked refer to recent activities, are clear and unambiguous, and respondents think the question merits a serious response and their privacy is not violated (Kuh, 2001).

We now turn to the presentation of the findings of our research, beginning with an analysis of how TLE was implemented.

Chapter 4: Putting TLE into Practice: A View from Outside the Classroom

In this chapter, we present our findings on how HWDSB has mobilized resources and strategically acted, administratively and organizationally, to put TLE into practice, and to implement key TLE aims. Our overarching research question was: What policies and plans were developed to implement TLE and what supports have been put in place to facilitate transformation, and to scale TLE up across the board? To examine this question, we will consider what strategic moves have been or are being made within the board (outside of the classroom) to support teachers and students (inside the classroom) at the level of organizational support (e.g, the provision of professional development, technology infrastructure, administrative leadership). Subsequent chapters contain our findings on what is happening inside the classroom, such as the adoption of IBL and innovative uses of one-to-one technology, and the effects these changes may have had on teacher practice and student learning.

The logic model given in Figure 1, which is based on the board's theory of action, points to six categories of inputs needed to ensure that TLE rolls out to meet the stated goals. These relate to (1) professional support for teachers, (2) professional support for administrators, (3) digital hardware and software for classrooms, (4) technical support for schools and teachers, (5) evidenced-based feedback on implementation, and (6) funding from the board and CODE. In addition, the figure shows a series of outputs that describe the activities that have taken place by specific actors. The inputs, together with the outputs, provide a high level overview of how TLE is being implemented and what short, medium, and long term goals are anticipated. The inputs and outputs correspond closely to the three categories of drivers proposed by the National Implementation Research Network (Fixsen, Blase, Naoom & Duda, 2015) to assess whether a program is implemented in the way it is intended to be implemented – competency, organization, and leadership. These three categories of drivers provide a clear and expedient means to organize our findings. For each respective driver we will provide a definition, describe the board plans and policies, and summarize the feedback we received from various participants. We begin with the competency drivers.

Competency drivers

The competency drivers are comprised of the "activities to develop, improve, and sustain educator and administrator ability to put programs and innovations into practice, so students benefit" (Fixsen et al., 2015). The competency drivers for TEL consist of the formal and informal professional learning opportunities and support given to teachers and administrators and coaches.

Teacher professional learning

Changing teacher practice is fundamental to the successful implementation of TLE. As articulated in the TLE aims, teachers need to fully understand and be fluent with inquiry-based learning pedagogies supported by one-to-one technology. The board's focus in 2015-16 has been on supporting a variety of professional learning opportunities to meet the unique needs of schools and teachers. The professional learning may have occurred in any one or combination of settings or networks: collegial collaborative learning with Instructional coaches; board-wide PA day events; school-organized professional learning activities; "lunch-and-learn" sessions; formal

or informal collaboration with external partners; and/or discussions at staff meetings and other knowledge-sharing opportunities. The board's planning clearly recognizes the basic principles of contemporary literature on professional learning: that ongoing professional learning both improves teachers' practice and students' learning outcomes. Wei, Darling-Hammond, Andree, Richardson, and Orphanos (2009, p. 9-11) summarize these, stating that professional learning should:

- Be intensive, ongoing, and connected to practice.
- Focus on student learning and address the teaching of specific curriculum content.
- Align with school improvement priorities and goals.
- Build strong working relationships among teachers.

They add that two strategies, both of which are used by HWDSB—coaching and mentoring—are "promising strategies" and can be "justified on common-sense grounds," but there is not solid research evidence available on their effectiveness or the conditions under which they may work best (p. 12).

When interviewing teachers, we inquired about the various formal supports and opportunities they may have had for professional learning. With respect to IBL, the consensus was that there was little, if any, formal training on IBL, and that most of the professional learning took place in prior years, or through less formal and/or collegial means. There appears to be a need for more formal, board-organized sessions, as one teacher said: "I requested, I said, 'Please, can we do something for inquiry learning'; nothing was being done this year.... I feel like there has been less of a focus on it, than there has been on math." This is not to say that no professional learning on IBL occurred. Teachers reported other kinds of PD opportunities, such as at staff meetings and/or through informal collaboration among peers. As a teacher stated:

> At every official staff meeting there is always a section – think about this when doing inquiry, think about that when doing inquiry, try this, try that, try having the students lead the discussion. There's always some pool of examples. Or staff will bring something that they've done in their class. Let's try this, this is what we did in grade 1, this is what we're doing in grade 8.

Others talked about picking up ideas at Ed Camp on PA days, particularly with regard to sharing and utilizing new apps. Book study was another opportunity available at one school that was discussed in the interviews: "We come together once a week to discuss a chapter and just have an open conversation about what we think about it and how we think it would apply to our classrooms or not", one teacher stated. Common prep periods were seen by some as very valuable learning opportunities as well.

With respect to formal iPad training, again, the consensus was that there was not much offered during the present school year in terms of formally-organized professional development. Nonetheless, one teacher reported that there was a valuable opportunity to learn more about iPad use by visiting another school on a PA day, and another talked about the value of just sitting down with colleagues to share ideas informally. Attending the Rewired Conference (a school district event) proved valuable for another teacher who found it useful to hear others present concrete examples of how iPads are being used by colleagues. The Digital Media through the Arts sessions, organized by the board and demonstrating the applied use of the iPad, was lauded by two teachers. Said one of these teachers:

> [The program] gets you thinking about how to engage the kids in your subject matter but through an arts umbrella and it could be anything, music drama and dance, anything. And it's fantastic, it's amazing. Because as much as I don't have a musical bone in my body but I've got a classroom of little musicians and they're the ones who are going to really, really enjoy building through that.

None of the teachers we interviewed seemed very enthusiastic about using Yammer, the board's social media tool, for learning, though some teachers indicated they used Twitter to network informally, or used social media to showcase student works. A few said they have subscribed to Yammer discussion groups and, on occasion, read them, but none actively contributed posts.

There was one topic related to professional learning on which all of the teachers interviewed agreed: their administrators were "very supportive" of TLE. Many described how their principals and vice-principals provided them time to share pedagogical ideas and practices with fellow teachers in the school, met with teachers to sort out issues, responded immediately to their requests for assistance, supported risk taking in their teaching, were actively engaged in their professional learning throughout the year, or simply inspired them to do their best. Indeed, in the teacher survey 90% indicated that they either agreed or strongly agreed that their school supports IBL. A quote from one teacher aptly sums up the supportive climate:

> In just letting us do what we have to do, like what we think is best for the kids, because [the principal] is all about what's best for kids. So [the principal] trusts that what you're doing is in the best interests of all the kids you're teaching, so I feel very supported.

Support from administrators is vital for an innovation to succeed. One of the authors of this report found in a study of 59 technology-using schools around the world that supportive leadership was a distinguishing feature of the most innovative schools and an essential factor if the innovative practices are to be sustained (Owston, 2007). However, the positive climate reported by teachers as being so supportive of TLE in schools could be further enhanced, as evidenced in the interviews, by more formal professional development and training/sharing sessions focusing directly on IBL and dynamic/effective iPad uses to further TLE goals.

Support for administrators and other professional staff

Not only did the board have plans for teacher professional learning, they actively planned to support administrators, consultants, and coaches professionally. The main goal of the professional support in 2015-16, according to the board's plan, was to promote understanding of IBL and the changing role of teachers to becoming facilitators of learning. The board also wanted these administrators and staff to understand how teachers can develop rich learning tasks and how they can support higher order thinking, problem solving, and critical literacies.

Capacity building of professional staff is managed by the board's department called Leadership and Learning which is made up of system principals and managers and directed by an executive superintendent. This department oversees and supports a variety of program consultants, including 21st century learning consultants. Leadership and Learning also has responsibilities for the professional support of instructional coaches who spend time directly in classrooms and with small learning teams in schools.

Monthly organizational leadership meetings are held for administrators. These meetings typically have a TLE component where administrators are able to discuss and learn about various aspects of TLE. At these meetings, principals and vice-principals will often be organized into large or small groups for professional learning. There are also administrator meetings

within families of schools which provide other opportunities for professional learning. For example, at the final meeting of this school year, each family of schools held conversational roundtables where administrators had an opportunity to express their feedback both verbally and in writing about central questions relating to TLE, e.g., *What have you seen in terms of changes in student and teacher engagement in your school? What does TLE mean to you? What are your recommendations for next steps for next year? How exactly is the technology being used in your school and what technology is being used in your school and for what purpose?* At a prior meeting there was a carousel type of session where consultants and other experts ran sessions for smaller groups and principals rotated through, focusing on questions like: *What does problem solving look like in the classroom at elementary and secondary levels, what does higher order thinking look like and what are the practices and strategies to achieve that, and what is critical literacy?* There have also been sessions on inquiry-based learning. We were told by an executive superintendent during an interview that the focus for administrators is typically on their role in recognizing and showcasing innovative pedagogies; and how they can coach and ask the questions that will encourage this type of learning in classrooms. Even when the topic of a meeting is not TLE, TLE is still a lens for viewing the topic. For example, at a meeting on positive climate, mental health and well-being, TEL was used as a lens for ensuring that these topics were not treated in isolation. Lastly, open professional learning sessions were occasionally held where any administrator could sign up. In response to requests from principals, the board plans to have more regular small group meetings where principals can network with their colleagues and share successes, challenges, and raise questions and concerns.

Similar to the administrators, the consultants meet as a group once a month. They begin the meetings as a large group for half a day and then they break up into their smaller groups for a more intensive sharing of evidence of "what they're doing and what is working". They also meet in family of schools teams with their superintendents approximately once a month, but with the exact schedule depending upon what the superintendents feel is needed.

Our research team did not receive any direct feedback from administrators, coaches, or consultants on how effectively they felt they were professionally supported by the board. This is because E-BEST selected interviewees and planned and conducted their interviews, and no questions were asked directly about this topic. We can surmise from the positive comments from teachers about the professional support they have been receiving that, on the whole, administrators, coaches, and consultants are working effectively with teachers to change classroom practice.

Organization drivers

National Implementation Network (Fixsen et al., 2015) defines organization drivers as "the organizational, administrative and systems components that are necessary to create hospitable community, school, district, and state environments for new ways of work for teachers and school staff." In this subsection we will discuss TLE's technological systems and supports, E-BEST's role in TLE, and provide a brief outline of the fiscal support of TLE.

Technological systems and supports

The technology used to support TLE's goals consists of iPads and their apps, school and board wireless infrastructure, and a portal called the Hub that has Desire2Learn and other technological resources to support teachers, including Yammer. The board's Information and Instructional Technology (ITT) department manages technology resources. As indicated earlier, in all pilot schools, all teachers and students (grades 4 through 8) were supplied with their own

iPads. The iPads came with a standard suite of apps vetted by ITT and 21st century learning consultants. The board has an app catalog of approximately 300 approved and licensed titles from which teachers can request installation to meet their specific teaching and pedagogical needs. Non-listed apps can be requested on a small-scale experimental basis if that teacher can provide pedagogical rationale. Neither students nor teachers are able to install apps on their own as the iPad configurations are locked down and managed by ITT. This department also provides onsite, email, and telephone technical support to schools (through a central helpdesk when teachers encounter difficulties).

According to the teachers we interviewed, the initial rollout of iPads to schools in 2014-15 was quite chaotic and rushed, but all report that, by the 2015-16 school year, processes were refined and going much smoother. We were told by one teacher that initially iPad distribution was "like Christmas…take it home. Do whatever you want with it. It was a bit of a nightmare. Cords were lost…chargers were lost like almost immediately. Inappropriate home use as no [content] filters [were installed]." Another stated, "We had a lot of parent complaints. I had parents that came back and said, 'I don't want this coming home'." Teachers reported that they were trained too early because they hadn't yet received their iPads, and when they did receive them they felt pressured to use them, but were uncertain what to do. An app management system was used this year to prevent tampering, and students are no longer allowed to take the devices home (in most cases). An unfortunate side-effect, with students not taking the iPads home, is uncharged devices – most classrooms do not have sufficient power outlets for charging. One principal interviewed described this as a "huge issue." Another said that they were unsure of board policy on who is responsible for paying for lost chargers or iPads. A consultant attributed many of the rollout issues to the then ongoing teacher work-to-rule campaign, suggesting that teachers may not have received "the proper messaging, so they didn't follow the proper procedures."

Wireless network issues, which plagued some schools early on, appear to be mostly ameliorated, although some teachers still reported problems. One teacher stated, "We don't use iPads as much as we might because the system cannot handle 5 kids doing the same thing on one web site at the same time." Another issue reported was the physical management of iPads, especially when students moved to other classes. Sometimes iPads were collected in bins at the end of the class and other times students carried them themselves. The latter procedure provided a challenge because students would take them into the bathrooms, and this, according to one principal, introduced the potential risk of inappropriate picture-taking. A principal and teacher expressed frustration in getting Apple TV connected to monitors and setting up their Smartboards in some classrooms.

The district's technical support service, however, received very positive comments from teachers and principals. A principal commented about the evolution of the board's technical support process and the quality of support received:

> I think last year, the way that the technicians were assigned, some were to the school, some were for different parts in the school, some were for the iPads. That didn't really work. You never knew who was the person you needed to contact. This year, I think that the board has worked to overcome that challenge by assigning just one technician. We're lucky our technician has great expertise in the iPads, but also the other technologies in the building. We've been very happy that whenever our tech comes in, he can help us with any area.

A few other illustrative comments from teachers were:

- Yesterday all of a sudden the calculator was gone off the iPad, all the kids didn't have a calculator. So I just emailed [the technician] and within 10 minutes he told me what to do.
- I literally, at 11 o'clock in the morning, decided to get an app and it was up by 2pm.

Consultants, teachers, and coaches work together to help each other solve technical problems. The initiation of the Student Technical Assistance Team (STAT) in some schools is a positive step, giving students agency in solving problems and even teaching teachers, but we received no feedback on the initial success of this (though some teachers did indicate that students were valued providers of input to application use). Apparently, the only major technical support issue to be solved is that it can take time – up to several days in some cases – for a technician to arrive at a school due to a backlog of service demands from other schools.

Role of E-BEST

As mentioned above, E-BEST (Evidence-Based Education and Services Team) is the research department at HWDSB. According to the department's website E-BEST "helps teachers, administrators, and decision makers at HWDSB to find, understand, and use the best available evidence." Researching TLE and providing evidence-based feedback to improve the program is one of its major responsibilities. E-BEST prepares an annual detailed research plan and conducts key informant interviews, focus group interviews, teacher and student surveys, and assessments of achievement in foundational skills and 21st century skills. The department submits annual reports to the Board of Trustees Program Committee each year. For example, the May 2016 report reiterates the program's rationale and goals and provides the action plan for the current year. Following the action plan are sections on "what we did," "impact of what we did," and "what we learned" for four different areas: learning approach, professional development, tools and infrastructures, and technical supports. The work plan for 2016-17 was next presented. An appendix to the department's report contains an updated five-year implementation plan. Not referenced in the report are any internal technical reports or formal analyses of data collected, nor were we made aware of either of these sources.

E-BEST considers its role to be one of conducting research—as opposed to evaluation for program improvement—and requires informed consent of all human participants (i.e., educators, parents, and students) in its data gathering. Consent is guided by policies set out by the federal Tri-Council Policy on Research Ethics used by universities and other research organizations. As a result of asking for informed consent, response rates for its research activities tend to be low (e.g, see the methodology section of this report), which may result in an incomplete and/or biased picture of the TLE's impact. Had they opted to consider their research as an evaluation or quality improvement undertaking they could have asked all students and teachers to participate.[2]

Fiscal support of TLE

TLE is an ambitious undertaking by the board with very significant financial outlays being required to roll out the program across the district. Funding for TLE comes from two sources: the board's internal resources and annual grants from the Ministry of Education's Technology

[2] Article 2.5 of the Tri-Council document exempts "quality assurance and quality improvement studies, program evaluation activities, and performance reviews, or testing within normal educational requirements when used exclusively for assessment, management or improvement purposes."

Learning Fund administered by the Council of Ontario Directors of Education (CODE). Internal resources have been obtained by recommitting existing school and central office budgets. Table 2 shows the revenue and expenditures for the past two years with a projection for 2016 – 2017. This information was obtained from the board's Finance and Facilities Committee report of May 5, 2016.

Table 2: Revenue and Expenditures for TLE Project for period 2014 - 2017

	2016-17 **Budget**	2015-16 **Budget**	2014-15 Budget
Revenue			
EPO - Technology and Learning Fund	745,053	758,034	635,004
Grant for Student Needs* (GSN)*	990,000	540,000	540,000
	1,735,053	1,298,034	1,175,004
* From:			
Central	490,000	150,000	150,000
Professional	300,000	300,000	300,000
School Budgets	200,000	90,000	90,000
	990,000	540,000	540,000
Expenditures			
iPads			
Purchased	-	-	**329,890**
Leased	971,802	548,911	**224,153**
Licensing	100,000	100,000	-
Covers	127,793	96,236	**57,617**
Apple TVs	13,451	25,178	**24,763**
Classroom Storage	50,000	56,304	-
Replacement of Damaged Equipment	40,800	40,800	**30,269**
Temporary Staff	134,250	133,648	111,333
E-BEST	90,000	90,000	
Professional Development	206,957	206,957	396,979
	1,735,053	1,298,034	1,175,004

From this revenue table it is clear that the board has made a strong internal commitment to fund TLE as they projected a significant increase in internal funding from $540,000 to $990,000 between 2015 – 2016 and 2016 – 2017, while at the same time the Technology and Learning Fund grants were projected to decrease modestly. On the expenditure side, the most significant single item is the cost of leasing iPads. The budget report projected that this expenditure will cover the cost of leasing an additional 3900 iPads. Also of interest is the line item of $134,250 for temporary staff to cover the cost of setting up and deploying the iPads to schools, and that professional development expenditures were reduced by $190,000 for the two years following startup.

Leadership drivers

Leadership drivers refer to the approaches taken by leaders to transform systems and create change. Two drivers will be discussed under this category – how TLE is managed and the leadership's plan for scaling TLE.

TLE management

TLE itself is managed by a steering committee led by the Executive Superintendent of Leadership and Learning and made up of a number of superintendents with specific portfolios such as student engagement and special education assisted technology. There is one superintendent responsible for TLE in elementary schools and one for TLE in secondary schools. The head of the steering committee reports to the board Executive Committee. The Steering Committee is responsible for overseeing all aspects of TLE including planning, monitoring, and reporting. The committee meets at least once a month and sometimes more often at particular times of year for example when they are preparing to report to the trustees.

Scaling TLE

The vision expressed in *Transforming Learning Everywhere* was that "Personalized, collaborative, inquiry based learning will exist in every classroom in HWDSB supported by 1:1 technology" (Malloy, 2014, p. 5). At the end of the 2015 – 2016 school year, HWDSB had iPads for every grade 4 to 8 student in the original 7 elementary schools in the North Digital Project, as well as for all students in Henderson Secondary School and Mountain Secondary School. They provided 1:1 iPads to all grade 9 students in Delta Secondary and Sir John A. Macdonald. All other secondary schools had shared kits of six iPads and shared kits of six were provided to all grade 4 and 5 classrooms and grade 6 at Glen Brae.

The rollout plan for 2016 – 2017 will be to have iPads for every student in grade 9, grade 7 at Glen Brae, and grade 10 in Sir John A. Macdonald Secondary and Delta Secondary, and all special education classes. Additionally, all grade 6 classrooms will have shared kits of iPads.

The board currently has 7821 iPads (after loss/damage) according to the 2015 – 2016 TLE Annual Report. With the addition of 3900 to be acquired in 2016 – 2017, there will be a total of 11,721 iPads in the board. Therefore, about 24% of students will have iPads during the next school year (based on the 2015 – 2016 student population of 49,167).

Yet, focusing on the number of schools involved in TLE, or on the number of iPads deployed, while simple to measure, does not capture the complexity of the reform initiative. Coburn (2003) and Dede (2016) maintain that in order to scale reform: (1) initiatives must result in deep and lasting change in practices; (2) initiatives must be sustainable in the face of competing priorities, new demands, and staff turnover; (3) the beliefs, norms, and valued principles of the reform initiative must be established across many schools/classrooms; and (4) ownership of the reform must shift from the central board authority to schools and teachers. While it is too soon to assess the extent to which these more complex changes have occurred, there is evidence that progress has been made on all four fronts. For example, there is evidence, as described in the next two chapters, that a shift in practice toward inquiry-based pedagogy is happening, to differing degrees, in the participating classrooms we evaluated. This shift appears to have been sustained, so far, in light of competing board initiatives (such as those relating to student voice, mental health, arts, and mathematics). The TLE philosophy and values are appearing to circulate and extend outward to other schools and classroom as the program expands. Lastly, there is evidence that principals and teachers – at least in the schools we examined – are taking ownership of the TLE initiative, some with a great deal of enthusiasm.

Looking at the scaling of TLE from another lens, that of Fullan and Donnelly (2013), substantial progress also seems to have been made in terms of linking new pedagogies with new technologies. In a report to the United Kingdom's agency, Nesta, the authors suggest that successful technology-based change initiatives must begin with good pedagogy (supported by appropriate technology rolled out with a solid implementation strategy). In order to scale, the initiative must provide full and ongoing dialogue about, and strategic support for, the TLE agenda, which is complex. There must be timely hardware and software support; continuous formal professional learning – with specific goals to ensure change – needs to be organized and embedded in practice; there must be follow-up and mentoring with professional learning; and a culture of risk-taking and dynamic collegial learning must be present. Again, our data suggests that there are encouraging signs that Fullan and Donnelly's criteria are taking hold in the 7 pilot schools, although we cannot generalize beyond these schools.

Summary

In this chapter we examined how HWDSB is putting TLE into practice using, as a framework, the three NIRN implementation drivers – competency, organization, and leadership. With regard to the competency driver, we found that a variety of professional learning opportunities are being employed for teachers that are regarded as "best practice" in the literature. However, despite the positive climate in schools involved in TLE, evidence of vibrant informal professional learning and sharing, and the encouragement of principals, teachers reported that, problematically, little formal PD was dedicated this year to IBL and/or iPad training. Support for administrators and other professional staff typically comes from regular monthly peer meetings. As for the organization driver, there was evidence that technical infrastructure and support was robust for the most part this year, except for classroom charging of iPads and some network latency. E-BEST provides ongoing feedback on the rollout of the TLE, though in some cases may be hindered to some extent by research protocols. We also found that the board has made a considerable financial commitment to TLE above and beyond the funding received from CODE. Lastly, as for the leadership driver, we found that a senior level steering committee manages the initiative, and that TLE is becoming embedded in the schools we studied and there is a strategic plan in place to incrementally spread and promote the innovation throughout the district.

Chapter 5: Inquiry Learning in the Classroom: Take-up and Impacts

So far we have examined the inputs and outputs of the TLE theory of action. We now turn to consider the outcomes that have stemmed from these actions. First we consider the extent and nature of the adoption and utilization of inquiry-based learning as a teaching practice in the six schools studied for this evaluation, and then examine its effects to date on student engagement and disposition, learning processes, and their development of specific skills and capacities. Of central importance to our inquiry in regard to the teachers' adoption of IBL is what is often termed the "fidelity of implementation": the extent to which the intended practice change is implemented fully in its optimal form so that it has maximal potential to transform students' educational experience and learning outcomes. In the analysis that follows, we look specifically at the degree to which teachers incorporated the key teaching strategies of inquiry-based pedagogy, as outlined by the Ministry of Education in its *Inquiry-based Learning* and *Getting Started with Student Inquiry* documents (from the Capacity Building Series for educators). These include:

- Building on students' curiosity and questions to develop deep inquiry topics;
- Connecting student ideas and questions to the big ideas of the curriculum;
- Keeping student thinking at the centre of the process by involving students in initial planning of the inquiry;
- Engaging students in collective knowledge-building by bringing them together frequently to share thinking and discuss the big ideas of an inquiry;
- Continually assessing student progress in the inquiry to make judgments about when and when not to intervene to teach specific skills or knowledge students need to progress;
- Teaching students about reflective thinking and metacognition, and providing opportunities to use these skills to further their inquiry;
- Using guiding questions and modeling to foster student reflection, assessment, and knowledge-building.

We also examine the nature of the learning activities and processes evidenced by students as they pursued inquiry learning projects. Guidance with respect to the desired student learning activities in each of the four phases of inquiry – focus, explore, analyze, and share – was taken from the expectations presented in *Getting Started with Student Inquiry.* The key student learning activities we looked for in our analysis for each IBL phase are as follows (see Table 3):

Table 3: Key desired student inquiry activities and behaviours by inquiry phase

Focus - Initial engagement, Selection of an inquiry, focus / question / topic • notice, wonder and ask questions about a topic of interest • share their thinking and questions with their peers and teachers • dialogue about possible ways to learn more • re-frame questions
Explore – Find out more, Investigate • gather and record information first-hand in a range of ways and from a variety of sources • connect current thinking to previous knowledge • clarify and extend questions • talk about observations and thinking to generate more questions
Analyze – Summarize/synthesize, Draw conclusions, Construct new learning • use information to answer questions and test hypotheses • draw conclusions about questions and hypotheses • think about the information to create new questions and hypotheses
Share Learning – Communicate findings, Dialogue, Go further, Reflection • plan ways to express their learning considering a variety of representations • articulate connections between prior knowledge and new discoveries • answer and refine questions • pose new, deeper questions for independent investigation • identify avenues for action and application • share learning with peers and others • reflect on what, how and why learning happened

In the present chapter we also assess key outcomes of students' inquiry learning experiences over the school year, focusing on their demonstrated levels of engagement and agency; their development of autonomous, collaborative, and critical learning skills; and growth in their capacity to communicate understanding and contribute to collective knowledge building using different media and modalities. Finally, we present our findings on teachers' perspectives on their inquiry teaching experiences, including their level of confidence, perceived skill, and sense of efficacy in using this form of pedagogy, and their views on its strengths and limitations as a teaching strategy based on their experiences to date.

Extent of IBL use in the classroom

The classroom teachers interviewed answered (in writing) a set of multiple-choice categorical questions which asked them to indicated the approximate proportion of their students' classroom time dedicated to specific learning activities in a typical week. The results are shown in Table 4 below.

Table 4: Student classroom time use for learning activities over a typical week (as percentage of available class time)[1]

Learning Activity	Mean Percentage Of Class Time	Average Deviation From Mean[2]
Engaging in math explorations/inquiries	19	28
Engaging in inquiry projects running longer than one week	42	23
Conducting online research	33	25
Engaging in online collaborative discussion and/or work	26	31
Creating digital art, music, or narratives	9	16
Building digital models or simulations	8	10
Using digital simulations or educational games	11	14
Engaging in whole-class or small-group discussion	42	25
Engaging in peer tutoring or peer assessment	24	23
Creating digital presentations or multimedia productions	28	25

[1]Categories were not exclusive so total percentage is greater than 100.
[2]Average deviation shown as a percentage of class time

On average, the teachers reported that their students spent between one third and one half of their time engaged in inquiry learning projects that ran longer than one week in duration. There was considerable variation between the teachers on this metric, with about 70% of the teachers' reported times falling within a range of 19% to 65% of student class time devoted to inquiry learning. As the total time used for the full set of activities inquired about averaged 242% of a school day, it is evident that the teachers saw some or all of the student time spent pursuing several of the other listed activities as being part of that project work, such as time devoted to discussions, conducting research, and creating digital presentations. In their interviews, many of these teachers indicated the time their students spent engaged in IBL varied considerably week to week, depending on whether a major inquiry was currently underway; if it was, much of the class time for several days might be devoted to it, while at other times, very little class time would be spent on inquiry work.

The students interviewed saw significantly less class time being spent pursuing inquiry learning; their estimates of the percentage of their total work that consisted of inquiry projects ranged from a low of 5% to a high of 40%.

Topical focus of students' inquiry projects

The large majority of inquiry projects teachers and students described addressed topics in science or social studies (history and geography). Of the few exceptions, one had a fine arts focus, and another involved the study and dramatization of segments of a novel. Several projects were to some degree interdisciplinary; the goal of meeting certain Language Arts curriculum expectations related to expository and persuasive writing in project work was mentioned by several teachers. A few others made a deliberate effort to incorporate artistic creativity and modes of expression such as the production of movie trailers, art collages, or skit acting in student projects that dealt with social, environmental, or historical topics. Mathematical inquiry and problem solving were integral to project work in a few instances. Examples of projects undertaken over the school year include:

- An inquiry into how stadiums can be best designed to meet accessibility needs (as part of a science unit on structures), which resulted in student construction of virtual stadiums using the construction simulator *Minecraft*. The project incorporated student mathematical problem solving to determine the size of playing surfaces, seating areas, signage, and other elements.
- An exploration of life in space (as part of a science unit on space), in which students inquired into how low gravity and other unique elements of living in space impact the human body and daily routines and activities.
- An inquiry into functions of the human body in which small groups of students researched different elements of human physiology and developed demonstrations of their findings that were presented at the school's science fair.
- An inquiry into First Nations perspectives on the history of residential schools, reconciliation, and native activism.
- An exploration of modern advertising techniques, with students inquiring into the persuasive strategies used in ads and commercials.

IBL in practice: The phases of inquiry

In this section of the chapter we examine how teachers and students worked in the four phases of inquiry referenced in Table 4 above, focusing on the degree to which in each stage (i) teachers employed the pedagogical strategies that foster deep student inquiry, and (ii) students engaged in the learning activities that have been shown to be critical for deep learning and capacity building through IBL. (Because teachers employed assessment practices in all phases of IBL, these are discussed separately in a subsequent subsection.)

In order to elicit accurate and detailed descriptions from the teachers of all phases of a classroom inquiry project they had recently engaged in, they were asked a sequence of questions intended to develop a sequential "walkthrough" of their most recently completed classroom inquiry project that had run longer than a week. Once that had been completed, they were asked to talk more generally about how they typically worked with their students in various phases of IBL projects, and what student learning practices and work products were common in each phase. In addition, students were asked in their focus groups to describe how they worked at various stages of their inquiries, and what forms of work were produced. These data, along with relevant findings from the teacher and student surveys, were used to develop the portrayal of the phases of inquiry found in these classes presented below.

1. Focusing the Inquiry: Initiating engagement and shaping inquiry questions

Teachers always introduced inquiry projects to their class within the context of a specific curricular focus, although the degree of curricular constraint imposed on student inquiry question selection varied considerably by teacher and to a lesser extent by project. That focus was nearly always shaped so that projects would address (to a greater or lesser degree of specificity) the expectations of one or more topical curriculum units teachers were expected to cover for the subject(s) they were teaching—for example, human impacts on the environment.

Most teachers used some type of resource presenting content directly related to the curriculum focus to simulate student thinking about the topic and provoke student wondering and initial question formulation. Typically this would be a video clip, photos, a documentary, newspaper article, web site, or a topically focused multimedia app on a subject such as the War of 1812. In most classes, after formulating initial questions in response to the provoking stimulus (and in some instances conducting preliminary research on them), students would share those questions with the class, either by means of an iPad sharing app like PadLet or by using physical Post-it notes. The merits of the questions as topics for inquiry would then be discussed, and the questions modified, re-framed, or culled. The teachers described themselves as having a critical role in these discussions, using modeling and prompting to help students understand and apply the criteria that allow them to distinguish deep questions appropriate for extended inquiry from superficial ones that are readily answered, and help them understand how their questions are related to larger curriculum concepts.

Several teachers indicated that many or most of their students were not initially capable of formulating good inquiry questions and required guidance and in some cases direct instruction in this skill to achieve any level of success. (A teacher who was very committed to using IBL stated that he had spent considerable time in the first few months of the school year "engaging students in how to create a powerful inquiry question".) As one teacher expressed it:

> I've learned students don't come in knowing how to ask questions. They don't know how to ask an inquiry question. They know how to ask those easy questions, "When was, what is, how is?" So for me you have to engage them where they're at and know that if they don't know how to ask questions and they don't know how to do inquiry in the traditional sense that we have defined it as teachers…you've got to slow it down, let them learn how to ask the right questions before they can start having the right answers.

A few teachers outlined specific pedagogical strategies they used to advance students' capacity to develop meaning full inquiry questions. One employed a question quadrant chart to get students thinking about the types of questions that were appropriate for powerful inquiry; another used a model he had learned from an instructional coach that led students from developing a topic, to shaping a viewpoint, and finally coming up with a question. Several teachers reported that many of their students still struggled with inquiry question development even after focused instruction and modelling, and as a result the inquiry question development process was often more teacher-driven than the teachers themselves would have liked.

Teachers varied in the degree of topical constraint they set for their students as they began developing their questions. Some gave students considerable scope to pursue differing interests within broader topical areas such as the development of aviation or a major event in Canadian native history like the imposition of residential schooling; others specified the subject

requirements for research questions more narrowly, for example asking students to come up with questions dealing with the impact of modern aviation on climate change.

A few teachers used a teacher-directed approach to topic selection, having students choose an inquiry question from a set list of wonder questions the teachers presented to the class. In three cases, projects considered by teachers to be examples of inquiry learning did not meet any reasonable definition of IBL. Although these students were given superficial topical choices (such as what species of animal or energy source to research) they were provided with a very specified and detailed list of questions that their research projects had to answer, providing little to no opportunities for self-directed, exploratory learning.

Topics and/or resource stimuli for question development were on a few occasions assigned at a small group or individual rather than a class level, as when for example different groups might be assigned a different historical figure to research and develop questions about. In a couple of instances, students were given the option to select alternative topics, or join another group if they were not interested in the topic or question they had been assigned.

In situations where a few students developed or chose very similar or identical inquiry questions to research, some teachers allowed those students to work collectively to research them. But when a larger number of students wanted to address the same question, or the teacher wanted students to work on individual and unique questions, the teacher would work with the students concerned to help them come up with different issues to explore.

Half of the teachers reported having an external expert visit their class or (in two cases) leading a project-related field trip during this phase of an inquiry project. A native arts and crafts specialist demonstrated traditional First Nations artistic practices; an environmental consultant taught students how to use Google maps and Google Earth to locate coal and other resources; and a local man whose home was entirely off-grid discussed how this was achieved. One class visited an environmental science field station at a conservation area; another, an aviation museum. These events proved to be very engaging, and were strong aids in helping students to come up with wonder questions and inquiry ideas. Students in focus groups cited several other examples of interacting with external experts, either in the classroom or via Skype, however it was not usually clear whether these activities were an integral part of an inquiry learning project.

About two thirds of the inquiry projects teachers initiated addressed contemporary societal issues at either a local or global level. Several focused on broad environmental issues such as pollution, species extinction and global warming; a few concerned local social issues like First Nations activism and reconciliation. Some students in one class doing an inquiry on slam poetry chose to use that medium to explore the life experiences of Syrian refugees, some of whom who were now students at their class. “Students were really engaged with that, they had tons of questions”, their teacher stated. In another class, students were told to develop an inquiry about something they did not like about their community, province, or country, to research solutions for it, and then formulate and undertake some form of community action to address it politically.

A majority of teachers indicated that in selecting subjects for student inquiry they took into consideration the need to address curriculum requirements, but they also chose topic areas that they felt would stimulate student interest and curiosity, address major issues, and be of direct relevance to their lives, either presently or in the future. “As teachers we’re looking at ‘this is the curriculum but how do we make it come alive, how do we make it connect?’ because we know that just trying to teach them about one little slot, that’s not inquiry and it’s not going to last in

their heads". One teacher commented that issues of social justice served as a powerful "hook" for intermediate level students, as they are very concerned about fairness: ""What does 'fair' mean and what does it look like? Does 'fair' mean everybody gets the same or does 'fair' mean everybody gets what they need? And we have had lots of great discussions around that."

In endeavouring to make it possible for students to pursue inquiries that were personally meaningful, a few teachers commented on how they had to push the boundaries of what was specified in the curriculum, focusing instead on addressing the "big ideas" behind the curriculum in unique ways. Two examples illustrate this well:

> We're discussing sustainability, that's a broad enough issue. One student said "I'm passionate about Zimbabwe, I'd like to learn about Zimbabwe." Perfect, that's not specifically in the Ontario curriculum to learn specifically about Zimbabwe, but it gets that point across. They gain that knowledge.
> One of the components of the grade 8 curriculum is looking at various parts of the world through the lens of the 3L's, so living standard, life expectancy and literacy. And we kind of refined it a little bit because of the [First Nation] issues going on in Attawapiskat so we took it from a global perspective to more of a refined focus on Ontario"

Mathematics was a subject area that teachers generally found problematic as a ground for inquiry. It was hard for them to find real-world applications of mathematics to issues that would be of interest. One teacher was experimenting with tying inquiry into practical living skills that made use of mathematics such as budgeting.

2. Exploring and researching

Nearly all of the exploring and researching that students engaged in was done online using their iPads; "analog" text resources were only used in a few instances. Most teachers directed their students to online resources that had been vetted, providing links to these in order to avoid students' use of unreliable or problematic materials, but students usually had the option of finding additional resources on their own if wished to do so. Students would very frequently make use of Wikipedia, despite the efforts of some teachers to steer students away from it. The district's Hub portal was used in some classes to gain access to leveled encyclopedias and ebooks, vetted online text, and links to other media such as documentaries. Students accessed other ebooks and media through iPad apps like PebbleGo and Epic! as well as YouTube, and Google search was used extensively to find external resources hosted at government, institutional, and media web sites such as NASA and PBS.

Teachers reported having a very active role in monitoring and guiding student exploration. The majority felt that many or most of their students were not yet capable of conducting inquiry independently, and required routine monitoring, guidance, and scaffolding. Their naïve notions of what constitutes valid evidence for an assertion were often very misguided. One teacher noted that she had students who when they ask a question using the Google search engine:

> Will go to the found images and then just take whatever they see and say "Okay, well, this is what this means", and they're referring—based on the picture—that they think this is factual information, so we have to go back and talk about fact versus opinion, a lot of that, conversations are happening, when we're researching and when reading information.

Most teachers had taught online research skills early in the year as part of a Digital Citizenship unit (or the resource librarian had done so); in classes where that had not been done, direct

instruction on this was incorporated into the early stages of the students' first inquiry project. Even with that preparation, in most classes many students still needed active guidance in the use of effective search strategies and the selection of reliable sources that presented information at an appropriate reading level. As one teacher put it, "I find even for my 8th graders it has to be very guided simply because of the wealth of information that is online. There's a lot of pre-teaching involved… I would just say "This is what you need to research." It's still a very guided process for them. I gave them some very guided instructions." A few teachers pointed out that their students were coming to inquiry with learning habits and expectations shaped by a long history of passive learning experiences, and that changing their passive orientation to learning required sustained intervention:

> I think even with inquiry, because of their lack of background in it, it still requires some prompting and it still requires some guidance. Maybe down the road, they'll be better at it but it still requires ...I mean they can come up with questions and they can research them, but it still takes some help. They haven't done it for that long.

As they monitored student research, teachers would probe and intervene for a number of other reasons: to keep students focused on exploring their questions; to help them deepen and refine their inquiry questions; to point out gaps in knowledge; and to ensure that students were verifying information found. One teacher described the process she used as follows:

> I'm constantly facilitating and stopping by and kind of checking in…. And sometimes I'll stop and sit and ask somebody to tell me what they've found. And sometimes they'll come to me and say look what I found, this is so cool. And then they're just constantly throwing questions, "Did you know this?" And I might respond with "What do you think would happen if…?" So I think we're always trying to plant more questions for them to go off again and dig deeper."

A few teachers specifically noted that they would have to occasionally rectify students who were cutting and pasting online text into their reports. Occasionally the basics of developing expository or persuasive text would need to be reviewed as students built their project content. Students with special needs such as IEP and ELL students who had difficulties with reading or writing received individual attention in some classes, getting assistance in locating and working with appropriate resources, and in using assistive technologies with the iPad, such as text to speech tools to acquire information and audio recording apps to capture research notes. Other forms of learning task differentiation were also utilized on occasion: those with language challenges might be asked to find images for their group's inquiry presentation, or their tasks would be otherwise simplified.

A few teachers made a practice of showing exemplary student work they witnessed to the whole class. When students in one class were conducting a short-term math inquiry using manipulatives, their teacher would capture video of students "when I see them do something interesting" which she would then share with the class and have them discuss it: "The students help each other solve the problem that way."

One teacher talked about the value of sharing out instances of students' exemplary inquiry processes as a powerful form of modeling:

> I think it's a value for the rest of the kids to see how deep some kids are digging. Because the kids who are arriving at that deep content are asking those questions that we really want for the critical thinking analytical piece. And that in turn prompts the rest of the

> kids – I didn't think about that. They might be very surface level and now they're deep because you have that moment where you're just stopping everybody and just giving that simple prompt based on student research."

Nearly all inquiry projects incorporated some form of student collaboration during the projects' research and development phases even when projects were being individually pursued. In many cases students worked in pairs or smalls groups throughout the inquiry to address a shared inquiry question. In most classes, students periodically gathered together to share learnings and get guidance and feedback on their inquiry progress from peers.

Membership in student pairings and groupings was typically determined by the students themselves or was based on students' shared inquiry topic interests. However a few teachers indicated that they favoured "strategic" groupings:

> Unless [groupings are] strategically designed for them oftentimes it won't work well. So I know who my reliable students are, I know that they are leaders in the classroom and can lead a peer discussion and subsequently collaboration. And its peer-to-peer learning, so they almost take over the role somewhat of the teacher because they know the access points to information and then they're guiding their small group of learners in being able to access those pieces.

Two teachers made use of knowledge building circles to develop collective knowledge in the research and knowledge-building phases of inquiry. In these circles students would assume teaching roles, sharing what they had learned and discussing issues and possible new avenues of research or analysis to explore. PadLet and Google Drive proved to be effective tools for sharing found resource links and materials within classes, and these tools were widely used for that purpose. Pair and group collaboration around inquiry was found to work well, students were able to do complementary research and integrate their findings successfully. Students indicated that they were usually able to choose their own partners to work with, although sometimes they were grouped by the topics they chose to investigate. Both teachers and students were unanimous in their view that the use of iPad apps like Mindomo and Google Docs and Slides that allowed simultaneous shared document editing significantly facilitated collaboration during the research and production stages of inquiry work.

3. Analyzing information and constructing new learning

Most teachers had relatively little to say about how students worked in this phase of their projects or how they supported them beyond what they had already mentioned in discussing the research phase of the projects. (They did offer assessments on how well students analyzed and synthesized information to construct new knowledge in their artefacts and presentations; those are presented later in this chapter in the discussion of student outcomes.) They appeared to see this phase as largely embedded in and coincident with the process of the students' development of a product that would demonstrate their learning, and it was primarily from formative assessments of the initial stages of that development work that teachers came to understand how students were integrating and developing conclusions about the information they had researched (see the discussion of assessment practices in the following section). When asked about how they assisted students in developing their ideas and arguments, no teacher made any reference to directly teaching reflective thinking or metacognitive skills to groups or the entire class, although a few did discuss their responsibility in furthering student thinking. One teacher pointed to the challenges this entailed:

> My students can find whatever piece of information they want but what I have to be able to do as a teacher is have them pull that information and use it now to think critically about that specific question that they're asking and it's not easy to teach critical thinking. It's something that's developed in us as professionals and it's taken us a long time to be critical thinkers about things. And to try and pass that on to the kids…

In this phase of inquiry, teachers continued to monitor students as they worked, and to intervene when they saw a need, based on either what they observed or the responses they received to questions they asked about what students were doing in their inquiries. These interventions would take the form of guided questions or modeling that addressed perceived deficiencies in their students' analysis and integration of information, reflective thinking, metacognition, and self-regulation.

Several teachers indicated that they held whole-class meetings in the analysis and production phases of the inquiry work. Students would report on their findings and the conclusions they were developing, and (in the production phase) how they were planning to demonstrate their learning. Both the teacher and other students would then raise questions for consideration and offer ideas and suggestions for advancing the inquiry being reviewed.

4. Expressing and sharing learning

In nearly every class, students were free to choose the form, the medium, and the technology tools they would employ to demonstrate and share their inquiry learning (subject usually to review by their teacher). Although students had access to district-approved apps library of 298 apps, in virtually all cases where students produced a digital artefact they used one or more of a very small subset of these apps to do so. With a few exceptions like Keynote, the apps employed had relatively simple interfaces which made them fairly easy for students to use. These apps allowed students to incorporate and integrate a range of expressive media within one project, and many of them did so. Media elements students employed included downloaded or linked audio or video clips; original or sourced video, audio, and music recordings; text, drawings, images, other graphics, and animations; and self-created narrative or explanatory voiceovers.[3] Minecraft, a simple-to-use construction and environment creation sandbox simulation was the tool of choice in a few classes that engaged in projects that had a construction focus; students used it to design and build stadium structures, lay out regional infrastructure for resource development, and map out War of 1812 battlefields.

Students would occasionally use two tools in sequence in order to add one or more features to their artefacts that the originating app could not provide; most commonly, this was the addition of a voice- over narration, as in the following case:

> Most of my students chose to create a digital collage, so they created basically a poster with images in PicCollage, and they did an Explain Everything [voiceover recording] over it, to answer the inquiry question and highlight parts of the collage.

As was the case during the research phase, students with language learning difficulties and ELL students were often steered to using apps that allowed students to circumvent the need for extensive writing by using voiceovers or video recordings to present their findings. Teachers

[3] The specific tools used, along with their affordances and limitations, are considered in later chapters of this report which analyze iPad usage and assess student project work.

found this made it possible for these students to participate fully in the inquiry activities, and so avoid being stigmatized for doing very different work than their classmates.

Not all students elected to produce their project artefacts using digital tools. In a few classes a minority of students (nearly all female) preferred to use analog media, creating Bristol board displays or handwritten poetry or other writing. Artwork montages with descriptive labels were the output of one class's inquiry. In a few other classes, groups of students produced live enactments or skits to demonstrate their learning. But even in these cases, digital tools were typically used to record and capture their work.

Revision and editing of draft work was commonplace practice for students as they developed their artefacts, and this was especially true with digital works, largely because (as several teachers noted) the editing affordances of the apps used to create them made revision much easier, and invisible to others:

> If the project was done on a poster board, it would have been glued on. There was no way—it would be too hard to go back and redo the whole thing…. Students are able to make modifications with videos that I think they would not be doing if we were doing more traditional work.

Two factors—the ability to easily share draft work for peer comment through the school network, together with the ease of text editing the iPad apps and tools afforded—often worked together to foster more revision of written work. As one teacher explained it,

> With language especially, I found it was really so much easier for them to just type, revise, edit, peer edit, and share their work. They can share it through the classroom, they can share comments with each other. So much easier than having to rewrite, it's so much easier and they're getting there now.

Once student artefacts were completed, they would always be presented to the whole class. Students would explain their inquiry findings and conclusions, and then respond to questions and comments from teachers and peers, typically as part of a formal or informal peer assessment process (see the assessment discussion in the following section). Students reported making use of presentation software like Prezi, Google Slides, and PowerPoint, as well as iMovie when making their presentations. In most classes, students were given options for ways to present; those who were extremely uncomfortable about doing a live presentation could make a video of themselves instead, or record an explanatory voiceover to accompany their presentation or artefact. Presentation was seen as an opportunity for students to practice and develop their communication skills, share knowledge with their peers, deepen their understanding of their inquiry subject through interactions with peers and the teacher, and see that their work is valued so that a sense of ownership and pride in their work is fostered.

Only in a minority of cases did inquiry artefacts or presentations have any audience beyond the classroom walls. Instances cited by teachers included:

- The public display of art collages at a weekend community art crawl event
- Presentations of slam poetry and artwork by a few volunteer students at a student activism conference held at a local private high school
- Mutual sharing of inquiry student work between two same-grade classes taught by the same teacher
- Sharing with parents at a school open house

- Presenting science inquiry projects to invited friends and family members at school science fair
- Presenting to another grade in "science fair style"
- Having selected student videos posted on a teacher's YouTube account and/or linked to their teachers' Twitter account

Students responded very positively when given these opportunities to expose their work to external audiences. One teacher commented that the excitement and elation generated when some of his students had their videos posted on his YouTube channel was "like Christmas day"; students loved the responses they got, and wanted to post more. In another instance, a teacher noted how engaged students were in developing their inquiries into human body functions when they knew that they would be showcased at the school science fair.

Very few instances of community action arising from student inquiries were reported by teachers (several stated either that they had no time left for it or that they planned to have their students pursue it in the future). Students in one project assessed electrical power usage at home and made recommendations for power conservation to their families. In another class, students were intending to write the federal government to present their findings and recommendations for addressing certain First Nations reconciliation issues. The most comprehensive involvement in community action mentioned was generated by a citizenship inquiry project:

> You [the student] had to think of something that you didn't like about either your community, your province, or your country and try to find solutions to it and then address it politically somehow. So some students did a fundraiser, some of them made posters and put them up around the neighbourhood, some wrote letters to the corresponding politician.

Assessment in the inquiry Process

Assessment was a significant focus of teacher activity in all phases of the inquiry process, and the nature of the assessment practices teachers engaged in progressed through a well-defined sequence of stages. When students were starting the process of developing and refining their inquiry questions, their teachers would in most cases introduce the use of rubrics or success checklists as criteria that students would reference to assess their own progress throughout their project work. By their own account, about half of the teachers made the development of the checklist or rubric an "assessment as learning" activity by having their students actively participate in developing the criteria and "look-fors", eliciting their ideas, and modeling the process to help students build their capacity to self-monitor using appropriate standards. Whether the proportion of teachers who involved students in rubric and checklist creation was actually this high is open to question; in their focus groups, students reported that very few of their teachers did this.

One teacher described how he engaged his students in creating criteria:

> I'll say "What do you think we should be looking for in our work? What should it look like? If you were going to assess it yourselves what would it have to have?" And then we create the class's success criteria and they're posted and I just make sure that if there's anything missing that I really wanted up there I suggest that that go up there as well.

About half of the teachers used success criteria checklists; a few used rubrics; and several used both. Those who did use rubrics would discuss with students what constituted performance at

the various levels. One teacher talked about how he got his grade 7 and 8 students to understand his level 4 standards:

> We don't talk or mark percentages, we talk levels. One two, three, four. And they know with me level four is really reaching, they have to really dig and push themselves to get up there. Because they have to show that they're taking what they've learned and applying it in a really creative and unique way, or applying it in multiple ways in new situations.

Both the rubrics and checklists employed addressed a range of student research, thinking, and communication/collaboration skills. Several teachers simply presented and explained a checklist or rubric to be used that they had created or found online; students would not participate in its development. Most teachers viewed the setting of criteria as a one-time process; but for one teacher, the evolving nature of student inquiries meant that mid-course adjustments in assessment standards were found necessary:

> Bringing students in for their feedback and input in as far as the specifics that we're targeting is key. Because I've set out before an inquiry this is what I'd like to do and I find that near the end of the inquiry we totally moved away from that and we're addressing something totally different now. So you always have a general sense of what you are looking at, that curriculum expectation does not change but the specifics of assessing the specifics in that evaluation do change.

Teachers would sometimes reference the criteria articulated in these rubrics and checklists when undertaking formative assessments of student work during the research and analysis phases of a project. During these stages, they would monitor student planning, research, and knowledge integration, observing and sometimes taking notes, and intervening when deemed necessary. These interventions might take the form of an informal conversation at times; but the great majority of the teachers also made sure to conference more formally with students on a few occasions over the course of project research and development to ensure that students were "on track" and making use of the learning practices and skills needed for success:

> A lot of times kids will start moving in a direction that you can kind of foresee will not allow them to meet the expectations or the criteria that we know we want them to meet. So I think conferencing with them is key. Because it's just an opportunity to keep them in check.

Teachers also used online commenting and email to provide formative feedback, depending on how the work was accessible to them and whether the apps used by students allowed comments to be appended to the students' work.

In several classes, teachers would display exemplars of student work in progress or completed to help students understand what constituted deeper inquiry:

> I show a level 3 or 4 and ask "Why is it a level 3 or 4? How can you raise the level?" Or get a kid who is willing to show a level 2 and talk about how to improve, compare to a level 3 – what is the difference. I do this as a formative exercise as well as for summative assessment.

Several teachers noted that it took some time to get their students comfortable with sharing work for peer comment, whether online or in front of the whole class, but students did come to accept the practice:

> I worked really hard at fostering a community in the classroom where they all feel comfortable sharing, so they're really good about having their work being put up and saying what needs to be improved on it. They like that, they like hearing what their classmates have to say about things and they're not at all embarrassed or upset if someone says maybe that's not the best picture to use to convince someone. And we do that every day we're doing that so they're super used to it.

Only a few teachers reported using peer conferencing for formative assessment in the analysis and development phases of the project, but several others had students use the online sharing capabilities of apps and platforms like Google Drive to share outlines, plans, and (most commonly) developing work with peers for comment. Requiring students to engage in individual formative self-assessment was atypical; only two teachers indicated they had students do so, and it was found that direct teaching and modeling was needed to make it work. Where students worked in pairs or small groups, a few teachers would occasionally require these teams to engage in an internal review of their progress and then discuss their assessment with the teacher.

Peer assessment was more widely used for summative purposes. It usually took place in whole-class discussions held immediately after students presented their completed work to the class. Teachers typically set norms and procedures for these discussions in order to avoid harsh criticisms and resultant hurt feelings. For example, students might be told to mention two strong features of a project, and suggest two areas where improvements could be made in future inquiry work without using any negative phrasing. The success criteria or rubric was usually visually present or easily accessible on iPads so that students and the teacher could refer to it when needed. Self-assessment of final projects by students was rarely done; only two teachers made use of this strategy.

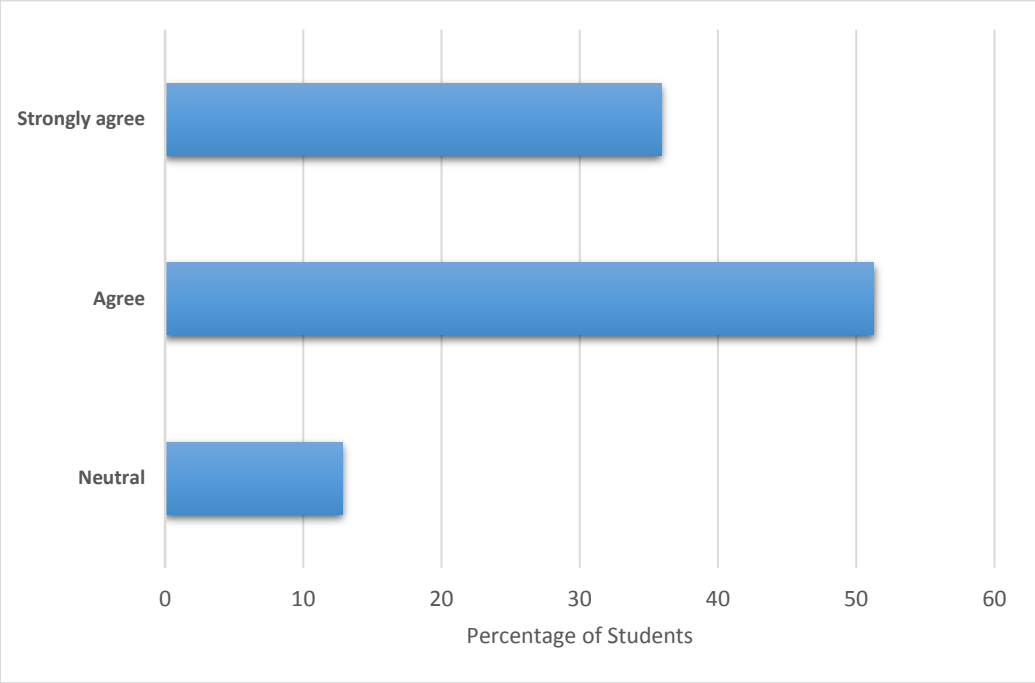
Teachers saw peer assessment as a powerful strategy for developing students' capacity to critically reviewing their own work, partly because students place great value on the opinions of their peers and so are more inclined to internalize the standards and values expressed. They also valued the discussion that often ensued from peer assessment as it expanded students' perspectives and trained them to think more rigorously about their inquiry, and how it might be deepened. However peer reviews were always considered secondary to the teachers' own summative assessment, which was in most cases communicated to the student in a face to face conference. In generating their assessments, teachers did not usually limit themselves to reviewing student presentations and any artefacts produced, but also used notes and recollections from their observations of student work processes over the course of the project, and they closely followed the evaluation criteria laid out in the checklists and rubrics students had been using to guide their work. During their conferences, teachers did more than assign a rating to a student's production or artefact. They would use the outcome categories in the checklists and rubrics to review with the student how effectively he or she developed their inquiry topic, conducted their research, analyzed and synthesized information, and developed conclusions. They also considered how effectively students managed their work time, collaborated with their peers, communicated in class discussions, and presented their findings, and they would discuss how future projects could be improved.

Student outcomes

Student engagement and agency

Of all the student outcomes related to IBL that were asked about, the one which most teachers agreed upon (and by a considerable margin) was increased student engagement in their learning. When surveyed, 87% of the grade 4-8 teachers in the seven 1:1 schools (whose students all had their own iPads) agreed or strongly agreed that using IBL engages students (see Figure 2 below).

Figure 2: Teacher perceptions of student engagement



The teachers we interviewed were close to unanimous on this point: 12 of the 13 regular classroom teachers characterized student engagement during their inquiry project work as being high and sustained over time, and notably better than what was seen with more traditional seatwork. Perseverance was demonstrated in the face of challenges. Few students were found to be resist IBL, or to be prone to going off-task. Some typical comments:

- "I find when they're involved in inquiry projects they're very interested and very engaged in it and they want to spend time on it."
- "You could hear a pin drop sometimes when they're researching and to kind of poke yourself in there and interrupt them is not conducive to their thinking. I find that they're so focused when they're researching something, I don't have anybody this year who is off track."
- "I can't tell you enough about the enthusiasm that they have and the focus that they have and just I really don't ever see anybody look bored or off track when it's inquiry based."
- "So instead of finding an answer and being done they're learning that there's more to be found out, and to stick with it."

These high levels of engagement were not found to be limited to those students who traditionally perform well at school tasks. “I have students that I would identify as exceptionally enriched as well as students that have learning disabilities, and both are equally engaged in participating in inquiry” noted one teacher. Students who typically struggled or were off-task showed greater persistence of focus and effort, which resulted in deeper learning and better skill development. These students also were reported by a few teachers to have demonstrated greater pride in their work and a growth in their self-efficacy.

By a large margin, students preferred engaging in inquiry projects rather than doing traditional seatwork. They found IBL projects were “more involving”, “more interesting”, and “more challenging”, and helped students better understand the problems in the world. However a few students did find that bigger projects went on too long and became boring.

Nearly all of the teachers we interviewed thought that the high levels of student engagement they observed were primarily driven by student interest and curiosity about the issues and topics their inquiries addressed. Giving students the freedom to pursue questions of personal interest was seen to allow that curiosity to flourish and to be maintained over time, and to spark in many a sense of ownership of their learning. As one teacher noted in a comment that reflected the perspective of many of his peers,

> I think my students had more of a vested interest in it because they got to pick some of the questions. I had students actually branching off and picking different forms of energy we didn't even talk about and include that in their video and Book Creator ebooks too. I think there was more of an excitement about learning this way.

Two other factors related to IBL pedagogy were also seen as helping to build student engagement: having students pursue topics that dealt with the realities and issues of the larger world relevant to students’ present and future lives, and having students engage in whole-class discussion about their findings and perspectives on these issues. A few teachers indicated that because students knew that they would have to share their knowledge and defend their positions in front of their peers, they tended to invest more of themselves into their work.

The practice of allowing students to inquire into topics that held some degree of personal meaning and relevance was seen by several teachers as enhancing students’ sense of personal agency and self-efficacy. Continually provoking students to be more autonomous in and responsible for their own learning, having students participate meaningfully in developing the criteria for assessing their work, and making students more responsible to their peers by engaging them in peer teaching and peer assessment were other stratagems teachers used that they thought helped to strengthen students’ sense of efficacy as learners and ownership of their learning. A number of teachers indicated that over the course of the year, this growth was clearly evident in their students’ behaviour. To cite two examples:

> At the beginning of the year, my students were constantly coming to me asking for the details of “How am I supposed to do this and where do I start” and now they're not. … They're understanding that the walls can come down and they can attack a project, or attack even a question, in whatever way that they want to.
> Their confidence has grown and when they are facing something like “Okay, you don't have enough of this, you don't have enough understanding of this particular area”, they're not turning around and saying “How do I do that? I don't know what to do.”

The affordances provided by ubiquitous access to technology were also viewed by most teachers as contributing significantly to sustain students' engagement in IBL and contribute to their sense of independent agency as learners. While these will be discussed in more detail in the next chapter of this report, two are worth mentioning here, as they were thought to have a significant role in sustaining student motivation and engagement in IBL: the instant, anytime access to knowledge the iPads made possible; and the myriad of options for developing creative, unique, and professional-appearing presentations and artefacts they opened up. One teacher spoke of student reaction to this expanded creative potential: "So it's not like "Oh my God I have to do another slide show", it's "I can do a movie, I can write a drama skit, I can make a rap in Garage Band, there's just so much potential there." As another teacher noted, utilizing this potential to create new types of artefacts stimulated student pride: "Some of the things students are making—I know they're proud of it, they think 'Wow I can't believe I could make that, I can't believe I can do this'." One educator remarked:

> I thought with the inquiry model I could see certain areas where the iPads could be applied very well. Other areas I wasn't too sure about it. And what I found is it's so incredible. Just the engagement alone is astronomical. The kids, they're not playing on them.

Not surprisingly, high levels of engagement and agency were not seen in all classes or all of the time. A few teachers noted that students long habituated to passive forms of learning would sometimes demonstrate resistance to pursuing more independent inquiry ("they just want you to tell them what to do"). A principal interviewed as a key informant had seen greater student engagement when observing some classes in his school conducting inquiry projects, but not in others. One teacher found that during a long-term inquiry students occasionally lost interest: "They'll be super engaged for the first little bit of it and then just want nothing to do with it anymore. Sometimes it happens as a whole class and we just drop it and move on, and sometimes there's only a few students that it happens with." Lower levels of interest seemed to manifest primarily in projects in which the students' topic choices and project success criteria were was tightly constrained by the teacher to align with specific curriculum expectations.

Knowledge building

The majority of the teachers interviewed felt that their students had developed a deeper understanding of the topics they had investigated in their inquiries than would have been the case had they used more traditional pedagogies to teach the content. This became apparent to teachers in a number of ways: through the kinds of questions students asked, the nature of the dialogs in group discussions, and occasionally in the learning students would pursue solely on their own volition, as in the following case:

> I don't regularly assign homework for inquiries but I have students coming in with "I found this website. I learned this about nuclear fission, I learned the difference between it and fusion." I think that's the evidence. That's the proof in the pudding that the traditional style [of teaching] just doesn't work, it's too regimented.

Deeper mastery on the part of some students was also evident to their teachers in the greater understanding these students demonstrated through the project artefacts and presentations they created. (Our own analysis of a sample of these artefacts and what they say about student knowledge development can be found in chapter X of this report.) The varied and novel modes for representing and embodying knowledge that IBL (in conjunction with technology) afforded in some projects led students to understand and express it in novel, creative, and insightful

ways: developing a dynamic, systems-based understanding of regional infrastructure by building models in Minecraft, for example, or understanding how mathematical concepts of angle and distance get applied in real life to stadium design.

A great part of this gain was attributed to the heightened student engagement and ownership of learning IBL fostered, which they had observed in their classes; but additionally, teachers pointed to specific teaching practices that seemed to foster deeper understanding and more critical thinking. Greater engagement in co-learning and educationally meaningful group discussion generated more interpersonal knowledge construction:

> It's no longer one student working on one task and handing that in. It's now multiple students working on multiple elements of a single task and coming together to share that learning and grow collaboratively.

Being able to share personal perspectives and varying viewpoints would drive lively exchanges that enriched knowledge building: "We get little debates going in there, and I find that even the kids who are reluctant to participate, you can see them they're really thinking, they're really, really thinking and sometimes they come out with a question later." One teacher cited giving her students opportunities to teach others in a knowledge circle as a key driver of their learning:

> The kids are wondering about different things. And what they really love to do is get together in that knowledge building circle afterwards and be the teacher….So there's a certain responsibility there that if they know they're going to be teaching the class that they really strive to get that deeper thinking so that they can teach the class something that they for sure don't know. There's a motivation that way.

A few teachers pointed to their weaker students as being major beneficiaries of IBL, demonstrating more understanding in their work and producing more advanced artefacts and presentations. In the words of one teacher, "I see a huge difference in the weaker students. So the students that may have struggled before in the old fashioned way of learning are not struggling like that anymore. The products they're creating are far better than what they were creating before."

Not all teachers considered IBL learning outcomes to be a substantial advance over those associated with other teaching approaches. Two thought knowledge building through IBL was too advanced an activity for their students; one noted that when students do not have a pre-existing knowledge schema for a topic it is harder to elicit knowledge building, and that some "front-loading" of information is required. The pre-teaching of specific skills was sometimes mentioned as a prerequisite for success; these skills included for different projects fundamentals of English usage, and artistic production skills One teacher who focused narrowly on content mastery reported a mixed learning outcome with IBL, commenting that some students did learn more through the inquiry process, but others would probably have learned more of the content if they had simply studied and memorized a sheet of information. Two teachers stated that their students' very basic questioning skills impeded a deep level of learning from their inquiries. A teacher who considered IBL to be not much different from what she had been doing for years saw no evidence of improved learning outcomes, and viewed the students as still needing a great deal of prompting and structure in their work. Concerns were also expressed by two teachers that while students might develop a deep understanding of the specific question they investigated, their broader understanding of the topic was not as developed (despite listening to other students' presentations).

Skill development

Inquiry formulation and research skills. At the beginning of the year few students had the skills needed to develop deep inquiry questions but with instruction and guidance, students typically gained the capacity to articulate appropriate questions. The experience of one teacher was shared by several others:

> At the beginning of the year I noticed that my students weren't asking good inquiry questions. And not good in the sense the questions were bad, it's that they weren't inquiry questions. There were a lot of, as we call it here, head questions. So "When was this made?" Well in 1947…. so I had to spend the first two months of school engaging my students in how to create a powerful inquiry question. Now they can come up with powerful questions.

A few other teachers were less sanguine about the progress of their students in this regard, stating that they still struggled with this task and needed considerable teacher input to come up with anything useful. In a few instances teachers simply provided students with questions to research.

The teachers were in agreement that online research skills had to be taught and modeled, either by the classroom teacher or the teacher librarian/TLE champion, and even after that instruction most students had to be re-engaged periodically with the strategies and heuristics need for evaluating sources and using information effectively. "You have to show them how to research, where to research and what do you do with that research…how do you use this information to make a judgment call" one teacher noted. Most teachers found that the research skills of the majority of their students developed significantly over the course of the year, but in some classes they were not yet seen as being at the point where students could conduct research effectively without close supervision. Students did for the most part improve substantially in their ability to find information efficiently and to distinguish strong from weak source materials. A teacher whose students were advancing quickly in their research skills stated that:

> They are learning it's so quickly it's insane….They're just used to it and they're getting better and better and better at it. I still provide those link supports for them but they're getting better and better at finding appropriate sites, finding information within a site, scanning for information. And that's at hard and big giant websites, our Board website is the worst.

But other educators pointed to impediments to research that still presented challenges to some students: readability difficulties arose when students encountered adult-level text, and deficiencies in students' abilities to assess the quality of information sources were still commonly seen by a few teachers, who had to address these directly: "Really making sure that they understand the difference between somebody on YouTube who's just on a rant versus something that's been posted by the government that's actually backed up by experts and so forth. Valuing that is still not there yet."

Thinking skills. Several teachers had little to say about any development of their students' critical reasoning skills, either because they had seen no improvements with IBL, or more commonly because they felt any such assessment was not yet meaningful as their own facility in applying IBL was still not advanced enough and/or they felt they had not done enough of it with their students for it to make a difference. Others though saw some positive outcomes in this domain. The gains in thinking skills listed below were each noted by two or more teachers:

- greater capacity to see and analyze both sides of an argument while developing their own positions on issues
- better levels of inferential reasoning
- greater capacity to synthesize multiple perspectives and information sources
- greater ability to interpret more complex information
- more independent, autonomous thinking

Planning, organizing, and self-regulating skills. The planning and organizing required for pursuing successful inquiry projects was relatively straightforward for those students who were usually successful at school tasks, but others needed more guidance and support in organizing their work and directing it at their goals:

> With a lot of our learners who have difficulty with organizing information, that's a challenge for them. They need more intervention. So they might need to prepare a graphic organizer for them, I say "Here you go you can put this information into this format."

Organizers, both analogue and digital (the concept mapping app Mindmodo was popular), were used by several teachers to facilitate and scaffold project planning and the organizing of information.

Planning was a relatively novel skill for many if not most students in grades 4 through 8. As one teacher expressed it:

> They're still really new at understanding how to write their own plan and evaluate their own plan. These are skills that we didn't even put on university students and now we're putting them on 10 year olds. There's a lot of jaw dropping and "What are the rules?" and there's still a lot of guided support for it for sure.

In spite of these challenges, teachers indicated that with support most students were able to develop inquiry plans and organize their information to address their inquiry questions, and that students' ability to apply these skills advanced over the year.

Student self-monitoring and self-regulation were commonly seen to be stronger (or at least more evident) during IBL, and to also grow over time as students assumed greater ownership of and responsibility for their activities. Nevertheless for many students these skills were not well developed, and in these instances teachers perceived a need for direct student oversight and guidance, especially when the students were first being exposed to IBL. This occasionally created a conflict between the teachers' desire to optimize outcomes and their understanding of the learner autonomy IBL required:

> Self-monitoring and self-assessing mean that you have to make the assumption that your students are self-driven and that they're willing to take a look at how hard are they working in that 80 minutes. Are they finding ways to waste time, are they getting lost in the technology? So again I hate to keep doing this kind of model but at the beginning of the year it was very difficult to not be controlling and say "Excuse me you have to have so many lines done by so many minutes by the end of this time," giving them the opportunity to engage in the learning. Not having the control, if you're doing inquiry can be a disadvantage if they don't have that self-monitoring and self-pacing and self-assessing of not just work progress but work quality.

Collaboration and leadership skills. Typically, collaboration was a significant element in all phases of student IBL work, from the collective refining of wonder questions through group discussion of research findings to summative peer assessment. Almost universally, teachers found that their students collaborated willingly and very effectively throughout the process, whether they were working in pairs to develop an inquiry, or sharing knowledge in larger groupings. One teacher's experience is illustrative:

> My students all work really well together, and I think they see the benefit of sharing what they know with other people instead of working in a bubble and "Don't cheat off me, don't copy". I think they see the benefits of working as a team to create something. Even if it's not creating something together but just researching together, just talking about what they're learning.

Students demonstrated a capacity to listen actively to their peers, respond respectfully, and acknowledge the value of others' contributions to collective knowledge. Little evidence of competitiveness was reported by teachers. Collaboration could be formal and structured into specific activities, as it was in knowledge circles, but it often occurred informally as students worked side by side, responding to each other's' questions and sharing information and strategies for developing their inquiries.

The students' ability to collaborate effectively in IBL changed the nature of their learning process: "It's no longer one student working on one task and handing that in. It's now multiple students working on multiple elements of a single task and coming together to share that learning and grow collaboratively." Occasionally it would advance student learning in unanticipated ways, as when pairs of students were doing a short-term inquiry into the construction of simple electrical circuits:

> They would just end up looking at each other's work and then a bunch of them just brought all their stuff together and said, "Let's try to make something like where there's motors going over here and lights going over here." They just were able on their own to figure out how to make a more complex circuit. They're learning from each other that way.

A few teachers remarked that they would occasionally have to intervene to draw out reluctant participants, to help them and others see that these students had something to contribute:

> What I try to instill as a teacher is that everybody has something to say and whether we agree or disagree it's still of value and it can still contribute. So a bit of what they're doing now had to be teacher directed…you pick the kids that don't always speak up. Because I've been amazed how many brilliant things come from those students, and then as soon as the student leaders in the group hear that, and you get them in a smaller group to collaborate, they're a lot more willing to participate in discussion. I kind of had to pave the way for it but they get it now.

Several teachers thought IBL experiences over the year had enhanced their students' collaborative skills and in one class eliminated arguments. In a few classes, the provision of direct instruction in accountable talk and proper forms of responding was found to be a necessary prerequisite for this skill growth.

Teachers recounted several instances of emergent student leadership during inquiry projects, although it was not seen in all classes. Certain students proved to be effective small group leaders, facilitating productive discussion and reflection and subsequent group collaboration.

Others acted as skit or film directors, managing actors and writers. Some provided technical leadership around iPad and app use (see the next chapter of this report).

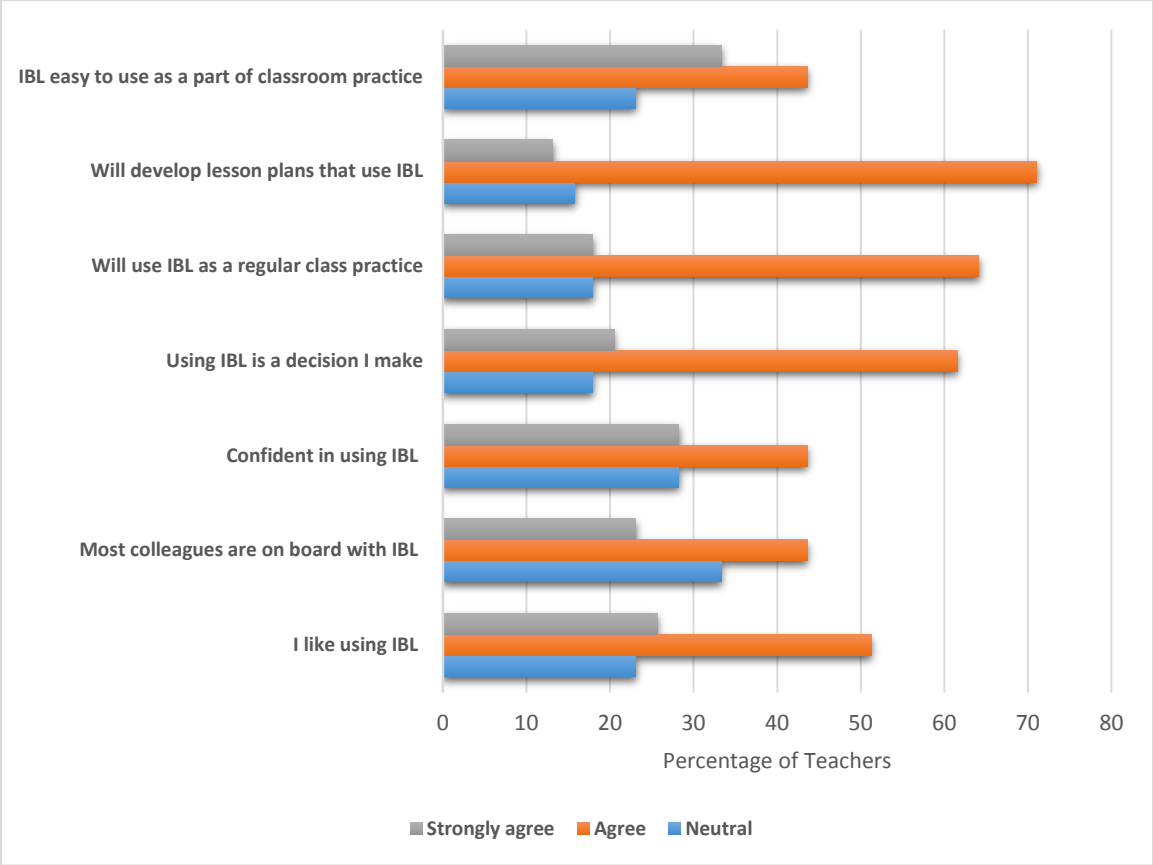
Communication skills. The group discussions and project presentations that were part of the IBL experience afforded students considerable opportunities to exercise their oral communication skills, and several teachers saw them improving as a consequence. "For the kids who present using media, they're getting really good at explaining their thinking", said one teacher. "The images are there and they will say 'This is why I picked this one, this is why I picked that one', and put it all together for us. They're getting very good at being able to stand up and express and even answer questions, which is hard to do."

The panoply of alternative presentation modalities teachers made available to students, ranging from art collages through rap music and videos to construction simulations, resulted in new forms of knowledge representation and expression being learned and experimented with. Many students chose to use these new modalities to create alternative, non-textual forms of demonstrating knowledge that one teacher noted were "interesting and enjoyable to listen to and watch." Limitations in spoken and written language no longer discouraged student communication as those with special needs in these areas used assistive technologies to overcome communication barriers and share their learning.

Teacher perspectives on IBL

The teachers responsible for teaching the one-to-one classes in the seven schools studied were asked in the district's annual survey a series of questions about their use of IBL and their perspectives on it (see Figure 3 below).

Figure 3: Teacher IBL use and perspectives



About half of the 39 respondents agreed when asked if they liked using IBL in their teaching; one quarter strongly agreed; and another quarter gave a neutral response. Slightly lower levels of agreement were seen when they were asked if their colleagues at their school were also "on board" with using it; a third of those responses were neutral. Most teachers expressed confidence in using IBL, but more than a quarter of them took a neutral position on this, and only about a quarter strongly agreed that they were confident. Over three quarters felt that they were the ones who decided if they employed IBL. Asked if they will use IBL as part of their regular classroom practice, about two thirds agreed, but only 18% strongly agreed and other 18% offered a neutral response. The teachers responded in near-identical proportions when asked if they would develop new lesson plans that use IBL. One third of the teachers strongly agreed and another 44% agreed that IBL was easy to use; a quarter were neutral about this.

Taken together, these survey findings portray a teaching cohort that is for the most part fairly comfortable and confident in using IBL in their regular teaching, and that they plan to continue to use it. But the fact that only about a quarter of these educators expressed strong levels of support for its use, and another quarter were neutral, suggests that both teacher enthusiasm and a strong sense of efficacy in relation to the use of IBL is as yet far from universal, and for a very significant number of them falls short of the type of commitment likely needed if IBL is to truly transform teaching in these classes.

Changing Pedagogy

When teachers were interviewed they were asked how their teaching practices had shifted with the use of IBL and what changes they had made in their conceptions of teaching as a result of their IBL experiences, they most often talked about the process of relinquishing control of the classroom and letting students assume more responsibility for their learning. Giving students the freedom to direct major aspects of their learning process, as the IBL approach required, was an alien experience for many, and making the transition from a teacher-directed pedagogy proved challenging for several teachers. One offered a very detailed description of her transition:

> I found it really difficult to manage. It felt like so much more work for me. And I think that was just because I wasn't ready to let them go. So I felt like I had to micromanage or control every single project to make sure the kids were on track. And that was a real detriment. It wasn't good for them, it wasn't good for me, it didn't work. So I learned a little more. So I've been learning a lot more about inquiry and [a curriculum coach] who has been coming in, she's really good at it, so we collaborate and collaborate with other people…. Planning, I'm getting better at work planning. Last year I had a hard time because I would get a picture in my head what the end product would be and where the kids would want to go and it was kind of frustrating for me.

The need to let go of their role as the expert in the room and assume the status of a co-learner at times caused a few teachers some concern, as they wondered whether they would still command the respect of their students. But teachers were gradually able to adapt to this new way of relating when they saw how students began to take ownership of their learning:

> Teachers by nature like to control. … Sometimes you have to let a 12 year old be the expert in that moment and you have to be the one willing to learn. You have to take that position of 'Tell us what you know and let's have some learning time together and you're passionate about something you just read on your iPad, let's listen.'

Several teachers noted that they had to more closely monitor student activity in all phases of IBL so they would know when to intervene with direct instruction, coaching, or guided discussion to ensure that students were "on course" and had the necessary skills to succeed. As a consequence, they found themselves placing a greater emphasis on understanding the thinking processes students were demonstrating in their discussions and work, and were undertaking more formative assessment and not relying nearly so heavily on the marking of students' work artefacts at the end of the inquiry to assess student learning. As mentioned earlier, they also spent more time instructing and modeling research skills so that students could assume more independence in that phase of their work.

A few teachers felt that IBL had not introduced any significant shifts in their pedagogy, either because they were just starting to explore it, or because it aligned with what they were already doing ("this is just good teaching practice" said one teacher).

Perceived strengths of IBL

When teachers were asked when interviewed what the greatest strengths of IBL as a teaching strategy were, the great majority mentioned an increase in student interest and engagement relative to more traditional learning contexts. This deeper engagement led to students staying on task more consistently and being more willing to persist in the face of challenges.

Developing students' sense of ownership and control over their learning was deemed a major strength of IBL by several educators. "They feel as though they own their learnings and that is a strength that they've now developed for themselves", one teacher remarked. "I think that is one of the biggest strengths to come out of it."

About half of the teachers thought that IBL had promoted deeper understanding of the domain content under study. Evidence for this was seen in both the more developed demonstrations of learning that students created, and in students' deeper engagement with shared knowledge building in their dialogs and discussions. One teacher commented that it was "just a thing of beauty to watch them create and watch them wrestle and convince and persuade and engage in "I don't agree with you", in a good healthy way. So 100% inquiry is a total advantage." Several other teachers also cited the increased amount and depth of collaboration as a strength of IBL.

A number of other strengths were noted by one or two educators. It was thought to allow more effective differentiation of learning:

> It's a huge advantage for the knowledge development. We've got kids at different entry points with regards to their background knowledge and what they know. So kids having that freedom to go from wherever their own background knowledge is and explore from there is huge.

IBL was seen to provide more opportunities for teachers to make observational assessments, and to use assessment as a tool for and as learning, dialoging with students about their progress in all stages of their work and having students assess peers' project artefacts. Well-chosen IBL projects made learning more relevant and meaningful to students, so they "do not feel as much like work". And IBL could be readily embedded in construction activities which heightened student interest:

> When I have my kids build something in science, that might not be the whole focus of the inquiry but that's the buy-in, that's the enjoyment of it. It's kind of like you're tricking them because they're learning all this stuff on aerodynamics through the construction of say this rocket that we're going to launch but all the time they're spending researching how many fins should I have on my rocket and what is the best shape to use for a nose cone. So inquiry happens as they're working towards an artefact.

Challenges and perceived limitations in applying IBL

Some teachers found themselves having to cope with significant challenges as they brought IBL into their classrooms. Three teachers mentioned that the loosening of teacher control IBL entailed and the resultant uncertainty about where the process may take the class were hard to handle. One teacher talked about how her class had headed off in an unexpected direction in their inquiry:

> Well at this time last year I was doing this. Well I'm not doing that now because they [her students] didn't take it there this year they took it another place. So it's just trying to get your head around letting go of your way of doing things and having it be their way of doing things.

Another also had difficulties relinquishing tight control of her class, and was lucky to have the aid of an instructional coach to help her overcome the challenge:

> I had to let go of a lot of control when I first started doing inquiry this year and luckily I had an instructional coach who worked with me who is really excellent at inquiry, and

> he said "Yeah, inquiry for the teacher is not the sage on the stage, it's the guide on the side and you have to let them fail and you have to let them not come out nice and polished in the first crack at it. You have to let them stumble." So my most challenging aspect of inquiry is definitely letting go of that control.

Several teachers pointed to a tension between giving student free reign to pursue their interests while at the same time ensuring coverage of curriculum expectations. As one expressed it:

> How do we know that they're learning what they're supposed to be learning if we just allow them to go off…I know that a lot of us struggle with – inquiry is a wonderful concept, we're not sure how far we can let them go on their own without reining them back, within the parameters of our curriculum.

IBL was not always found optimal for imparting certain content and skills. One teacher talked about what she had seen in her class and her reaction to it:

> Some students who didn't get as much out of it as if they had been asked to study a sheet with some specific information and go through that whole memorization process. I would never just do that alone, but I think that sometimes you need to have a balance of both so that you get that exploration piece and students can delve into what they're truly interested in but you have that good solid content knowledge as well.

One teacher remarked that his students learned deeply about the specific, narrow topics and questions they researched, but their learning from other students' presentations was not as complete, "So they might now be an expert in this one area but there were four other events that occurred that they don't know as well as another student because that wasn't their topic."

Using inquiry in math education proved a challenge for a few teachers. One felt he had no real grasp of how inquiry could be used to teach certain math concepts and skills in his curriculum, and felt the need for guidance. A grade 6 teacher stated that the pressure to have students master math skills needed for their EQAO testing in the late spring meant that he did not have the "luxury" of conducting math inquiries until June following the testing. Some teachers contended that in the Language Arts area, certain fundamental competencies were not amenable to learning through inquiry and had to be taught and practiced more directly. "I do mini lessons now", one teacher said. "So as their work is coming in and I see a problem, I say 'Okay everybody stop, here's a mini lesson on capitals, conventions.' And they're not emphasized in the curriculum but they're critical, that's critical skills." More generally, in a few classes students' lack of basic content knowledge or relevant background experiences had been found to impede inquiry.

The proliferation of modalities and tools being used to create project artefacts and presentations, together with the differing topics students pursued, usually resulted in a highly diverse set of products that teachers had to assess, and some found this to be a real challenge that they were still struggling with:

> Your students will give you different forms of showing their learning, so some kids love to do videos and that's the way they want to present. Some kids love to read it and that's the way they want to present. It all looks different, so you wonder, "Well, what is that a 3? What is a level 2?" I've always really struggled with that assessment. I've taken a step back this year and I haven't really looked at it as a benchmark of say level 3. I've kind of looked at it as "Where has this student's growth been?" I look more at what are they telling me.

In the face of the flood of resources accessible to students through the internet, teachers found that students' research skills were often not sufficiently developed to address their inquiry questions effectively. As mentioned earlier, direct instructional intervention and ongoing support from teachers was required, but even with this assistance some students still struggled with it, and plagiarism in the form of cutting and pasting of text segments was occasionally found in some classes.

Although student engagement was generally high, a few teachers mentioned that some of their students could veer into off-task behaviour on occasion, and managing this could be challenging:

> You might be at one corner of the room working with a group of students, involved with them, getting a good discussion going, and you look up to the right and the other group you were talking to earlier is now on YouTube listening to music and watching videos. That can be challenging at times.
> I want them to work independently and be responsible for their own learning to a certain extent, especially so I can work with those struggling kids. That's not always the case, especially with this grade 6 class, they're very chatty so even though they know what their responsibility is they're not always following through.

One teacher felt that students' off-task behaviour was a function of inquiries not being sufficiently engaging: "If the task was engaging then the student wouldn't feel compelled to be off task and be on YouTube for example. So that's difficult for people to reflect on and to understand that the tool is fabulous but ultimately it's the task."

Student passivity and lack of initiative in inquiry work were obstacles encountered by several teachers at times. A few teachers saw this passivity as being engendered by students' prior experiences of direct teaching, which led them to have certain expectations about their role: "When I first told students they were to determine what they want to learn about next they looked at me like I'd lost my mind. It was very, very difficult." Another teacher noted that "Students just have a hard time with it because they're not used to it – 'What do you mean I have to think of my own question?' They just want you to tell them what to do."

Two teachers reported what they saw to be pressure from administrators to use IBL as problematic. One remarked that "We feel pressure as teachers in a school that has this project [TLE] that we should be doing inquiry all the time with every subject every moment of every day. And we can't possibly. That's not true inquiry."

The next chapter of this report examines the role iPads as a ubiquitous 1:1 technology had in IBL and other forms of teaching and learning in the schools we studied.

Summary

Among the teachers we interviewed, both the extent and fidelity of IBL pedagogy utilization varied considerably. Most teachers reported spending anywhere from a fifth to two thirds of their class time having students engage in longer-term inquiry projects; their students saw an appreciably smaller proportion of their time being devoted to it (between 5 to 40%).

The majority of inquiry projects addressed topics in science, history, or social studies; several had interdisciplinary elements intended to develop students' literacy and/or mathematical skills. Many were framed by teachers around social or environmental issues of current relevance either in the local community or (more typically) the world at large, such as global warming. Very few inquiry projects were undertaken in mathematics; teachers found this subject a hard

"fit" for IBL and wanted more guidance in it. Some of the teachers were comfortable with "pushing the boundaries" of the specified curriculum, allowing students to investigate topics that were not closely aligned with the curriculum expectations.

Teachers would typically use a provoking stimulus like a newspaper article or a video to stimulate student questions on a board topic, and then (sometimes following preliminary research) lead some form of guided class discussion to help students select, refine, and deepen the primary questions for their inquiries. Teachers varied in the topical latitude they gave students to formulate questions of personal interest, and in the degree of constraint and specificity of content they articulated in their expectations for student inquiry artefacts or presentations: some allowed students to pursue their interests relatively freely, others provided only superficial choices of topics and so tightly dictated reporting requirements that the project activities could not really be considered IBL.

Teachers made use of rubrics and success checklists to help students plan, structure, monitor, and self-assess their learning as they progressed in their inquiries. In the majority of cases students would participate in the development of these through class discussions.

Nearly all inquiry research was done online using the iPads. Most teachers provided their students with vetted learning resource sources and links which were principally governmental and institutional, but usually gave students the freedom to locate other sources as well. Many of the resources students used were not primarily text-based, such as content-focused iPad apps in the district catalog, documentaries, and YouTube videos. Leveled resources available through the district Hub and other sources were also called upon; these, along with iPad-based assistive technologies, were used by students with language difficulties or special learning needs to overcome literacy barriers to project participation and learning. Both individual and paired or small-group inquiry projects were run; students proved capable of working together willingly and effectively, further developing their collaboration skills, and the affordances the technology provided for collaborative work made doing so substantially easier.

In nearly all classes, students were free to choose the form and modalities for their learning demonstrations (artefacts or presentations) and the tools needed to construct them.

Students strongly favoured the creation of dynamic multimedia artefacts and presentations over static traditional text reports or posterboard-style project presentations. Completed project artefacts and presentations were nearly always presented to the whole class, after which the findings were discussed as a group and peer assessment undertaken.

Teacher assessment typically shifted away from a primary focus on student work products to a more process-oriented examination of student thinking as well as their learning and work processes; teachers made more use of observational evidence in both formative and summative assessment, and the amount of formative assessment they undertook increased. Only in a minority of cases did the presentations have any audience beyond the teacher and classmates, but students clearly valued these opportunities and were highly motivated by them when they did occur. Community action stemming from inquiries was very rare.

Students generally demonstrated much higher and more sustained levels of engagement and persistence in inquiry work, and little off-task behaviour was reported in most classes. This engagement was not limited to high-performing students; it was also found among those who typically struggled or had special needs. Most teachers felt that the large majority of their students who engaged in IBL developed significantly deeper understandings of the topics they

researched than they would have in more conventional forms of learning, and thought their demonstrations of learning provided clear evidence of this advancement.

Increased student skill in developing deeper inquiry questions was also noted, although a minority still struggled with this and required ongoing guidance and in some cases "structure". On the whole, students' research, planning and self-regulation skills were found to advance through the use of IBL, but in a few classes teachers reported that these remained poorly developed. Only a few teachers reported seeing evidence of enhanced analytic and inferential thinking skills stemming from IBL.

Teacher survey findings revealed that as a group the 1:1 teachers were largely comfortable and confident in their use of IBL in the classroom. But both teacher enthusiasm for this form of pedagogy and the possession of a strong sense of competence in its use are far from universal, which suggests that the commitment to IBL required to truly transform teaching in these classes remains to be realized

The biggest shifts teachers perceived in their pedagogy with the use of IBL was a letting go of close control of student learning activities and their associated role as the expert in the classroom. These changes proved a challenge to some, and raised concerns about adequately covering curriculum expectations in a few.

Teachers saw the greatest advantage of IBL as lying in the heightened engagement it generated, which fostered persistence in the face of learning challenges and greater initiative and agency on the part of the learner. Related to this was an accompanying expansion of students' sense of ownership and control of their own learning as they were afforded greater opportunities of direct their own course of action.

Chapter 6: An iPad for Every Student: Impacts and Outcomes

At the time we began conducting interviews for this study, most of the grade 4 to 8 teachers were more than halfway through their second year of teaching in classrooms where each student always had a personal iPad at hand to support his or her work. As our analysis of survey and interview findings in this chapter will make clear, in most cases the iPads had been integrated into many aspects of teaching and learning in these classrooms. Teachers frequently incorporated its use into conventional modes of teaching practice as a substitute for other media, or drew on its capabilities to augment traditional forms of pedagogy; but most of them also employed it in transformative learning contexts such as IBL, leveraging its unique affordances to promote deeper learning.

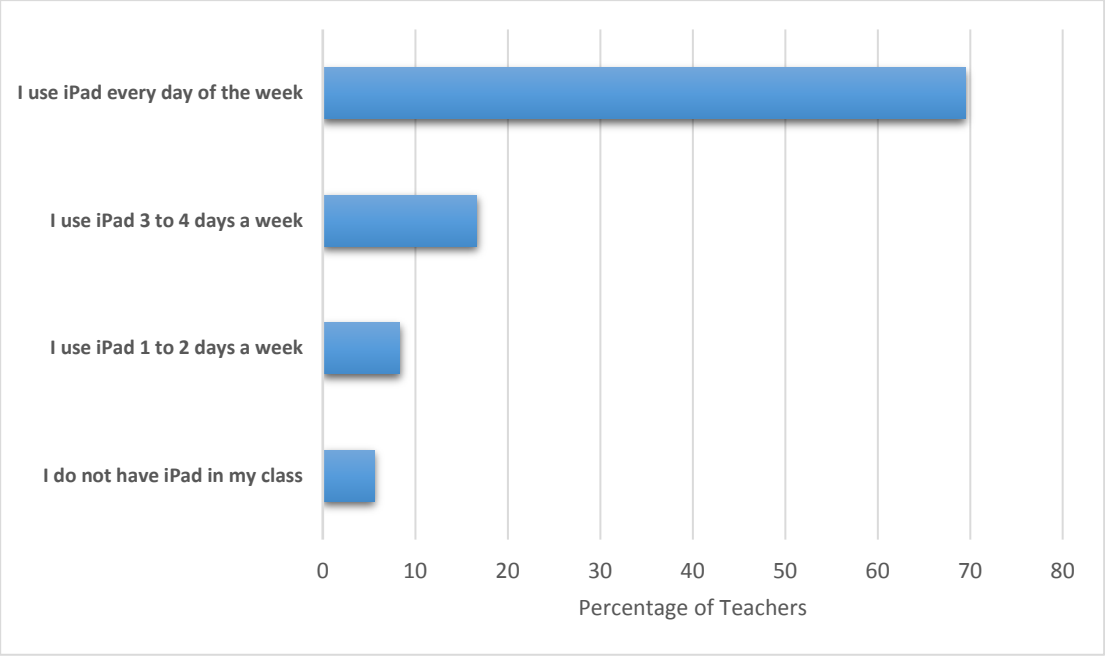
This chapter begins by exploring the patterns of iPad use as reported by teachers and students, looking at how iPad applications (apps) and online and cloud-based tools like the Google suite were employed in different subject areas and learning contexts to augment or in some instances transform learning. It then reviews teachers' and students' perspectives on how the adoption of iPads, and their one to one distribution, has impacted teaching, learning, and assessment. Discussions of classroom management of the devices, their uses in managing class work, and the problematic issues of home use and developing parental understanding of the iPad's role follow. The perceived impacts of 1:1 iPad integration on student disposition, learning and skill development are then summarized. Other topics, including the effect of iPad implementation on teachers' patterns of collaboration and professional networking, teachers' perspectives on the educational strengths and limitations of iPad applications in teaching and on the one to one distribution of the devices, and TLE's overall impact on teacher professional growth and self-efficacy are also addressed.

Patterns of iPad usage

Frequency of use

When surveyed, 70% of the grade 4 to 8 teachers indicated that they made use of iPads every day in the classroom, and a further 17% stated they did so three or four days a week (see Figure 4 below). Less than 10% used iPads only one or two days per week.

Figure 4: Teachers' frequency of iPad use



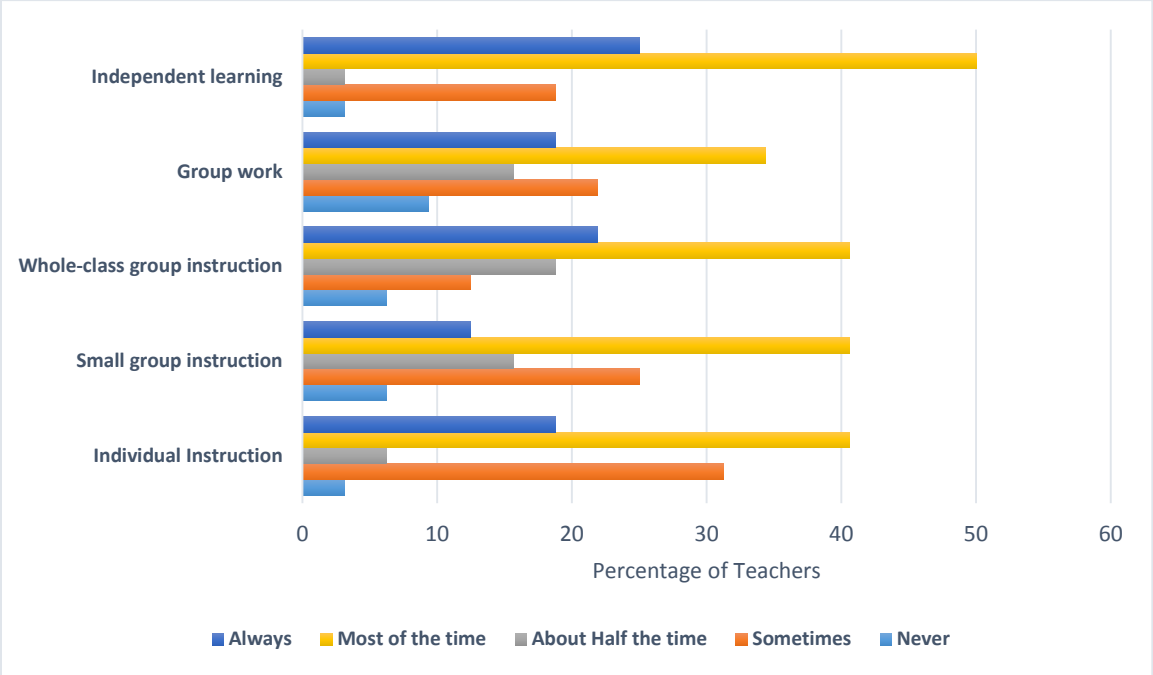
In their interviews the majority of the teachers stated that their students were typically using iPads over most of the day, although this varied day to day depending on what students were doing. For the remaining teachers use averaged one to two hours per day. (The special education teacher interviewed had her students working with their iPads between 20% and 50% of their withdrawal session time.)

Use in different learning formats and tasks

Teachers were asked in the survey about the learning formats into which digital tool use was incorporated (see Figure 5 below).[4]

[4] While this question was not specifically about iPads, they were by far the most prevalent digital tool used by students, and most other forms of technology employed by teachers or students were used in conjunction with iPad use (such as projectors and Apple TV), making this question and others asking about digital tools a reasonable proxy for understanding iPad usage in the 1:1 classes.

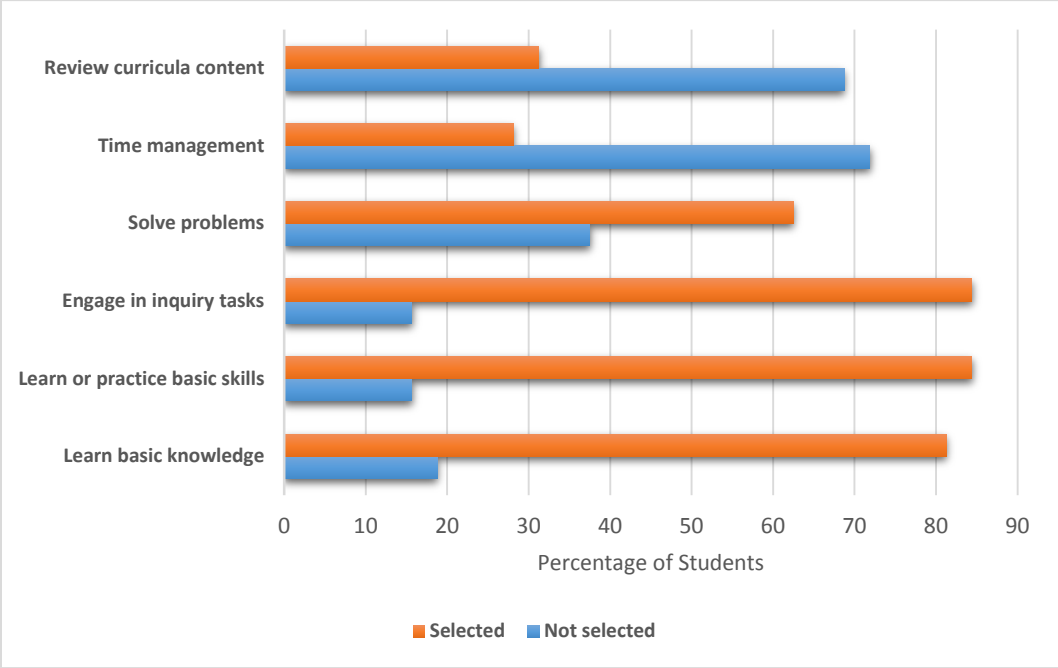
Figure 5: Digital tool usage by learning format



A majority of teachers indicated that digital tools (almost exclusively iPads) were in use most or all of the time in individual, small-group, and whole-class instruction as well as independent group work. For independent student learning those levels of use were reported by 75% of the teachers. In the case of individual and small group instruction and independent group work, a significant minority of teachers (between about 20% and 30%) indicated that iPads were only used some of the time.

Teachers were also asked to indicate for what purposes their students used digital tools (see Figure 6 below).

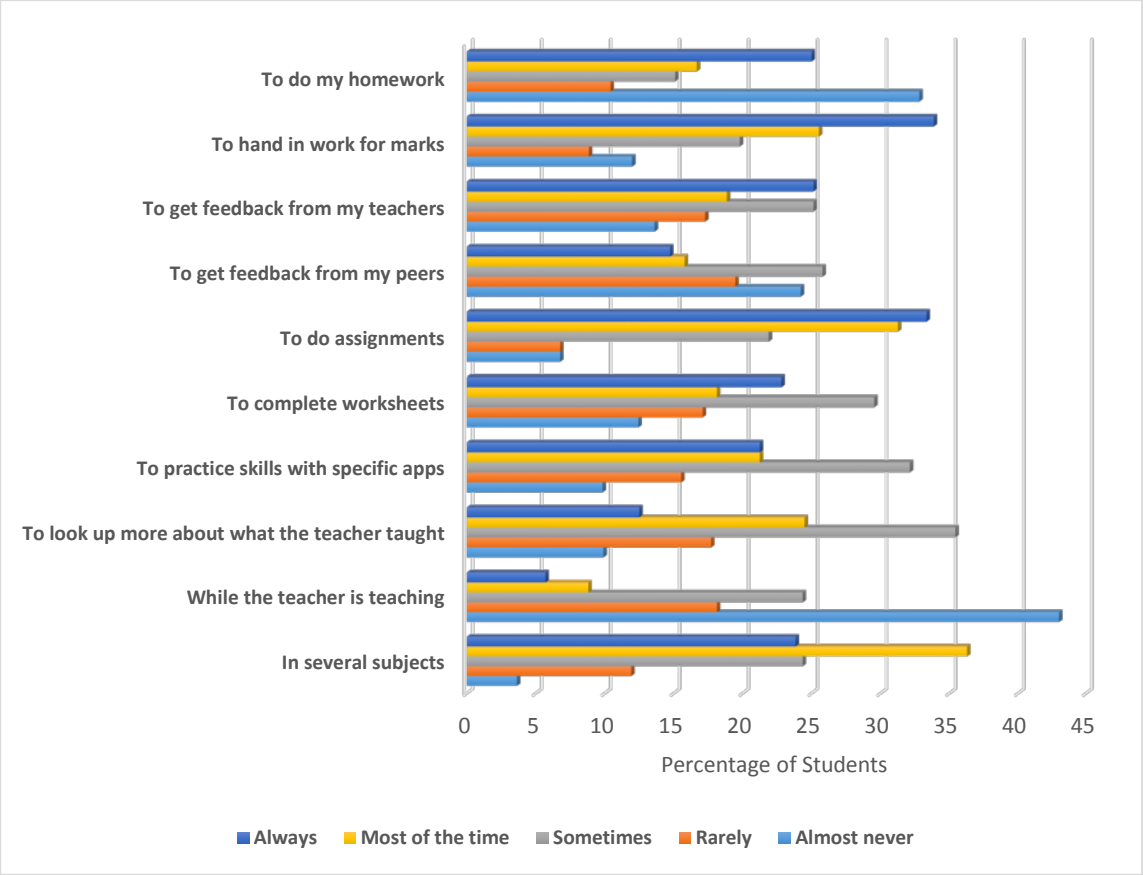
Figure 6: Purposes of student iPad use



As this chart shows, over 80% of the teachers reported that their students used iPads for learning basic knowledge, practicing basic skills, and engaging in inquiry tasks, and about two thirds had students using them to solve problems. Use for time management and reviewing curriculum content was much less common, being limited to about 30% of respondents.

The school district's student survey asked students to indicate how frequently they used their iPads for different purposes (See Figure 7 below).

Figure 7: Students' reported frequency of iPad use by purpose



About 60% of the students indicated that they used it most of the time or always in different subjects, and only 15% used it rarely or never. A majority made little or no use of their iPads when teachers were actively teaching the class, but about 40% of respondents indicated that they operated it "sometimes" or more frequently in that context. It was more commonly used to follow up on a subject the teacher had taught; over 2/3 of students reported doing this "sometimes" or more frequently. The use of iPads for skill practice was even more regular, with about 75% of students doing so "sometimes" or more frequently; use for completing worksheets was nearly as high. The broader learning task category of "doing assignments" had the highest iPad use associated with it, with 85% of the students indicating it was "sometimes" or more frequently applied to this task.

IPads were not used quite as frequently to receive feedback from classmates; just over 40% of students did so "sometimes" or more frequently. The percentage of students receiving feedback from teachers at these levels was much higher—about 70%. The percentage using iPads "sometimes" or more frequently to hand in work for marking was about 80%. The number of students who reported using iPads to do homework seems high given the iPads could be taken out of the school; about 60% indicated they used them "sometimes" or more frequently for that purpose.

Taken together (and allowing for differences in the usage categories inquired about between teachers and students) the usage levels reported by students accord with those recounted by teachers. These data indicate that IPads were frequently in use in these classrooms to support and augment a wide range of teaching and learning activities, of which IBL was only one of

several; most of the others were more "traditional" forms of learning and teaching. (The specific ways in which the technology was used in non-IBL contexts is explored later in this chapter).

Use in recent learning tasks

In order to gain a deeper understanding of the day to day learning activities in which students were typically engaged in within the 1:1 classrooms and how iPad use was embedded in these activities, the teachers we interviewed were asked to describe the tasks students were doing over the prior two days of classes, and any role iPad use played in those tasks. The tasks described and the subject areas addressed varied considerably, and the forms of pedagogy the tasks were embedded in ranged from very teacher-directed to student-centred IBL. IPads were almost always used by students for both research purposes and document or artefact production in these learning activities. The tasks included traditional research assignments in areas like social studies, history, and science in which students pursued teacher-specified topics and objectives, such as a grade 8 geography assignment in which students were to access with their iPad browsers the UN's human developmental index (with the teacher providing the links in a source document uploaded to a shared Google Drive workspace), and to develop a comparison of a developed with a developing country from that source. Some assignments blended elements of IBL and more traditional approaches to research. A science class project exemplifies this blending: Students got to choose a planet to research using teacher-vetted sites, and could also choose how to present the information they found using iPad apps like Explain Everything, iMovie, or some other presentation tool, but they had to answer a provided list of specific and fairly narrow questions about their planet so students had very little freedom to pursue their own wonder questions.

In a minority of cases, teachers reported that students were engaged in fully realized IBL. One teacher had her students pursuing an art project that more closely met the definition of IBL: students looked through art gallery and museum web sites to find a painting that they found very interesting; they were then to research the artist's life, create a 3D diorama representing the painting, and present that along with material about the artist to the class.

Language Arts learning tasks were also described, and these ranged from having students work in small groups to develop movie trailers in iMovie based on a chapter they had read in a novel, to getting students to source images online that reflected a writing topic or theme of personal interest and then integrate those in a Word document which described what was happening and the writer's reactions to it. In the latter case, the documents were then shared with the class from students' iPads using Apple TV, which led into a discussion about what unanswered questions each image raised for other students.

Longer term patterns of use

When questioned about how they and their students had made use of iPads in the classroom over the school year to date, most teachers described several ways they had applied the technology in each of the subjects that they taught. These are described in summary form for each subject area below. In some instances, iPad use was simply substituted in for some other medium of research or work production and its adoption did not change teaching or learning in any substantive way, but in many cases, the affordances it introduced did have a substantial impact on classroom practices. In the following section of the chapter, we look more broadly at the nature and extent to which teachers came to adapt and in some instances transform their teaching approaches and strategies in response to 1:1 iPad infusion into their classes.

Language Arts. Teachers indicated that in most instances iPads had become the medium for all student writing activities and all types of writing (students in some classes could "opt out" and use traditional materials for certain assignments, but few did). In the intermediate grades the predominant writing app used was Google Docs, which provided cloud storage for easy document access and sharing with a teacher or classmates. Creative writing done on the iPads ranged from the graphical Zines to haiku poetry and illustrated eBooks. Writing was also integral to the creation of other iPad-produced digital artefacts such as iMovie trailers; in one project students in small groups created movie trailers in which they enacted a part of a novel they had read that had been left out of the film adaptation, which they had viewed in class.

The use of the iPads as a medium for reading literature was a widespread practice as well, as teachers had access to digital texts through the district Hub, virtual libraries and a few reading apps like Raz-Kids, which included levelled books. A few of these apps allowed students with reading challenges additional reading support through text to speech functions and virtual dictionaries, and with the Raz-Kids app students could also record and listen to their own reading of text segments, a feature teachers used with struggling students for assessment and self-tutoring purposes. In one unique instance a class conducted a shared novel study with a class in the United States, using Skype for structured cross-class discussion of the novel's chapters as they progressed with their reading. Quiz apps were occasionally used to practice language skills; students mentioned Quizett being used for this purpose. Kahoot, a learning game platform, was used by a French teacher to create French games for her Junior division students in order to "catch the kids' excitement and engage them in learning the language, which isn't the most popular thing in grades 4 to 6" according to her principal.

Mathematics. Several teachers indicated that they now had their students doing most of their mathematics work in Explain Everything rather than on paper, as it was easier to erase and correct, and students could add voiceovers explaining their solutions to share with the class or their teacher. (Explain Everything provides several virtual math tools for student use like a protractor and graphing paper.) One teacher would have her students work collaboratively every day on a challenging word-based, cross-topic math problem on paper, then photograph their solution with their iPad, embed it in an Explain Everything document, and send it via Apple TV to the projector for whole-class sharing and discussion.

A range of other iPad tools were also used to support math learning, including calculators, digital manipulatives, and graphing apps. Google Sheet was used for calculating statistics and graphing the results. A few teachers had moved away from using textbooks and were using Nearpod to display student learning materials and problem sets. Google Classroom was also used for sharing out assignments and accessing student responses to questions and seatwork.

Students were sometimes given choices in the medium they used to generate their solutions. A principal described one such instance he observed in his school:

> After a math lesson, students worked in groups to solve problems, and talked about different strategies. The teacher wanted to see what they could do on their own. He posted a question on the Google Classroom platform he uses. Students can choose to answer it however they wish. They can do it on paper and solve it. They can use Explain Everything as an app and solve it. They can type right into Google Classroom. In this case, he said he wanted them to reply in a private comment, so only he can see their thoughts and their answer. Then, he is able to go in and provide them feedback.

Students made use of math practice apps that were part of the apps catalog, sometimes on their own initiative: “They've got a ton on there [in the catalog]” one teacher remarked. “I'm actually amazed at how many students have download math practice apps without me directly saying these would be good to put on there. They make use of them and acknowledge them. I'm surprised they haven't burned out the iPads with how much they make use of it.” A math quiz game, Prodigy, was employed by several teachers occasionally and was seen to be popular with students.

Another math learning aid some students turned to on their own initiative when they needed help (after their teachers had introduced them to it) were the Khan Academy tutorials; several teachers found these helped with their students’ engagement and their learning of specific skills.

Science and Social Studies. For these subjects, the iPad was primarily used as a gateway to online knowledge sources when conducting research, and as a tool for the creation of written documents and multimedia presentations. Many teachers provided students with links to topically relevant media or apps that students were to play, read or (if they were interactive) work through. Vetted institutional and government sites with an educational component like museums, National Geographic, and NASA were the most commonly used sources. A few teachers had students access online science demonstrations and experiments that could not be conducted in class for reasons of cost, time, or safety. Gizmos (interactive 3D simulations) were also employed in science teaching to demonstrate and explore physical laws and processes. In a few cases, students used environmental construction simulations to build operating models of physical systems in order to learn how such systems function. For example in one class students built a renewable-energy-based city in the Electro City modeling simulation.

No computer science topics were part of the formal curriculum, but two teachers reported using the Hopscotch drag-and-drop coding environment – one in students’ free time, and another in a student coding club.

Art and Music. While most fine art work continued to be done in non-digital formats, a few teachers stated that they allowed students who were frustrated with hands-on work the option of creating digitally-based artworks. IPads were also used exclusively for a few specific artistic tasks mentioned by teachers such as the creation of animation clips, and the making of virtual story boards which students then videoed in sequence to create a narrated story. One teacher had students use digital media to study the use of perspective in art. Online access to works housed at different art galleries and museums allowed students in another class to easily search for and locate works by an artist they wished to study.

Garage Band, a music creation and editing app, was fairly commonly employed to add music to presentations being created for projects in other subject areas; even grade four and five students who receive no formal music instruction in school would learn to use it by watching YouTube tutorials and learning from their classmates. Garage Band was also utilized by older students in their music classes for composing music.

Interdisciplinary applications. Many of the student inquiry projects in which iPad use played a prominent role were interdisciplinary in nature. These include several that were described in the previous chapter of this report, such as the project examining art and artists from the War of 1812 time period, in which students produced tableaus for dramatic scenes based on art of the era; and the creation of digital models of stadiums using the Minecraft simulation environment, which incorporated elements from both the mathematics and science curriculum expectations. In these contexts, iPads were used to research topics and (in most cases) to develop some or all

of the project artefacts and student presentations. They also played a key role in supporting collaboration by allowing the sharing of research and the simultaneous co-creation of content by team members.

iPad apps in use. When asked what iPad applications and toolsets were most frequently used by their students, three stood out as the most popular, and were cited by a majority of teachers: Explain Everything, iMovie, and the Google suite of apps for education (primarily Google Docs, Google Slides, and Google Drive). Teachers saw the appeal of Explain Everything to students stemming from a combination of its ease of use and its capacity to integrate various media into a multimodal presentation which could be easily shared, and could incorporate a voiceover recorded by the student. Students' great enthusiasm for recording video, together with the ease with which they could create and edit short clips and movie trailers using iMovie templates was seen to account for the popularity of iMovie. The high use of Google tools was more teacher-driven; they favored these for their functionality and reliability, relative ease of use by students, and especially for the security and portability they afforded with their cloud-based document storage and multi-platform support, which let students work without any danger of losing their documents from either home or school on virtually any device with a web browser and internet access.

A few other apps were each mentioned by several teachers as being among the most frequently employed by students. Minecraft, which was used in four classes, was found to be a highly engaging sandbox app for the collaborative construction of structures and environments (although in at least one class it was used on PCs rather than iPads as the iPad version was not as full-featured). Book Creator and Pic Collage were commonly used for content creation, and YouTube for sourcing video and watching tutorials such as those from the Khan Academy. Prodigy, Animation Desk, Paper, Photo Booth, Epic Books, Puffin (a Flash-enabled browser that made it possible to use web-based simulations and games) and Prezi were each mentioned by one teacher as being frequently used.

The students in the 1:1 classes at the seven schools were asked to enter the three apps they most frequently used. The apps mentioned by 1% or more of the students are shown sorted by frequency of choice in Table 5 below.

Table 5: iPad apps most frequently used (student survey)

iPad App	**Frequency of choice (in %)**
Explain Everything	11.86
Google Docs	9.60
Safari	8.66
Google Drive	7.16
Google Classroom	5.46
Google/ Chrome	5.27
Doulingo	3.77
Epic	3.77
Ixl Math	3.39
iMovie	3.20
Prodigy	3.20
Google Slides	2.26

Hopscotch	2.26
Puffin	2.07
Calculator	1.69
Keynotes	1.69
Nearpod	1.69
Pic Collage	1.69
Sumdog	1.69
Garage Band	1.51
Math Slide	1.32
Cool Math Games	1.13
Total %	**84.34**

N=526

While the iPad uses most commonly mentioned in the student focus groups were very congruent with those cited as most frequently used by their teachers, the findings from the much broader student survey show some disparities. With the exception of the Safari web browser (which the teachers never mentioned as they doubtless did not regard it as an app), the students' most frequently used apps match up reasonably well with those given by the teachers, but they were mentioned by a far lower proportion of students than teachers. Most of the apps listed in Table 5 that were not cited by teachers—Ixl Math, Sumdog, Math Slide, Collaborative Math Games, Nearpod—are gamified tutorial or skill practice apps, primarily in mathematics. A further 43 applications not shown on the table were cited by less than 1% of student survey respondents of these, gamified learning apps like Kahoot! and Math Monkey comprised a slight majority, but the list also included information sharing utilities and organizers like PadLet and media creation tools like Stop Motion and Toontastic.

Taken together, these frequency of use data indicate that the teachers and students we interviewed made more use of apps and tools of the type commonly utilized in IBL learning for content creation and presentation and significantly less use of tutorial and drill apps than did typical teachers in the 1:1 classes in these schools. This strongly suggests that the teachers in our sample were on average making greater use of IBL in their practice and dedicating less student time to the use of iPad-based tutorials and drills, than was typical in the 1:1 classes at these schools.

iPad impacts on teaching and learning

Most of the shifts in pedagogy that teachers reported as being related to the iPad implementation were undertaken in order to take advantage of (or in response to) the new educational affordances and opportunities that the technology was seen to offer. As teachers came to see the potential benefits various iPad apps and tools could have for enhancing student learning, they began to transform their teaching practices to better leverage that potential. The majority of the changes the teachers made moved them away from teacher-directed pedagogical practices and adopting more student centered, collaborative, and project-based teaching strategies that typically incorporated some or all the elements of IBL. In fact, when asked about the impact of iPads on their teaching teachers cited many of the same changes they mentioned when queried about how IBL had shifted their pedagogy, which strongly suggests that these two elements—IBL and 1:1 iPad technology—were mutually reinforcing factors in bringing about transformations in practice.

The most frequently described pedagogical shift, mentioned by several teachers, was the relinquishing of tight teacher controls over student learning. The affordances for independent research and learning that the iPad made available to students meant teachers were no longer the sole or even primary source of knowledge in the classroom. With nearly unlimited learning resources now instantly accessible, it became far more feasible for students to pursue their own individual learning interests. Teachers were very aware of this and for the most part encouraged more autonomous learning, using modeling, scaffolding, and discussion strategies to help students build up the skills and (in some cases) the initiative they needed to pursue it successfully. But for these teachers, following this course of action meant giving up much of the classroom control that traditional direct teaching methods had made possible, and there were concerns about how students would respond given these new freedoms. As the principal in one of these schools expressed it, "The challenge is having teachers feel comfortable giving up their role as the sage on the stage so to speak. For some people it's really difficult to not be the person in charge of the learning and to not have control over the learning and the direction that it's taking." Here is how three teachers saw this role transformation:

- "I have become the facilitator in my classroom. I'm more of the person that guides and helps them along their journeys. The engagement level is huge in the classroom."
- "Instead of being up at the front teaching a lesson and having them sit and listen, I'm now sitting down at a table with my thinkers listening to them, sitting back more. Then throwing out the odd probing question to then engage the conversation."
- "It has completely changed what I do in the classroom. There is so much more freedom and choice for my students now that I couldn't have before because there wasn't really a lot of choice to give. I think I see the potential of the technology as giving students something that they could never have had before….The freedom is huge, the allowance for me not to tell students what to be or what to learn is a big huge shift for me."

One consequence noted by a few teachers of the move to student-directed learning that the technology facilitated was that they became less focused on making certain students met pre-specified curriculum expectations. One teacher expressed how this had transformed her approach: "I always started with curriculum first and then my lessons stemmed from that and I don't do that anymore. Now it's like, 'What are we going to do?' Then I find the curriculum expectations that match that."

The process of learning to use the technology itself had a direct impact on why teachers saw their role shift from expert to more of a co-learner. Teaching staff did not have the time to master the details of more than a few of the tools and apps students chose to use, and consequently they often had to rely on students to teach them (and the class) app functions and operations. (In a few classes teachers had students choose an interesting app from the district catalog to learn about and then present to the class.) A principal observed that bringing in the technology had forced his teachers to acknowledge that they can't know everything about it and so had forced them to become co-learners, which had had a salutary effect on classroom culture: "That helps with relationships. It's huge. It has a huge impact on developing those relationships. It changes the classroom environment."

Some educators found that used in the context of student-centred learning, the technology's capabilities substantially enhanced their ability to accommodate different student learning styles. Several teachers gave examples of how the technology supported this type of differentiation, and its educational benefits:

- "The boy who doesn't like reading can now have text read to him, versus the girl who wants to collaborate with her friends. It has sort of given most of my students vastly different entry points but they're all entering the same topic, they're all entering the same ideas, themes, discussions and wrestling with that material."
- "Once I establish that core set of apps kids can use it's [their] choice. And to me that speaks to learning style. So if a kid is a visual learner and prefers to do perhaps a drawing to explain something they now know what app they can use to explain it. I always tell them the content has to be there, you still have to answer the question. The way you arrive at that answer is up to you, and that allows them to really demonstrate individuality and expertise."
- "I had kids using Garage Band and creating a song, I had kids using iMovie. So again it gets back to what they're comfortable with – some kids aren't comfortable filming themselves whereas they're very comfortable singing or creating a piece of music for them to voiceover. So it really allows for individuality based on their strengths."

One teacher stated that by enabling her students to work more independently, iPad usage had freed up more of her time which she could then devote to helping individuals and groups that were struggling.

Most of the teachers indicated that the expansion of modalities for student work the technology enabled made it possible for them to give students a much richer set of options for expressing their learning, and that this allowed them to better accommodate students' individual learning styles and interests. This was seen as another element in an overall process of stepping back and releasing responsibility for learning to students. One teacher's experience illustrates this transformation very well:

> I thought I was doing [my students] a favour by giving them a choice on what civilization they wanted to learn about, but then I said "Everyone has to make this flip book. So your first page is clothing, the next page is family life, the next page is this." And then that's what I marked. Whereas now their product may be an iMovie to show me what life was like in the Egyptian days. Or it may be a slide show or it may be a graffiti wall they created. It's very different.

A few educators talked about how their initially low expectations for the impact of iPad technology were turned around as they began to see what students were doing with them. One moved from viewing iPads only as a tool for online research and the emailing of student work to understanding it to be a technology that could deepen many aspects of inquiry work: "It took a long time until I really understood there's a lot more here [to the technology] than I thought. This year it's really become seamless…. Every year I learn more and more about how to make these experiences more genuine for the kids and how to really get them involved in their own learning." A second teacher commented on how her vision had expanded:

> I initially felt they were leaning too much on one thing, the iPads, to make a big change. But I actually found that it's different than that, it's not just about the iPads, and the inquiry based learning is more than just about kids doing research, it's more than that. And it's that engagement piece that's so important. If the kids are engaged your job is easy.

IPads in assessment

iPad use in these 1:1 classrooms had a substantial impact on most teachers' assessment practices. Most of the tools and apps students could choose for creating and submitting work had affordances for sharing work that allowed teachers fast anywhere/anytime access to student output in all stages of development, from initial plans and outlines to final products, and this made both formative and summative assessment of student work much more convenient. Consequently teachers were much more inclined to iteratively assess student work and provide feedback and guidance as the work progressed. IPad tools and apps provided teachers with a way of providing near-instant feedback to students, either by directing adding written or voiceover comments into their digital artefacts, or by email. The technology could even make assessing student works that were created manually easier; some teachers would have students take photos with their iPads of their handwritten text and other analog artefacts and email those images for teacher review and feedback.

A majority stated they were spending putting more time and attention on conducting formative assessments of student thinking and learning skills based on their ongoing observations, and placing less emphasis in their summative evaluations on the content of student presentations and work artefacts. One teacher described her shift in practice as follows:

> I find that assessment has completely turned on its head. I don't have assessment books that state "this is the curriculum expectation" and I'm going to put a mark to it. Now I have assessments that look at "this is the parts that they know. This is how they're thinking, this is how they're communicating, this is how they're applying that."

Another talked about the kinds of questions he focused on when assessing student progress:

> Are they really thinking about and analyzing their own work? Are they using their meta-cognitive skills so that they can truly represent what knowledge and skills they've gained? Are they selecting tools that show their answers in the most effective way? Are they successfully communicating their thinking and their understanding? So it's not so much about the content, because they can look up content at the touch of a fingertip.

Several teachers made use of the Sesame Snap app for supporting their assessment practices, which they found to be of great value in facilitating the creation and distribution of rubrics and checklists, documenting observations (including video), rating work, and providing timely, rapid feedback to students. It also made very easy for teachers to update rubrics and checklists as needed. Because the app made it so straightforward for her to capture and record her observations, one teacher found using Sesame Snap led her to shift from her assessment focus away from simply grading a final product to one that was also concerned with evaluating student work processes and learning behaviours.

Use of iPad-related technology was said to have had other positive impacts on assessment practices. A few teachers mentioned that it was much easier to actually see what students were doing when thy worked on iPads rather than on paper, which made observational assessment more effective. Depending on the app a student was using, this observation could sometimes be done remotely in real time:

> I can actually open up my iPad, find their folder, find the document they're working on, and actually watch them type, and see what they're putting down. If I'm ever wondering how my kids are doing, especially my IEP students, who I'm monitoring, I can actually do that, physically do that which I haven't been able to do before.

Whole-class sharing of work for peer evaluation was made much easier with the use of Apple TV, and this led a few teachers to have students engage each other's ideas and provide feedback on developing work in earlier phases of a project rather than restricting peer assessment to a single summative review when the work was finished. The reading app Raz-Kids proved to be of considerable value for enabling student self-assessment, as students could record their reading of text and have it played back to them. "They can hear where they've made their mistakes and that helps them a lot", one teacher noted.

Meeting special needs

Many iPad apps had functionalities that teachers found very valuable in addressing the educational needs of ELL students, as well as others struggling with reading and writing. The text to speech capacity built into the iPad's OS, as well as that found in other apps, made it possible for students without the requisite reading skills to read along as the text was read to them, which helped them develop their reading skills, while learning from the same resources other students were using. In a few classes, the iPad's speech to text capabilities also proved their worth, allowing students with limited writing ability to express themselves creatively in narrative writing. The Book Creator app made it possible for students with limited writing skills to add images and video to ebooks, and to easily insert audio at any point in the book being created, allowing them to generate narratives and present the findings of their inquiries without being unduly restricted by their inability to produce extended text. Students would also capture and present their research findings and inquiry results using the recording and voiceover functions in other apps like Explain Everything and iMovie. Teachers found these tools valuable for several reasons: they made it possible for struggling students to more fully participate in class activities, enhancing the students' sense of participating meaningfully in the class and reducing the risk of their being stigmatized by classmates; they allowed students to more fully exercise their creativity as well as their analytic and critical reasoning skills in their work; and their use resulted in better demonstrations of students' true understandings, as student expression was no longer inhibited by their written language limitations.

According to the teachers we interviewed, ELL students as well as those with special needs also made use of a range of non-text learning resources that the iPad opened up to them, ranging from simulations and documentaries to YouTube videos. For ELL students, translation tools and primary-oriented language arts apps were resources that gave them more learning autonomy. They also freed up teacher time that could then be given to others. Access to leveled texts in Raz-Kids and a leveled encyclopedia (GebbleGo) allowed for critically important reading level differentiation for those with reading challenges. One teacher talked about how the technology benefited her and her colleagues, who were faced with high numbers of ELLs in their classes:

> I don't know how we would teach without it. We have so many stage ones that are coming in without any English acquisition whatsoever. So Google Translate is huge for our communication piece, but then there's just some really good primary apps that are teaching them the alphabet and teaching them how to spell simple words. I don't know what we would do without that.

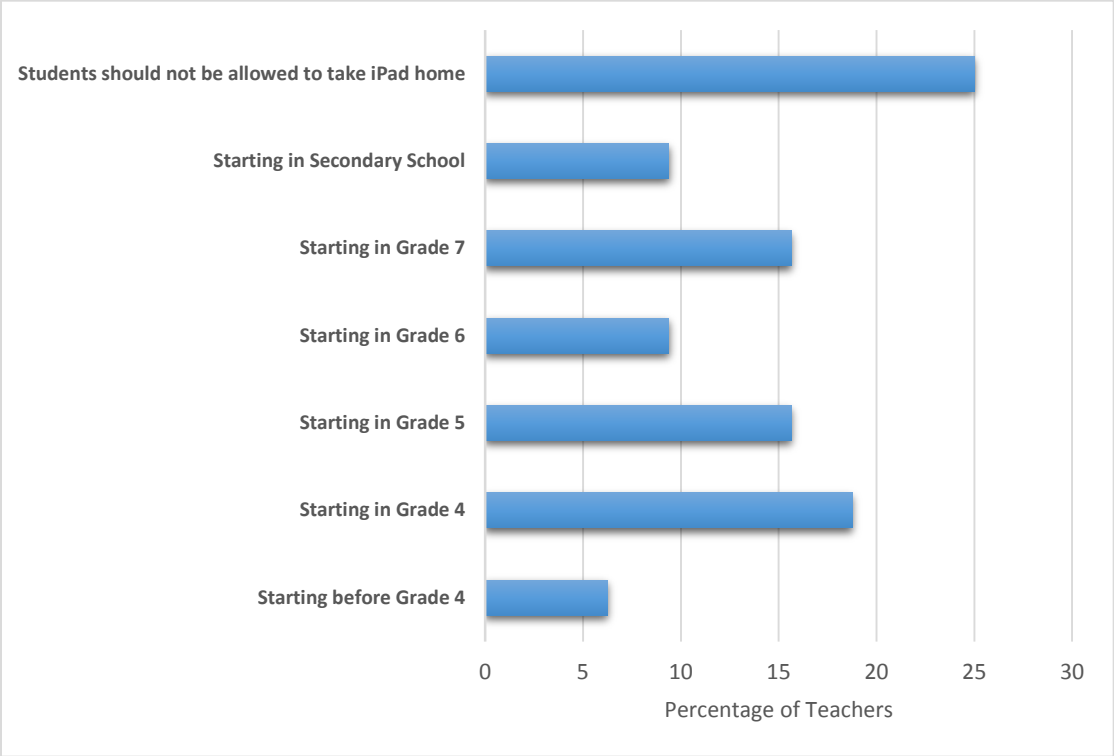
Managing iPad use

In the previous school year, students had been able to take iPads home with them after school and on weekends. According to the teachers we interviewed the school district reversed this policy for the current year because of inappropriate home use by family members, the "jailbreaking" and adding of unauthorized apps onto the iPads, and the loss and damage of iPads

and chargers. (One principal also mentioned that with a teacher work action in effect through the fall of 2015, nobody was available to track the iPads in a manner that would permit home use.)

Teachers were asked in their survey whether and at what grade students should be able to take their iPads home with them (See Figure 8 below).

Figure 8: Student iPad home use: teacher opinions



Despite all of the difficulties encountered with home use in the first year, most teachers wanted their students to be able to take their iPads home once a certain level of maturity had been reached, although what that level was thought to be varied. A quarter of the teachers felt students should never have the option of taking iPads home; about a third felt they be able to do so in grade 4 or 5; and another quarter recommended that option starting in grade 6 or 7.

In their interviews, the teachers who favoured home use indicated that they did so because they wanted their students to be able to continue their work seamlessly from home. They knew that many of their students could access most of their working documents and other digital artefacts at home using other devices by connecting to their Google Drive account and to web-based app sites, but were concerned that not all of their students had such devices with the needed internet access available to them. As one teacher expressed it,

> I think it's an equity issue because before you could say to the kids “Okay take it home”. Even if you didn't have internet you could still use the apps, you could still do the work and bring it back the next day. You have a school that is totally integrated using the iPad but the iPads aren't going home anymore. I find that is a drawback because now some kids are actually, if their families have the internet, they can afford it, they're fine because they're still working on it. The kids that can't, you're trying to make up for that in class and it’s just not fair.

The students themselves objected to not being allowed to take their iPads home to use both for schoolwork and for other school-related educational activities such as blogging.

The option to install unauthorized apps on the school iPads was blocked by the start of the 2015-2016 school year; every iPad received the same locked disk image and had its access to apps restricted to common catalogue of vetted educational software maintained by the school board. That catalog contained 298 apps, tools, and web-based programs for which the district had licensed access; most were intended specifically for students at the elementary level, although the catalogue also included more general tool suites such as MS Office and Google Apps for Education. While a few social media apps were made available (e.g. Skype and Twitter) others (like Facebook) were not. Teachers could request the addition of an app to the available catalog if it were free or licensed by the Ministry; the request went through an approval process that took a few weeks. A principal reported that a number of app requests were denied without any reason being provided, and teachers found it frustrating that apps that did get added following a request would be deleted over the summer, forcing them to repeat the request. A library of vetted resource links indexed by level and subject were provided in the district's Hub portal, teachers and students were not limited to those for learning purposes.

For the 2015-2016 school year, teachers were provided with an Apple management app that allowed them to lock down the class set of iPads to one specific app at either a class or student level, and to see which app a student was running, but teachers made little use of it as it was found to be awkward to work with; instead they relied on visual monitoring to ensure usage norms were being followed.

Aspects of iPad management and care for which students were responsible, as well as acceptable standards and norms for iPad use, were topics covered in digital citizenship lessons students received from either their home room teacher or the school's resource teacher/TLE champion. This instruction took place in the fall of 2105, prior to or coincident with students receiving their iPads. Teachers indicated that partly as a consequence of this pre-teaching, very few or no instances of inappropriate iPad use such as online bullying or accessing unsuitable web sites had occurred during the current school year.

Procedures for the physical management of the iPads varied across classes and schools. A few teachers had students put the iPads in storage bins when they came to class, and they were only taken out when they were to be used, but most let students keep them at their desks. Some schools used bins for moving the iPads from room to room as students rotated through classes, having a designated student transport them. This avoided the problem of students taking iPads into bathrooms, which raised privacy concerns and so was disallowed, as was unsupervised use at other times such as recess and nutrition breaks.

Classroom management

We consider here two aspects of classroom management in relation to iPad use: first, management of the iPads themselves; and second, the use of iPads and related technology to manage classroom processes and work flow.

When the iPads were introduced, teachers soon realized that they needed a quick way to get students to stop attending to their iPads when their attention was needed, and the phrase "Screens down!" became common parlance. Most teachers found that students responded well to such instructions, but a few mentioned that a minority of their students did not; and monitoring what 25 students were each doing with their devices was challenging especially when a teacher was working with an individual or a small group. One teacher remarked that the

same students that would "act out" without the iPads present were the ones that would do so with them. Generally though the teachers did not consider ill-timed or off-task use to be a major issue that interfered significantly with their teaching or seriously impeded student learning. For their part, some students reported that certain board-approved iPad games were not really educational and served as a distraction for some of their classmates.

The major classroom management issue that teachers had to deal with centered on the hardware itself: the need to charge the devices at least every second day to keep them operating. When iPads were taken home the previous year, most students would charge them up overnight, but now that had to be done in the classroom; but with only six or so power outlets per room and no charging stations, and students misplacing or losing chargers, that became time-consuming and more difficult than teachers thought it needed to be. Several students noted in their focus groups that a lot of times iPads would not get charged up because of a lack of charging spots.

With the introduction of 1:1 iPad technology, many teachers chose to move to a nearly paper-free work management system, which they found reduced the amount of time they had to spend dealing with logistical and management tasks. For a few of the teachers we interviewed, the path to paper-free took the form of adopting the Desire2Learn learning management system (which the district had incorporated into their Hub portal), using that as their platform of choice for posting learning resources, schedules, assignments, and assessment rubrics or checklists; emailing students; receiving student work (or links to it when it was in a form that could not be made internal to D2L), and providing feedback on it; and in a few cases hosting student blogs and/or discussion groups. Several other teachers used Google Classroom for these purposes. One teacher described its advantages as follows:

> Google Classroom makes is very easy to manage and distribute assignments – I create them in it, students access Classroom through their accounts, see my news and assignments, the resources I make available. They can upload work and I can offer private comments. It allows me to give feedback right away.

Google Drive was nearly universally used for storage and easy sharing out of student work at any stage of development (although artefacts created with certain apps had to be stored on that app's server, through their web site). The autosaving of work, together with remote and cloud-based work storage, were seen as great aids in managing student work since they prevented work loss and allowed students and teachers to access that work from most internet-connected devices.

As mentioned earlier, the Sesame Snap app was widely used for managing assessment and marking; teachers employed it to create rubrics and checklists, record observations, and assess student work (which students could upload directly to it). "It's great for mathematics," said one teacher, "because it gives you all of the students' work information without having to deal with piles of paper". Other apps such as Google Docs and Explain Everything had commenting functionality built in (either in written form or using voiceover recording) which made providing descriptive feedback to students in a timely manner easier and faster. The district's online app catalog was widely valued as it made finding and loading educationally useful apps a much more efficient process.

Conducting and managing shared learning activities was greatly facilitated by the use of iPads and related technologies. With Airplay and Apple TV, a student could effortlessly share their screen with the class without leaving their seats; tapping a button on their iPad would send the

image to a projector screen or SmartBoard. Teachers very much appreciated the amount of time this saved, leaving more time for productive discussion. Airdrop made sharing resources between 2 iPads over the wireless network extremely easy.

The ease with which students could share and collaborate using iPad tools encouraged some teachers to expand the role of collaborative learning in their practice. A few teachers noted that using certain tools such as the Google Apps for Education students could work simultaneously on the same document, which was seen to facilitate real-time collaborative learning, as students discussed and commented on entries their partners made. In the context of the 1:1 iPad deployment, this functionality eliminated the student arguments over access teachers had witnessed when iPads had to be shared and only one student could work on a collaborative document at a time. A superintendent who had spent time observing 1:1 classes commented on this collaboration:

> One of the things that I've seen happen in a few classrooms, this is not a lot of classrooms but a few classrooms, is that some teachers have really embraced the use of Google Apps for Education and are using them in a way with their students to really encourage collaboration. So to me that is a major step forward and a change in thinking about how students work with each other and how we work with technology as the accelerator.

Building parental understanding

Teachers and principals both indicated that parents initially expressed varying levels of support for the 1:1 iPad infusion, A few schools employed school-level strategies for developing parental understanding and buy-in, and educating parents in how to guide and monitor their child's use of the device at home. For example, one school ran iPad cafes for parents where basic iPad operations were taught and guidelines for a child's use were presented, and its use in the classroom discussed. In other cases teachers interacted directly with their students' parents for these purposes. Two teachers showed student-produced videos on parents' night; one of them expressed the view that "It's a really good way to introduce parents to how we do things and what their child is actually accomplishing. It gives them a different perspective of what school is like." A few teachers provided parents with web links so they could access student lessons, assignments, and even student comments to see "everything we do". Students were encouraged to show their media projects artefacts to parents at home.

Several teachers felt that parental knowledge was still insufficient to properly support and structure home use. In the words of one educator,

> The kids go home and they say they're doing their homework and the families don't understand that they have the right to say "It's done let's lock it up". A lot of coaching needs to happen there so that it doesn't get negatively viewed that it's just a play thing and also that the kids have some proper structure at home.

Of the three principals interviewed, two indicated that in this second year of 1:1 they had heard far fewer concerns about inappropriate use and that it was now "taken as a give" that students would have them. The fact that the iPads were fully locked down in the current school year, and that students were no longer taking them home, no doubt greatly lessened parental concerns. The third principal stated that most parents seemed apathetic about their presence, although some "did not understand why were need to give kids technology at school". A few parents were worried that their children were not going to learn cursive writing properly as they did most of their writing using virtual keyboards.

Student Outcomes

Engagement and agency

The teachers we interviewed found that nearly all of their students demonstrated strong levels of engagement in most learning contexts where iPad use was integral to their work. Student engagement was noted to be particularly robust and universal when students were using iPad tools to create non-textual and multimedia artefacts ranging from iMovie trailers and animations through music created or edited with Garage Band to design simulations built in Minecraft. Working with iPad-based learning resources that incorporated visual and audio elements in addition to or in place of text also proved very engaging to most students. These resources ranged from YouTube videos and other web-based resources to multimedia learning apps and ebooks. One teacher tested the appeal of traditional texts as compared to learning apps her students had been using:

> One day as a class we read some articles out of textbooks, and then I asked them "All right, do you want to keep working with these or do you want to try and use the apps?" Because I wanted to see how they were. Almost all of them said, "No, let's use the apps instead." We put the textbooks aside and we focused on the apps and that was the last time we opened those textbooks.

Teachers noted that students when doing work with iPads were more likely to persist at tasks when they ran into some difficulty, demonstrating more initiative in working to solve their problems, either independently or with peer assistance. The technology's ability to lower communication barriers was seen as the main reason why teachers saw greater persistence and higher levels of personal agency in ELL students. "I see a lot more initiative from them", one teacher commented. "I'm guiding them through the information but they're coming up with different things, connecting with what they already know…I would never want to go back [to not using the iPads]."

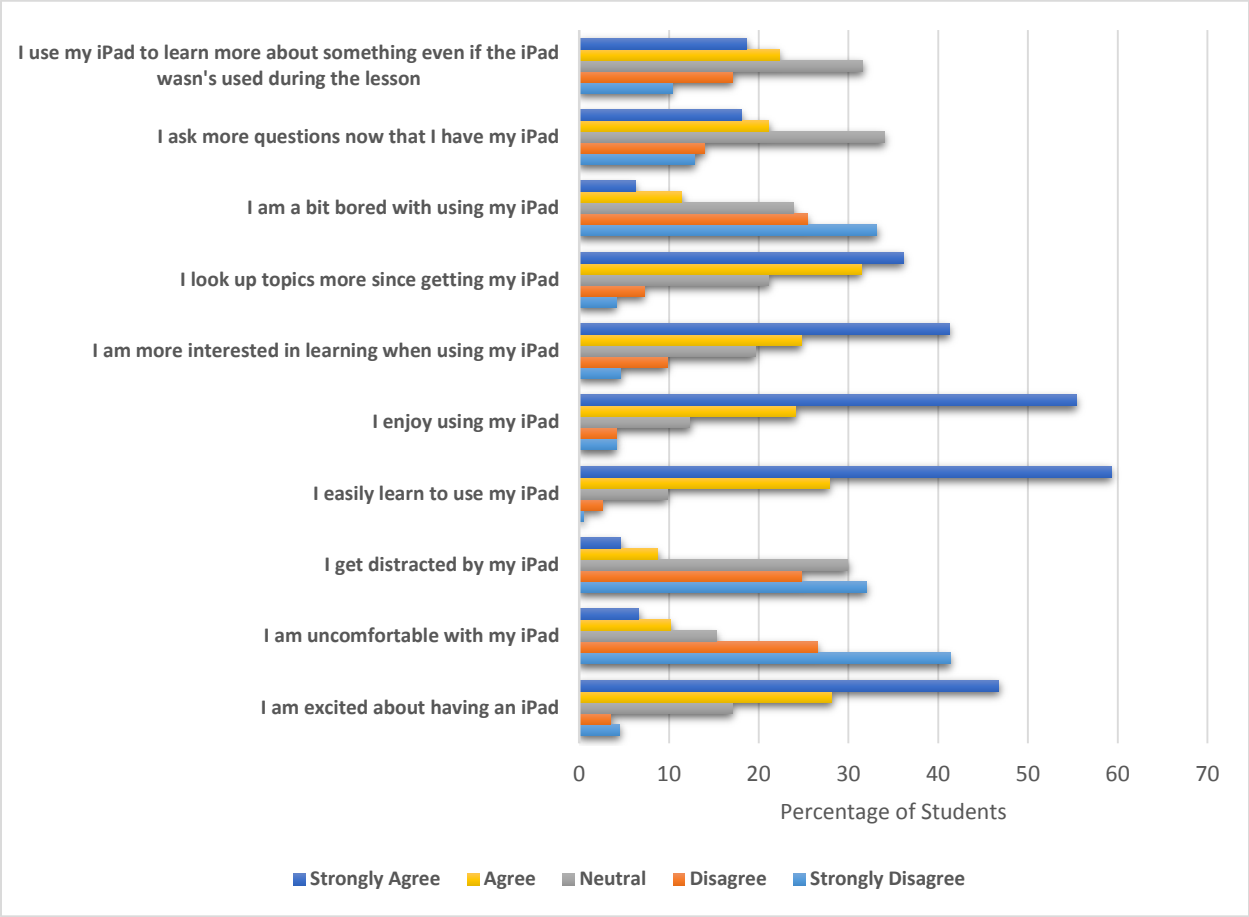
Teachers cited many instances where students working with iPads had shown greater autonomy and initiative in pursuing independent learning and creative endeavours both inside and (in instances where students had access to other technology) outside of class. In a few classes students made use of math practice apps on their own initiative. Khan Academy online math tutorials were also used in some classes; initially this followed from a teacher's suggestion, but students later began accessing them without any prompting when they needed assistance. Independent of assigned work, students produced their own iMovies; created iBooks; and researched and created DIY projects. Several girls pursued different forms of writing: a pair of them shared poems they wrote on their iPads; one wrote an entire mystery novel on a writing blog the teacher had pointed her to; and another created a blog about volunteer work at her church. A number of other students were reported to have their own blogs as well. One pair of students created a picture dictionary using a book creator app for new Syrian refugee students to use; a few others had created music using Garage Band. At one school, students in the Social Media Club regularly create school news productions that are presented at assemblies. While only a minority of students engaged in these extracurricular activities, teachers saw them as a manifestation of an overall increase in engagement and ownership of learning that the use of iPads had fostered.

The majority of teachers interviewed reported no instances of students resisting iPad use; in the words of one teacher, "Students would use them all day if they could." A few students brought their own personal iPads into school so they could use certain apps for learning that were not

accessible through the school district's catalog. At the beginning of the year some students were not happy about the lockdown of the iPad app set which had not been in place the previous year; they missed being able to access a few social apps that were no longer available. Passive resistance did manifest itself in a minority of grade 7 and 8 students at one school; these students would repeatedly "forget" to bring their iPads to class, or would neglect to keep them charged, but they would use the devices when prompted to. Often the source of resistance had to do with the limitations of the iPads, specifically their lack of real keyboards and their inability to send documents to a printer. In the student focus groups, a few students mentioned preferring using non-digital modes for conducting research and making some types of presentation, but they constituted a very small minority of those participating. A few also indicated that they were bothered when certain classmates got distracted playing games or connecting their iPads to their home computers without the teacher's knowledge.

In their survey, students were asked a series of questions about their attitudes and feelings regarding iPads and their use in the classroom, and their responses reveal that most of them hold a positive view of the technology and see it as a valuable learning aid (see Figure 8 below).

Figure 8: Student attitudes about iPads and their use in class



More than half strongly agreed with the statement "I enjoy using my iPad", a further one quarter agreed, and less than 10% expressed any disagreement with it; the agreement ratio was nearly identical for the proposition "I am excited about having an iPad". Response to the statement "I am more interested in learning when using my iPad" was only slightly less positive, with about

40% strongly agreeing, 25% agreeing, and 20% neutral. Only 16% of respondents indicated any discomfort with having iPads in the classroom, and less than 15% felt they got distracted by it (although about 30% were "neutral" on this statement, suggesting a significant number of students were not sure about that). Asked if they were a "bit bored with using my iPad", only 17% agreed or strongly agreed; the majority disagreed, and less than a quarter were neutral. Eighty seven per cent of the students agreed or strongly agreed that they had easily learned to use their iPads; only three per cent disagreed.

Two thirds of the students found that using the iPads made learning more interesting, and this was greater interest was reflected to some degree in reported changes in learning behaviours. Two thirds of the students indicated that they looked up topics more since getting their iPads, and 40% agreed that they used them "to learn more about something even if the iPad wasn't used during the lesson" (25% disagreed). Finally, just under 40% felt that they "ask more questions now that I have my iPad", with 25% disagreeing.

It is worth recalling here that at the time students were responding to the survey they were most of the way through their second year of 1:1 iPad use in school. Consequently the positive attitudes and changes in learning behaviour they reported cannot be discounted as short-term effects attributable to novelty and likely to diminish over time, but instead reflect stable, long-term changes in perspectives and behaviours.

Developing digital literacies

The teachers we interviewed observed many manifestations of their students' development of digital literacies over the year. One of the most prominent was the ease with which students would learn to use new apps and discover new functionalities in ones already in use without the benefit of any teacher instruction or demonstration. A number of teachers remarked on how their students picked up new technology uses faster than they did, and a few felt that their students had developed some ability to independently assess the value of an app for achieving specific ends. Teachers regularly leveraged their students' technical facility by having students teach them and/or the class how to use a new app or employ more of the capabilities of a known one. This served both to advance the educators' own knowledge of apps, and to give students an opportunity to assume responsibility for teaching and to exercise their communication and reasoning skills. As mentioned earlier, in a few classes this was undertaken as a structured learning activity, with students choosing an app from the school district's catalog to learn on their own and then demonstrating its use to the class as a whole. More commonly teachers informally requested student assistance, and then had students share their knowledge with peers. Here in their own words are a few examples of how teachers made this happen:

- I've brought students into it a lot because a lot of the times they know more than I do. So I'm really using them now as almost more than helpers, I call them my student tech leaders. So in so far as the literacy component—exploring what things can we find or pull as far as apps that can help them, or complement this area that we're learning and I have them doing that quite a bit. So again it's research but it's not researching content it's more researching what we can use to further enhance our learning.

- If I don't know how to work something or if I want to use an app and I don't know how to use it I just say "Go home and figure this out" and then they come and they're the expert and they can tell me how to do it.

- I'll say "Well you're the expert on iMovie", so it takes the pressure off of me as the teacher to have to know everything. And our TLE teacher started that trend a couple years ago in her own classroom.

In their focus groups, students indicated that they learned apps through exploration, with the help of peers and occasionally teachers, and through online tutorials. Most of the teachers stated at some point that students were very comfortable with experimenting with apps and not at all afraid of making mistakes; they frequently relied on students to learn apps with very little or no teacher input, letting them assist each other and seek out YouTube tutorials as needed. Several teachers noted that over time their students had come to relay far less on them for app support; they would ask peers or search online for solutions first. Students were aware that their teachers were not usually experts on app use, and would sometimes take the initiative to learn new apps autonomously and informally teach their peers.

Students would occasionally demonstrate without any prompting what they had learned about apps to their teacher: "With the new Skyview astronomy app, I showed them the basics but they came back with all these capabilities and functions I had no clue about and explained them to me." Several students in one school led lunch-and-learn sessions for teachers on specific apps. In a few schools, a structured process was being piloted to make the growing pool of student expertise available to all teachers in the schools. A teacher involved in developing this process described its rationale and format:

> I think a lot of the technology problems that teachers have can be solved by our students. So what we're trying to do (and it's hard always to get the buy-in—we're trying to create a network of understanding that between all of us in here the expertise level is there, so it's a matter of connecting with the people that can support you and the problem with teachers is our time is very limited too. So I look to my kids. Some of these kids have time all day because they're finished this, this and this, so I'm going to put them to work. So basically with our 21st century learning lead, he's put a ticketing system in place for me. Teachers are going to start submitting work orders, kids access them, they go solve the problems.

Other dimensions of student digital literacy growth also became evident to the teachers over the school year. As discussed in the IBL chapter earlier, in most cases students' capacity to conduct research online using digital tools was improving; they were more able to weed out unreliable sources, and to find relevant information to further their knowledge building and support their arguments. The majority of teachers found that their students' ability to integrate different media (such as videos, images, text, artwork, music, and voiceovers) into one artefact, using each media in ways that enhance the communication of their understandings and arguments and express their creativity, had progressed. One teacher stated that for her students,

> Turning their work, their ideas, into a finished product that they're presenting, that's the biggest leap that I've seen this year. So taking regular research that they normally would have just written an essay for and turning it into a little product or a movie or whatever. It's amazing.

Teachers with older students who had been using iPads for two or three years reported that they had mastered the use of a number of different apps (although to differing degrees). Students proved to be able to cope with the operational logistics of saving, sharing and displaying documents using the Google tool suite, AirDrop, and AirPlay. In their reading and

writing, students had learned to make use of tools to enhance and error-check their communication, employing spellcheck as well as consulting online dictionaries and thesauruses. One teacher commented that she had t spend far less time dealing with students' spelling mistakes as students could now quickly self-monitor and correct, and as a result she and her students had more time to focus on writing content: "I think it's a huge, monumental shift in terms of how we're using our time". Students had no difficulties using the editing capabilities of the apps they used, finding it much easier to revise digital documents than handwritten drafts, which encouraged more frequent and thorough editing. And as discussed earlier, ELLs and students with special needs were (after some instruction) able to use the iPad's assistive technologies to bypass or minimize the impact of their reading and writing deficiencies on their learning and communication.

One digital skill that many students struggled with was "virtual typing" using the iPad's on-screen keyboard. One intermediate division teacher found that her students much preferred real keyboards, and would regularly abandon their iPads t use one of the 12 desktop computers he had in his class for that reason.

According to their teachers, once they had received some basic digital citizenship instruction, students very rarely engaged in any inappropriate commenting on social media or in others' work, and were able to collaborative effectively when drafting and editing co-created digital documents. A few teachers felt that because students knew that their teacher and their peers were seeing their work they were much more careful about the content and tone of their remarks and comments.

Gender difference in iPad usage

Teachers were split as to whether there were any systematic differences in how boys and girls made use of their iPads. Several had found that the few students who would occasionally get off-task were exclusively boys, who would play online games. Two teachers commented that their female students showed a greater preference for collaboration, while males sought out opportunities to compete:

> The girls tend to gravitate towards more of a collaborative type of activity. They will sit together and work off of one iPad together because they want to do the same thing, whereas the boys if we've got New World Colony going or something like that, they want to play against each other and battle it out. It's very stereotypical to be honest.

Boys were seen by several teachers to prefer using gamified learning apps, and play online games in their free time; girls were more inclined to use an app like PicCollage to create montages, or listen to music or watch YouTube videos in their free moments. One teacher found that boys were less inclined to read on their iPads, and would seek out alternate ways to learn, watching videos instead or having their iPads read to them. In two classes, there were a few girls but no boys who initially resisted using the iPad's virtual keyboard and preferred to do written work by hand.

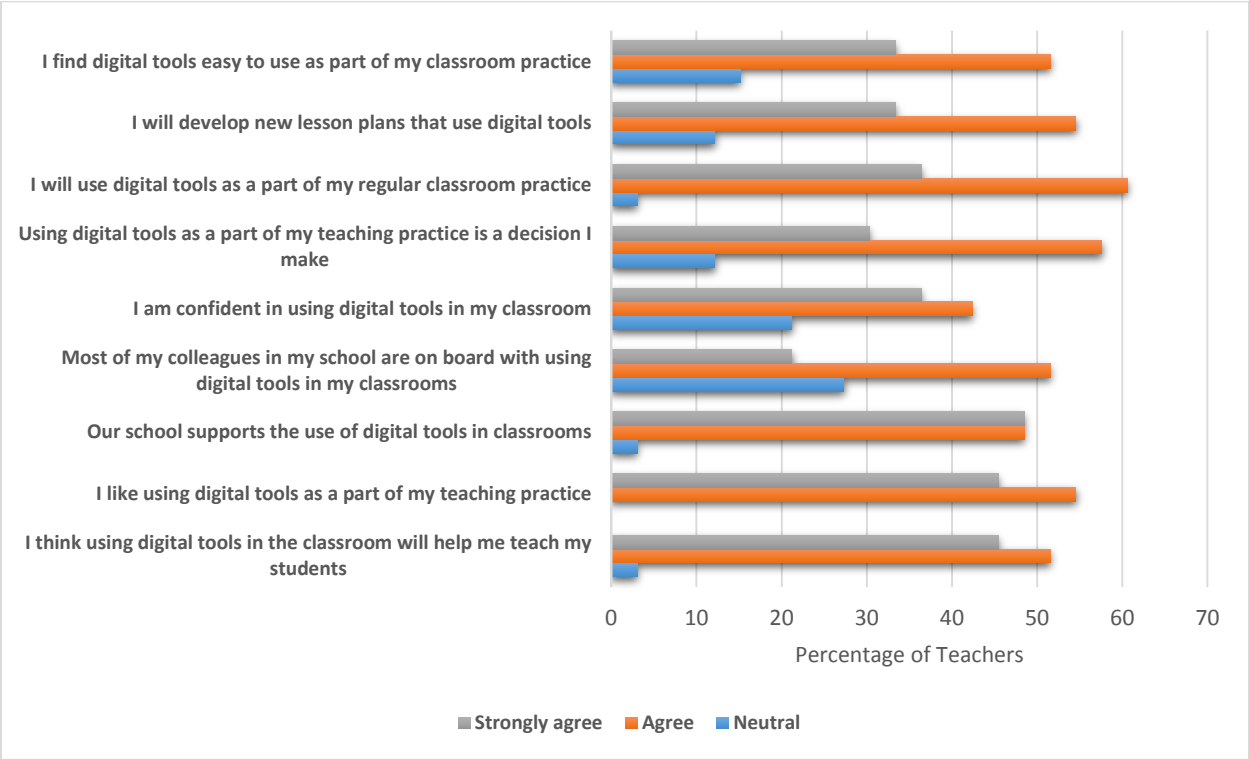
Teacher perspectives on iPads in the classroom

Self-perceptions of skill and efficacy

When surveyed, the 1:1 teachers at the seven schools were asked a series of questions on their attitudes and perspectives on iPad and related technology use in teaching, including their sense of their own level of relevant professional knowledge, skill, and comfort in use. The first set of

questions focused on their general attitudes, perceptions and dispositions related to using the technology in the classroom (See Figure 9 below).

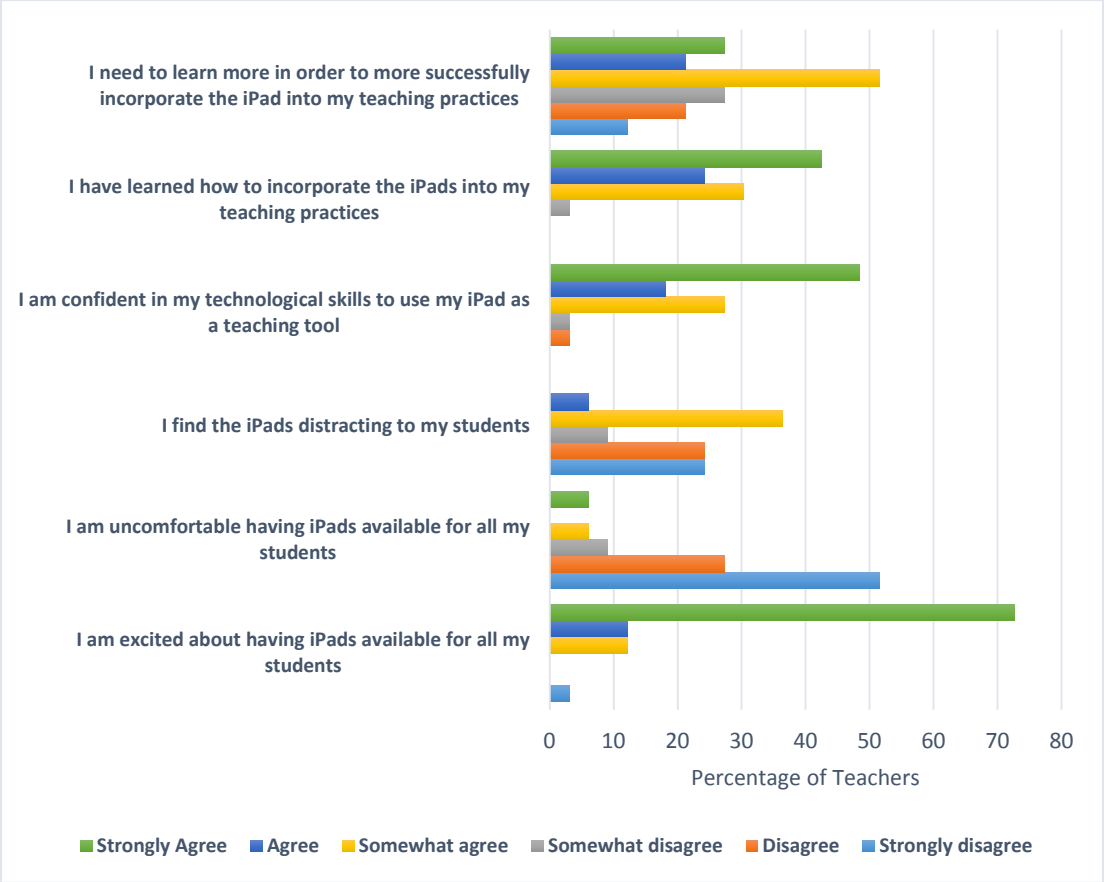
Figure 9: Teacher perceptions of technology use in the classroom



The large majority of teachers held positive attitudes about the application of digital tools to teaching. All of them agreed or strongly agreed that they liked using digital tools as part of their teaching practice, and over 95% thought using them would "help me teach my students". Over 75% expressed confidence in using digital tools in the classroom (although only about a third of the teachers strongly agreed they had this confidence, and nearly 20% were neutral about this). Eighty five per cent found the tools easy to use in the classroom, but here too only a third were in strong agreement with that statement. About 90% saw using digital tools as something they chose to do, and about 95% intended to use digital tools as part of their regular classroom practice in the future. Slightly less than 90% planned to incorporate their use in new lesson plans. All agreed that their school supports the use of digital tools in teaching, but the results were slightly more mixed when teachers were asked if their school colleagues were "on board with using digital tools"—while overall agreement was at 80%, only about one third strongly agreed, and 20% were neutral.

Asked more specifically about having iPads in their classrooms, most teachers expressed similar positive attitudes towards them and their ability to use them successfully (see Figure 10 below).

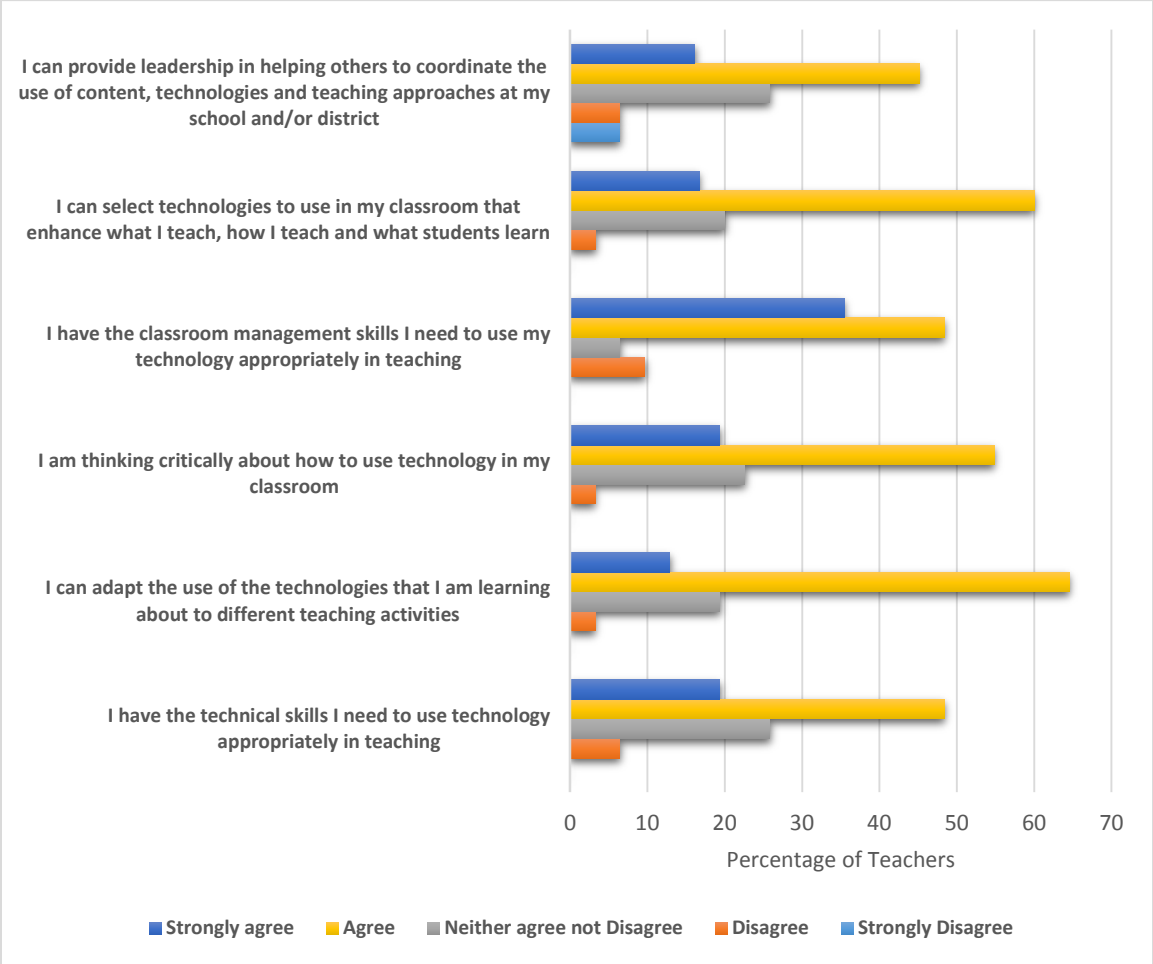
Figure 10: Teacher perspectives on iPads in the classroom



Nearly 75% of the teachers strongly agreed that they were excited about having iPads available for all of their students, and all but 3% of the rest expressed lesser levels of agreement. Just 12% felt that having iPads for all students made them uncomfortable to some degree. (However about one third of the teachers "somewhat agree" that iPads are "distracting" to their students.) Only about half of the teachers strongly agreed that they were confident in the level of their technological skills related to using iPads in teaching; a further 45% "agreed" or "somewhat agreed". And while nearly all of the teachers agreed that they had learned how to incorporate iPads into their teaching practices, only about 40% strongly agreed, and 30% "somewhat agreed". Taken together, these findings portray a teacher population that while virtually unified in its enthusiasm for using iPads and related technology in teaching, includes a substantial subgroup that is not fully confident that they have the knowledge and skills needed to use it effectively.

The teacher survey included a series of more granular questions about the teachers' perceptions of their levels of pedagogical expertise in using technology (see Figure 11 below).

Figure 11: Teachers' perceptions of their level of expertise in using technology



Only about two thirds of the teachers agreed that they had the technical skills needed to use the technology appropriately in teaching; a slightly higher proportion (about 75%) agreed they could adapt the use of the technologies that they were learning about to different teaching activities, and that they were thinking critically about how to use technology in their classrooms. The great majority (85%) agreed that they had the classroom management skills needed to use technology appropriately in teaching; and about 75% agreed that they can adapt the use of the technologies that they are learning about to different teaching activities. Half of the teachers felt they were able to provide leadership "in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district". Worth noting here is that with the exception of the management skills question, only a small minority or respondents chose the "strongly agree" answer options for this set of questions, indicating that the average teacher's confidence and self-efficacy in these areas were not yet fully developed.

Observations made by the key informants interviewed (three principals, a senior TLE consultant, and a superintendent) largely corroborated the teachers' own perceptions of their skill in applying iPad technology to teaching and learning. Two of the principals saw most of their teachers as having the skills needed to use iPads effectively, but the third saw his teachers as "all over the map" in terms of this capacity, and this was the broader observation of the superintendent as well. Most teachers were seen as willing to learn how to use the iPads,

although a minority needed "nudging" as one principal put it. One principal saw wide disparities in teachers' willingness to experiment with the technology and learn independently; some, he found, think they need to be trained on everything before they use it. The consultant noted that there is a small minority of teachers who are firmly resistant, arguing that "it is the wrong way to go" and not willing to learn. (More detailed discussion of the perceived limitations of iPad use and teacher resistance is presented later in this chapter.)

Time to learn

Finding adequate time to learn new apps and to develop a deeper and more transformative integration of technology use into classroom practice was problematic for most teachers. As one teacher put it, "It takes a lot of time to really understand the ins and outs of all that it can do and then also connect it to what you need to achieve and then go back to the expectations." Another found that her colleagues felt this time pressure:

> I think that's where most the teachers struggle with the use of these, their ability to use the iPad. And I think the factor in that is they don't feel like they have the time to go and explore everything. It's just a mindset you got to do. I'm interested in it so I tend to be more motivated to do it.

The majority of those interviewed indicated that they had to use their own personal time to develop the requisite knowledge and skills for iPad use. New teachers who came into a 1:1 classroom without any prior training were especially hard pressed, as the district had made no provisions for providing them with the basic inservicing that their school colleagues had received in the first year of the 1:1 implementation. One such teacher commented:

> It would be great to have half a day or a couple hours to spend with my colleagues or other people saying, "This is what we've been doing lately." I sat down at break yesterday and tried to set up some stuff on a couple of iPads for my IEP kids. But it would be great if, at some point somebody could say, "Yeah we did this or we did that."

A TLE champion noted that

> It's hard to get release time. I get released often to do various things. I just went to the Rewired conference where I got to view inquiry learning using technology and stuff like that. That's great, but that's just me. Can everyone have the opportunity?

This champion indicated when he was interviewed that he was about to run a session on the district's Hub for teachers at his school, and anticipated that "It's going to be a struggle because some of the teachers either will not want to put in the time or don't have the time."

Perspectives on peer collaboration and support

For most of the teachers interviewed, collaboration with colleagues was of critical importance in developing the capacity to utilize both iPad technology and IBL pedagogy to promote deeper student learning. As one teacher expressed it,

> You have to collaborate when doing TLE. You have to. You can't be an expert on everything and you certainly can't be an expert on everything technology. So it naturally forces you to say "Hey, what app are you using in science? Oh how would this work for me in geography? Or how can I take Explain Everything but use it differently?"

This search for knowledge had led most teachers to significantly increase their degree of collaboration with peers relative to their past practices. A school principal who had observed this in his school noted that teachers who had previously felt they had little to offer colleagues

feel they do after developing some knowledge and skill with the technology and IBL, and this resulted in more sharing.

Much of the collaboration teachers reported was informal, consisting of conversations in corridors and the staff room about what apps or teaching strategies teachers had tried and what had worked and what didn't, or how an app could be used to accomplish a specific end. In some schools, time in staff meetings was allocated to sharing ideas to try, or to more formal presentations given by those who had progressed further in their use of technology or IBL. School TLE champions were consulted regularly. Those with teaching partners worked with them to share ideas and figure out what using different apps could do for their classes. A few schools allotted release time or scheduled shared prep time so teacher teams could collaborate in their planning and share experiences.

A few teachers followed the Twitter feeds and blogs of teachers outside of the school district to source and share teaching strategies and lesson plans, and one of the more advanced teachers who had presented at a district-wide TLE conference had even built his own personal learning circle using his Twitter account:

> Within a month I'd been able to build a professional learning community of at least 15 reliable peers that I know can contribute to this or this…. There's always stuff that I pull from there and try it in the classroom. And a lot of the times it'll just be one of my peers saying "Check out this website", and it will have a wealth of ideas. And it'll just simply be something that I would have not known otherwise to look for.

For most teachers, their collaborations were strictly with school colleagues, although they used on-site district supports when available such as instructional and 21st century learning coaches. A district-limited social media tool for teachers accessible through the Hub, Yammer, was intended to serve as a medium for professional sharing, but it was reported to be used by relatively few teachers. ED Camps, run for teachers on PA days by some schools, allowed teachers to collaborate extensively in small breakout groups with the participation of an advanced colleague, and these were very well received:

> It's fabulous because it allows someone who really understands the inquiry model and technology to be a part of a conversation and provide some insights. It also allows someone who doesn't to be able to learn from that but without any particular person being deemed the expert in the center of that conversation.

Not every teacher thought that collaboration had increased in their school, but the exceptions were rare. One had observed that in her school teachers had been overwhelmed as they had received no iPad training and this had actually led them to collaborate less. And one advanced teacher stated that the collaboration that did occur was often at a very basic level; he found himself helping colleagues with elementary tasks such as creating folders in Google Drive.

There was broad agreement that the new technology had made collaborating with colleagues much easier. The use of Google Drive and Google Classroom made the sharing of resources, links and ideas very much less time-consuming and nearly effortless. The ability to share and collaborate at any time and from any location that these tools made possible was also highly valued, as is illustrated in this instance of a teacher working with her teaching partner:

> Three times last night she and I were back and forth—"Use this tomorrow it's awesome. I have this video to support that tomorrow." Again it's just ease of use. We have so many

resources that for me I can't go through them all. Between the two of us if we can wean it down.

Perceived advantages of technology usage and one-to-one iPad distribution

Technology use. When we asked the teachers what they thought the major educational advantages were of providing an iPad to every student, they offered a broad spectrum of responses based on their varied experiences and their diverse applications of the technology. (As all of the iPad affordances they saw as advantages have been discussed earlier in this report, we provide only summary points here.)

The advantages of iPad use cited by several or a majority of teachers were as follows:

- It provides students with on-demand access to virtually unlimited information and knowledge.
- It makes student collaboration much easier and consequently more frequent and productive as students are able to share resources and working documents, discuss and comment on each other's work online, and (with some tools and apps) work simultaneously on the same artefact .
- It caters more fully to different learning styles and preferences through provision of learning resources in different modalities: text, images, video, simulations, and educational games.
- It provides students with a much greater range of expressive options for demonstrating their learning and creativity, which fosters student engagement and persistence.
- It meets the unique learning needs of ELL and special education students far more effectively and with more student autonomy by employing assistive technologies to address reading and writing deficiencies, and making libraries of leveled reading resources available.
- It makes sharing student work with the class for discussion faster and easier.
- It provides access to tutorials, simulations, and other learning resources that facilitate active, independent learning, and engender student ownership of their own learning.
- Certain apps make uninteresting learning activities much more engaging (e.g. Kahoot! for vocabulary building).
- Revision and editing of documents is much easier which results in students being more willing to assess their work and work and revise it.

Additional advantages mentioned by one or a few teachers are listed below:

- Students have more pride in their work products as they appear more professional.
- Teachers can access, monitor, and comment on draft work much more easily, which has encouraged more effective formative assessment.
- With students having instant information access it is easier to pursue unplanned learning and inquiry at "teachable moments", such as when students raise unanticipated questions.
- The greater connectivity with the world beyond the classroom it affords makes it possible to provide students with a more situated and authentic educational experience tied to community and world issues.

- The technology provides the tools and apps for teachers to offer better, more individualized learning differentiation both for advanced students needing enrichment and for those performing well below class norms.
- Absent students can stay up to speed with learning through remote access.
- Student work is not lost.

For their part, students saw a number of benefits stemming from the use of iPads in the classroom. In their focus groups, a substantial number stated that it helped them develop their research skills, and their ability to organize information; and they thought it enhanced their productivity. It made research easier, and was seen to improve their reading, writing, music creation, and drawing skills. They found it made collaborating easier, and they liked the way it allowed them different channels and modalities for learning and demonstrating that learning.

One-to-one device distribution. Having one iPad for every student was universally perceived by teachers as a better distribution model than using class packs that provided an iPad for every three or four students. Several advantages to 1:1 distribution were cited by a majority of teachers interviewed. Teachers were better able to take advantage of "teachable moments" since every student had the tools needed to pursue questions of immediate interest at any time. One to one distribution was also seen as more equitable as it gave all students access to the same affordances at all times. In the words on one teacher:

> I think it really levels the playing field, it allows everybody equal access and everybody the ability to try using different programs and presenting their learning in different ways. I have 4 or 5 kids that have their own iPads, sometimes they'll have them at school and I think if only 4 or 5 had it; it limits the ability of the other kids."

When each student had his own device, the frustration and conflict that sharing would often generate (a phenomenon teachers who had taught in classrooms with class packs had experienced in prior years) was eliminated. One teacher noted that her students "have a low threshold for frustration, so if they have to share with somebody else and that person is on a website that doesn't have what they need, they get frustrated easily". In shared contexts, students without iPads had often been less focused and more off-task than those who had them in hand. Students in 1:1 contexts seemed more engaged and happier. Sharing also stymied real-time access to information in teachable moments for most students. In addition, it generated logistical and operational issues as students would have to log in and out of personal accounts when transferring devices.

Sharing also brought with it classroom management issues that a 1:1 distribution avoided. "Without 1:1 I would have had to send groups off to work on their own so there would be two completely different activities going on in the classroom at the same time. As an individual I could only really focus on one and give the students the same amount of attention that I can now through the whole room." There were certain learning activities that teachers thought would be very difficult to pursue if iPads were being shared. One teacher cited the following example:

> Each kid gets a chance each week to post a YouTube video that they find engaging, entertaining or inspiring. They have to write a reflection on that. Everybody has to respond to the reflection and one discussion question that that person has put on related to that video. There is some collaboration piece with that.

Perceived disadvantages and limitations of technology usage and one-to-one distribution

When teachers and were asked about the disadvantages and limitations of having iPads in their classrooms, their responses almost exclusively centred around logistical, managerial and operational issues with the devices and associated operating software; only one significant pedagogical limitation were mentioned. By far the most commonly raised concern was the difficulty in keeping the iPads charged up; the large number of lost chargers coupled with the inadequate electrical infrastructure in classrooms for charging made keeping the full set of devices usable at all times was at best time consuming add frustrating and at times impossible. A teacher who provided technology support in his school raised a common operational issue: connecting the older projectors typically found in classrooms with Apple TV was difficult and very time consuming, meaning teachers would only do it when there was a lot of student work to share.

Three other problems were each mentioned by several teachers. The lack of physical keyboards for the iPads made typing difficult for some students and this led a minority of students to resist using them for text entry. This was much more of an issue in the intermediate division classes, in which students would need to type significantly greater amounts of text for projects and assignments than would students in lower grades. The second problem presented a more significant impediment to learning (although it was only a concern for a minority of the teachers): the iPads could occasionally become a distraction to students, leading to off task activities and inappropriate use like playing games. The third limitation teachers brought up was directly related to the challenge of managing this off-task behaviour. Several of them observed that it was difficult to see what all of their students were doing on their devices, which made it challenging to ensure students were on task. A few teachers did mention that in the current school year better management software had been provided that allowed them to see what app was being run on a student's device but it was found to be awkward to use and slow to respond; and if a student was using a web browser, it did not seem to show them what sites were being accessed.

Several other limitations of iPad use experienced by one or two teachers were as follows:

- The apps available to accomplish certain tasks were not always the best for the task; more advanced apps were not accessible due to district licensing restrictions which do not allow their use by anyone under 18.
- The inability to print directly from the iPads made printing anything a time-consuming chore.
- Getting new apps approved took a week, by which time it was too late to make use of them.
- Because students could not take their iPads out of the school, further learning at home was impeded for those students without the needed technology.
- A few students would intentionally leave iPads in other classes so they would have an excuse to absent themselves.
- Locking down of app use provides insufficient control if you allow students to go anywhere with their browsers.
- There are insufficient reading resources available that will read the text to students.
- iOS updates to iPads cause some apps to cease functioning.

The three principals interviewed corroborated the most common issues mentioned by teachers, and raised additional concerns based on their observations. Physical management of the devices at the school level was seen as challenging, with breakage, theft, and losses (especially of chargers) still being a cost concern (although these problems had been greatly reduced since the ban on home use went into effect). One principal thought the iPad cases provided were inadequate and prone to far too much breakage. Two principals mentioned technical glitches, which, while far less common now than in the first year of 1:1 implementation, were occasionally still an issue—primarily account setups for Google apps not working and networking interruptions. A few teachers at one school had told their principal that would have preferred to stay with the partial class packs of iPads for the junior grades rather than going to a 1:1 distribution as they felt they had more control of device usage that way.

Students who participated in the focus groups also mentioned several limitations and problems with the way iPads were being used and how they functioned in their classrooms. IPads were often found not to be charged sufficiently or at all due to a lack of charging stations. Intermittent operational and technical issues arose: difficulties downloading apps (likely due to network bandwidth limitations), slow updates, iPad crashes (in one class), and app bugs were mentioned. Students not being allowed to take the iPads out of the school made homework completion difficult for some who had no means to access their blogs or other needed software tools from home. Finally, some students found that the non-educational games that were available through the district's app catalog were not educational and were a distraction.

Professional growth

The majority of teachers (but not all) felt that their experiences with TLE had triggered meaningful professional growth, developing their capacity to foster student inquiry through IBL and to deepen student learning through the use of iPad technology. Several teachers spoke in various ways to the sense of accomplishment this success had engendered; in the words of one teacher,

> I feel like I've moved forward as an educator far, far more in these two years than I have in my previous eight, absolutely. I feel like I'm an instructional leader now which I didn't feel like I was before. So I do feel like it's playing to my strengths, definitely but it's allowed me to be the teacher that I think I always wanted to be.

One teacher who had led a session about his TLE practices and outcomes at a district conference remarked on what he felt he and his school colleagues had achieved so far:

> As a school community, the things that we're able to accomplish in the demographic that we're in with the learners that we have—and to have people who teach in more affluent areas say "Holy crow, that is amazing." For me that's validation that this stuff works.

Another detailed the evolution of his pedagogical thinking as he gained more experience with IBL:

> When I started with IBL, I felt inadequate, I was wondering ""Are they learning, are they just goofing off, are they just sitting around going 'What is this?'" But in the last four months that has been gone. Now it very much strikes me as being like a professor at a university—how you just open up doors and you're letting them decide how far into the room they want to go. Some students take it really far and really wrestle and take this stuff seriously…. It's a different satisfaction for me because it's like I was a part of that, I

> allowed this to happen in my room and they allowed the learning to happen back. So I definitely enjoy it more than traditional teaching.

A few teachers who had initially been uncomfortable with IBL felt that they had learned to trust the process and get beyond concerns about covering off all aspects of the curriculum:

> There are days where you just look out and you go "Where did we go today?" In the end I do know that it doesn't matter. I don't have to worry so much about "Are they going to completely understand all the different tribes of a First Nations community?"

Several educators expressed considerable satisfaction in the outcomes they had observed. Seeing their students more deeply engaged in their learning made teaching more engaging and exciting. "It gives me greater joy because you see them and they're happy. The kids are happy and they're engaged in their work" one teacher stated. Two teachers found that seeing their students take ownership of their learning had been professionally rewarding. Another remarked that her sense of accomplishment had grown because "I feel that they like to learn better than they used to and I feel like not only are they learning important things but they're learning a lot of life skills at the same time, like transferrable skills."

Summary

Students used iPads in most classes for much of their class time, and for a range of learning tasks, extending from the practice of fundamental skills to solving problems and pursuing inquiries. Most of that use was for forms of learning other than IBL. The nature of that use varied: at times it was a simply a substitute for another medium such as a text or paper and pen, and brought with it no significant change in classroom practice, but sometimes it substantially impacted and even transformed how teaching and learning took place.

The iPad was the platform of choice for most of the student research done in science and social studies, serving to locate and access text and multimedia learning resources ranging from videos to simulations. Student writing activities of all types were predominantly undertaken on iPads as well. Learning game apps were used with some frequency by many teachers to practice basic literacy and numeracy skills. Some teachers also applied it to the teaching of mathematics, using virtual manipulatives with their class, or having students do problem solving in Explain Everything rather than notebooks as this made revision easier and students could readily record and share explanations of their work with teachers and peers. iPads were sometimes used as a creative medium for artwork and music composition, and had broad application when interdisciplinary projects were undertaken. The assistive technologies iPads made available proved valuable in helping students with special language needs overcome literacy barriers to full participation in class learning activities.

iPad tool use was found to better accommodate students preferred learning styles and interests by making it possible for students to learn from a variety of media in addition to written text, and by providing a much broader spectrum of expressive modalities for artefact creation. The apps students most commonly used for document and artefact production were multimedia-capable tools and presentation software that allowed for the easy integration of multiple communication modalities such as text, images, video, and voiceover recording; these were applied to the creation of many different forms of production such as multimedia slide shows, eBooks, movie trailers, photo collages, virtual constructions, and animations. The Google tool suite was very widely employed for the creation of text, graphics, and slide shows; and Google

Drive was the default location for storing student work in the cloud, which ensured easy access from many locations and prevented work loss.

To varying degrees, teachers altered their pedagogical practices to better leverage the affordances the iPad tech offered them. There was a general shift away from teacher-directed learning to the adoption of more student-centred, collaborative, and project-based learning strategies that often included some or all of the elements of IBL. The most frequently reported transformation involved the relinquishing of tight control over student learning, not structuring learning content expectations so tightly and letting students take advantage of the access to knowledge that the iPads opened up to pursue learning more independently. With this came a major shift in the role of the teacher, as he or she no was longer the sole or even primary subject matter expert, and often became a co-learner with the students.

iPad use had a major impact on classroom assessment practices as well, with teachers engaging in more formative assessment of student thinking and skill development based on observations of student learning activities, rather than depending primarily on a summative assessment of product for marking and feedback purposes. The end result was more assessment for learning, and a major consequence of this was that students engaged in more meaningful and extensive revision of their work—a process greatly facilitated by the ease of digitally-based document editing. Formative assessment was made faster and more feasible by the instant, ubiquitous access to student work as well as the commenting functions that the technology provided. The Sesame Snap iPad assessment app proved to be a major aid in various aspects of assessment for and of learning.

The sharing of student learning demonstrations with the class was considerably facilitated by iPad-associated technology and led to more discussion and peer assessment of student work. Tasks related to the management of that work such as sharing out assignments, rubrics, and resource links to students and having them submit work was found to be much simpler and faster with the use of cloud-based sharing-enabled apps like Google Apps for the Classroom. The affordances iPads provided for student work sharing, cross-commenting, and the simultaneous creation of some types of products led some teachers to have students collaborate more frequently. One-to-one device distribution was seen by teachers to have eliminated arguments over device use, removed class management issues, and made spontaneous, ad-hoc pursuit of inquiry at any time much more feasible.

Home use of iPads was disallowed at the start of the 2015-2016 school year due to issues of device misuse, loss and damage outside of school the previous school year, and this impeded the ability of a minority of students who had no personal device access to pursue digitally-based learning at home.

Teachers found engagement to be strong and persistent in most learning contexts where iPads were employed, especially where rich media learning resources were being used or multimedia artefacts were being created. Students typically demonstrated greater autonomy and agency in pursuing their learning when iPad use was integral to their activities. The vast majority of students enjoyed using iPads; resistance to their employment was rare, although a few students in some classes would go off-task on occasion, using iPads for purposes unrelated to their learning such as online games.

Growth in most students' digital literacy was evident to teachers, and it took many forms: in the ease with which students learned new apps and could use them appropriately for their work, often with no teacher input; in students' gradually increasing skill in sourcing relevant and

reliable sources of information when pursuing online research, and using those sources to good effect; and in students' creative exploitation of the capacities of dynamic media creation tools to create artefacts and presentations that effectively demonstrated their learning. However, the research skills of a minority of students were still considered weak, and in need of recurrent teacher scaffolding and guidance.

By a very large margin teachers held strongly positive views about the application of iPads and other digital tools to teaching and learning. They found them easy to use, and a majority was confident that they had the skills to apply them in varied contexts to enhance student learning.

Ongoing professional collaboration, both formal and informal, was considered by teachers to be critical to their success in integrating iPads into the learning process. It was reported to have increased significantly with the 1:1 implementation, and was largely school-based; embedded support from the TEL champions was a key element of this support. The technology itself, with its affordances for anytime, anywhere connectivity and resource sharing, made it easier for teachers to collaborate with peers and facilitate each other's professional learning.

The limitations of iPads in the classroom were seen to be primarily logistical, operational, and managerial in nature—keeping iPads charged; connecting Apple TV to older projectors for sharing student work; and monitoring what students were doing on their iPads. The use of the iPad's virtual keyboard for extended text entry proved to be a source of frustration to some students.

iPad deployment had a significant impact on the majority of the teachers' professional growth over the past two years. Several teachers reported that their experience with iPad use and TLE more generally had significantly enhanced their capacity to educate their students for the 21st century, and a number noted that their sense of efficacy and professional satisfaction had been positively affected by it.

Chapter 7: Descriptions and Analysis of Student Work

In this chapter, we provide descriptions and analysis of student work samples provided by HWDSB teachers from six of *TLE* pilot-schools. In our analysis, we explore what and how student project work samples reflect or enact TLE objectives for student learning. Specifically, we examine if, how, and to what extent the student work samples provided evidence of effective inquiry-based learning (IBL) practices, and to what extent the affordances of technology and 1:1 iPad distribution were effective in supporting student learning and/or the acquisition of 21st century literacy and communications competences.

Part 1: The first section of this chapter will provide a narrative overview of a diverse set of student work samples from the six contributing schools (representing project work from grades 4, 5, 7, and 8). This section describes and evaluates student artefacts using, as criteria, the HWDSB document *Transforming Learning Everywhere* (Malloy, 2014), as well as key documents from the Ontario Ministry of Education that inform the TLE action plan, including *Achieving Excellence: A Renewed Vision for Education in Ontario* (Ontario Ministry of Education, 2014) and documents from the Ministry's *Capacity Building Series* on Inquiry-Based Learning. This will enable us to describe and assess student work and demonstrated competences in relation to defined TLE goals and expectations for deep student learning. When useful, we will also evaluate tasks and technology applications by utilizing the well-known SAMR (Substitution, Augmentation, Modification, Redefinition) model (Puentedura, 2013).

Part 2: The second section of this chapter will focus on student work through a holistic quantitative analysis of three sample sets from three TLE pilot schools (representing project work, respectively, from grades 4, 7, and 8)[5]. Samples of student work from these schools were selected where at least three or more assignments/projects on the same topic were available for coding *and* where the assignments/projects were substantive, requiring a minimum of one week to complete.

The sets of student works were rated using criteria developed by SRI International to specifically assess them for evidence of 21st century learning competences. The SRI International rating scales consist of four dimension that closely align with TLE aims and objectives for student learning: knowledge building, applied ICT use, real-world problem solving and innovation, and communication skills. Details of the SRI International scales/dimensions, a brief overview of our methodology, and the results of our analysis are recounted in detail in the second part of this chapter.

Descriptive analysis of student works: Methods and frameworks

In this section we will provide a detailed narrative overview and evaluation of a diverse set of student work samples submitted by the six *TLE* pilot schools. In describing and assessing student works, below, we articulate if and to what extent student works may enact or evidence TLE objectives, including digital/ICT literacies, inquiry-based learning and knowledge-building practices, as well as the demonstration of learning through the authentic construction and design of knowledge and art. At the student level, our goal in this section is to:

[5] No student work samples were submitted by teachers sampled in grades 5 and 6.

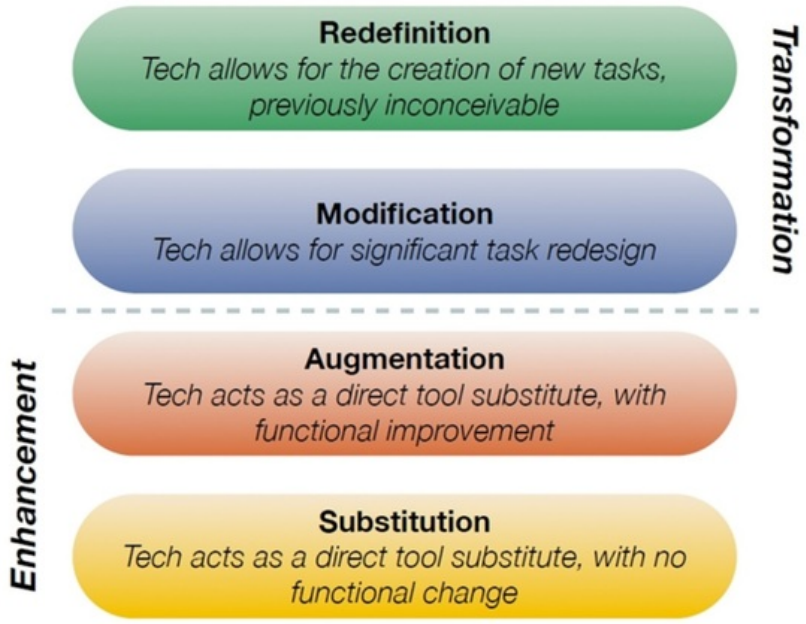
- Understand what kinds of learning activities, types of projects/tasks, and 21st century competences are occurring in TLE classrooms, and to discern what role(s) 1-to-1 technology is playing in supporting student accomplishment.
- Identify and evaluate implicit or explicit evidence of the inquiry-learning process and the "fidelity of implementation" of IBL through the analysis of the completed projects.
- Identify evidence of formative assessment or summative measures (success criteria) that may be in play to assess, scaffold, and improve student learning.
- Examine the affordances (and limitations) of media tools and apps during phases of inquiry-based learning and in culminating projects where evidence of creativity, critical thinking, and significant learning may be demonstrated.

The *Transforming Learning Everywhere* document is grounded in the view that 'the basics are changing', and that students must, today, not only master literacy fundamentals, but also 'create, think, evaluate, and collaborate in order to be successful students, and engaged citizens […where…] technology is a tool that enhances the learning process' (Malloy, 2014, pp. 2-3).

While attending to the fundamentals of essential literacy skills and traditional competences, we also identify how student works may express outcomes representative of 21st century competences, technology skills, multimodal literacies, and collaborative, student-directed knowledge-construction. This is important, for if we evaluate transformed learning environments using *un*transformed evaluation tools, we risk contradicting ourselves in our own analytic and assessment methods. Jenson, de Castell, Thumlert, and Muehrer. (2016) point out, for example, that 'conventional assessment tools used to measure the learning of well-specified curricular knowledge are unable to measure [new] forms of learning' enacted within 'digitally-mediated learning environments' (p. 24). Similarly, Dede (2014), Ketelhut, Dede, Clarke, Nelson, and Bowman (2007), Merchant (2010), and Curwood (2012) all signal the need to transform analytic assessment tools for deep learning tasks in digitally-mediated and multimodal learning contexts – and to some extent this mandate applies to our description below.

When useful, we will evaluate assigned tasks and technology applications by using Puentedura's four-tier SAMR model (Substitution, Augmentation, Modification, Redefinition). The SAMR model alerts us to how new technologies are being integrated into learning environments, and helps us examine if or to what extent technologies are being applied in pedagogically transformative ways that might support "significant task redesign" and enrich and even redefine 21st century learning tasks.

Figure 12: SAMR Model (Puentedura, 2013)



Limitations

While the student works provided by the participating schools are diverse (in terms type of activity and media format) and represent grades 4, 5, 7, and 8, we should note that not all of the schools were forthcoming with requested samples, and some sample sets are very small. These limits apply to our quantitative analysis in part 2 of this chapter.

This limited the total sample size we could draw upon for coding or assessment purposes, and many promising projects described in teacher interviews were not available for our analysis. Second, the range of submitted works was limited by what forms could be uploaded to shared storage drives. Student works analyzed may not represent the full spectrum of technologies used to support learning or to communicate final project work. For example, in interviews, teachers made reference to student demonstrations of learning through media tools like blogs, *Minecraft*, games and simulations. These kinds of work are not represented in the sample sets.

Finally, while we attempt, below, to discern evidence of inquiry-based learning and transformative applications of digital technologies in the student samples, we were not always provided with teacher task descriptions (notably, for grade 7 and 8 samples). Task descriptions of learning processes, methods, and stages would have provided a richer context for the analysis and evaluation of samples.

Narrative description of student work samples

Student sample 1: Wildlife habitat project (Grade 4)

Media tool(s) and task description

The wildlife habitat sample consisted of eight (n=8) student slideshow or movie documents (research projects). Samples were created by grade 4 students using iPads and the *Explain Everything* application. In teacher interviews, *Explain Everything* was frequently cited as one of the primary (preferred) iPad applications that they employed to support student research, knowledge demonstration, and project design and presentation (sharing). *Explain Everything*

enables students to create and share multimodal presentations, integrating written text, and annotations; curated digital images/maps/infographics; original digital pictures and video taken through the iPad lens; digital drawing (using the application's drawing tools) and simple animation functions; audio voice-overs and sound integration. Documents are publishable and exportable as shareable digital movies and/or multimodal slide-decks.

Based on the completed samples provided to us, students were asked, following a collaborative group demo, to individually research wildlife in Canada and explore issues surrounding animal habitat, survival needs, and the impact (positive or negative) of human activity. All student samples indicated that a template was provided by the teacher to structure information-gathering and knowledge-demonstration based on the following questions: 'Where does the animal live?' 'What does the animal need to survive?' and 'What threats compromise their lives and homes?' These questions were researched and answers were presented through an *Explain Everything* presentation (movie or slide-deck) composed of written answers to these questions, curated pictures representing information or ideas presented by written text, as well as a non-digital mixed media work that represented knowledge through collage (e.g., pictures, clay, and written text). Digital photographs of the mixed media collages were included in the final *Explain Everything* document. Audio voice-over may have been additional feature of these documents, but was not available on the versions of the documents received by us. Teacher-designed rubrics were also integrated into the project, appearing as slides (2) at the conclusion of the document, where students assessed their own work on the rubric and provided evidence how they accomplished (or failed to fully meet) project expectations.

Analysis: Evidence of inquiry-based learning

Applications of inquiry-based learning (IBL) were evident in this sample, with a question template provided by the teacher to guide student research and knowledge building. Referencing the four-phase IBL process (described above), task focus was initiated with a "Brainpop" video on endangered wildlife. The video was used to introduce the project theme and engage students (simulate interest and curiosity). Students were invited, following the video, to dialogue and share what they "already knew" and post "what they wondered" using *Padlet* – a virtual wall application – that supports the real-time collaborative posting of texts and images from individual iPads to a digital whiteboard or screen (e.g., Apple TV).

To model the final (individual) project tasks, students were first asked to work in groups to address the three wildlife habitat questions through research and knowledge presentation (on sea lions), presumably using *Padlet*. We found this integration of media tools and modeling to effectively enact the first phase of the inquiry-learning process, integrating student wonder with dialogue and collaborative research on a shared topic. Students were then asked to choose an animal and habitat of their own and pursue the individual research projects (that constituted the work samples).

The final samples indicated that the research questions were clearly, if succinctly, answered, though there is little evidence of student research and knowledge extending beyond factual responses to the three research questions. What was noticeably absent was evidence of student agency in the initial planning process, or in developing or refining research questions, or in extending and deepening the scope of related research/details beyond the provided 3-question research template (and the required paragraph expectations outlined in the template). If we refer to the four-phase inquiry-based learning process, we see evidence of choice in selecting topics (wildlife), with little evidence of students participating in the planning process of

research-question design (e.g., refining or extending template questions based on student interest, curiosity, or wonder).

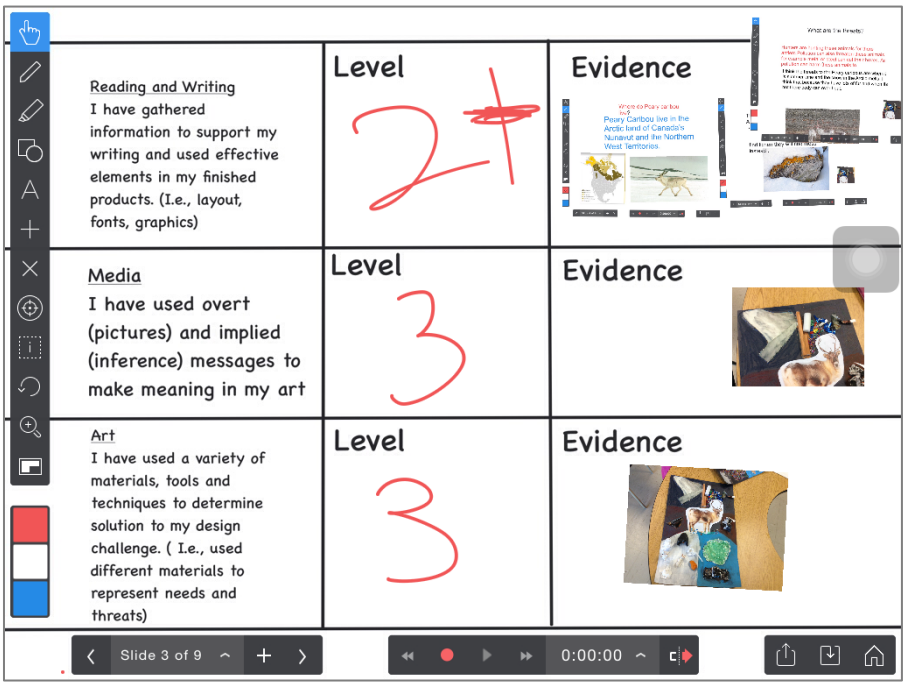
Second, there is ample evidence of students using available research resources/sites and technologies to gather information for knowledge-building, and to effectively curate images that illustrate written statements or conclusions (e.g., images of a plastic products or nets entangling animal life, animal pelts and fur clothing, pollution, melting ice, etc., to represent changing conditions and the threats of human activity).

While most of the samples indicated that students could research, analyze, and concisely synthesize available information based on the given questions, there is, in most of the samples, a lack of detail or depth beyond "answering" the questions. And while this task connected with real-world issues and contemporary concerns ("big ideas" in the curriculum), the project might have been augmented, to some extent, with further prompts where students might have speculated on, or made inferences about, possible courses of action to address the described threats to wildlife; moreover, at the level of planning and student agency, there may have been more latitude provided for students to engage and explore novel or unexpected information, and thus refine (or develop new) questions in ways that might incite (more) wonder and deepen the inquiry-learning process.

With regard to the final phase of the inquiry-learning process, a rubric was explicitly designed for the assignment by the teacher and was included within the *Explain Everything* digital document. There is clear evidence that students were required to reflect upon and critically assess their own learning prior to receiving formative/summative remarks from the teacher. The rubric consisted of 1) Reading and Writing 2) Media: Use of Technology Tools 3) Art: Use of a variety of materials and techniques to meet the design challenge 4) Science Content: Demonstration of research and knowledge-building with regard to the template questions. As part of the actual final projects, students were required to fill-in the rubric to self-assess "level" (mark) and provide evidence of learning (using pictures of discrete elements of their project work to demonstrate that they met rubric criteria). The teacher responded to student self-assessment (on a separate Word document) with summative feedback and scoring (grade) specifically referencing the rubric, with commentary recognizing good work and/or providing critical feedback where further attention or focus was required.

Here, we felt that the integration of the student self-assessment tool (using the rubric and documenting their own evidence learning) to be an exemplary model of involving fourth grade students in meta-cognitive processes: students were invited to reflect upon what and how they learned, provide evidence, and consider where their work might be improved for future projects. In most cases, their critical self-assessments were on the mark, with regard to scoring shortcomings in their own work.

Figure 13: Sample student self-assessment



Finally, based on teacher and student interviews, projects like the one described here often culminate in student knowledge-sharing, where students take the role of teacher and present knowledge about the specific topic to their peers. While not noted in the materials we received, we might confidently assume (based on the data gathered in interviews) that this knowledge-sharing phase of the inquiry-leaning process was in all likelihood carried out.

Technology Application, 21st century competences, and SAMR

The uses of *Padlet* and *Explain Everything* – in conjunction with IBL and authentic research sites and tools – provided opportunities for some meaningful transformations in learning environments, learning processes, and student research products.

If we refer to the simple SAMR model (above), we see evidence of technology supporting "significant task redesign", particularly in relation to IBL. Using *Padlet* during the initial phase of inquiry enabled group question-posing, research, and knowledge presentation to support and guide the individual task. We found this to be a dynamic use of the "virtual wall" application, as students could, using iPads, collaboratively research and co-construct knowledge in "real time" based on the common group task (sea lion), and collaboratively perform the group/collaborative task as a model their individualized research project.

Student work samples (*Explain Everything* documents) indicated effective combinations of written text, images and maps, suggesting a successful enactment of basic multimodal literacies and content knowledge through digital tool use (including audio voiceovers). Multimodal documentation was not restricted to digital forms, as students also demonstrated learning through their non-digital mixed-media collage work (documented with digital photos inserted into their final documents).

Moreover, the wildlife habitat projects provided a rich context for learning across the curriculum, integrating real-world science content/expectations with basic literacy, art, and design practices, as well as digital tool use. Using the SAMR model, the wildlife habitat project

samples are indicative of "significant task redesign" (M), with effective combination of IBL processes and effective digital media evident in the final student work samples.

Potentially compromising the SAMR rating, we also signal that students could have been more directly involved into the initial planning phase, and invited to notice, wonder, and ask questions that might inform or re/shape the template or research content.

Finally, while the affordances of *Explain Everything* invite the dynamic integration of text, images, maps, infographics, and voice-over to create potentially rich digital documents, we suggest that students might be provided with "good prototypes" of *Explain Everything* projects which model compositional strategies (for assembling text and image elements in clearer or more refined forms). While we recognize that student samples in this case were from grade 4 classrooms, we more generally suggest that, when employing tools like *Explain Everything*, models of formal "best practices" may support (digital) communication literacies, and the presentation of richer, more detailed, and more carefully constructed research content.

Student sample 2: Healthy eating project (Grade 4)

Media tool(s) and task description

The healthy eating sample consisted of two (n=2) student slideshow documents (projects) created by grade 4 students. Based on the samples provided to us, students were provided with a slide-show template, and while it is unclear which software program was used, students were able to fill in the template written text, curated images and pictures taken with iPads, and digital drawings.

The provided template outlined the following initial tasks: to reflect on an introductory video (embedded in the template document) by celebrity chef, Jamie Oliver, and to respond to a webpage from a Government of Canada site representing a "rainbow" of food groups and health information (nutritional facts, guidelines, and tips and recommendations). Students were invited, within the digital template, to provide a written response to the video and/or website based on the following prompts: what they see; what they think they know; and what they wonder about. Students were asked to then (within the template) keep a food journal (using photos and text). They also engaged a digital polling application, *Plicker*. *Plicker* is a tool that enables students to respond to teacher polling queries, providing real-time graphical feedback based on input from student devices (in this case, about health and diet practices, e.g., "how active are you every day?"). Using a different Government of Canada health website, students were (evidently) asked to research information about health and diet practices, and over the course of the project compare their own journal entries and dietary intake with the recommended guidelines for food group consumption. Using a pie chart embedded in the template, students are asked to reflect upon and represent, using fractions, how they might meet or change dietary practices.

Analysis: Evidence of inquiry-based learning

The application of inquiry-based learning was evident in this sample, though learning expectations were largely predetermined by the digital template, and there is little evidence of student contribution to planning and task design.

The four-phases of IBL (described above) were implemented in a very basic though procedurally clear way. For example, we see some evidence of basic IBL processes, including the use of video to engage interest and focus themes and subject matter; the invitation to collaboratively respond to the video and/or website and to identify what they already knew and

what they wondered about; the initial framing of inquiry research was followed by a student food journal, where students evidently documented, using photos and text, what they ate for a day or two).

Given the use of the real-time polling application, *Plicker*, it was evident that students were invited to discuss and explore inquiry questions (through dialogue) in response to graphical feedback provided by the tool. Images of the polling feedback were documented (screen-captured) and placed within the final presentation document.

Given the practical topic and limited scope of this project, evidence of more sophisticated IBL processes we might expect from higher grade levels is absent (e.g., hypothesis formulation, revision or reframing of inquiry questions, student-directed inquiry, and so on). The template provided to students to guide learning adhered, if mechanically, to some IBL phases, with mostly superficial propositional knowledge restated in the student sample.

Supporting 21st century and digital learning competences, it was clear that students were invited to engage authentic research sources (Government of Canada website), gather information, and interpret multiple forms of data (text, graphs, nutritional facts tables). In the one complete culminating document (student sample) provided, there is evidence that the student accomplished all phases of the task, with some cursory reflections on health/nutritional practices.

Employing the pie graph, and the contextualized use of fractions skills, the student was able to critically reflect upon dietary intake and identify avenues for knowledge application (behavior change, increase in intake of fruit and vegetables, represented in mathematical fractions along with the pie chart).

It is unclear, based on the final document, if the IBL culminated in knowledge sharing (student presentations on findings or reflections) or further critical reflection on the learning process itself.

Technology Application, 21st century competences, and SAMR

The use authentic research websites, multimodal presentation tools, video, and the interactive *Plicker* application provided a digital media environment that effectively supported basic task and inquiry-learning expectations.

If we refer to the SAMR model, we see evidence of technology being used to primarily augment (A) or improve learning environments and tasks, with trace evidence of modification (M), where technology enabled some task redesign. For example, using the template-embedded video and a Government of Canada website during the initial phase of inquiry enabled group question-posing, though there is no evidence that student questions or expressions of wonder affected the inquiry process or the teacher-provided presentation template.

The one completed student work sample enacted basic literacy and 21st century media competences, with combinations of simple written text, images and photos, screen-shots of *Plicker* results, and a pie chart. Based on evidence in the final work, the use of the interactive *Plicker* tool may have supported critical discussion on the student-generated polling answers, as well as practical understanding of the graphical data yielded through the polling tool.

As with the wildlife habitat project examined above, we discern evidence of multiple literacies (multimodal and ICT) integrated in a cross-curricular task: the task integrated health content expectations with digitally-mediated research skills and applied mathematical literacies (e.g.,

the pie chart, fractions). However, while we keep in mind that this task was directed to a fourth-grade class, we would like to signal again, in relation to the "fidelity of implementation" of IBL discussed in the previous chapter, that true inquiry-learning processes more directly involve learners in the student-directed shaping of research questions, learning opportunities, and project templates.

Student sample 3: Poetronica project (Grade 5)

Media tool(s) and task description

The Poetronica sample consisted three (n=3) short video documents of varying quality, with respective running times of 6 seconds, 18 seconds, and 37 seconds. Poetronica is a mixed media art form that combines poetry with visual and musical elements. Students were asked to compose their own poem, draft a storyboard, film images/footage, and compose an original piece of music to be integrated into the final document.

The samples were created by grade 5 students using iPads and the *iMovie* and *Garageband* applications. In teacher our interviews, *iMovie* was sometimes cited as one of the more dynamic and involving design tools that students utilized to present multimodal research, knowledge, and art.

In all of the Poetronica videos, original poetry (recorded in voiceover) and examples of poetic imagery and/or simile were simultaneously spoken and illustrated (with corresponding video footage/imagery that represented the written similes, imagery, or idea in the student poem). Moreover, students were asked to record an original musical work in *Garageband* that reflected the tone/mood of the poem. This was likely a group project as there are indications of teamwork and collaboration in the creation of the video document.

Analysis: Evidence of inquiry-based learning

Because of the nature of this arts-based inquiry sample, it is difficult for us to evaluate the IBL process as we would a more formal research project. That said, it is very evident that students enacted (in at least two of the videos) a methodical use of arts-based methods to inquire, explore an idea or theme, and multimodally represent that knowledge through artistic means and using digital media.

In the short explanatory note provided by the teacher, it was clear that students were provided with success criteria for accomplishing the task, though it was not a fixed template. Project expectations ("success criteria") were articulated – in detail – across three arts-based categories: poetry composition, visual art/design competences, and music. While we will not rehearse all of the expectations below, we noted that the "success criteria" provided to the students supported integrated and sophisticated literary, musical, and digital design competences – from the use of camera angles to communicate ideas to the use of musical scales (major/minor) to communicate the feeling or tone of the poem; specific literary/compositional expectations were also clearly stated for students on word choice, clarity, imagery, organization, use of figurative language, and so on. Given the detail and clarity of expectations, we might infer that students were also provided with appropriate models for achieving the specific success criteria.

While all three of the video samples indicated that the student had accomplished the task, one video in particular demonstrated excellence in terms of accomplishing expectations and meeting the stated success criteria.

Concluding the inquiry process, teacher notes indicate that students posted their Poetronica works on their blogs to share their video documents and receive feedback, and engage in critical discussions about the works.

Technology Application, 21st century competences, and SAMR

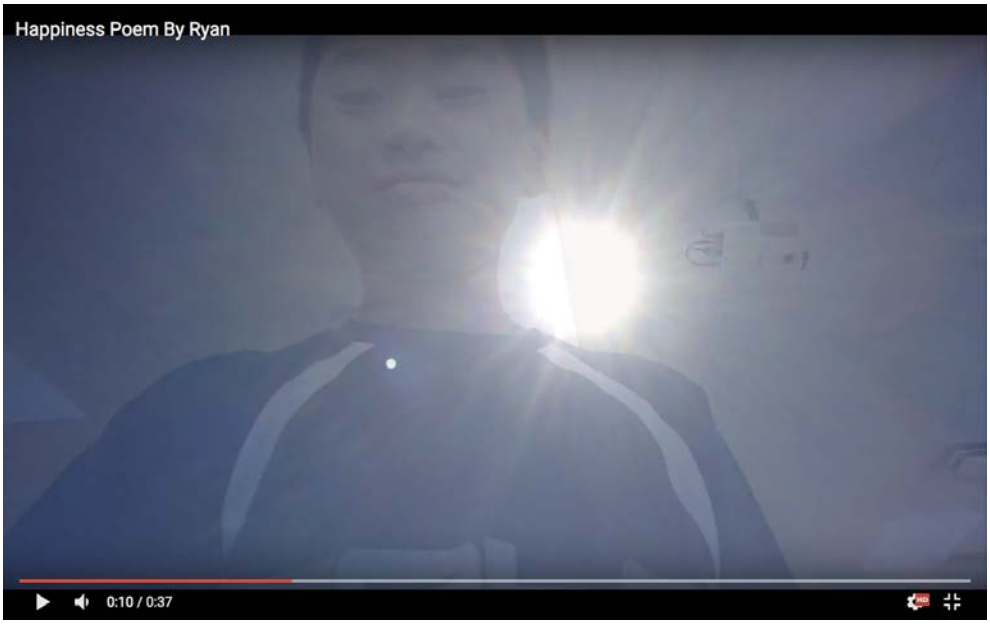
The strategic combination of *iMovie*, *Garageband* and the use of student blogs – in conjunction with an arts-based inquiry task – we find to be an exemplary model of pedagogy mobilizing innovation uses of technology to support 21st century literacies and digital media (design) competences.

If we refer to the SAMR model, we see evidence of "significant task redesign" (R = Redefinition). There is clear evidence of pedagogically transformative uses of digital tools during the (collaborative) making processes, as well as during the sharing of final products (on blog portfolios). Two of the student works indicate the seamless integration of multiple, cross-curricular expectations (literacy/literary, visual, musical, and technological), with one of the works displaying compositional and aesthetic sophistication (in addressing the teacher-provided success criteria).

In the most sophisticated document, the 5th grade students were able to mobilize many of the features of *iMovie,* making strategic choices relating to filming and editing, including utilizing formal conventions associated with video and film (including elements like fades and dissolves). Moreover, the filmed footage was not only appropriate in terms of expressing the poem's metaphors and imagery, but the strategic framing of shots and the use of camera angles indicated that students were making complex technical/formal decisions to communicate content – and to generate intended artistic (cinematic) effects. For example:

"Happiness is like a growing bright light [video footage of student face dissolving to shimmering sunlight] and becoming happy is as easy as walking" [dissolve to video footage of legs/feet walking across the screen, with camera positioned at ground level; the original music work provides an aesthetically appropriate major-key soundtrack].

Figure 14: Sample student project screenshots



Along with modeling the possibilities of integrating arts-based inquiry learning with digital technologies, the Poetronica project also enacts several *Transforming Learning Everywhere* aims and values, including the use of digital technologies to support rich, interdisciplinary learning tasks that situate "students' ideas, observations, and creative actions at the centre of the learning experience" (Malloy, 2014).

Modeling pedagogically transformative applications of new media, the students who composed this one Poetronica sample clearly enacted roles as poets and media producers, creating authentic products - generated with real-world media – for real-world audiences.

Significantly, while students were supported with detailed criteria for constructing their digital media texts (including a story-boarding process), the "success criteria" *formatively* scaffolded – rather than constrained or predetermined – both learning processes and culminating products.

In this regard, while not all works demonstrated excellence, we feel this sample represents an exemplary TLE model, providing students with potentially deep, collaborative learning tasks, where student agency is encouraged in shaping the task and course of learning, with multiple literacies (and diverse ways of learning) engaged through the processes of inquiry, multimodal design, and creative production and sharing.

Student sample 4: Government letter project (Grade 5)

Media tool(s) and task description

The Government Letter sample consisted six (n=6) formal letters written to a government official (*Google Docs* or *Pages* documents, posted on HWSDB blog). As part of a government and citizenship unit, grade 5 students authored, based on their own interests or concerns, formal letters to a governmental agency or actor (e.g., Mayor of Hamilton, Premier Kathleen Wynne) addressing a relevant social or environmental issue, as well as proposing an action plan to be taken.

To support initial research and the exploration of selected topics, students were provided with a rich resource document comprised of several categories (e.g., poverty, transportation, law, human rights, the environment, animal welfare), each with numerous links to current events, news, and research websites. Included were several possible letter addressees: a list of governmental ministries (e.g., Aboriginal Rights, Community and Social Services, Ministry of Education, Child Welfare, Attorney General) with descriptions of respective agency responsibilities and ministers' names. Students were asked to gather evidence, interpret information, and develop an action plan to address the problem. Success criteria were provided through a checklist that identified the key expectations of the task (placed in an organizing letter-writing template). The project culminated in a public-facing formal letter that was published to the teachers' blog on the HWSBD website Hub.

Analysis: Evidence of inquiry-based learning

Evidence of basic IBL processes is evident in different phases of the government and citizenship project: in the short explanatory note provided by the teacher, it was clear that students were invited to formulate questions or "I wonder" queries based on their own interests or social concerns. The diversity and scope of the selected topics confirm student agency in initial engagement and selection of topical issues (e.g., child media use and obesity, depression in nursing homes, texting while driving, solar-powered cars, protecting endangered turtles, and even one letter critically exploring the issue of online privacy and data mining).

These student-formulated questions and topics were, in some cases, developed, extended, and enriched through the inquiry and research process. While the IBL process was guided by the teacher (through the teacher-provided research document), there were multiple outbound links situated under each topic category, and students were able to engage multiple authentic sources, with their research conducted on news, library, and organization/expert websites.

Teacher notes indicate that, using Google Docs/Google Comments, students were supported with formative feedback (an "ongoing conversation") through the process, in combination with face-to-face conferencing.

Moreover, success criteria were provided as a checklist – essentially a template indicating how students should organize content, with features and function of different paragraphs, and where content, evidence, or proposed solutions should be inserted therein. While the organizational template provided structure and guidance for writing a formal letter, it is clear from the samples that students enacted their own research trajectories, with different rhetorical and evidential strategies present across all of the samples, including narrative discussion, appeal to emotion, use of statistics, and quotes from experts. While not all of the letters mobilized evidence to justify opinions or substantiate "I think" statements, most of the letters indicated some degree of investment in the issue being explored.

In most of the documents, students evaluated evidence to create new questions or hypotheses: in this case, with differing degrees of creativity or originality, they articulated possible solutions to the problems or made a call to action to the letter addressee.

Supporting TLE values, and enacting the IBL process, the culminating letter (final project) required students to demonstrate learning and build knowledge in engaged, meaningful ways. Writing expectations and digital research and communications literacies were mutually-contextualized within an authentic task that connected student interests to real-world research concerns. While it is unclear if students presented work to one another, or to what extent students were able to critically reflect on the IBL process, the final letters were published and accessible on the teacher's blog site for (possible) discussion or presentation purposes.

Technology Application, 21st century competences, and SAMR

While the Government Letter project might be seen as a continuation or augmentation (A = SAMR model) of a traditional civics letter-writing task, the utilization of online resources and authentic websites, as well as Google Docs and the comments feature, indicates a strategic integration of digital research literacies and communications/writing literacies, along with (digitally-mediated) formative assessment practices.

Additionally, there is evidence (in a few of the samples) of students leveraging the affordances of the iPad and the *Google Docs (*or *Pages)* applications to format and stylize the final letter, including utilization of spell-check features, text justification, and the embedding of active links to reference citations or supporting evidence.

While innovative ICT use was limited in this project, the final letter and proposal for action, with its publication on a public-facing blog, powerfully models forms of democratic intervention and participatory citizenship in online spaces.

Student Sample 6: Pollution project (Grade 7 Environmental Science)

Media tool(s) and task description

Note: For the following sample set, no task description was provided.

The Environmental Science project sample consisted three (n=3) products created by grade 7 students. All three presentations used different technology or media tools to demonstrate and present learning: 1) *Googleslides* slide show on Light Pollution 2) Word document on Air Pollution with one image 3) a pencil and paper document on Deforestation (appears to be incomplete, insufficient to analyze for IBL, technology use).

We should note, here, that in teacher interviews, students were often given latitude to choose different media tools for presenting final works, and some teachers invited students to "go with their strengths" in selecting media, or advised students to differentiate media means for

demonstrating knowledge on different projects. This might explain the diversity of the product types.

Analysis: Evidence of inquiry-based learning

For this sample set, no teacher description of task or IBL process was provided, so we are limited in terms of analysis and discussion of IBL processes, formative assessment practices, or how the final projects might have been shared or reflected upon.

The diversity of topics and approaches indicates that students were provided with some degree of agency in selecting a topic, and that the inquiry process was not entirely templated in advance. For example, in the Light Pollution (4 slides with topical background images), there is evidence that the student co-developed inquiry questions, focusing on issues and questions possibly refined through the process of research (e.g., How might light pollution affect human health? What is disability glare?). Second, after researching one site and stating (in own words) basic health facts associated with light pollution, the student concludes the short presentation with a hypothesis: that people in developing countries without light pollution may be healthier (less obesity, depression, cancer, sleep disorders). While this hypothesis is not explored or tested, it appears the student used available information to articulate a question that, through further research, may have been confirmed or modified based on further information gathering. This indicates some basic IBL processes in play – though further exploration or verification of the hypothesis is not pursued.

The word document on Air Pollution presented more topical research content. However, what appeared to be the application of expert vocabularies and new knowledge turned out to be copy-and-paste text extracted directly from source websites. Most of "the summary" part of this document is a pastiche of cut-and-paste (with little evidence of the students' own reformulation or synthesis of information into their own words). The "opinion" section of the document is also composed of some copy-and-paste text from other websites, though there is some original speculation on future health conditions if environmental protection is not prioritized. In the final "comparison section", the student is able to make the ecological connection between air pollution and deforestation (in terms of carbon in atmosphere).

Technology Application, 21st century competences, and SAMR

It is difficult to evaluate the use of technology in this sample set as the samples were diverse (slide show, word document, and incomplete pencil and paper document) and there were no teacher notes describing the process.

While some phases of IBL are discernible in this project, we do not see rigorous fidelity of implementation evident in the samples and, in the case of the air pollution document, any evidence of critical research skills and knowledge-building are compromised by the predominance of cut-and-paste content. With regard to using ICT/technology for research purposes, what gains leveraged in terms of access to sources are quickly translated to losses when students copy and paste information into final presentations. As we will see below, this is a problematic feature of the grade 8 Biomes project.

Student Sample 7: Biomes project (Grade 8 Environmental Science)

Media tool(s) and task description

For the following sample set, no teacher task description or notes of IBL process (pedagogy) were provided. Only student PowerPoints were included in this set.

The Biomes project sample consisted eight (n=8) PowerPoint presentations created by grade 8 students for an environmental science project. Biomes are often taught as part of environmental science curriculum, and provide opportunities for self-directed inquiry and research, with applications to ecology, conservation, and debates surrounding how to address issues like climate change or the impact of human action on Biomes. In the sample set provided, selected Biomes included desert, tropical rain forests, swamp, and taiga.

The *PowerPoint* consisted of a template with questions like: animals found in the biome; plants in the biome; presentation of a map; why the biome is important and threats; things you might need if you visit the biome; additional facts. Most of the completed PowerPoints were comprised of propositional statements answering the template questions, combined with related relevant maps or images (of flora or fauna).

Analysis: Evidence of inquiry-based learning

Note: For this sample set, no teacher description of task or IBL process was provided,

The Biome project template suggests that there may have been (some) limited contribution by students in the initial question-posing or "wonder" phase of the project, though it is unclear if, or to what extent, students' own questions contributed to design of the template. Template questions are structured in a conventional way, requiring basic Internet research by students and concise answerers presented as factual reports, propositional statements, or bullet points. There is little variation among the samples (in terms of questions researched), and little development of questions or refinement of issues through the research process.

If the purpose of this Biomes project was to ask students to navigate websites and answer template questions, the students acquitted themselves. It is evident that students engaged a variety of web-based research sources. This is at times clear because several of the final presentations were comprised of copy-and-paste answers taken directly from the source website (without referencing the source).

While students effectively gathered appropriate information in response to template questions, and a great deal of raw information is re-presented on PowerPoint slides, the preponderance of copy/paste text in the samples signals that opportunities for deep learning tasks, rich IBL exploration, and authentic knowledge-building are missed. In fact, by the standards of most contemporary rubrics, the reproduction of content in this way does not count as a demonstration of knowledge-building or communication skills.

While other samples indicate the restatement of information in the students' own words, there is still little evidence of the kinds of dynamic IBL processes encouraged in Ministry and TLE documents. For example, absent from these samples are evidence of investment in the process or product of learning; development of research questions; the formulation or new questions or articulations between prior knowledge and new discoveries; any synthesis of new information in meaningful ways, that might matter to students; and, finally, there is a lack of extended applications or imaginative solutions or hypothesis-making (e.g. with regard to environmental crises or conservation issues) except in the most cursory forms.

Again, as no teacher description of task was provided, we do not know if or to what extent the presentations were shared, or if students critically reflected on the inquiry process.

Technology Application, 21st century competences, and SAMR

While the *PowerPoint* presentations were, in many cases, very creatively designed (with effective integration of curated images and maps, and displaying careful attention to design and

formatting choices), the information presented, as detailed as it was in some cases, did not indicate that technology tools were being mobilized in ways that support deep learning, rich task applications, or memorable synthesis (or critical application) of new knowledge.

The use of *PowerPoint* to present static facts and propositional statements we find to border on the SAMR model's Substitution (S) category, where the pedagogical use of technology may offer some functional improvement and enhance – rather than *transform* – traditional teaching methods. Paralleling the SAMR model, TLE affirms that the pedagogical aim is that new technologies should not "simply be used duplicate existing practices on-line" (Malloy, 2014, p. 4).

On one hand, there is ample evidence of students' ability to navigate sources, gather data, and re-duplicate that information in response to well-defined prompts. On the other, there is scant evidence (in most of the samples) of meaningful knowledge construction, or deep concern or engagement in the selected topic or inquiry process – and it is difficult for us to ultimately assess student "uptake" of knowledge. This may, too, be attributable to certain *PowerPoint* conventions (e.g., presenting short facts, creating bullet-point answers, focusing more on superficial slide appearance than deep understanding and/or knowledge construction), and we must consider, here, how applications like *PowerPoint* act upon the users in establishing tacit constraints that may limit deep learning opportunities.

Student Sample 8: Child labour project (Grade 8 Social Science)

We would like highlight an exception: a single, stand-alone (n=1; grade 8) PowerPoint found in the same set (from a different task). This sample – on child labour – models, in our view, many of positive attributes that are absent in the Biome samples: student-formulated research questions based on authentic concerns; an ongoing shaping of questions and issues through the discovery process; original synthesis of information to construct new knowledge (and communicate it in visually-compelling ways); articulation of knowledge in own words; nuanced use of images/infographics to support claims, or to affect the reader emotionally; connecting with real-world issues and critically reflecting upon contemporary social-justice issues by linking them to everyday consumer practices in North America. A bibliography with references is included.

Though teacher notes were not included with this sample, we would suggest that there is more evidence of student agency (and genuine interest) in shaping the direction of inquiry and learning. In this sample, it also appears that a fixed set of "answerable" template questions did not predetermine the breadth or depth of inquiry and application of communication skills. While the presentation is still punctuated, at times, with bullet-point facts, these facts are more elegantly woven into the fabric of the digital presentation as a whole. The ensemble of multimodal elements – bereft of copy-and-paste content – results in an effective integration of topical research and content with rhetorical, digital-design, and communication literacies.

Figure 15: Student child labour project screenshots

Companies Who Use Child Labour

You might be wondering who in the world would use child labour but some companies that we recognize are associated with it. Whether they have child labour in their own factories, or purchase supplies from factories who use child labour too many well known companies, in my opinion, are connected to it.

What do you think all of these companies have in common?

HERSHEY'S

FOREVER 21

Toys"R"Us

AÉROPOSTALE

urban outfitters

NIKE

Walmart

H&M

JOE FRESH

Disney

GAP

Sears

The issue of child labour can have many different causes depending on the specific situation. In some cases the children are working because their parents are unemployed or sick. Other times factories are employing children because they can be paid less and work in small spaces doing jobs that adults aren't able to do. In places like Africa, parents getting sick with diseases and viruses like HIV AIDS can be a big contributor to problems like child labour. When global issues like these become so connected it can get more difficult to solve them. For example, child labour is connected to poverty, diseases, child soldiers, access to free education, migration and child abuse. These types of issues are very complicated because you can't stop them without doing something to stop the issues connected to it.

Student Sample 9: Advertising techniques Project (Grade 8)

Media tool(s) and task description

The Advertising Techniques sample consisted of six (n=6) digital presentations (silent videos) created by grade 8 students focusing on common rhetorical techniques found in commercial advertising. This is common media literacies curriculum task, enabling students to analyze advertising messages and learn about how commercial artefacts work to persuade consumers of products or information.

For this task, students were asked to select an advertising artefact (based on a selection of YouTube videos) and identify what rhetorical techniques were being utilized in the ad. It appears that a template or checklist was provided by the teacher with three to four questions: What is the ad selling? What techniques does it use? Who is the intended audience? How does the ad get your attention? Students drew from a set of available rhetorical categories to analyze their selected videos and present their analyses.

In communicating findings, students apparently used a presentation tool (e.g., *GoogleSlides* or *PowerPoint*) that was converted to a video (slide-show format) where their analyses were presented. The videos were composed of screenshots of the selected Youtube commercials, followed by usually brief written answers responding to the questions above.

Analysis: Evidence of inquiry-based learning

Given the sample set, it is difficult to determine how the project was initialized, or if or to what extent students' own queries or "I wonder" questions framed the template/question design. It is also unclear if students' own critical observations of video models during the first phases of inquiry helped inform or enrich the rhetorical techniques (categories) that were utilized to analyze the final video artefacts.

It is clear, however, that students were supported with some discussion or modeling prior to their project work: for example, across the different video samples, student identify several rhetorical categories: e.g., humour, testimonial, celebrity, statistics, bandwagon, sensory appeal, sex appeal, bait/switch, loaded language, plain folks, and even one more complex technique relating to viewer identification through "Transfer/Fantasy". This is a rich set of rhetorical categories.

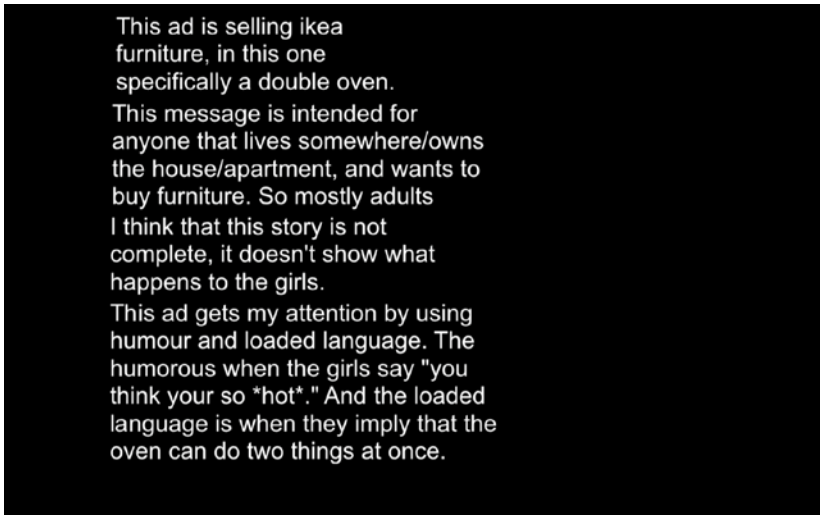
Sadly no teacher task description of IBL (pedagogy) was provided, which is unfortunate. Media literacies can be "taught" in a routinized, didactic way where students are informed about a set of advertising techniques and asked to apply that knowledge through analysis. Alternately, using critical IBL processes, media literacies can be situated in dynamic ways where students collaboratively engage video models, and work together to help co-generate, based on previous knowledge and critical observation of the video texts, the set of conceptual tools and categories mobilized to help analyze advertising techniques and cultural artefacts. The latter (IBL method) supports student agency, as well as provides opportunities for students to co-shape the set of analytic tools and research questions used. It also provides opportunities to enrich the scope of the task, as students might (and often do) contribute ideas, frameworks, and experiences that the teacher may not have anticipated or known about.

While this set of advertising/rhetorical categories explored are very comprehensive and potentially rich points of departure for extended critical analysis, most of the final student samples are composed of a simple one-word identification of the dominant advertising technique/s, (e.g., humour, celebrity, statistics), and the three key questions are often answered in very short paragraphs or "short answer" form.

Figure 16: Student advertising project screenshot 1

Given the quite rich set of rhetorical techniques presented, we find that final projects indicate a lack of deep engagement with advertising techniques. "Short answers" are presented where students could have developed more detailed and rich analyses. For example, in one of the more detailed samples (below), the student does provide a very brief analysis of how humor and "loaded language" works in the ad, though that kind of discussion is absent from many of the other samples. Students are also asked if the ad is "complete" or not, but there is no definition of completeness, or how the in/completeness of the ad might affect the viewer.

Figure 17: Student advertising project screenshot 2



Most importantly, in terms of IBL processes and outcomes, avenues for extending and applying the learning – and connecting that learning in interdisciplinary ways – are not present in the samples. Here, critical issues surrounding consumer culture and the ethics of advertising are not explored; nor are important issues like how the same rhetorical techniques found in advertising might be utilized in other spheres of culture and communication (in politics, persuasive writing, news and social media, interpersonal communication, propaganda-like discourses, etc., and in shaping student identity and everyday cultural stories).

Technology application, 21st century competences, and SAMR

Given the nature of this the task (analyzing media), as well as the dynamic scope of the rhetorical categories presented by the teacher, we feel that some opportunities may have been missed for leveraging technology tools to support deep learning and extend inquiry-based learning in meaningful ways, with critical and creative applications of knowledge and learning.

As noted above, analyzing advertising techniques has remained a common, if not somewhat routinized, curricular task over the past decades in schools across North America. In this sample, we do not see evidence of significant task redesign or meaningful pedagogical modification of tasks in relation to technology tools; the slide-show presentations in many respects reduplicate the traditional ways these curricular objectives have been taught in the past. Moreover, demonstrations of knowledge using the presentation template is restricted to short answers, in turn truncating opportunities for deeper engagement, bigger questions, and extended connection-making to society and culture. In this instance, the pedagogical use of technology may offer some functional improvement (in presenting image, text, and screenshots) but there is little evidence of pedagogically transformative uses of the available technology tools.

As media techniques are in many respects the content and focus of this project, we suggest that the 1:1 media tools available to students could have been more creatively and collaboratively mobilized, where students might have ultimately applied learning and knowledge (the rhetorical techniques and categories) in a more dynamic way. For example: taking roles as media producers and then scripting and creating their own advertising movies, or persuasive digital documents (applying rhetorical techniques) expressing more positive social messages, or even critical “counter-advertising” artefacts.

By shifting the emphasis (in a culminating project) from *answering* questions to *producing* dynamic digital documents, the students could have built upon their analyses, collaboratively applied their learning, and thus creatively enacted many of the aims and values of the TLE initiative.

Part 2 Holistic analysis of student work samples

In this second section of this chapter, we shift from a qualitative narrative analysis of student samples to a holistic quantitative analysis of three sample sets from three TLE pilot schools (representing project work, respectively, from grades 4, 7, and 8).

Methods and rating tools

Samples of student work were selected from schools where at least three or more tasks/projects on the same topic were available for coding *and* where the tasks/projects were relatively substantive, requiring a minimum of one week to complete. In addition, samples were selected from across grades to ensure that diverse TLE grade levels would be represented in our analysis. Three sets of student assignments were found that meet these criteria.

Next, two experienced Junior/Intermediate teachers (from outside of HWDSB) were selected to rate the student work according the scales developed by SRI International for their international study of Microsoft's *Partners in Learning Program*. To provide a bit of backdrop, these comprehensive scales were designed to assess and measure (internationally) 21st century skills, innovative teaching practices, and learner-centred pedagogies where technology tools/ICT are integral.

For the purposes of our research study, the teachers were trained by a member of the research team to rate the student work according to the scales using different work samples from the same classes. In accordance with recommendations by SRI International, we placed an emphasis on training teachers to ensure consistency in rating. Once trained, the teachers were then asked to rate the three sample sets. In cases where teachers disagreed on a rating(s), the average rating was computed and recorded.

The rating scales themselves were developed by SRI International to specifically assess evidence of 21st century learning. The SRI International rating scales were selected because they consist of four dimensions that closely align with TLE objectives for student learning, as well as TLE aims for innovative digital tool (ICT) use, deep learning tasks, and learner-centred pedagogies. As will we see in the four dimensions of the scale below, the SRI International tools also align very well with Inquiry-Based Learning (IBL), as articulated above in the discussion above.

Dimensions of scale

The four dimensions of the SRI International scale include: 1) Knowledge Construction 2) Applied ICT Use 3) Real-world Problem Solving and Innovation 4) Communication Skills. See the Appendix for scale descriptions.

The term "ICT" (in the rubric above) is defined the full range of available digital tools, including hardware and software (everything from an Internet browser and iPad applications to social media and collaborative editing and work-sharing platforms). Many of the rubric dimensions align with TLE and Ontario Ministry of Education aims, particularly in relation to innovative, technology-mediated IBL processes and deep learning product outcomes.

Scoring

The rating scheme ranges from 1 to 4, where a score of 1 indicates that the student work demonstrates no evidence of the skill to a high of 4, which demonstrates a very high skill level.

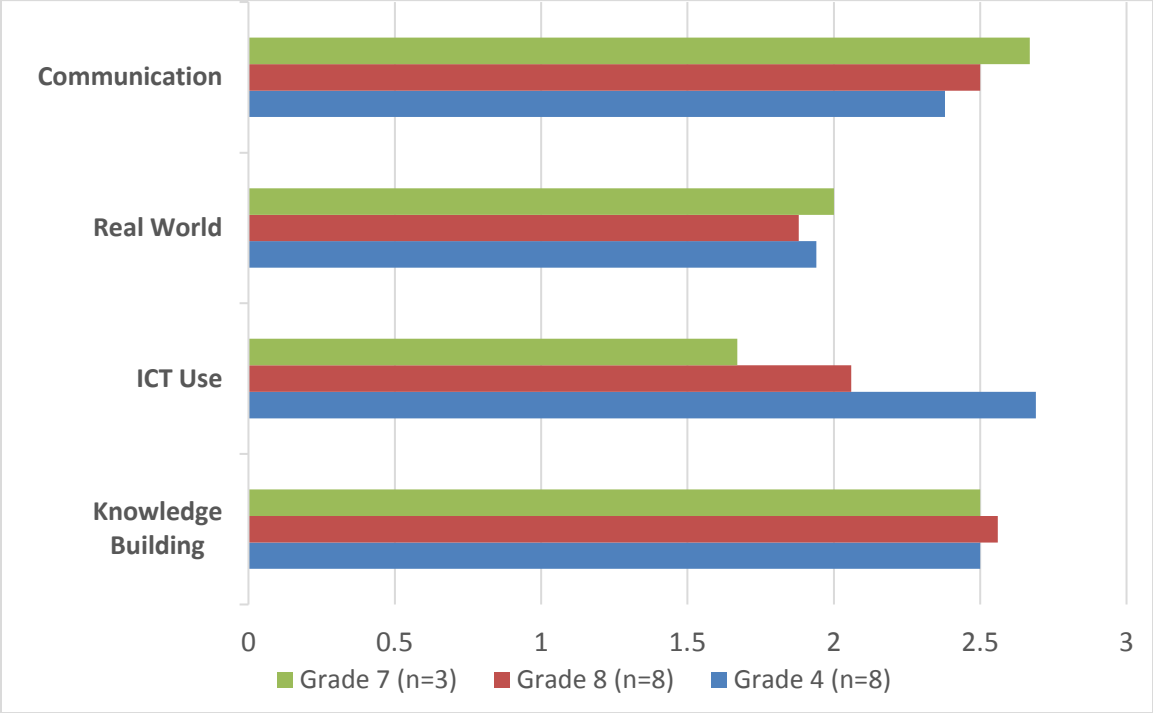
In interpreting the scores and graph (below), a rating of 1 indicates little to no evidence of the competency or skill in the respective dimension (e.g. instead of knowledge construction, students reproduce information and use rudimentary procedures to demonstrate learning); a rating of 2 indicates some basic evidence of the respective competency or skill (e.g., there is some evidence of superficial knowledge-building or effective ICT use in demonstrating learning, but knowledge construction or innovative technology use was not the student's "main effort" or the dominant characteristic in the work); a rating of 3 signals that the competency or skill was clearly demonstrated (e.g., the student's "main effort" was knowledge construction or effective ICT use, though deep, interdisciplinary learning and innovative tool use may not be a characteristic of the work or effort).

A rating of 4 indicates a high level of competency in the respective dimension(s), e.g., the student demonstrated sophisticated conceptual understanding and interdisciplinary knowledge construction is a dominant feature of the work; technology tools/ICT are utilized in innovative ways to communicate knowledge to an authentic audience and knowledge construction is supported by ICT through the creation of an authentic product; real-world connections and problem-solving play an instrumental part of the effort or work where innovation is demonstrated; communication skills are demonstrated through multimodal practices where knowledge is contextualized and extended in meaningful ways with supporting evidence.

Analysis student project samples

The results of our analysis are shown in the figure below.

Figure 18: Mean student 21st century skills scores at three different schools



As can be seen, the mean scores in each of the dimensions are above the mid-point of the scale in most cases. To provide a bit of reference, SRI International (2010) reported that in their international study, over 50% of student work samples were scored 1 on every dimension.[6]

Still, the scores above do not rate on the high end of the SRI International scale – and there is room for significant improvement across all of the four dimensions. However, we must also acknowledge the limited sample sizes, as well as the small number of available samples sets provided by teachers in the pilot schools we studied.

In interpreting and evaluating the results the holistic quantitative analysis, we therefore suggest cross-referencing the quantitative scores in this part of the chapter with the qualitative discussion above. Comparatively, the qualitative section will provide a window onto the types of tasks students engaged, evidence of IBL processes, and critical discussion of technology (ICT) use. We hope this will enable our readers to better understand the results of the analysis, as well as consider possible avenues for moving TLE forward.

Summary

We briefly distill, below, observations from our analysis of the student samples, and signal possible areas of focus to refine TLE goals and better support IBL practices and innovative tool use supportive of new pedagogies and new learning partnerships. We consider to what extent IBL practices and digital technologies were mobilized to support deep learning tasks and student acquisition of 21st century literacies and communications competences.

[6] http://itlresearch.com/research-a-reports/2010-pilot-year-itl-findings-and-methods

IBL fidelity of implementation and deep learning

Many of the learning tasks in the sample sets were, or seemed to be, largely governed by teacher-provided templates. What was absent in many of these samples was evidence of student agency in initial planning processes, or in refining inquiry questions, or in extending and deepening the scope of related research beyond the provided templates. In many of the samples, we observe that students could have been more directly involved in the initial planning phase, and invited to notice, wonder, and ask questions that might have re/shaped the research questions through the ongoing process of discovery.

As is often the case in traditional classrooms, the use of a fixed template to guide and predict learning outcomes can also delimit the degree of affective engagement and the depth of self-directed intellectual inquiry. We refer, here, to TLE documents and the Ministry of Ontario *Capacity Series* on IBL, which encourage student agency in the initial planning stages and, further, through the entirety of the inquiry-learning cycle. In these documents, teacher guidance refers to supporting dynamic learning engagements – not predicting and regulating the inquiry process itself, nor anticipating learning outcomes in advance. The use of templates in the samples also contradicts some of the enthusiasm for self-directed exploration as reported in teacher interviews (though that enthusiasm for IBL was not shared by all teachers in the interviews).

As Dede (2014) and Fullan and Langworthy (2014) point out, deep learning happens when students, in "new learning partnerships" with teachers *and* technologies, are positioned to co-construct and share knowledge using media tools. A key aspect of deep learning is the fabrication of media products that involve students in real-world problem solving, and invite them to engage critical issues and creative purposes that matter to them.

With the exception of the Poetronica project (grade 5), the Government Letters (grade 4), and to some extent the Wildlife Habitat project (grade 4), we did not see a great deal of evidence (particularly in the 7th and 8th grade samples) of students being enabled to co-make knowledge in ways that enact deep, interdisciplinary learning – where new knowledge is "extended" in meaningful ways. In these latter samples, the capacities to drive the learning process and co-construct knowledge are not clearly evidenced (with the exception of the "child labour" sample examined above).

Given these latter sample sets, it is difficult to reconcile the TLE goal of students acquiring dispositions as *autonomous* "life-long learners" when inquiry processes are fixed by *heteronomous* (i.e., teacher defined) template(s), often requiring students to answer pre-given questions and reproduce static information (rather than produce living knowledge that is meaningfully interwoven with problems, issues, and controversies in the world outside of the classrooms).

Technology use and new pedagogies

While the use of digital tools for research and knowledge demonstration was present in almost every sample, not all of the sample tasks modeled transformative uses of technology to support new pedagogies. In fact, while digital tool use was pervasive, so were abuses of digital tool use, as apparent in the frequent instances of copying and pasting source text into final documents (7th and 8th grade sample sets).

The most pedagogically transformative uses of technology were present in 4th and 5th grade sample sets, where teachers were integrating multiple tools – and setting up rich media

ecologies – to support deep learning *throughout* the IBL process as a whole, e.g., using *Brainpop* videos to engage interest and stimulate wonder; using virtual walls (*Padlet*) for collaborative learning and modeling purposes; using interactive polling systems to stimulate discussion; and mobilizing storyboarding to scaffold digital design and communications literacies.

This ecological use of (digital) media also facilitated more dynamic culminating projects where students were more likely to engage real-world problem solving and "multiple literacy practices" (Cope & Kalantzis, 2011), as well as engage in designing knowledge for real-world audiences (e.g., iMovie products and letters posted to public-facing blogs).

In the 4th and 5th grade samples, there was also evidence of more interdisciplinary contextualization (by teachers) and application (by students) of research and knowledge. If we cross-reference some of these tasks and student samples with TLE and Ministry goals, we see promising models for deep learning, where new student/teacher/technology partnerships are being forged, and student action is not as narrowly circumscribed by templates.

Innovative formative supports and assessment methods were also employed in the grade 4 and 5 samples. In the case of the Poetronica project, we see well-defined "success criteria" *formatively* encouraging (rather than delimiting) student agency and creative knowledge application. In the Government Letter project, formative feedback was conducted as an "ongoing conversation" with students (using Google Docs' comments features and face-to-face meetings). In the Wildlife Habitat project, forms of student self-assessment/meta-cognitive reflection were nested into the final digital *Explain Everything* document.

The 4th and 5th grade samples also indicate a greater degree of student critical reflection on IBL processes and products of learning, and in these samples (based on teacher task descriptions) students were more likely to take collaborative roles sharing and teaching one another using digital presentation media.

Our analysis of student samples indicates that TLE aims and purposes were most likely to be enacted when and where 1) templates did not predetermine student learning or solicit propositional statements, short answers, or the conventional reproduction of static facts 2) dynamic digital media ecologies were in play to support *all* of the different phases of the IBL cycle, including formative assessment 3) students assumed authentic roles, using authentic media tools, as producers of knowledge, in turn demonstrating learning through the creation of dynamic products for real-world audiences 4) digital research, knowledge production, and communications literacies were mutually-contextualized within digitally-mediated tasks driven by student concerns, and interwoven with the extended world (issues and controversies) outside of the classroom.

Again, we encourage readers of this chapter to cross-reference our quantitative holistic analysis scores (Part 2) with the qualitative narrative (Part 1) to acquire a more complete picture of the data.

In the next chapter we conclude this report a summary overview of the research project findings together with recommendations for action.

Chapter 8: Summary and Recommendations

In this report we studied the implementation of *Transforming Learning Everywhere* during the 2015-2016 school year, the second year of a five-year initiative begun in 2014 by the Hamilton Wentworth District School Board. The research was guided by a logic model we developed based on the theory of action espoused by the board. This theory suggests that by supplying iPads with a comprehensive suite of apps to every teacher and student, providing teachers with professional learning opportunities to use inquiry-based pedagogy, giving schools technical infrastructure and support, and supporting administrators and other professional staff in their understanding of the project, there will be a transformation of pedagogy such that students will learn more deeply and develop the knowledge, skills, and characteristics necessary to succeed in the 21st century. The logic model aided in clarifying (1) the inputs the board contributed to the TLE such as funding, professional support for teachers and administrators, technology, and project evaluation, (2) the activities than resulted from these inputs, and (3) the outcomes expected from the project. Our research questions related to board, teacher, and student level issues and our findings for each level are summarized in this chapter followed by recommendations. Before doing so it is important to recognize the limitations of this evaluation.

Study limitations

For data sources we relied on the analysis of publically-available board documents and interviews that we conducted with a sample of teachers and students. Only a small sample of student work was obtained because few consent forms were returned by parents/guardians. All key informant interviews, except for one, were conducted by the board without our input on the interview questions, and we were only able to make minimal additions to the district's teacher and student online surveys. Nor were we able to observe classes or collect learning task assignments as initially planned. One of the seven pilot schools also chose not to participate in the study. The 2015-16 school year got off to a slower than normal start as well due to labour-related issues so teachers did not have the full complement of planned professional development experiences, and students may not have been as fully exposed to IBL pedagogy as would otherwise have been the case. Despite these limitations we believe that the findings provide a valuable basis to help the board move forward in its planning and scaling of TLE. The methodology we employed in this study will also provide guidance for other Ontario school districts in designing and evaluating Technology Learning Fund initiative.

Board level findings

Our research questions at the board level concerned policies and plans developed to implement TLE and what practices have been put into place to bring about transformation and to scale it up across the board. Our findings suggest that the board has developed a program that has solid support in the literature. Inquiry-based learning, supported by technology, can result in enhanced student learning outcomes that fall under the general rubric of 21st century skills. The challenge the board faces is to implement such a fundamental shift in pedagogy—and indeed culture—in all grades, across all schools in the district. Such a fundamental and wide transformation cannot occur in only a few years and we are uncertain that it can occur within the five year span of the project. Even in the pilot schools we studied, which were in their second year and given substantial support, the transformation has not fully happened, although significant progress has been made. The integration of one-to-one technology into IBL both

facilitates and exacerbates the transformation. The convenient availability of iPads for teachers and students facilitates student research, a crucial component of IBL, intrinsically motivates students, and makes learning more visible; on the other hand teachers have to learn to use the iPads themselves, manage a class of students all who potentially may be working on different projects, assess a wide range of projects, and physically manage the devices in their classrooms. As the board continues to roll out the program to other grades and schools they must continue to support teachers in schools where the project is underway. For example, teachers reported little if any professional learning sessions on IBL during the 2015-16 school year, and some teachers still have questions about use of iPads in their teaching. One cannot assume that teachers who have been already been exposed to basic concepts of IBL and iPads are up to the desired skill level. Thus professional learning must continue to be supported for current as well as new teachers in the project.

More generally, with regard to professional education, the board's strategy that involves school-based professional learning, including individual teacher support from coaches, and family of school professional learning is sound. An annual survey of teachers on their professional learning needs may be desirable because not all teachers are starting with the same pedagogical and technological background. Principals appear to be fully supportive of TLE and the incorporation of professional learning sessions in the agenda of the monthly family of school meetings is a very practical strategy. As the project gets more entrenched and other priorities arise (e.g., student mental health) the natural tendency to give lower priority to ongoing initiatives must be avoided. As we heard one informant say, TLE should be a lens through which all new initiatives must be viewed.

TLE is clearly expanding across the district. In 2016-17 all grade 9 schools and two secondary schools grade 10 classes set to receive 1:1 iPads and all grade 6s to receive shared iPad kits. This will result in approximately 24% of students in the board having their own iPad. We did not see a plan for rolling out the project beyond the initial five pilot projects, nor a rationale as to why grade 6s are to receive kits. Presumably grade 9 students will be receiving iPads because they will be using them next year in grade 10 where iPads are already in use. Budgetary considerations and community interest in TLE likely are two other factors weighing into expansion decisions. Nevertheless, we believe that the plan and rationale for the rollout should be shared with the community more broadly as we assume that the Steering Committee has a plan in mind for scaling the project. Ideally, as the project expands, the advice of Fullan and Donnelly (2013) that clusters of schools should learn from each other for a project to scale successfully should be heeded, and a process and mechanism for this sharing to occur ought to be established.

HWDSB has made a significant financial commitment to support TLE. The projected 2016-17 budget is approximately $1.7 million of which the board is contributing over nearly 60% by re-allocating existing funds including school budgets and the CODE/Technology Learning Fund the remainder. Although this is a very significant contribution, especially in times of competing fiscal demands funding and cutbacks, funding TLE at this rate will not be sufficient to implement 1:1 iPads in all schools and grades within the next three years. Therefore, the board might approach the Ministry of Education/CODE for additional funding to achieve their very laudable goal within the projected timelines. TLE could, in this case, become a demonstration district on 21st century learning transformation, and be in a position to "lead from the middle" (Hargreaves & Ainscow, 2015) in collaboration with other Ontario districts. At the same time the board may

wish to draw up plans to roll out 1:1 iPads to all schools and provide professional learning support should additional funding beyond the current rate not be forthcoming.

The board has had considerable success in building out the necessary technological infrastructure and support after suffering from growing pains in the first year of the project. For the most part networks are functioning well, the iPads desktop apps are being managed efficiently, and the helpdesk appears to be responsive to teachers. At the same time, however, according to teachers some wireless networks may need additional bandwidth to handle the traffic demands being made in schools. There is also room for improvement in timeliness of onsite help, although this would seem to be a lower priority given the competing demands on the ITT team. If iPads are not taken home by students then improvements are needed to ensure sufficient access to charging outlets is available in classrooms as teachers may have their lessons disrupted if not all devices are available to students.

TLE is managed centrally by a senior level Steering Committee chaired by the Executive Superintendent of Leadership and Learning and made up of a number of superintendents with various responsibilities. This model appears to be working well, but again, we turn to Fullan and Donnelly (2013), who have observed that innovative reform initiatives that scale do not require strong central support, and instead rely on local clusters of schools that lead the implementation because they find the innovation so compelling that they want to take ownership and see it succeed. To the contrary, a hallmark of unsuccessful innovations are those that require a heavy, top-down central support. The Steering Committee must continually strive to try to maintain a balance between central authority and local autonomy. One of the responsibilities of the Steering Committee is to monitor progress of the project's success. The E-BEST department has been tasked with providing feedback to the committee. We believe that by approaching the collection of data from teachers and schools as a research endeavour as opposed to a program improvement undertaking limits the validity of the feedback to the Committee. With the former approach ethics approval is required from all participants, whereas in the latter approach it is not. The consequence of the research approach is that gaining required consent severely limits the number of participants open to study. Without the restriction of consent a very high response rate is attainable without imposing the burden on schools of gathering consent forms. We also suggest that internal technical analyses be shared with the community as the evidence for the claims made about the project in the annual reports is not always clear. This evidence will keep decision-makers better informed and increase public accountability for TLE.

Teacher findings overview

At the teacher level we investigated the extent to which teachers' roles shifted toward becoming facilitators of students taking more responsibility for their learning, how teachers are promoting deep learning particularly through inquiry-based methods, and what methods they are using to assess deep learning.

With regard to teachers shifting their role to become facilitators of student learning, our data provide convincing evidence that this transformation is occurring, but to varying degrees across teachers. Generally speaking most teachers reported that relinquishing control to give students more agency was very challenging. The availability of iPads for all in the class played a significant role in this change. Nonetheless, it was an alien experience for those who were used to teacher-centred pedagogy where tight classroom control was the norm. A few felt that that they had not introduced any significant shifts in their pedagogy, however, either because they were just starting to explore inquiry-based learning or because it aligned with what they were

already doing. Some expressed concern that letting go of being the expert in the room and becoming a co-learner would cause students to lose respect for them, although as they began to see how readily students took control of their learning the worry began to dissipate. Some teachers were apprehensive about students heading off in directions not anticipated and they became anxious about covering curriculum expectations when this happens. There was a feeling among some that deep learning on one topic did not give students enough breadth because they would not necessarily learn from their classmates' presentations on other topics. The use of inquiry learning for mathematics was questioned; so to was its appropriateness for teaching basic skills in language arts. A grade 6 teacher considered math focused inquiry learning to be a "luxury" that could be indulged in after preparation for the EQAO. Since these issues and no doubt others are on the minds of teachers, we recommend that they be addressed by coaches, principals, or other appropriate board staff. Another suggestion is to prepare an FAQ document to address the concerns that teachers are grappling with or to have peers share how they have dealt with these issues.

Despite the concerns of teachers about their changing role we found evidence that teachers, in fact, were promoting deep learning particularly through inquiry-based methods. Teachers reported on average that their students spent between one-third and one-half of their time engaged in inquiry learning projects that ran longer than one week in duration. Many teachers described to us very engaging projects that they developed. Again, as would be expected, the frequency and nature of the projects varied considerably across teachers in our sample. Strongest evidence for IBL was found in the 4th and 5th grade student work samples where teachers integrated multiple digital tools throughout all stages of the inquiry-based learning and new student/teacher/technology partnerships were forged. In these samples we saw that in their projects students began with "wonder questions," engaged in real world problem solving, and critically assessed and shared their work. Unfortunately, more frequently we saw that there was little student agency in the initial planning processes, or in refining inquiry questions, or extending and deepening the scope of related research beyond teacher-created templates. In many of the samples, we observed that students could have been more directly involved in the initial planning phase, and invited to notice, wonder, and ask questions that might have reshaped the research questions through the ongoing process of discovery. These more frequent cases that were guided by templates could have been a result of teachers not feeling prepared to relinquish control, lack of understanding of IBL, or they could have been an attempt to speed up the inquiry process to meet particular deadlines. Clearly, continued professional support is needed to help teachers fully understand and make use of IBL.

With regard to assessment methods used by teachers, we found encouraging evidence of a shift from a summative, product emphasis to more attention to and observation of student learning processes and recurrent formative assessment, facilitated by the technology. Most of the tools and apps students used for creating and submitting work had affordances for sharing work that allowed teachers fast anywhere/anytime access to student output in all stages of development, from initial plans and outlines to final products. Consequently teachers were much more inclined to iteratively assess student work, and to provide feedback and guidance as student work progressed. About half of the teachers we interviewed reported involving students in the initial development of rubrics or checklists for assessing inquiry projects (a crucial component of IBL), although few students we interviewed had any recollection of doing this. As student projects proceeded teachers would remind students of assessment criteria to provide guidance on how they would be graded. Teachers would sometimes conference with students about their progress as others continued to work away on their projects. Assessment criteria were normally

available to students and teachers any time on their iPads, which was a valuable convenience. Whole-class sharing of student work via AppleTV further facilitated the assessment process as peers would have the opportunity to critically and constructively comment on each other's work.

Student findings overview

We wanted to understand how engaged students were in their work, what kinds of learning tasks were occurring and what the 1-to-1 technology played in supporting these tasks, and what evidence there was that 21st century competences were being developed.

With respect to engagement, teachers reported that nearly all of their students demonstrated strong levels of engagement in most learning contexts where iPad use was integral to their work. Student engagement was noted to be particularly robust and universal when students were using iPad tools to create non-textual and multimedia artefacts, ranging from iMovie trailers and animations through music created or edited with Garage Band to design simulations built in Minecraft. This engagement was not limited to high-performing students; it was also found among those who typically struggled or had special needs. Teachers noted that students when doing work with iPads were more likely to persist at tasks when they ran into difficulty, and they demonstrated more initiative in working to solve their problems, either independently or with peer assistance. Teachers also cited many instances where students working with iPads had shown greater autonomy and initiative in pursuing independent learning and creative endeavours both inside and outside of class (in instances where students had access to other technology). Little off-task behaviour was reported. On the whole, students' planning and self-regulation skills were found to advance through the use of IBL, but in a few classes teachers reported that these remained poorly developed. Only a few teachers reported seeing evidence of enhanced analytic and inferential thinking skills stemming from IBL. Not surprisingly, the vast majority of students liked using and learning with their iPad; however one cannot assume that all students like using them, as about 10% to 15% preferred learning without them, found iPads distracting, or were bored with them.

Teacher reports and our analysis of student work showed that a wide diversity of inquiry-based learning projects were undertaken using iPads across the curriculum, with the majority in science, history, or social studies; several had interdisciplinary elements intended to develop students' literacy and/or mathematical skills. Many were framed by teachers around social or environmental issues of current relevance either in the local community or the world at large, such as global warming. Very few inquiry projects were undertaken in mathematics; teachers found this subject a hard "fit" for IBL and wanted more guidance in it.

We examined in detail grade 4 wildlife habitats and healthy eating projects, grade 5 poetry and government letter writing projects, a grade 7 pollution project, and grade 8 biomes, child labour, and advertising projects. Undoubtedly students acquired specific knowledge and understandings in these projects; however, absent in many was evidence of student agency in initial planning processes, or in refining inquiry questions, or in extending and deepening the scope of related research beyond the teacher-provided templates. In many of the samples, we observed that students could have been more directly involved in the initial planning phase, and invited to notice, wonder, and ask questions that might have shaped and refined the research questions through the ongoing process of discovery. This could have been because, as some teachers suggested, students had difficulty doing this, or simply because teachers felt the initial stages of IBL are overly time-consuming. With the exception of two of the projects, we did not

see evidence of deep learning or new learning partnerships where teachers and students co-constructed knowledge and shared it using media tools as envisaged by the Ontario Ministry of Education (2013), Dede (2014), and Fullan and Langworthy (2014). Our quantitative assessment of three different samples of student projects, using a 21st century learning scale developed by SRI International, indicated mean scores around the mid-point of the scales. These scores are slightly higher than those of students in 50% of classrooms assessed in an international study led by SRI International.

Although some may consider the above findings on the quality of student work somewhat disheartening, one must take into consideration possible sampling bias. Also the theory of action does not suggest that transformation is going to happen overnight as TLE is only in the second year of implementation, and only short term goals can be expected to be accomplished at this early stage (see logic model Figure 1). Teachers have for the most part embraced TLE aims, and their descriptions of innovative inquiry projects, given in chapter 4, that involve elements such as outside visitors, cross-curricular research, co-learning with peers, use of multiple apps, multimedia sharing with tools such as Prezi, Google Slides, and PowerPoint, and iMovie, paints a promising future for TLE. In addition, teachers were extremely positive about their experiences with iPad technologies, appreciated the new learning affordances they offered, and observed major impacts of them on student engagement and digital literacy, and saw significant educational benefits in the 1:1 distribution of the devices. But it is going to take time and ongoing effort to bring about the full transformation of teaching and learning TLE is aiming for. We emphasize, once again, the importance of the board providing opportunities for teachers to grow professionally – to learn from peers and experts alike, to experiment with different approaches from year-to-year, to learn from failures, to induct new teachers into the changing school culture, and to receive guidance from principals and consultants.

Summary of recommendations

Throughout this report we have interspersed recommendations for board decision-makers on how TLE could be enhanced. Below is a compilation of our high level recommendations; however we suggest that the reader consult the body of the report for their rationales and relevant details.

Professional learning recommendations

- Continue to support teacher development in the pilot schools at the same time as supporting teachers in the schools that newly join the project.
- Provide support for new teachers assigned to TLE schools.
- Create conditions in schools to support a variety of formal and informal professional learning opportunities including coaching, peer mentoring, lesson observation, "lunch and learn," professional learning communities using social media (e.g., Yammer) and other similar kinds of opportunities.
- Address the formative and summative assessment of digital artefacts and presentations more fully in professional learning activities.
- Conduct an annual professional learning needs assessment and plan programming accordingly.
- Develop an FAQ that answers teacher questions on topics such as use of IBL in mathematics, student question formulation, multimedia project assessment, and how IBL relates to and can directly support EQAO preparation to aid in fostering a shared of understanding of IBL and assessment strategies across all TLE schools .

- Produce exemplary demonstration videos of IBL in action, particularly in mathematics, and make them available in the Hub.
- Provide the opportunity for "learning walks" within and across schools participating in TLE to observe teaching and learning strategies and student products

Scaling TLE recommendations

- Make public the plan and rationale for expanding to other schools and grades.
- Provide financial projections on how TLE can become district-wide within a five-year timeframe.
- Seek additional funding above and beyond current levels to make TLE a demonstration initiative that can provide leadership for the province in development of 21st century learning.
- Encourage and provide mechanisms for clusters of schools to share and support each other.
- If home use is reinstated, provide support and training to parents so that they can better monitor and regulate their child's iPad use
- Host a "celebration of learning" (in families of schools) for students, teachers, and community as an opportunity to showcase teaching and learning strategies and student exemplars.

Hardware, infrastructure, and support recommendations

- Consider supplying keyboards iPads or moving to laptops for intermediate/senior grades.
- Review the policy on students taking home iPads and develop policies based on taking them home being a privilege that is first earned, but can be revoked for misuse.
- Develop a district strategy for educating parents in the value of iPads in their children's education, and the standards of care and rules for use they should apply when their children bring them home.
- Address the network latency issues reported in some schools.
- Provide solutions for classrooms that do not have sufficient outlets for charging iPads.
- Consider giving new teachers and those in new schools the option of receiving iPad kits during their first year rather than a full class set.

TLE evaluation recommendations

- Continue to refine and extend E-BEST research practices to more directly interface with and support professional learning to enable teachers to become active researchers and collaborators/contributors; encourage teachers to build this into their professional growth plans.
- Collect data from principals, teachers, students, and parents as a program accountability/improvement initiative that does not require the informed consent, rather than considering it a research undertaking that does require consent.
- Make public internal analyses or reports on project outcomes to increase accountability.
- Provide references to internal analyses or reports in the annual reporting to the board to increase credibility.

Future Technology Learning Fund (TLF) recommendations

- Develop guidelines and common instruments/protocols for boards to help them conduct internal TLF research and reporting to CODE; in doing so provide boards with a

menu of choices from conducting very rudimentary research where resources are limited to more fully fledged undertakings.

- To establish uniformity in methodology for future research supported by the Ministry of Education/CODE, encourage the clear articulation of program theories of action and related logic models.
- Support arms-length evaluations of TLF projects that are reaching a stage of implementation maturity in collaboration with board research departments.
- Develop a readily accessible database to share internal board-initiated and CODE-sponsored research on TLF projects.
- Encourage boards to place teacher education candidates from Ontario faculties of education in TLF project schools for their practicum experience to better prepare them for teaching and learning with technology.

References

Bruce, B. C., & Casey, L. (2012). The practice of inquiry: A pedagogical 'sweet spot' for digital literacy? *Computers in the Schools*, *29*(1-2), 191-206.

Beauchamp, G., & Hillier, E. (2014). *An evaluation of iPad implementation across a network of primary schools in Cardiff*. Cardiff, Wales: School of Education, Cardiff Metropolitan University.

Bittinger, M. L. (1968). A review of discovery. *The Mathematics Teacher*, *61*(2), 140-146.

Burden, K., Hopkins, P., Male, T., Martin, S., & Trala, C. (2012). *iPad Scotland evaluation*. University of Hull. Retrieved from http://www.janhylen.se/wp-content/uploads/2013/01/Skottland.pdf

Christensen, C. M., Horn, M. B., & Johnson, C. W. (2008). *Disrupting class: How disruptive innovation will change the way the world learns.* New York: McGraw-Hill.

Coburn, C. E. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher, 32*(6), 3–12.

Cope, B., & Kalantzis, M. (2011). 'Design' in principle and practice: A reconsideration of the terms of design engagement. *The Design Journal*, *14*(1), 45-63.

Curwood, J. S. (2012). Cultural shifts, multimodal representations, and assessment practices: A case study. *E–Learning and Digital Media, 9*(2), 232-244.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession.* Washington, DC: National Staff Development Council.

D'Angelo, C., Rutstein, D., Harris, C., Bernard, R., Borokhovski, E., & Haertel, G. (2014). *Simulations for STEM learning: Systematic review and meta-analysis.* Menlo Park, CA: SRI International.

Dede, C. (2014). The role of digital technologies in deeper learning. Students at the center: Deeper learning research series. *Jobs for the Future*.

Dede, C. (2016, February). *Transforming education for the 21st century: The process of system scaling.* Presentation given at the Ontario Ministry of Education Fourth Annual 21st Century Teaching and Learning Roundtable, Toronto, ON.

Egan, K. (2010). *Learning in depth: A simple innovation that can transform schooling*. London, Ontario: The Althouse Press.

Fixsen, D., Blase, K., Naoom, S., & Duda, M. (2015). *Implementation drivers: Assessing best practices* (Report No. NIRN v. 5/2015). Chapel Hill, NC: National Implementation Research Network, University of North Carolina. Retrieved from http://implementation.fpg.unc.edu/resources/implementation-drivers-assessing-best-practices

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and *mathematics. Proceedings of the National Academy of Sciences of the United States of America, 111*, 8410–8415.

Friesen, S., Scott, D., Snyder, S., Mourshed, M., Chijioke, C., Barber, M., & Canadian Education Association. (2013). Inquiry-based learning: A review of the research literature. *A Paper prepared for the Alberta Ministry of Education.*

Fullan, M. & Donnelly, K. (2013). Alive in the swamp: Assessing digital innovations in education. London: Nesta. Retrieved from http://www.nesta.org.uk/publications/alive-swamp-assessing-digital-innovations-education

Fullan, M. & Langworthy, M. (2014). *A rich seam: How new pedagogies find deep learning.* Pearson (with the support of ISTE: Always Learning Series). Retrieved from: http://www.michaelfullan.ca/wp-content/uploads/2014/01/3897.Rich_Seam_web.pdf

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi experimental studies of inquiry-based science teaching: A meta-analysis, *Review of Educational Research*, *82*, 300–329.

Gee, J. P. (2004). *Situated language and learning: A critique of traditional schooling*. Psychology Press.

Hargreaves, A., & Ainscow, M. (2015). The top and bottom of leadership and change. *Phi Delta Kappan*, *97*(3), 42-48.

Hermann, G. (1969). Learning by discovery: A critical review of studies. *Journal of Experimental Education, 38*, 58–72.

Ito, M., Gutiérrez, K., Livingstone, S., Penuel, W., Rhodes, J., & Salen, K. (2012). *Connected learning: An agenda for research and design*. Chicago, IL: MacArthur Foundation.

Jenson, J., de Castell, S., Thumlert, K. & Muehrer, R. (2016). Deep assessment: An exploratory study of game-based, multimodal learning in Epidemic. *Digital Culture and Education, 8*(1). Retrieved from http://www.digitalcultureandeducation.com/volume-8/jense/

Ketelhut, D. J., & Dede, C. (2006). Assessing inquiry learning. National *Association of Research in Science Teaching*, San Francisco, CA. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.134.7151&rep=rep1&type=pdf

Ketelhut, D. J., Dede, C., Clarke, J., Nelson, B., & Bowman, C. (2007). Studying situated learning in a multi-user virtual environment. *Assessment of Problem Solving using Simulations*, 37-58.

Kuh, G. D. (2001). *The national survey of student engagement: Conceptual framework and overview of psychometric properties*. Bloomington, IN: Indiana University Center for Postsecondary Research, 1-26. Retrieved from http://nsse.iub.edu/pdf/psychometric_framework_2002.pdf

Lazonder, A., & Harmsen, R. (2016). Meta-Analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research, 20*(10), 1-38.

Malloy, J. (2014). *Transforming learning everywhere.* Hamilton, ON: Hamilton Wentworth District School Board. Retrieved from http://www.hwdsb.on.ca/about/innovation/transforming-learning-everywhere/our-thinking/

Merchant, G. (2010). 3D virtual worlds as environments for literacy learning. *Educational Research*, *52*(2), 135-150.

National Research Council (Ed.). (1996). *National science education standards*. Washington, DC: National Academy Press.

Ontario Ministry of Education. (2013). *Capacity Building Series: Inquiry-Based Learning*. Retrieved from http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/capacitybuilding.html

Ontario Ministry of Education. (2104). Achieving excellence: A renewed vision for education in Ontario. Retrieved from http://www.edu.gov.on.ca/eng/about/renewedVision.pdf

Owston, R. D. (2007). Contextual factors that sustain innovative pedagogical practice using technology: An international study. *Journal of Educational Change, 8*(1), 61-77.

Owston, R. D., & Wideman, H. H. (1997). Word processors and children's writing in a high-computer-access setting. *Journal of Research on Computing in Education*, *30*(2), 202-220.

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47-61.

Prince, M. J. & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*, 123-13.

Puentedura, R. R. (2013, May 29). SAMR: Moving from enhancement to transformation [Web log post]. Retrieved from http://www.hippasus.com/rrpweblog/archives/000095.html

Richardson, W. (2013). Students first, not stuff. *Educational Leadership*. *40*(6), 10-14.

Rogers, P. J., Petrosino, A., Huebner, T. A., & Hacsi, T. A. (2000). Program theory evaluation: Practice, promise, and problems. *New directions for evaluation*, *2000*(87), 5-13.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology. 25* (1) 54–67.

Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A Status Report on Teacher Development in the United States and Abroad.* Dallas, TX: National Staff Development Council. Retrieved from https://learningforward.org/docs/pdf/nsdcstudytechnicalreport2009.pdf?sfvrsn=0

Yin, R. K. (2006). Case study methods. In J.L. Green, G. Camilli, & P.B. Elmore (Eds.), *Handbook of complementary methods in educational research* (pp. 111-123). Hillsdale, NJ: Lawrence Erlbaum.

Zheng, B., Warschauer, M., Lin, C. H., & Chang, C. (2016). Learning in one-to-one laptop environments: A meta-analysis and research synthesis. *Review of Educational Research*. doi: 0034654316628645.

Appendix

SRI International scoring scale dimensions

The four dimensions of the SRI International scale are as follows[7]:

1) Knowledge Construction. "Knowledge construction happens when students do more than reproduce what they have learned: they go beyond knowledge reproduction to generate ideas and understandings that are new to them. The skills of knowledge construction are often considered 'critical thinking'. Students build knowledge when they interpret, analyse, synthesize, or evaluate information or ideas. The strongest student work (4 rating) demonstrates that students applied the knowledge they constructed to a different context, and connects information and ideas from two or more academic disciplines (for example, integrates ideas from both science and literature" (SRI International: Microsoft's *Partners in Learning Program*, Student Work Rubrics).

2) **Applied ICT Use:** In this rubric dimension, the term "ICT" encompasses the full range of available digital tools, both hardware and software (including everything from an Internet browser and multimedia development tools to social media and collaborative editing platforms). "Student use of ICT happens when students use ICT directly to complete all or part of the learning activity. The teacher's use of ICT to present materials to students does not count as student use: it is important that students have control over the ICT use themselves. Some teachers' use of ICT can enhance their teaching significantly: for example, teachers can show simulations that make difficult content easier for students to visualize. However, this rubric focuses only on whether the students used ICT actively in their learning. There must be evidence of that student ICT use either in the work product itself or in the process that led to the work product" (SRI International: Microsoft's *Partners in Learning Program*, Student Work Rubrics).

3) **Real-world Problem Solving and Innovation:** "In traditional schooling, students produce work that is often unrelated to what they see and do in the world outside school. This rubric examines whether students' work demonstrates problem-solving and the use of data or situations from the real world. The strongest student work for this rubric demonstrates that the student: developed a successful solution to a real-world problem [ideally] putting into practice his or her ideas, designs or solutions for others." (SRI International: Microsoft's *Partners in Learning Program*, Student Work Rubrics).

4) **Communication Skills:** "This rubric examines whether students produced extended or multimodal communication, and whether the communication includes a logical explanation or examples or evidence that supports a central thesis. At higher levels of the rubric, students designed their communication for a particular audience. In written work, extended communication is the equivalent of one or more complete paragraphs rather than a sentence or phrase. In electronic or visual media, extended communication might take the form of a sequence of video, a podcast, or 1 or more pages of a presentation that connects or illustrates several ideas." (SRI International: Microsoft's *Partners in Learning Program*, Student Work Rubrics).

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[7] Available http://www.itlresearch.com/research-a-reports/2011-itl-research-design-and-methods

While SRI international suggests that, in the case of comparative international studies, classroom observations should be a part of analysis to ensure consistency across cultures, we could not include classroom observations due to HWSDB restrictions. This does not compromise study reliability as 1) our samples were limited, geographically, to one school board and 2) the teachers who rated the samples were locally-trained by the same researchers and all rated the sample sets together, ensuring consistency. Other limitations do apply to our analysis: the sample sets were limited to relatively small numbers of student works, and not all TLE pilot schools were forthcoming with providing sample sets.