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Synergistic Collaborations among K-12 Technology, STEM Coaches, and Tech-Industry Partners

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ABSTRACT

This project focused on how two technology coaches, a K-12 Technology Coach and a Science Technology Engineering Mathematics (STEM) Coach collaborated with their coach colleagues and tech-industry partners to offer teachers resources and embedded professional learning (PL). As part of a multiple-case study of coaching models of PL, over the course of two academic years, the researchers gathered observational data during classroom coaching sessions, small group professional learning sessions, and professional development workshops hosted by a tech-industry partner. Additionally, the coaches and a subset of middle school teachers participated in one-on-one interviews and the coaches had discussions in a focus group. Data analyses distilled two main themes: (1) coaches appeal to and collaborate with tech-industry partners; and (2) coaches solicit support and collaborate with school district administrators. Conclusions suggest that technology and STEM coaches serve an integral role in the implementation of technology across the district when collaborating with tech-industry partners. Recommendations include the need for technology coaches to be resourceful and initiate and foster tech-industry partnerships as well as dedicate time to collaborate with other coaches to enhance their own professional knowledge and skills.

Keywords: coaching, school administrators, technology procurement, knowledge brokering

INTRODUCTION

With continuous technological advancements, it is becoming increasingly imperative that students understand the applications of different technological resources and learn how to utilize them for various purposes. School districts recognize the saliency in supporting classroom teachers in utilizing technology to enhance their teaching practices (Liao et al., 2021) and support students in learning how to use such technology. As a way to provide such support, districts often utilize coaches (specialists in the area) to assist teachers in integrating technology in their classrooms and practices, provide technical support, plan professional development (PD), and fulfill the responsibility of purchasing technology and other resources (Liao et al., 2021). However, limited research has examined how technology coaches procure such resources and ensure ongoing support is provided by the tech-industry partners.

This two-year multiple-case study documented the collaboration among a K-12 Technology Coach, a STEM Coach, and their coach colleagues (a Digital Consultant, a Librarian Consultant) and tech-industry partners in providing elementary school teachers with resources and job-embedded professional learning (PL). The purpose of this research was to learn how school district coaches and consultants (with a focus on technology integration) procure resources and work with tech-industry partners to improve their own professional practice and that of

their teachers, while leveraging the knowledge and resources of each respective party. This study sought to answer the research question: How might STEM and Technology coaches impact the implementation of technology through collaboration with tech-industry partners? The findings provide insight into how coaches appealed to and collaborated with both tech-industry partners and their school district administrators when incorporating technology into the classroom for STEM lessons.

BACKGROUND LITERATURE

The Role of Technology and STEM Coaches

Trusting relationships among teachers and coaches is integral to support collaborative professional development (Stover et al., 2011). As coaches understand and appreciate teachers' professional knowledge, skills, and experience, the more this trusting relationship is fostered, the more effectively coaches can support teachers in their professional growth. When the needs and interests of teachers are acknowledged and considered, opportunities for collaboration among colleagues are provided, reflective practices are fostered, and meaningful change can occur (Stover et al., 2011). When teachers become invested partners in their own learning, they continue to pursue ongoing support from their coach and sustained growth in their practices (Stover et al., 2011).

In addition to ongoing coach support, providing teachers with the opportunity to collaborate with colleagues through goal-directed, self-regulated learning and critical reflection, can support teachers' ability to enhance their knowledge and beliefs (Gutierez, 2016). Recommendations within the research (Kopcha, 2010, 2012; Lowenhaupt et al., 2014) have called for the development of collaborative communities of practice, reinforced by a mentor to support teachers' learning of how to integrate technology in their classrooms and how to overcome the barriers they may face. Specifically, there needs to be a focus on barriers related to time spent learning, planning, and implementing technology; teachers' beliefs about the importance of, and confidence with, technology; teachers' access to technology; and their abilities to use technology to enhance the curriculum and teach through student-centered approaches (Kopcha, 2012).

Technology coaches have deep knowledge of the local curriculum, understand how to make curriculum connections and address grade-level standards (Sugar, 2005), and how technology can best be implemented in the classroom – this knowledge can be imparted to the teachers with whom they work. In addition to this support, technology coaches can also foster teacher collaboration, and provide technical and maintenance assistance (Sugar and Slagter van Tryon, 2014). To remain current in STEM instructional approaches and meet teachers' needs, technology coaches must serve as a connector among people and resources; a procurer of grants and funding; a coordinator among individuals within and beyond the school community; as well as an educator for both students and teachers (Giamellaro and Siegel, 2018). Technology coaches must also provide necessary instructions for technology applications to assist sometimes apprehensive teachers (Sugar, 2005). Finally, technology coaches must foster healthy coaching relationships with teachers that promote in-depth communications, provide opportunities for guided practice in integrating technology, and supply teachers with resources that assist them with such technology integration (Liao et al., 2021).

Professional Learning (PL) of Teachers

The educational context is continually changing, and it is imperative that teachers dedicate time to their ongoing professional learning (PL) to ensure their knowledge, skills, and practices remain current and relevant to best support their students (Australian Institute for Teaching and School Leadership Limited (AITSL), 2020; Durksen et al., 2017; Karacabey et al., 2022). Teacher professional learning (PL) differs from professional development (PD) in that, PL '… places the focus and responsibility for learning on teachers and their evolving needs' in comparison to PD, which 'referenc[es] activities that are arranged *for* teachers' (Durksen et al., 2017: 53-54) that focuses on further developing their knowledge, skills, practices, and expertise (Campbell et al., 2017; Labone and Long, 2016). Teachers become active participants in their own learning and become responsible for their growth as professionals through processes embedded in their daily activities (Labone and Long, 2016).

The four main components of PL outlined in the literature involve quality content, learning design and implementation, support and sustainability (Campbell et al., 2017), and reflective practice (Avalos, 2011). A series of key features provide a foundation for each component. When considering quality content, professional learning should be *evidence informed*, prioritize *pedagogical and subject specific content knowledge* to support various learners' needs, *focus on student outcomes*, and allow for a *balance of system-directed PD and self-directed learning*. The design and implementation of PL should provide *active and variable learning,* whereby teachers are able to engage in various learning and inquiry opportunities; provide *collaborative learning experiences* within their own and neighbouring schools and districts, as well as outside professional networks; and provide *job-embedded learning*. As is often highlighted with PL, the learning is *ongoing,* should provide teachers with access to *resources*, and should be *supported by system and school*

leaders who engage in the practice of PL themselves (Campbell et al., 2017; Hilton et al., 2015; Machado and Chung, 2015). The PL of teachers and school leaders should not, however, be limited to attending such opportunities, but instead include some level of reflection whereby they analyse their learning needs, recognize problems they are experiencing, consider if and/or how the processes and practices they use must change, and evaluate how their beliefs have evolved (Avalos, 2011). Each of these components can be supported by knowledgeable technology coaches to support teachers in their professional learning related to technology and STEM integration, with recent research (Giamellaro and Siegel, 2023) documenting how a STEM coach enhanced teachers' practices by bridging and broking relationships and knowledge between educators and field-based STEM workers (e.g., state park rangers, engineers). Although the role of coaches in teachers' professional learning has been well documented in the literature (e.g., Knight, 2011), research on digital resource procurement in K-12 schools, collaboration with tech-industry partners, and administrator support of such partnerships within school districts are relatively unexplored in the coaching literature. This paper addresses this void in the literature.

Educational Technology Resource Procurement

Educational technology (ed-tech) resources have been adopted by school districts at an exponential rate over the past three decades as a means to enhance student achievement (Morrison et al., 2019). Morrison et al. (2019) have proposed an operational framework that aligns with the process school districts typically follow in the procurement of ed-tech products. This operational framework has been presented as a series of five key action points: the allotment of funding, assessment of needs, discovery of ed-tech products, product quality and effectiveness evaluation, and acquisition of selected products. Morrison et al. (2019) note that the action points within this framework should be seen as overlapping (at times) and interactive, as procurement of ed-tech is typically not a linear process (Machado and Chung, 2015), and action points might be entirely skipped depending on the school or district's approach to resource procurement (Dexter et al., 2021; Morrison et al., 2019).

The rapidly evolving and increasing need for ed-tech products – a challenge in and of itself – is also met with several additional challenges for both tech-industry partners and school districts (Morrison et al., 2019). Both parties acknowledge the overwhelming number of products currently available on the market. This overabundance of resources negatively impacts tech-industry partners' ability to market products to the proper individuals and the likelihood that the districts are receptive to the resources. It is impossible for districts to be aware of and knowledgeable about every ed-tech product and software available, and given the constant and rapid changes to technology, districts also struggle with staying up to date with the new technologies and required infrastructure (e.g., reliable internet connections) (Morrison et al., 2019). Additionally, school districts have highlighted challenges associated with insufficient funding for ed-tech programs (Morrison et al., 2019). The increasing cost of ed-tech products coupled with the decreasing budgets school districts have for resource procurement, emphasizes their struggle with adequate funding. Tech-industry partners find the purchasing process to be a significant challenge, as they are often unfamiliar with how to respond to requests for proposals (RFPs), the buying cycles of school districts, and the procurement processes districts utilize, which can be time consuming for tech-industry partners (Morrison et al., 2019).

Despite the significant challenges both tech-industry partners and school districts experience, Morrison et al. (2019) share several factors that facilitate the procurement process. Opportunities for schools to pilot and trial products is viewed as an important evaluation practice as districts require testing before investing in a larger district-wide purchase; this also affords tech-industry partners an entry point into that same district. Tech-industry partners have shared that a product's features, its compatibility with current platforms and existing hardware, available PD, ongoing user support, and ease of use, are key factors for districts when deciding on such purchases (Morrison et al., 2019).

Partnerships/Collaborations within Private Sector or Industry

Based on the limited research available on K-12 schools partnering with the private sector or other industries, the focus of these partnerships tends to emphasize authentic classroom instruction and the creation of 'real-world' student learning experiences (Badgett, 2016; Willems and Gonzalez-DeHass, 2012); there is often limited consideration of school funding for PD and supplies (Wieselmann et al., 2021) or provision of ongoing teacher supports for procured resources. Interestingly, teachers and school district administrators view ongoing relationships with tech-industry partners as an integral component of their partnership (Morrison et al., 2019). In the context of procured resources, instead of focusing on selling the latest technology as soon as it becomes available, school district administrators are seeking vendor support before, during, and after the purchase (Morrison et al., 2019). They see this as the most important part of the partnership, so much so that the tech-industry partners' ongoing support (or lack thereof) influences the district's decision to purchase additional products and/or software licenses. There has also been increasing interest in deliberately expanding

> '(…) the number and types of adults with whom students interact [with] about STEM careers and learning' (Gamse et al., 2017: 32)

to foster interest and engagement among students. Now schools are typically collaborating with tech-industry partners who are STEM researchers, STEM-related business employees, or workers in the health-care sector (Gamse et al., 2017). Through experiencing the work of tech-industry partners, students have the opportunity to learn from experts in the field. These partnership opportunities, whether resource or knowledge and experience focused, are only feasible if school and district administrators are actively involved, and staff (such as technology coaches) are deployed as liaisons (Morrison et al., 2019).

Administrators' Support in the District

School and district administrators serve an influential role in the PL of teachers as well as the receptiveness of teachers to integrate new teaching methods (Karacabey, 2021) and resources into their classroom (Kafyulilo et al., 2016; Machado and Chung, 2015). As Karacabey (2021: 62) notes,

> 'the value attributed to professional development by school district administrators can play a motivating role for teachers to pay more attention to the subject'.

Teachers who engage in PL not only support their own learning, but the learning of their students as well. We can see this as a trickle-down effect – the more enthusiastic and motivated school district administrators are in advancing their practices and those of their teachers, the more eager and inspired teachers will be to continue advancing their practices. This continuous dedication that teachers have for PL, can help ensure students are open to learning as well (Karacabey, 2021). Accordingly, to promote positive change, it is integral that school district administrators support teacher PL regarding technology use.

It is clear that school and district administrators serve a dominant role in the selection and acquisition of technology resources (Morrison et al., 2019). Research has also demonstrated the impact school district administrators have on teachers' receptiveness to integrating technology in their practices with a strong relationship among the school district administrators' influence on teachers' practice in the promotion or prevention of successful technology integration (Kafyulilo et al., 2016; Machado and Chung, 2015). Although some teachers are unaffected by their school district administrators' perspectives on utilizing technology in the classroom, teachers' technology use increases or decreases depending on the support (or lack thereof) the school district administrator provides (Machado and Chung, 2015). When administrators believe that student achievement increases when technology is effectively utilized, they more readily invest in technology tools, develop a schoolwide vision for integrating technology, and promote necessary PL opportunities for teachers (Machado and Chung, 2015). In addition to school district administrator support, teachers look for school district support such as release time to learn about new resources and how to effectively utilize them in the classroom, and access to funding for technological resources to integrate into their practice. Technology coaches need school district administrators to value the integration of technology in the classroom and validate their time to support teachers' practices (Machado and Chung, 2015). This school district administrator support coupled with the affordances of collaborating with tech-industry partners was explored throughout this project.

PROJECT DESCRIPTION

The context for this two-year study was within two different neighbouring (approximately an hour apart), medium-sized, publicly-funded school districts (District A and District B) in Southern Ontario, Canada. In District A, a technology coach (Helen) and her coaching team explored technology initiatives to introduce robotics, coding mini-computers, and 3D printing in middle-school classrooms. In District B, STEM coach (Jodi), worked on incorporating design thinking and 3D printing within middle-school classrooms. Jodi was assisted by a Digital Consultant (Tessa) and a Librarian Consultant (Paige). In both of the districts, the teachers received one-on-one coaching sessions to support them in implementing design thinking practices – there was a distinction between the districts on the type of technology focused on. The coaches in both districts were responsive to the teachers' requests to provide support for topics, content and/or instructional methods that they believed their students would benefit from and aligned with provincial curriculum standards.

The last two of the authors had pre-existing working relationships with Helen and Jodi from previous projects related to PD/PL, classroom demonstrations, and coaching, and actively encouraged a collaborative, professional learning, working relationship among them. These two coaches did not know each other before the collaborative project was developed.

During the first year of the collaborative project, in District B, there were PD sessions hosted by the tech-industry partners in collaboration with the coaches. The former became cognizant of the importance teachers place on classroom implementation. Accordingly, there was a focus on integrating design thinking and STEM activities in the classroom through the use of 3D printers and coding mini-computers. These sessions also provided teachers with opportunities to discuss their current practices and share instructional strategies with their colleagues. In Year 1, there were three sessions (2 hosted by Jodi and her staff; 1 hosted by Jodi and attended by Helen).

In Year 2, all four coaches and consultants took part in four collaborative STEM meetings (2 hosted by Jodi and her staff; 2 hosted by Jodi and attended by Helen). At these meetings the coaches and consultants shared how they were supporting teachers' design thinking and STEM instructional practices with reference to a book study that they were engaged in with one of the researchers (see: Gallagher et al., 2023). They also discussed how to connect what they were learning about in the book study with technological applications and devices that their industry partners were providing. These collaborative STEM meetings were instrumental in allowing the coaches and consultants to translate theory-to-practice-to-resources.

It is important to note that the one-on-one coaching sessions, as well as the PD sessions hosted in the second year of the study were limited in comparison to Year 1 because of the unexpected, provincially-mandated school closures as a result of the COVID-19 pandemic. Of the sessions that took place, the focus was still on STEM integration, but there was additional emphasis on cross-curricular connections and the use of design thinking.

METHODS

Generic qualitative methods (Creswell, 2012) were employed to extract meaning from the fieldnotes, artifacts and transcribed interview data. Generic qualitative methods were used as they provide space for interpretation and the opportunity to explore the perspectives of each participant within their context without being constrained (Caelli et al., 2003; Kahlke, 2014). Additionally, generic qualitative research elucidates the documented attitudes, beliefs, personal opinions, or reflections of one's experiences (Percy et al., 2015). This method was utilized in this study, as the perspectives of the coaches were garnered and evidence of their practice was gathered.

Participants

This study spanned two academic years (2018-2019; 2019-2020) in two neighboring, publicly-funded school districts (District A and B) with consistent coach participants and some changes to teacher participants year-over-year. The coaches represented the entire potential participant sub-sample (i.e., these were the only coaches in one district and two of the three coaches in the other district) and the teacher participants were among those teachers that were coached by them and willing to participate in this study.

In District A, Helen, worked as both a Technology Coach (referred to by the district as a Digital Learning Coach) and Design Thinking Coach while at District B, Jodi was a STEM Coach. In District B, Tessa served as a Digital Consultant and her role was dedicated to the broad integration of technology into classrooms and also school sites as a whole. Paige worked as a Librarian Consultant with an emphasis on supporting School Librarians with technology within school-based library settings. Pseudonyms have been assigned to all participants.

Data Collection and Analyses

This study employed qualitative methods to gather data. Over the course of the two years, researchers collected artifacts and field notes during coaching and PD sessions and interviewed both coach and teacher participants. (Note: Meta-data are not openly available due to university and school district research ethics board restrictions).

Field Notes. In the first year, nine field notes were collected during observations: two from one-on-one coaching sessions with Jodi (the STEM coach) and four from co-teaching sessions. There were also three observed STEM PD Days introduced by Jodi and facilitated by Tessa and a tech-industry partner with approximately 10 to 15 teacher attendees.

In the second year, five field notes were collected. One observation was from a one-on-one STEM coaching session with Julie (middle school teacher) and STEM coach, Jodi. Two observations were during a collaborative STEM meeting between the coaches (Helen and Jodi) and the consultants (Tessa and Paige in a supportive role), and the two additional observations were during design thinking PD Days with approximately 40 to 100 teacher attendees at each session (3D printing and coding mini-computers for computational thinking and procedural writing).

Interviews. During the coaches' interviews, they were asked to discuss their vision for their coaching initiatives, their collaborations with tech-industry partners, how they support teachers' learning how to integrate STEM and design thinking in their lessons, and their greatest accomplishments/challenges in the role. In addition to the one-

Table 1. A summary of the participants and data collection

Year 1 and 2 coaches				
District	**Name**	**Role**	**Years experience as**	**Data (2 years)**
A	Helen	Technology coach and design thinking coach	4 (coach); 17 (teacher)	4 interviews; 2 fieldnotes
B	Jodi	STEM coach	10 (coach); 25 (teacher)	5 interviews; 14 fieldnotes
B	Tessa	Digital consultant	9 (consultant); 18 (teacher)	4 fieldnotes
B	Paige	Librarian consultant	8 (consultant); 19 (teacher)	2 fieldnotes
Year 1 teachers				
District	**Name**	**Grade**	**Years experience**	**Interviews**
A	Caitlin	3	24	1
A	Trisha	3/4	14	1
A	Matthew	7/8	13	1
B	Melody	8	5	1
B	Jane	8	15	1
Year 2 teachers				
A	Jayden	K	19	1
B	Julie	7/8	12	1
B	Molly	6/7	2	1
B	Jane	8	15	1

on-one interviews, both Jodi and Helen participated in a focus group specific to collaborative conversations about their role as technology and STEM coaches, challenges they have encountered, and the technology being utilized.

Across the two years, during the teachers' interviews, they were asked to discuss their coaching experiences, what PD they found effective, and any challenges they have needed to overcome throughout the school year in relation to the respective PL projects that they were participating in. Refer to **Table 1** for a summary of the participants and data collection.

Artifacts. During the study, artifacts were also collected. These included email communications, handouts from PL sessions and a researcher prepared summary of a shared coaching design-thinking focused PL resource.

To analyse the data, all field notes, interview transcripts, and artifacts were uploaded into qualitative software, NVivo (QSR International Pty Ltd, 2015). Once the excerpts were read within the NVivo program, nodes were created using its open-ended coding process. There were 23 nodes (teachers' affect; teachers' impact; teachers' implementation; teachers' learning; general teacher support; support for barriers; technology support; lack of technology; technology challenges; time restraints; technology integration; student-peer interactions; coach-student interactions; coach-coach collaborations; coach-coach mentoring; self-determined teacher professional development; online resources; technology resources; technology enhancements; professional development; researcher role; technology leads) that were then clustered into nine categories (coach role; coach learning; relationships; teacher learning; teacher support; technology tools and strategies; technology challenges; resources; professional development) illustrating the data set. This clustering process is reflective of axial coding (Johnson and Cristensen, 2004). The nine categories were discussed by the researchers and then clustered into two common themes with four and three respective subthemes (Saldana, 2009) – these are presented below as the findings. Quotes pulled from the raw data are thematically presented in the findings below.

FINDINGS

The findings describe the influence, integral role, and impact these STEM and technology coaches had on the implementation of technology in the classroom through collaboration with tech-industry partners. More specifically, the findings explore how **Coaches Appeal to and Collaborate with Tech-Industry Partners**, and how **Coaches Solicit Support and Collaborate with School District Administrators**. These two broad thematic findings are elaborated on next with a series of sub-themes.

Coaches Appeal to and Collaborate with Tech-Industry Partners

Through collaborations with tech-industry partners, the STEM and technology coaches utilized *knowledge brokering as a function of their partnership*, developed *robust PL opportunities for teachers*, introduced the opportunity to *elicit ongoing support for tech resources*, and *fostered ongoing dialogue and support* with and from tech-industry partners.

Knowledge Brokering as a Function of Tech-Industry Partners. The tech-industry partners' ability and willingness to translate and transfer their knowledge of instruction technology into an 'educator-friendly' format

was appreciated by both coaches and classroom teachers. For example, during a PD session, the tech-industry partners played a video with steps for the participants to set up their coding mini-computers. When

> "a complicated step happen[ed] on the screen, [the teacher] participants [said] 'pause! Pause!'. [The tech-industry partner] was waiting for the explanation to end… [before] explain[ing] in layman's terms what the video was saying" (Research Assistant's Field Notes, November 2019).

This served as an important aspect of the partnership, as the technical and educator-friendly language that coaches and teachers are exposed to, assisted them in implementing the technology in their classrooms in a manner for students to understand. By providing teachers with opportunities to learn from tech-industry partners, coaches also provided them with the chance to learn 'tips about the design to ensure success in printing,' which, as one 'teacher note[d], she finds this one-on-one support from [the tech industry partner] to be invaluable' (Researcher's Field Notes, June 2019).

The tech-industry partners also benefited from partnering with the coaches, as they learned key factors that impacted the implementation of their devices and software by educators. For example, Jodi shared that tech-industry partners are used to 'a private system (…) and (…) hav[ing] one-to-one devices with the best Wi-Fi (…)' but when '(...) trying to run the Wi-Fi in a public setting, (…) it's slow' (Interview, December, 2018). Schools do not have the luxury of the best Wi-Fi, and this can have implications on the ability to utilize certain tech resources – this is something that tech-industry partners must consider with product development and classroom integration and keep these limitations in mind when developing or updating resources to be utilized in the classroom. Through these partnerships, those in the tech-industry also learned more about supporting K-12 teaching practices, as during PL sessions,

> '[the coach] is the real expert when it comes to the curriculum and planning' (Researcher's Field Notes, June 2019).

These partnerships also provided tech-industry partners insight into how coaches and teachers work together to learn and implement these resources in the classroom. This knowledge brokering that occurred during discussions between tech-industry partners, coaches, and teachers, was apparent during co-delivered PL sessions.

Development of Robust Professional Learning (PL) Opportunities. Robust PL opportunities were developed by coaches for teachers to share others' knowledge and experiences when collaborating with tech-industry partners. While tech-industry partners are experts in the use of their devices/software and are able to troubleshoot quickly, coaches have a strong understanding of how the technology fits within the curriculum, and how it can best be implemented in the classroom. During a STEM PL session, the researchers noticed the synergistic collaboration (i.e., interaction that when combined produces effects greater than the sum of the individual contributions) between Jodi and a tech-industry partner, and

> 'wonder[ed] if they both [saw] the other as interdependent – [the tech-industry partner] needs Jodi's [district's] buy-in and Jodi needs their tech support' (Researcher's Field Notes, April 2019).

When considering the long-term implications and implementation of specific PL for teachers using the resources afforded by tech-industry partners, coaches were aware that it 'takes years to get the team in place and the thinking behind creating a long-term plan' (Researcher's Field Notes, April 2019). Developing robust partnerships and PL sessions does not occur overnight. When working with tech-industry partners, either as co-facilitators of PL workshops or with tech-industry partners as resource providers, the coaches aimed to ensure their PL sessions were

> 'hands on and exploratory for the teachers (…) [and] (…) [they] want[ed] to [be able to] follow up with the attending teachers' (Researcher's Field Notes, October 2018).

They focused on helping teachers in the 'here and now' to build their knowledge and skills related to technology integration in the classroom and potentially supporting them in taking what they learned into their teaching for future years.

Affordance of Partnerships to Elicit Ongoing Support for Tech Resources. Collaborating with tech-industry partners not only afforded these school districts with the opportunity to incorporate these new resources in their classrooms and leverage complimentary technology, but also provided a foundation for initial and ongoing support. Coaches here recognized the need to creatively problem solve and support schools in leveraging free technology resources. For instance, when working on increasing the number of 3D printers within the school district, Helen was faced with competing initiatives for free printers. Of the printers the district had obtained, 34 were placed at schools where a 'teacher or the [school district administrator] (…) applied for the printer' through

an internal district competition that Helen encouraged each of them to apply for (Helen, Interview, September 2019). As a way to provide broader access to these 3D printers, the agreement was that the printers

> 'stay at the school (…) [either] at the library (…) [or] on a rolling cart… [so that] the teacher [could] use it and help train the other teachers' (Helen, Interview, September 2019).

With the 3D printers, in Jodi's school district, the tech-industry company agreed to

> 'go to [the] school[s] with the equipment and (…) set the equipment up (…) and (…) walk [the school staff] through [how to use] it,'

and the staff would then be able 'use it on the PD Day (…) or session' (Jodi, Interview, February 2019).

It is important to recognize that the support from these partnerships extended beyond the initial setup and access to the free technology. When incorporating technology in the classroom, teachers and students often ran into challenges with the devices and/or software being utilized. For example, during a STEM PD session, Jodi spoke with a tech-industry partner that offered professional development and tech resources about an issue she was experiencing with some of the devices. One of the tech-industry partners 'said it is a firmware issue and that he [could] update it through the software' (Research Assistant's Field Notes, November 2019). This brings to light the need to ensure tech resources stay up-to-date which is something only tech-industry partners can help to ensure.

Partnerships Foster Ongoing Dialogue and Support. Educators must consider the long-term impact and feasibility of utilizing technological resources in classroom instructional practices. When speaking of the school district's partnership with a professional development and digital resource company, Jodi highlighted that

> 'they can help us look forward over two or three years and really support the teachers' (Interview, February 2019).

Jodi also shared that this is

> "One of the things that they talked about in the expert panel [within the provincial Ministry of Education] (…) that if we're going to go deeper with technology with kids, we have to give teachers the knowledge of what to do and that's not just (…) one session" (Interview, February 2019).

In order to foster student success and teachers' willingness to adopt the new resources, these tech-industry partnerships need to be developed and maintained for long-term involvement. This was acknowledged here. For instance, during a 3D printing workshop,

> 'as the teachers continue[d] to co-plan, [the coaches and tech-industry partners] talk[ed] about what is needed to support the teachers for [the following] year' (Researcher's Field Notes, June 2019).

During this discussion with the tech-industry partner it was

> 'note[d] that they need [to provide] support for 3D printing first, and then [they can] support the process of the designing software' (Researcher's Field Notes, June 2019).

It was recognized that it is not enough to just obtain or gain access to resources as implementation in the classroom is most effective when teachers are provided with the ongoing support to utilize it.

Coaches Solicit Support and Collaborate with School District Administrators

As coaches collaborated with school district administrators, they learned the impact of *school district administrators' receptiveness* in implementing STEM initiatives, the importance of *ensuring technology equity across the district*, and how to *foster multilevel teamwork and collaboration* within the partnership.

School District Administrator Receptiveness. In addition to collaboratively developing and delivering PL opportunities for teachers with tech-industry partners, coaches recognized that

> '(...) it is not enough to fly in an expert, that the teachers need to know that the [district] is interested [in these partnerships] in the long-term and not going against their values and vision' (Researcher's Field Notes, November 2019).

Teachers were more open to integrating technology in the classroom and their daily practices when their school district administrators (principals and superintendents) intended to engage in these partnerships over time. In some cases, principals served as a connector among the coach and teachers – inviting coaches into the school,

encouraging teachers to sign up for coaching sessions, and just keeping the momentum going. When school district administrators were fully supportive, they had ambitious implementation plans and

> 'really pushed (…) for tech everywhere (…) [and were] good at allocating [the] budget [to those resources]' (Researcher's Field Notes, February 2019).

It is important to note that the school district administrators' receptiveness was not limited to obtaining and incorporating technology resources within the classrooms, but also included PL opportunities for teachers to learn how to effectively implement such technology. During a district-wide PD session, it was noted that the

> 'day [was] well planned, [and that] clearly, Jodi and Tessa have the 'buy in' from their superintendent and is obvious in the support that they have for this' (Researcher's Field Notes, November 2019).

During discussions with Helen, Jodi shared

> 'how she [did] a presentation to the board of directors [about incorporating coding mini-computers in every grade 6 classroom] and had a student (…) do the presentation [to get] the buy-in (…) and the funding from them [the school district]' (Researcher's Field Notes, April 2019).

She further shared how this

> 'roll out (…) [was] part of their [school district's] strategic plan and [that] they [had] the endorsement of the superintendent' (Researcher's Field Notes, April 2019).

This highlights how teachers not only require school district administrator buy-in, but that this support is also required at the school district level.

Technology Equity Across Schools with Tech-Industry Partners. Technology equity across schools within a given district was an ongoing challenge, but was supported through the coaches' teamwork and collaborations with the tech-industry partners. Beyond securing funding for technology and partnerships with the tech-industry, coaches also needed to consider how these resources were dispersed among schools within the district. Helen shared that, since the

> 'Ministry [of Education] Report came out (…) [we] really [had to] look at [if] we [were] hitting target schools that have [technology resources, and] those schools [that] don't have the Chromebooks to be able to [address all the needs]' (Interview, December 2018).

Jodi noted that 'a lot of [her district's] lower income schools (…) are loaded with technology' that has been acquired through various programs (Interview, December 2018). Despite their best efforts to ensure technology equity across the school districts, the coaches did work with some schools that had limited access to devices given their locations, and as a result, it was imperative that both the teachers and coaches did what they could with the resources available.

Fostering Multilevel Teamwork and Collaboration. Working together in both the planning and implementation of educational technology serves as an essential component of school district tech-industry partnerships. Learning about the devices/software and how to use them fostered collaboration and teamwork at four levels: among tech-industry partners and coaches; coaches themselves; teachers and coaches; and students, teachers and coaches. During several PD sessions, the coach(es) and tech-industry partners would circulate the room to assist groups of teachers during the facilitation. This teamwork among the coaches and tech-industry partners supported teachers in developing their understanding of concepts in relation to the technology being used. The collaboration among the coaches and tech-industry partners was not limited to the PD sessions as it was further enhanced through ongoing dialogue and support. When coaches were afforded opportunities to collaborate with coaches in other school districts, they were able to share their knowledge, experiences and practices. More specifically, they had the opportunity to share what their district was working on as well as future goals, and discuss how other districts might adopt similar practices and projects. For example, during the first collaborative STEM meeting,

> "Jodi ask[ed] Helen about the projects that she [had] going on in [her school district] and she share[d] with her what they [were] doing in a roll out capacity [in their school district]" (Researcher's Field Notes, December 2019).

These connections fostered a willingness to share knowledge and resources among colleagues, and support cross-district teamwork and collaboration. As Helen shared,

> '[Jodi and I are] not in the same [district] which is nice, and [there is a] willingness to share (…) her wealth of knowledge (…)' (Interview, June 2022),

further adding that

> '[Jodi] (...) discussed what she did with her [school district], and the design thinking model. [How] it passed on and moved forward (…). To see how it was successful with them and how we can do that with our [district]' (Interview, June 2022)

was extremely helpful for her PL. This collegial collaboration was also seen at the teacher-coach level when integrating new technology into the classroom and supporting students with the technology. As one teacher also shared, it was a positive experience learning from fellow teachers in the district as well, as

> 'there are teachers in this [district] that are so tech-savvy! So just embracing that. You can learn from them too' (Jane, Interview, June 2020).

Interestingly, discussion about student

> 'engagement seem[ed] to depend on teacher presence. The students [were reportedly] more engaged when the teachers [were] directly involved with the group' (Research Assistant's Field Notes, January 2020).

The relationships that the coaches fostered with students in the classrooms where they visited, supported student engagement, a desire to learn, and an eagerness to work with the coach again.

RESEARCH FINDINGS SUMMARY

Although the technology and STEM coaches were responsible for appealing to and collaborating with both tech-industry partners and school district administrators in order to develop robust PL opportunities that supported teachers' technology integration practices, their own practices were informed in the process. Through *knowledge brokering as a function of such partnerships*, they learned specific ed-tech product terminology, how to utilize the provided resources and how to troubleshoot when issues with the technology arose. They were able to further refine their abilities in *developing robust PL opportunities* for teachers through their collaboration with tech-industry partners. Coaches began to recognize the importance of maintaining *ongoing support from tech-industry partners for tech resources*, as both partners saw each other as interdependent. They learned how to obtain *school district administrator buy-in* for the implementation of STEM initiatives within select schools, while highlighting the importance of ensuring *technology equity across the district*. Through their work with both tech-industry partners and school district administrators, the coaches were able to foster *teamwork and collaboration at multiple levels*. These responsibilities held by both the technology and STEM coaches, speak to the complexity of their roles.

DISCUSSION

As part of the complex role of technology coaches, they are required to support teachers with integrating technology in their classrooms through PL and provide on-site assistance to resolve technology issues that arise (Sugar, 2005). When teachers receive technology coaching, they are able to more effectively implement it in their classroom, feel more confident in using the technology available, and are more prepared in navigating usage obstacles that may arise (Kopcha, 2012). However, the task of securing and distributing technology among schools can be challenging as well as providing ongoing implementation supports (e.g., Morrison et al., 2019). This research has provided insight into how can coaches appeal to and collaborate with tech-industry partners, as well as how they solicit support and collaborate with school district administrators in order to distribute technology and provide the necessary PL opportunities for successful technology integration. We bear in mind that the dynamics among coaches and those with whom they collaborate can be regionally unique and the literature on technology coaching collaborations is limited. Like all coaches though, it is essential for technology coaches to nurture meaningful relationships with the teachers (Skues and Cunningham, 2013). Significantly, this study supports and extends recent research that has demonstrated the benefits of a STEM coach bridging and brokering relationships with educators and field-based STEM workers (Giamello and Siegel, 2023), by documenting the impact and beneficial effects of technology coaches developing such relationships with tech-industry partners and school district administrators.

As coaches collaborated with tech-industry partners, both parties were afforded the opportunity to learn from one another and foster synergistic relationships. Each are specialists in their field and are able to respectively reach

users and learners, but it is the robust learning experience as a function of working together that has the potential to support many students and teachers while also providing school districts and tech-industry partners opportunities to build capacity. Existing literature tends to examine these partnerships as a school-to-work pathway or as a means of procuring resources (Sugar and Slagter van Tryon, 2014), however, by approaching these partnerships with an emphasis on knowledge brokering, they extend the impact of their relationships with each other, and foster ongoing dialogue that supports the learning of all parties involved. It is important to highlight that these partnerships do not always entail resources, materials, etc. (for free or at a nominal cost), but instead focus on knowledge and data sharing. The reason such partnerships are formed and maintained, is thus dependent on the intended, mutually beneficial outcomes of the partnership.

In this current project, this mutually beneficial partnership served as a driving force for the collaboration between both parties in the procurement, implementation and maintenance of ed-tech resources. Through such collaborations, tech-industry partners are afforded an entry point into the district – a competitive advantage over other tech-industry partners working for their chance to be noticed by the district among an overabundance of ed-tech products available on the market (Morrison et al., 2019). This, in turn, provides schools with the opportunity to pilot such products or explore the other components of their partnership (e.g., available PD, platform and hardware compatibility assessment, etc.) (Morrison et al., 2019). In this project, the coaches and tech-industry partners recognized the independence they respectively had throughout the process, while each party was benefitting. When coaches and teachers engage with the ed-tech products or implement suggestions provided by tech-industry partners, they gain experience with the resources, while also providing the school district (Morrison et al., 2019) and tech-industry partners with their end-user feedback. This can serve as a key factor in the school district's determination of whether to continue with the implementation of such ed-tech resources, and it is an opportunity for tech-industry partners to learn more about the successful implementation of their products, where schools require additional supports in the use of such resources, and how the products could be modified to better assist end-users – this was the intention in this current project. However, as data collection in this project was cut short by the COVID-19 pandemic, regrettably we were unable to ascertain the longitudinal effects of the tech-industry partnerships here.

The potential synergistic collaboration among coaches and tech-industry partners would be limited if school district administrators were not receptive to the partnership themselves. Although school district administrators often do not work as closely with the tech-industry partners, their willingness to welcome partnerships into their schools influences teachers' openness and dedication to the resources, support, and professional learning (Karacabey, 2021; Kafyulilo et al., 2016; Machado and Chung, 2015). Clearly, school district administrators need to be amenable to these partnerships to encourage teacher buy-in and promote collaborative teamwork. School district administrator receptiveness is also needed to support district-wide technology equity.

Implications for Practice

Technology coaches need to be resourceful and savvy to initiate and foster productive tech-industry partnerships. For instance, coaches could collaborate with tech-industry partners in a manner that provides schools with free materials in exchange for end-user feedback and programming data that records how the resource is being utilized. Alternatively, coaches may provide curriculum, planning, and assessment advice and feedback to tech-industry partners in exchange for ongoing support for educators and students.

Although often not conducted, needs assessments are seen as an important factor in facilitating resource procurement (Morrison et al., 2019). Employing needs assessments not only ensures products are purchased to meet an identified gap, but also ensures that school districts evaluate what is essential and possible, to guarantee that their needs are met. School districts and tech-industry partners should also consider implementing a formal purchasing process that includes detailed product features and criteria for attaining the best value for the product (Morrison et al., 2019). This ensures that the districts are able to afford and equally distribute resources across schools, and it also ensures that the tech-industry partners receive the appropriate funds to not only produce the materials, but also provide the ongoing support school districts are often seeking.

Districts rely on teachers' review of ed-tech products given their end-user involvement as a deciding factor in purchasing technology with the assurance that it will be well implemented in the classroom (Morrison et al., 2019). They also look to peers (often from other school districts) for recommendations for product selection, specific to the effectiveness of the technology and overall product evaluation. Given the preference to refer to colleagues from other schools and districts in comparison to relying on the research provided by ed-tech companies, districts should consider cross-district collaborations. This might provide coaches with the opportunity to collaborate with other coaches and enhance their own professional knowledge and skills.

Coaches should plan opportunities for teacher collaboration and support, beyond PL sessions with teachers and tech-industry partners to ensure continuous, effective programming implementation. Coaches can support teachers with curriculum requirements and lesson development, while tech-industry partners can provide insights

into using the resources or software towards a specific instructional goal, and assist teachers with troubleshooting any issues that may arise. It remains imperative that technology and STEM coaches continue to connect individuals within the school community to external partners and resources, procure grants and funding, and work with teachers and students to support their learning in the classroom (Giamellaro and Siegel, 2018).

Limitations and Future Research

There are existing limitations to this research project. Unexpectedly, educational sectors in Canada, like many jurisdictions in the world, were required to suddenly shift to online learning in March 2020 in response to the COVID-19 pandemic. This shutdown resulted in many district PD and PL initiatives being paused – in some cases, indefinitely. This led us as researchers to end our data collection for this project early, halting our intentions to follow the tech-industry partners, coaches and teachers as their synergistic relationships continued to be established. There is a rich opportunity for other researchers to explore the longitudinal effects of tech-industry partnerships like those developed and explored here.

Given that this study only followed two school districts in Ontario, it is unclear how these partnerships are developed, encouraged, and maintained in districts beyond Southern Ontario. It also is unclear how tech-industry partners viewed their role in their partnerships, as interviews were not conducted with tech-industry partners. Future research could focus more closely on the perspectives of the tech-industry partners, and what the partnership with districts specifically affords them. Despite the sessions being focused mainly on STEM education, technology was at the forefront which resulted in less focus being placed on science, engineering and mathematics. Potential studies should explore changes in teachers' practices year-over-year, when working with technology and/or STEM coaches, and tech-industry partners. As well, future research could investigate technology integration in STEM within the classroom and across the curriculum and student achievement outcomes.

CONCLUSION

This two-year multiple case-study has demonstrated the importance of technology and STEM coaches synergistically collaborating with tech-industry partners to improve their practice and support the PL of elementary school teachers. It became apparent that the effectiveness of such partnerships is influenced by the school and district's receptiveness to such partnerships, as their beliefs impact teachers' willingness to engage in the collaborative process within the partnership themselves. Further work should continue to explore how all parties (coaches, tech-industry partners, school district administrators, teachers, and students) play an active role in the formation and maintenance of these partnerships.

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