Teachers and Technology: Present Practice and Future Directions

Isha DeCoito
Western University
CANADA

Tasha Richardson
OISE/University of Toronto
CANADA

Technology cannot be effective in the classroom without teachers who are knowledgeable about both the technology itself and its implementation to meet educational goals. While technology use in the classroom is increasing, improving learning through its application should remain the goal. In this study, the authors explored 74 middle school teachers' beliefs about and use of technology through a technology, pedagogy, and content knowledge (TPACK) lens. They sought to understand how middle school teachers use and perceive technology in practice and the factors influencing their pedagogical decisions to incorporate technology into their practice. Data included surveys, administered after a science, technology, engineering, and mathematics (STEM) outreach program and teacher interviews. Findings revealed that both internal and external barriers were present and influenced how teachers situated their pedagogy in terms of technology integration. It was also found that teachers were confident in content, pedagogy, and technology; however, most viewed technology as a tool rather than an embedded part of the learning process. This study contributes knowledge about professional development initiatives and the need to address not technology knowledge as much as the interdependence of technology, pedagogy, and subject content matter.

In Canada, there continues to be a shortfall of students entering science, technology, engineering, and mathematics (STEM) degree programs. In 2013, a report from Statistics Canada on the gender differences in university programs revealed that 40% of men and 20% of women entering a university program were entering STEM programs, with the majority of first-year students entering degree programs in social studies and business (Hango, 2013). What continues to be troubling is that, despite women performing well in mathematics and science on the Programme for International Student Assessment (PISA), they are less likely to choose a STEM degree program than are their male counterparts, even when their PISA scores in mathematics and science are higher.

Much research has examined why women are less likely to pursue studies in STEM fields, and common themes of low self-confidence, lack of interest, and lower expectations abound in the literature (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011; Sadler, Sonnert, Hazari, & Tai, 2012; Weber, 2012). For students, a significant decision-making period about possible careers occur in middle school, so much so that by the time a student enters Grade 9, their career destination is already firmly established in favor of or opposed to STEM fields (Sadler et al., 2012). Considerations then need to be made during this time to support the efforts made by middle school teachers to increase students' contemplation of possible STEM career pathways (Iskander, Gore, Furse, & Bergerson, 2013). One possible way to affect students' beliefs is the integration of certain technologies into classroom practice.

The Ontario government announced in 2014 that they would invest $150 million dollars over 3 years to support the integration of technology into the classroom (Government of Ontario, 2014). This integration includes improving both access and support for students and teachers, including purchase of devices (tablets, netbooks, and cameras) and software, improvement of connectivity, and teacher professional development.

The exponential increase of access to technology and its potential impact on student learning (DeCoito & Richardson, 2016; Higgins, Xiao, & Katsipataki, 2012) warranted further exploration of the ways practicing teachers use technology in the classroom. An opportune time to explore this phenomenon was during a longitudinal STEM research study, conducted by one of the authors and designed to investigate the impact of an outreach program (OProg) on student and teachers' attitude and interest in STEM. To this end, we used a technology, pedagogy, and content knowledge (TPACK) framework (Koehler & Mishra, 2005) to investigate how teachers integrated technology into their practice, guided by the following questions:

1. What technologies do teachers currently integrate in their classroom?
2. What factors influence teachers' decisions to integrate technology in their classroom?
3. How do teachers use the TPACK framework in their decisions to integrate technology into their classroom?

This work provides further insight into how teachers are using technology in the classroom and can impact programmatic development in STEM and inform teacher professional development and teacher education programs as to best practices for effective technology implementation within a TPACK framework.

Theoretical Framework

We explored middle school teachers' decisions to use technology in their classrooms through the lens of the TPACK framework (Koehler & Mishra, 2005). TPACK, described as the intersection of three types of knowledge (technological, pedagogical, and content or subject specific; see Figure 1), is a framework used by researchers to better understand how teachers support student learning through technology integration in their practice (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013).
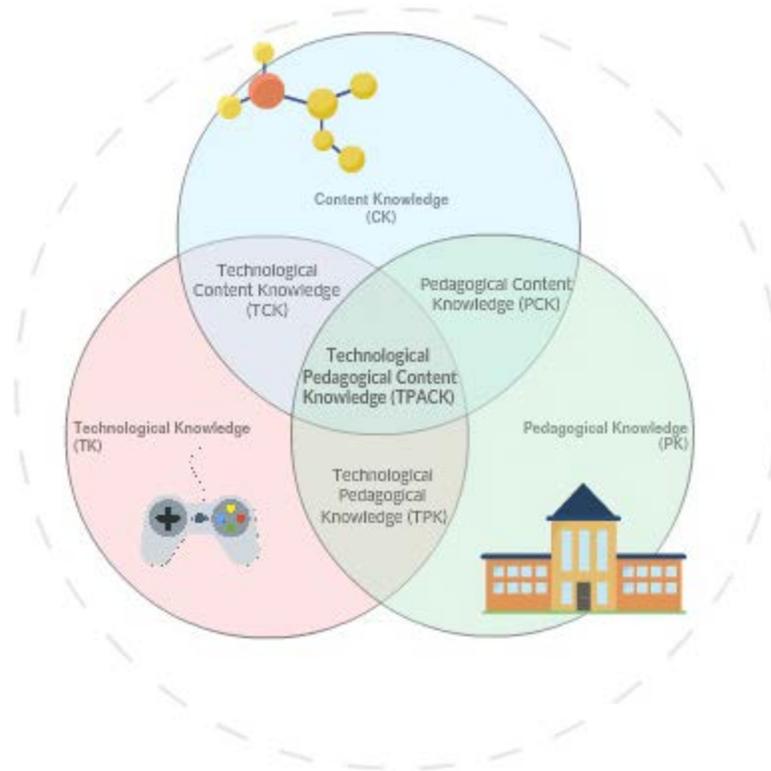
Figure 1. *The TPACK framework (adapted from Koehler & Mishra, 2009).*

The TPACK framework has been demonstrated to be an effective means for examining teacher education programs (Günes & Bahcivan, 2016; Nordin & Faekah, 2016; Özdemir, 2016) and has led to significant recommendations regarding subject-specific pedagogical instruction, information and communications technology (ICT) education, and increased opportunities for the use of technology in teacher education programs.

For teachers to integrate digital technologies into their practice, they need an ever-evolving understanding of which technologies exist and their functionalities (technological knowledge or TK). Baturay, Gökçearslan, and Sahin (2017), in their exploration of teacher use of computer-assisted education and its relationship to gender, found TK to be the biggest indicator of technology inclusion in practice, with males reporting higher TK than females.

In addition to TK, Koehler and Mishra (2009) explained that teachers are required to be creative and flexible when using technologies in the classroom, recognizing that integrating technologies shifts the pedagogical landscapes of the classroom (technological pedagogical knowledge or TPK). Teachers also need to have a deep understanding of technology's influence on content areas (technological content knowledge or TCK).

TPACK is – in addition to mastery of content knowledge, pedagogical knowledge, and pedagogical content knowledge – the integration of these practical and theoretical types of knowledge. Skilled teachers artfully incorporate technologies to enhance student learning by capitalizing on their capabilities to support and promote learning, while at the same

time they are cognizant of the interdependence of technologies and subject content area (Koehler & Mishra, 2009). In science education, Jimoyiannis (2010) discussed the integration of these three types of knowledge as "what science teachers need to know about [ICT] in science education" (p. 1264), where technologies (such as computer simulations) can support students in their understanding of science (Khan, 2011).

Part of the ongoing challenge is the rapid evolution and availability of technologies. School boards make decisions about which technologies are permissible and available, and from those, teachers are ultimately left to make decisions regarding which technologies they will incorporate into their classrooms. Research in recent years shows that teachers have been using the available technologies (Hechter & Vermette, 2014; Kong & Song, 2014; Kyriakides, Meletiou-mavrotheris, & Prodromou, 2016; Ruggiero & Mong, 2015; Uluyol & Sahin, 2016; Zimlich, 2015). Teachers primarily use presentation technologies (Uluyol & Sahin, 2016), however – and even more so in secondary schools (Ruggiero & Mong, 2015) – with online discussions, podcasting, Web 2.0 technologies, and simulation software utilized the least (Hechter & Vermette, 2014; Ruggiero & Mong, 2015).

Unfortunately, technologies that are least used tend to have greatest impact on student engagement for both males and females (Hayden et al., 2011). When students use technology (such as online class discussions with classmates or collaborating with others in the global community via the Internet, conducting research, using animation-based online learning or digital video games), it empowers them to the extent that they are more engaged with science learning (Kyriakides et al., 2016; Mistler-Jackson, & Songer, 2000) and are intrinsically motivated (Kong & Song, 2014; Shroff, & Vogel, 2009; Wang & Reeves, 2006), as well as demonstrating increased interest (Rosen, 2009; Zimlich, 2015) and improved attitudes towards science (Hayden et al., 2011).

These technologies (e.g., for design, communication, and social interactions) are also preferred by middle school female students (Weber & Custer, 2005). Similar trends have been reported by Mims-Word (2012), who found that although both male and female middle school students were equally enthusiastic in terms of using technology, girls viewed the computer primarily as a communication tool, perhaps resulting from influences in the home beginning as early as kindergarten.

Given the aforementioned considerations, we explored the choices and challenges teachers face when incorporating technologies into their practice.

Methodology

The 3-year longitudinal study reported here followed a sequential explanatory mixed-methods design (Creswell, 2014; Mills, Dupreos, & Wiebe, 2010). This methodology facilitated the collection and analysis of both quantitative (surveys) and qualitative (interviews and reflections) data.

The study was launched in an effort to support the positive development of middle school students' attitudes toward and interest in STEM education. To this end, multiple stakeholders, including a Canadian university, an outreach provider, the business sector, and a large Canadian school board collaborated to help meet the overall aim of the project and answer specific research questions related to the impact of outreach programs on STEM preparation in the early grades. The business sector selected the participating schools to meet each school's unique needs.

Participants in the study included teachers, students, and administrators from 95 Grade 6, 7, and 8 classrooms (74 teachers and approximately 2,500 students) in four schools of similar profiles, as identified by the Social Risk Index. Even though the schools included in this study are considered high risk, they are part of a school board that promotes the use of technology in the classroom through relatively seamless wireless access, with an onsite supply of devices for students unable or unwilling to bring their own to class.

Student participants attended two half-day, hands-on inquiry-based STEM workshops, conducted by scientists and engineers, in each year/phase of the study from Grade 6 through Grade 8. In total, they attended six workshops per student, or 540 workshops over 3 years for 2,500 students. During the OProg workshops, each of the 74 teachers were involved in six workshops over the 3-year study and assumed various roles, including supervision, cofacilitation, and other professional activities.

This paper reports on a subset of teacher data, including 74 teacher participants (25 males and 49 females) from diverse ethnic backgrounds, including Afro-Canadians, Middle Eastern, Caucasian, Asian, and South East Asian. Participants taught Grade 6, 7, or 8, and their teaching experience ranged from 2 to 37 years (see Figure 2).
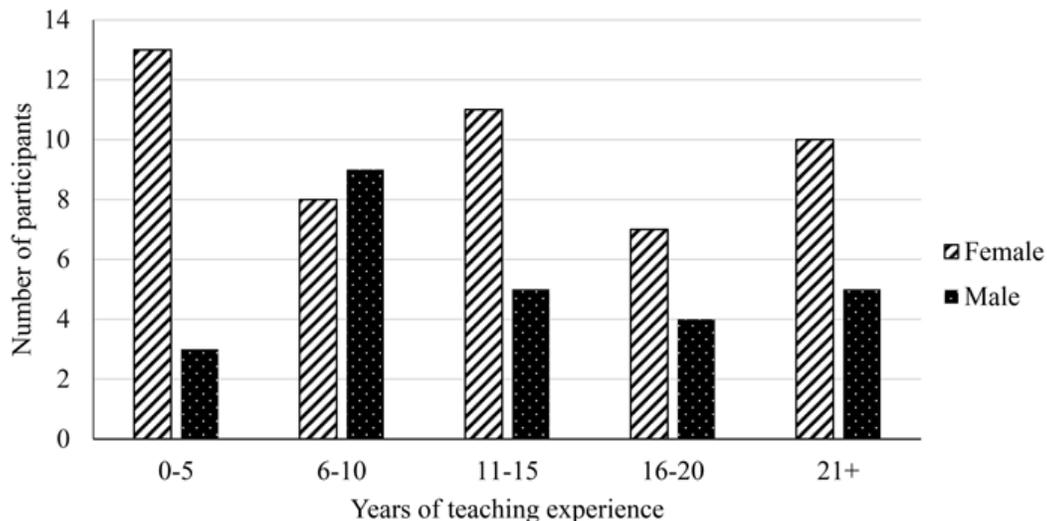
Figure 2. *Participants' gender and teaching experience.*

Data Sources

Data sources included surveys and semistructured interviews. Teacher participants completed the Teacher Efficacy and Attitudes Toward STEM (T-STEM) survey [a], validated and tested for reliability through the National Science Foundation. All scales on the instrument were found to have Cronbach's alpha internal consistency reliabilities over 0.80 (Erkut & Marx, 2005).

The T-STEM survey includes the following 5-point Likert scales: Science Teaching Efficacy and Beliefs, Science Teaching Outcome Expectancy, Student Technology Use, Science Instruction, 21st Century Learning Attitudes/Skill, Teacher Leadership Attitudes, and STEM Career Awareness. This paper describes teachers' responses on the Student

Technology Use (STU) scale, which included eight statements (see the following sample statements):

- "Use a variety of technologies, e.g., graphing tools (Excel), research (Internet), and communication tools (Prezi, MovieMaker, PowerPoint, SMART Board)."
- "Use technology to communicate and collaborate with others, beyond the classroom."

The STU scale provided insights into teachers' beliefs about the role and value of technology in the classroom and its potential to support the development of student attitudes toward STEM.

Seventeen teachers (nine males and eight females) volunteered to participate in semistructured interviews (deMarrais, 2004) exploring STEM teaching, understandings, and beliefs, as well as specifics related to their teaching practice, including pedagogy, curriculum, outreach programs, and the integration of technology into their practice.

Data Analysis

Quantitative data were analyzed using descriptive statistics (SPSS). Qualitative data were analyzed through an interpretational analysis framework using NVivo 11 data analysis software and executed through the process of thematic coding and constant comparative method (as in Stake, 2000) to address the research questions. Transcripts were imported into NVivo, and quotes were selected based on their inclusion of TPACK elements, including content knowledge (CK), pedagogical knowledge (PK), TK, pedagogical content knowledge (PCK), pedagogical technological knowledge (PTK), and TPACK. The spreadsheet software MS Excel was used to create figures.

Results

In exploring teacher integration of technology into their classroom practice, we gathered data and mined for themes related to both teacher and their student's uses of technology. The results are discussed in three sections as they relate to the overarching research questions addressed in this paper: (a) Use of technology in the classroom (including frequency and purpose) and, specifically, the kinds of technologies used; (b) factors influencing decision- making in terms of integrating technology into classroom practice; and (c) teacher decision to integrate technology using a TPACK framework.

Use of Technology in the Classroom

In addressing the first research question we examined the reasons teachers use the technologies they do and, specifically, what technologies they use to this end.

Technology in the Classroom. Survey findings revealed that teachers reported integrating technology into the classroom (3.03). When asked how often they use technology in their practice, 47% of respondents described their technology use as *frequently* and 23% as *everyday*. When prompted to respond to why they use technology, each of the following themes appeared in 29% of responses: *proficiency for the modern world* and *research*. The themes *recording* and *visuals, illustration of a concept* each occurred in 17% of responses. In terms of how teachers integrated technology in their practice, 35% said *research*, while 29% said *visuals, presentation.* Three participants (17%)

mentioned *online classroom interactions,* and two (11%) mentioned learning *new software, apps* (Figure 3).
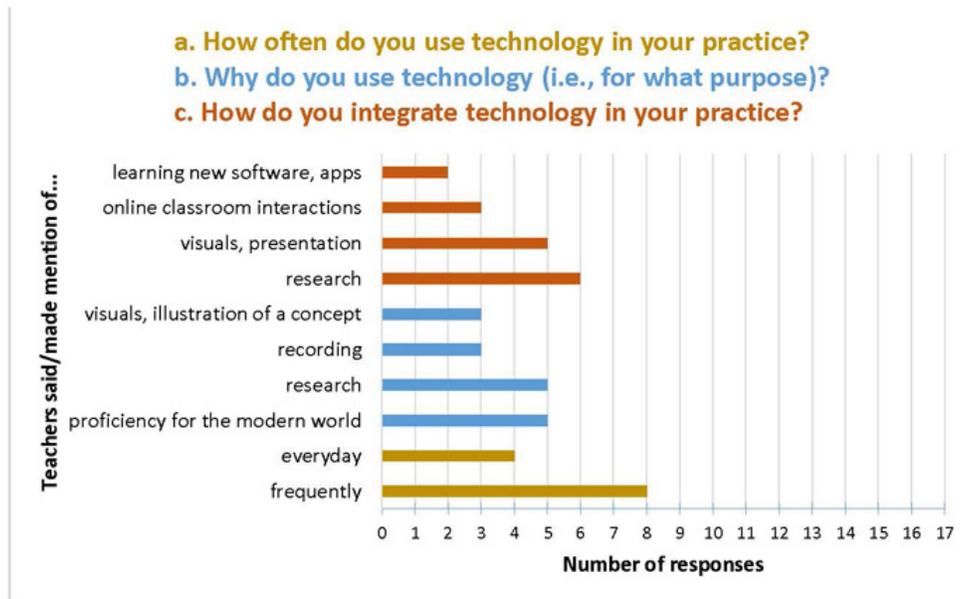
Figure 3. *Technology use by teachers identified in interviews.*

Teachers in this study indicated that they used a variety of technologies for multiple reasons in their classrooms. Emergent themes of motivation – "Try to keep it fun if possible, and involve the students. ... I'm trying to use technology more when I can, and use computers when we can," and, "Because I think it's important for the kids to be comfortable with it, because they are going to be using it" – and accessibility were highlighted in the interview data.

Survey data revealed that teachers identified student use of technology as slightly more positive than neutral, and included accessing online resources (3.68), working on projects (3.11), problem solving (3.27), supporting higher order thinking (3.03), and generating new ideas and representing information (3.14; see Table 1). Both online collaboration (2.57) and the use of researchers' professional tools (2.19) were rated slightly negatively by teachers.

Types of Technology. Within the interviews, teachers responded to questions about specific types of technologies used in the classroom (Figure 4). The most commonly used technology was digital cameras (88%), followed by presentation (82.4%), and tablets (including Chromebooks; 77%). Simulations and email followed (71% each), then digital video games and social platforms (47% each) and class planning (35%). Four technologies were each reported by 29% of respondents: clickers, Web 2.0 technologies, discussion boards, and recording marks. Three technologies were each reported by 24% of respondents: virtual field trips, Prodigy, and other administration tasks. Only one respondent reported using Moodle (6%).

Table 1
Teacher Mean Responses on Student Technology Use in the Classroom

Item	Mean (SD)
1. Use a variety of technologies	3.24 (0.86)
2. Use technology to communicate and collaborate with others, beyond the classroom	2.57 (1.14)
3. Use technology to access online resources and information as a part of activities	3.68 (0.94)
4. Use the same kinds of tools that professional researchers use	2.19 (1.13)
5. Work on technology-enhanced projects that approach real- world applications of technology	3.11 (1.41)
6. Use technology to help solve problems	3.27 (1.19)
7. Use technology to support higher-order thinking	3.03 (1.14)
8. Use technology to create new ideas and representations of information	3.14 (1.19)

Which of the following technology do you use in your practice?
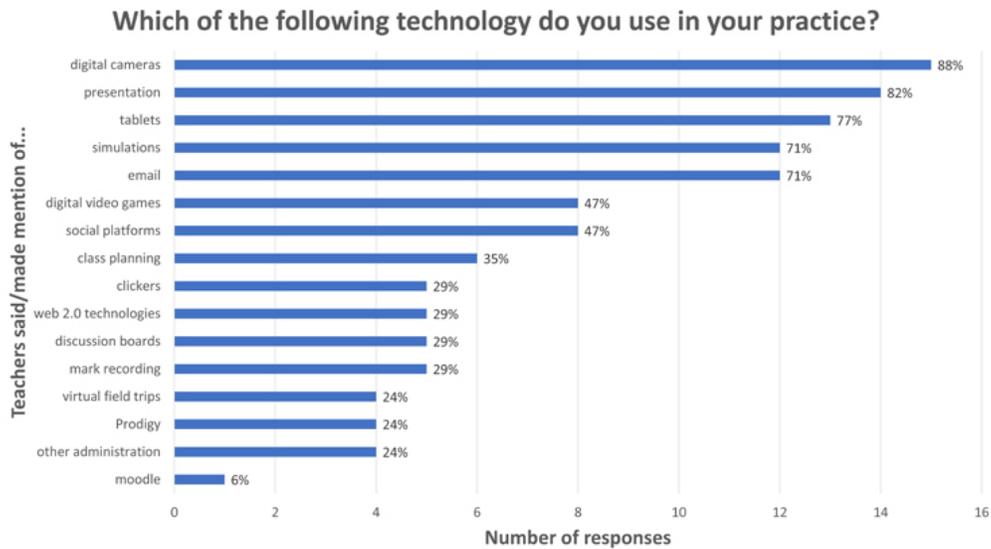
Factors Influencing Decision Making and Technology Integration

In exploring the second research question, teacher demographics including gender and teaching experience were considered possible factors influencing their decisions to use technology. Interview findings identified a third influencer, teacher readiness, referring to factors teachers identified as empowering, encouraging, overwhelming, challenging, or other type sentiment.

Gender. A Spearman correlation was conducted to explore the relationship between teacher gender and reported student technology use, as literature exploring the role of teacher gender on the decision to incorporate technology into classroom practice is sparse. Results from this study demonstrated a weak correlation, r (35) = .19, p = .25, with female teachers (3.17) reporting more student technology use than male teachers (2.58).

Teaching Experience*.* A Pearson correlation was conducted to explore the relationship between teaching experience and reported student technology use. Results from this study demonstrated a weak negative correlation, *r* (32) = -.02, *p* = .91, with less student technology use reported by experienced teachers (16-20 years, 2.43) and more student technology use reported by teachers with 11-15 years teaching experience (3.38).

Teacher Readiness. Teachers reported that the abundance of technology presents a challenge in terms of decision-making and choice as to which technologies to integrate into their lessons. They also noted in the interviews that some forms of technology take more time to set up than their perceived value.

Teacher Decisions to Integrate Technology Using a TPACK Framework

Table 2 illustrates types of knowledge identified by the TPACK framework, in association with technological knowledge.

Within the interviews, teachers' responses to the following questions were coded using the TPACK types of knowledge identified in Table 2:

- How often do you use technology in your practice?
- Why do you use technology?
- How do you integrate technology in your practice?

The most commonly identified knowledge was TPK (82%), with the majority reported as positively developed. TK was reported as the second most commonly identified knowledge (65%), with the majority indicating a positive development. The least frequently identified types of knowledge included types of technological knowledge that intersected with content, with only four instances of TPACK (100% positive) and three responses for TCK (67% positive).

In assessing teachers' responses regarding their use of technology in the classroom, constraints to using a TPACK framework in their practice were identified 40 times. These responses were most commonly associated with pedagogy (55%), such as teacher preference, time constraints, and teacher readiness, as illustrated by a teacher:

We have an app that will allow [students] to build a simulated roller coaster sort of game, so they get an idea of force and speed, but in the end, I don't want them to make a project on the computer. I want them to physically make an item. It's a choice, because it's great if everybody can make everything on the computer, but then I feel you lose something. (Male teacher, #3)

Teacher readiness was also cited as a constraint to using the TPACK framework by another teacher:

> I'm not too clear on the technology piece apart from the devices or apart from instruments that you might be using in science. I'm not too clear on how the technology piece factors into this whole thing. Does it mean a device or does it mean how kids use devices or how they use it to do their work? I'm not too clear how that technology piece factors in or if it is a holistic thing incorporating anything in STEM, or if it's futuristic, or what angle is this technology piece, that's the one … that I can think I kind of have on the technology part. (Male teacher, #1)

Table 2
TPACK Knowledge Types

Type of Knowledge	Positive Response (frequency)	Negative Response (frequency)	Examples From Teacher Interviews
Technological knowledge (20 responses)	65% (13)	35% (7)	"The technology part is tricky, because there is so much coming at you all the time. It's hard to keep up. I just got Apple TV. I've got this white board. I have iPads and laptops, and people give you, 'Oh, here's 37 things that you can do with them,' and it's like, give me five. Two maybe, because that's on top of everything else you're doing." (Female 2)
Technological pedagogy knowledge (17 responses)	82.4% (14)	17.6% (3)	"I think I use technology too much just for that basic ... to augment what they are doing, to find out information to help them with the task, and I want to move it to ... But my goal – and this is something that I'm still working on to improve – is, how do I use technology to actually change the task that I want them to do? So the pop bottle rockets for next year, I love doing them, and it's a great starter, but how do I use technology to actually change that activity?" (Female 1)
Technological content knowledge (3 responses)	66% (2)	33% (1)	"... anything to do with chemistry. I would like them to learn about certain chemistry, and when you are doing pure substances and mixtures, what happens if certain chemicals are mixed? And in middle school, for safety reasons, I cannot actually physically perform the experiment. This is where the technology comes in. You have sites, you have apps that could, at least, show them visually what it would have looked like." (Male 3)
Technological pedagogical content knowledge (4 responses)	100% (4)	0% (0)	"Well we've adopted a physicist ... from the American Physicist Society ... and when you have science questions, you email them, and they can webcam, and they can do any of that stuff.... Its citizen based science, and so what it is, there's so much information now, because we have videos everywhere that you can go on and do some of the observations for scientists, and you could tell them if you see things. ...But every now and again we get that our research, our observations helped to provide research. So actually, recently we got one from the University of Tennessee, and they were saying that our penguin observations were included as part of their. ... And so it's nice for the kids to see that they are doing real world science." (Female 4)

The lag between training and implementation of technologies presented a challenge for teachers, as illustrated in the following quote:

> The Google docs, well now they are doing lots of PD on it. ... That's what we are moving to allow right now, the Google classroom in September, and a lot of us are trying to sensitize ourselves, because it would be somewhat easier if you know how

to use it. I think Padlet, Apps, and so on. Again, I haven't used a lot of those, but it's currently in discussion, something we are seriously contemplating. I know a lot of schools [are] already implementing these. We are sort of at the bottom of the curve, so to speak. But we're getting there. (Male teacher, #17)

The remaining challenges associated with technology (45%), such as access, lack of awareness or familiarity, and design limitations were highlighted by a teacher:

I would need to take workshops or something. That's the problem. I don't know. Some of the meters and stuff that [the outreach program] use, I don't know. I'm not sure how to use them. ... Yeah, I mean computer, sure, fine, scales, calculators, spring scales. These kinds of things, but some of the newer, like electronic type tools we don't have currently. We don't have robotics. We don't have that kind of stuff currently. So that's definitely an area for improvement. (Female teacher, #1)

Teachers did not identify any challenges associated with content knowledge.

Discussion

The teachers who participated in this study represented a wide range of opinions and thoughts about the integration of technology into the classroom. Most expressed an interest in learning more about technologies, others reported that they had altogether abandoned using some technologies due to the lack of resources and time constraints for learning new technologies, and some were skeptical about the benefits of using technologies.

The findings are next considered through the lens of a TPACK framework, followed by recommendations for effective supports for teachers as they move toward a more consistent TPACK framework for their classroom practices. The OProg was primarily targeted to students in an effort to develop their awareness and positively impact their attitudes toward STEM. Teacher professional development focusing on STEM attitudes and interest was a secondary outcome, which explains why no significant change regarding teacher technology use occurred.

We consider this data cautiously, as Hechter and Vermette (2014) found that teachers often overreported technology use by students. Our findings that teachers use technology in the classroom is congruent with studies (Hechter & Vermette, 2014; Kong & Song, 2014; Kyriakides et al., 2016; Ruggiero & Mong, 2015; Uluyol & Sahin, 2016; Zimlich, 2015), as are the types of technologies teachers selected. Interestingly, our study found that female teachers reported more student use of technology when compared with male teachers.

For all teachers, the range of uses of technologies varied, even within their own administrative practices (not all use mark recording programs, and some no longer use email, but prefer messaging), but more consistently teachers used those technologies that support access (general web searches) and dissemination of knowledge (presentation software, such as Prezi and PowerPoint, and YouTube videos).

Few teachers reported using sites that promote online collaboration (2.57), with comments that reflect a range of reactions, from hesitation, "I have still a little bit of a phobia in making dramatic statements that ... one liners, so I'm not myself proficient at Twitter and that type of thing" (Male #12) to dismissive, "Discussion boards? No. Live discussion is what I use in class" (Male #3). These responses are of concern considering Weber and

Custer (2005), and Mims-Word's (2012) findings that communication technologies encourage female student participation. Without the inclusion of technologies that are found to increase female student engagement, their interest in technology cannot be capitalized upon.

An inference may be made that teacher enhanced TK will translate into increased use of a variety of technologies in the classroom (Baturay et al., 2017). Despite female teachers in our study reporting more overall student technology use, the limited opportunities for students to engage with technologies beyond information capture and dissemination impedes student TK development.

While teachers envisioned where they could use technologies through the lenses of TK and TPK, there is little evidence that teachers understood the scope of the interdependence of technology with content, or how the intersection of all three TPACK domains of knowledge can be used to fully realize the potential technology affords.

Four teachers (three male, one female) described using projects and approaches that successfully utilize a TPACK framework. For example, one teacher described her integration of technology through a TPACK framework in that (a) technology shaped her students' work; (b) technology was used to gather and share data with professionals; and (c) shared data was used by professionals through a citizen science project. For the remaining 13 teachers interviewed, technology was viewed more often as a tool rather than part of an integrated process.

Factors that may have potentially influenced the teachers can be categorized as both external (resources, training, and support) and internal (personal investment in technology, attitude toward technology, and peer support) barriers, as described by Ruggiero and Mong (2015). External barriers, such as access to computers (Hecter & Vermetter, 2014) and websites (Zimlich, 2015), were identified in this study. This result was surprising considering the school board's positive and access-for-all technology policies. Nevertheless, teachers spoke about access to devices, such as type of devices, numbers, and those that are dated; board platforms from home; and school Wi-Fi access. For teachers to move toward a TPACK framework they must be able to effectively use the technology, which requires reliable access.

The second most common theme identified was a misalignment between the purpose of the technology and teachers' expectations of the technology. Some challenges were about compatibility, for example, "The other thing has been access to certain apps, we haven't been able to use the iPads, and they're available on Google chrome," or responsiveness of design (e.g., virtual fieldtrips were abandoned by one teacher because she found it "big and boring").

Other challenges existed because of the timeliness of support. Unlike Uluyol and Sahin (2016), who a found lack of support as an external barrier, these teachers reported that new technologies are being supported on a regular basis, but that there is a time delay between implementation and training, as evidenced in the data. These challenges can be addressed through professional development and opportunities for collaboration with colleagues. Support needs to be readily available for teachers to incorporate technologies early in their practice rather than later. Aldunate and Nussbaum (2013) found that teachers who incorporated technologies early were more likely to continue with more complicated systems rather than abandoning them altogether.

The prevailing themes connected to internal barriers in this study were teacher readiness ("Not enough. Because I'm old," and "I still have a little phobia"), perceived tension between technology or in-person ("The problem is with that stuff; they're not getting this stuff. You can't do both"), devaluing online experiences ("They want experience, not the same thing"), and even negative attitudes toward technology ("I don't because I don't like that"). Teachers who devote much time to carefully and effectively implementing the curriculum require both direction and support to positively impact their beliefs about the value and significance of technology as a necessary part of the learning process for students. This impact on beliefs is essential, considering the constant production and evolution of technology that some teachers find overwhelming.

In conclusion, disconnect appears to exist between beliefs and practice, as teachers believe technology is important, but do not implement it in practice to effectively meet the needs educators wish to address, such as developing 21st-century learning skills and motivating students to continue pursuing science as an area of study. In addition, teachers have good CK, PK, TK; however, there are concerns raised by teachers themselves about their competencies (in TPK, TCK, and TPACK) to use technologies to maximize learning for their students.

Looking Ahead

Our findings contribute to the ongoing discussion among STEM education researchers and practitioners to increase understanding of the kinds of technology that are most beneficial for students of STEM in middle school. Aligned with the call of many other scholars (Badia, Meneses, & Sigales, 2013; Buckenmeyer, 2010; Hechter & Vermette, 2014; Özdemir, 2016; Uluyol & Sahin, 2016; Ward & Parr, 2010; Zimlich, 2015), teachers must receive more and ongoing professional development in the area of technological integration.

In order to witness significant changes related to teacher technology use, professional development initiatives will have to specifically target teachers as the primary recipients. The professional development should take different forms and focus, housed under the umbrella of a TPACK framework, including contextualizing technology integration (Ruggiero & Mong, 2015); utilizing technology, introducing technology to students, and considering educational purposes of technology (Kong & Song, 2014; Zimlich, 2015); providing opportunities to learn from peers in terms of how to effectively integrate technology (Lin, Lin & Lee, 2015); and building confidence in and exploring benefits of using ICT rather than focusing on skills (Ward & Parr, 2010). Furthermore, findings of this study can inform curriculum development, teacher education programs, and outreach programs as to the types of technology and effective implementation in terms of TPACK for engaging students (especially girls) and promoting STEM career pathways.

Note

[a] Additional information on the T-STEM survey can be accessed by contacting Maximizing the Impact of STEM Outreach (MISO), North Carolina State University (http://miso.ncsu.edu/articles/t-stem-survey-2)

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