Jl. of Computers in Mathematics and Science Teaching (2014) **33**(1), 27-47

Tech-savvy Science Education? Understanding Teacher Pedagogical Practices for Integrating Technology in K-12 Classrooms

RICHARD HECHTER AND LAURIE ANNE VERMETTE
University of Manitoba, Canada
richard.hechter@ad.umanitoba.ca
laurieannevermette@gmail.com

This paper examines the technology integration practices of Manitoban K-12 inservice science educators based on the Technological, Pedagogical, and Content Knowledge (TPACK) framework. Science teachers (n= 433) completed a 10-item online survey regarding pedagogical beliefs about technology integration, types of technology used, and how often each of these technologies was utilized in pedagogical practices. Results indicate that technology is integrated to promote student engagement, teach 21st century skills, as best teaching practice, to stay current, and for hands-on interactive learning. Through quantitative descriptive statistics, results identified that interactive whiteboards and digital communication programs are frequently integrated; while podcasting, digital hand-held data collection sources, online discussion boards, and simulation software are almost never integrated in Manitoban science classrooms. In addition, data indicates that teachers over-report how often classroom technology is actually placed in student hands. Implications of this study inform school division technology purchases, preservice teacher education, and professional development opportunities.

INTRODUCTION

According to the Programme for International Student Assessment (PISA) (2009) results, only six countries outperform Canada in science. While Canadian students rank high on their understanding of science, students in the province of Manitoba lag significantly behind national averages when contrasted against the results of the Pan-Canadian Assessment Program (PCAPs) (2010). Manitoba Education, the governing body for education in the province of Manitoba, has recognized that effective and appropriate technology integration in science education promotes engaging students in science content, sparks their interest in scientific and technological endeavors (Manitoba Education[a], n.d), helps students develop 21st century skills (Windschitl, 2009), and can improve the teaching and learning of science in the province.

Student engagement in science classrooms is an important aspect of developing interest in science (Emdin, 2011). However, teachers and administrators too often mistake "using lab materials, following directions, and getting prescribed results to lab assignments" (Emdin, 2011, p. 2) as what they consider to be engagement in science. Emdin (2011) argues that "true engagement in science such as questioning, sharing one's thoughts about a concept, argumentation, and debate" (p. 2) are better descriptors of active participation and engagement in the science classroom. How then is technology integration used to promote student engagement? This is a multifaceted question rooted in teacher beliefs and pedagogical practices about the value of providing technology-rich K-12 classroom environments. While there is some debate about whether the environment of technology use in classrooms should be student-centered, teacher-led or a combination of both (Chang, Hsiao & Chang, 2010; Ertmer et al., 2012; Harris, 2005; Ottenbreit et al., 2010; Sandholtz, Ringstaff, & Dwyer, 1997), it is beyond the scope of this paper.

Ertmer et al. (2012), report that, "teachers' own beliefs and attitudes about the relevance of technology to students' learning were perceived as having the biggest impact" (p. 423) on successful technology integration in the classroom. Recognizing that a discrepancy sometimes exists between teachers' espoused and enacted beliefs when it comes to integrating technology into teaching and learning in their classrooms (Ertmer et al., 2012; Ottenbreit-Leftwich et al., 2010), and that teachers' pedagogical beliefs affect both the mode and teaching methods (Ertmer, 2005) of their science-content delivery (Graham et al., 2009); it is imperative that specific and related research that addresses science teachers' beliefs and practices be explored.

Our research study therefore attempts to understand technology-related teacher beliefs and practices in science education in Manitoba.

Chang, Hsiao and Chang (2010) note that the ‘learning environment is a complex construct where instructional approaches are one of the mediating factors” (p. 136). Thus, creating classroom environments where teachers can facilitate technology integration such that students can access information, and use multimedia content to communicate and collaborate (Ertmer et al, 2012, p. 425), are more likely to create open communication experiences where students can engage in authentic learning experiences in the science classroom (Emdin, 2011). Technology-rich classroom environments, where technology is used effectively to improve teaching and learning, is seen as a contributing aspect to overall student achievement (Haertel, Means & Penuel, 2007; Lei & Zhao, 2007; Odom, Marszalek, Stoddard & Wrobel, 2011) and understanding in science.

It is perhaps necessary at this stage to distinguish between instructional technologies and educational technologies as they relate to the K-12 classroom. While these terms are used both independently, and at times, interchangeably in the extant literature (Earle, 2002), they have some fundamental differences. In sum, our operational definitions are such that instructional technologies are considered to be those that help teachers hone their craft of teaching; these are predominantly teacher-driven and used. These modern technologies enable teachers to present information; assess, communicate, and report on student achievement and progress; interact with students, parents, and administrators; and communicate with other teachers within their profession. Examples of instructional technologies that teachers utilize include interactive whiteboard technologies; digital communication softwares such as Powerpoint and Excel; school assessment and reporting software; classroom blogs and wikis; and, divisional and general electronic-mail (email) communication programs.

Educational technologies are used in the classroom to encourage and facilitate student learning. Predominantly in the hands of students, these technologies enable students to select, share, research, graph, plot, interact, present, and communicate with information, with their teachers, their peers, and at times, larger audiences including their parents and administrators. These digitally fluent (Wang, Myers & Sundram, 2012) students process, reconceptualize, and produce knowledge and information through complex communications in the digital environment. Students’ technological skill set often surpasses the technological abilities of their teachers (Prensky, 2001). Students with digital fluency use technologies that include, but are not limited to: class sets of laptops or graphing calculators, online classroom discussion boards, digital probes and sensors, digital photography and movie making programs, simulation software, digital communication software, Youtube videos, and social-networking applications. Similar to the distinction between Type I and Type II technologies (Maddux & Johnson, 2006), where Type I applications are technologies students learn from, and Type II applications are technologies students learn with; educational technologies encompass the digital fluency of students including what they are bringing to the classroom, learning from, and learning with, essentially encapsulating the student experience. It is with an understanding of the distinctions between instructional and educational technologies that we now examine the theoretical framework that frames our study.

THEORETICAL FRAMEWORK

This study is grounded in the Technology, Pedagogical, and Content-Knowledge (TPACK) framework (Mishra & Koehler, 2006), as shown in figure 1. TPACK, as a theoretical model, describes how technological knowledge, pedagogical knowledge, and content-specific knowledge form the three tenets of effective technology integration. This model positions the relationships of these three knowledge aspects as the basis by which technology is integrated, with purpose and design, into the pedagogy of specific content areas. While the original model is presented as a Venn-diagram, with each base occupying equal proportions of the design, we believe the model is in fact dynamic and fluid, where the circles oscillate in and out of the center in ratios that are dependent on the context. The TPACK model has been applied in different academic settings, including the science classroom (Graham et al., 2009; Niess, 2005).

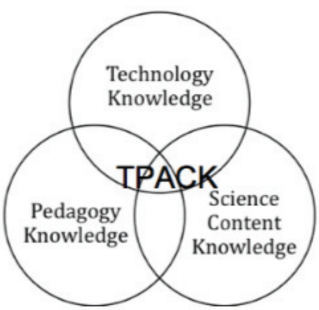

Figure 1. TPACK Model, Mishra and Koehler (2006).

Understanding how to effectively apply TPACK in the pedagogical decisions made by classroom practitioners can be a challenge (Graham, 2011; Graham et al. 2009; Mishra & Koehler, 2007). Mishra and Koehler (2007) found that a teacher's knowledge base is a key factor in determining technology integration in classrooms. Recognizing this, it was necessary to understand the types of factors that impact a teacher's knowledge base for understanding and applying technology in their classroom practices. It is not merely understanding the language associated with the model (Graham, 2011), but rather that teachers needed more support to link content-specific educational technologies to their science lessons (Graham et al., 2009). This paper does not address the language around the TPACK framework, nor the factors or support necessary to bring the TPACK model within reach for classroom practitioners. Instead, this paper focuses on understanding and describing the context that Manitoban K-12 science educators teach in, and the frequency that specific technologies are used in their pedagogical practices to improve teaching and learning in their classrooms.

Effective technology integration in K-12 science classrooms restructures existing curricula (Moersch, 1995), by allowing teachers' positive value judgments (Judson, 2006; Ottenbreit et al., 2010; Watson, 2006) to decide which pedagogical approaches and technological tools are most relevant to their goals. When teachers' beliefs about the value of using specific technologies are high, they are more likely to integrate that technology into their pedagogical practices (Judson, 2006; Ottenbreit et al., 2010; Watson, 2006). Technology training for teachers should be content and grade-level specific, so that the skills are more transferable to classroom settings (Hughes, 2005). Incorporating TPACK into the K-12 science classroom is a complex activity where the personal comfort level of each teacher in working with technology is in constant flux varying with prior experience with the project type, technology used, and familiarity with background content-knowledge (Hofer & Swan, 2006). Therefore it is necessary to educate teachers (Hughes, 2005), to enable them to make positive pedagogical decisions about how and why to use technology in their classrooms to enhance teaching and learning (Harris, 2005; Ottenbreit et al., 2010).

RESEARCH PROBLEM

The following paper examines the technology integrated pedagogical practices of Manitoban K-12 inservice science teachers in an effort to describe and understand how technology-supported science classrooms improve the teaching and learning of science throughout the province. Specifically, we are interested in: How often are technologies being used to support teaching and learning? Are these technologies most often used in the hands of teachers or students? And finally, what drives Manitoban science educators' pedagogical choices to include technology in their teaching practices?

METHODOLOGY

Participants

This study targets a convenient sampling of Manitoban K-12 inservice science teachers (n = 433). Education/Nursing Research Ethics Board (ENREB) approval was obtained to contact the superintendents of Manitoban school divisions, as well as the administrators in Manitoban independent schools, to invite participation in our study. Those who chose to have their staff participate, distributed the email survey out to all of their K-12 inservice science teachers during winter term of 2011. In order to qualify to complete the survey, teachers needed to be currently teaching any level of K-12 science, or to have recently taught science within the previous two school years.

Survey Instrument

The online survey instrument was a 10-item questionnaire administered through Survey Monkey, an online survey program, for use with Manitoban inservice science teachers. Email invitations to participate were distributed to teachers via their administrators. A written informed consent outlining the rights and responsibilities of both researchers and volunteer participants formed the opening page of the survey. The survey consisted of demographic, LIKERT-type, and open-ended questions. Questions probed for information regarding grade levels taught, years of teaching experience, class sizes, frequencies for types of technologies integrated, teacher confidence levels for integrating technology, who directs the use of technology in the classroom, who most often handles technologies in the classroom, reasons to integrate technology in science teaching, and barriers to integrate technology into science teaching. For the purposes of this paper, we focus only on the questions regarding the reasons teachers choose to integrate technologies, who directs the use of technologies in the classroom, who handles the technologies, and the frequencies for using technologies.

Procedures for Analyzing Data

All data received was compiled in Survey Monkey. Frequency tables of the data were generated, and are presented below. Quantitative statistical analysis of the numerical data occurred through Survey Monkey and SPSS. Qualitative responses were gathered, compared, and grouped through grounded theory approaches (Creswell, 1998).

Reliability and Validity

To provide consistency within the data, thereby lowering the margin of error, clear and concise language is used in the survey. Participants were encouraged to contact the researcher with questions or concerns about the language or format of the questions, about the questions themselves, about the process, or about the way that compiled data are being used. Overall, the survey was designed to be completed within a 15-20 minute time frame by most participants. As volunteers, the diversity of the sample depended largely on the divisions that chose to participate, as well as the individual teachers who chose to participate. As a convenient sampling, the demographic questions were the best means of understanding the diversity of the surveyed population. From the responses to the demographic questions, the surveyed population was acknowledged in terms of years of teaching experience and the teaching stream of the teacher. As such, the demographic comparisons are descriptive in nature and not contrived by filling quotas of teachers falling within specific groups. This survey was available online for over three months. This time-frame ensured teachers had ample opportunity to fill out the survey when and where it was most convenient for them. This helped to ensure reliable results as teachers should not have felt pressured by time, or by the people around them. Anonymity for participants is promoted by allowing respondents to select the time and location in which to complete the survey.

Compiling aggregate data from open-ended survey questions has some degree of researcher subjectivity and bias as to how the responses are categorized. As such, while efforts were made to reduce the subjectivity by having each author independently review open-ended responses, this is nevertheless recognized as a potential bias in the analysis of data.

Limitations of the survey instrument and of data analysis are presented to speak to the validity of the data. Due to the online format of the survey, results may be skewed slightly in favour of teachers who are already comfortable using technology, as this study required the use of technology in order to participate. While the format of the questionnaire led for rich, qualitative data from open-ended responses; had the open-ended questions instead been in the form of a check-list, particularly for the 'reasons teachers integrate technology' question, it is possible the percentages of teacher responses may have been significantly higher. This survey does not ask demographic questions about the race, ethnicity, or socio-economic status of the teachers, students, or the communities in which they teach, nor does it ask about teachers' age, gender, educational background, number of years of science teaching experience, rural/urban teaching experience, or public/independent school teaching experience. Those areas of diversity were not within the scope of this survey, and therefore no results were obtained that pertain to these areas. This survey does provide information on what technology is being used, as well as how often, but not how it is being used to improve the teaching and learning in science classrooms. Further, while the survey asked whether the technology was mostly in the teachers' hands or the students' hands in general, it did not ask this question specifically for individual technologies. These limitations will be addressed in future research.

RESULTS

Demographic Results

Out of the 505 teachers who opened the survey, 433 Manitoban K-12 science educators completed it, a response rate of nearly 86%. Data was collected on behalf of 22 participating Manitoban school divisions, and 16 Manitoban independent schools. Teacher demographics range across all years of teaching experience, and across all teaching streams (Early Years K-4, Middle Years 5-8, Senior Years 9-12, and those teaching in multiple streams). Teachers reported having an average of 21-22 students in each of their science classrooms, with smallest class sizes being one-three students and largest being 35-36 students.

Table 1

Teachers include technology into their classroom pedagogical practices for a variety of reasons. Out of 433 teachers who completed the survey, 407 (94%) said that they integrate technology into their science teaching and learning. When asked 'what is/are the reason(s) you integrate technology into your science classroom?' aggregate data from the open-ended responses of those 407 teachers found that:

Reasons teachers choose to integrate technology into their classroom teaching and learning	Response Count (n=407)	Response Percentage
Student engagement	227	56%
Promote 21st century skills as way of the future	146	36%
Best teaching practice	133	33%
Stay current	104	26%
Hands-on interactive learning	81	20%
Vary instructional methods	78	19%
Perform labs and demonstrations	69	17%
Research and communication	63	15%
Visual aids	54	13%
Meaningful connections	51	13%
Teacher convenience	44	11%
Support learning outcomes	44	11%
Demands of the division	14	3%

Other, less frequently reported, reasons that teachers integrate technology into their classroom teaching and learning (in descending order) are: to collect data and record daily activities; to make up for a lack of science equipment; to ensure safety in the classroom; for organization and aesthetic appeal; to enhance discussions, questions, and inquiry; because technology is a form of science; to improve classroom management and change classroom routines; to promote problem-solving; for assessment purposes; to promote creativity; for professionalism; and to watch wildlife on webcams.

Table 2

Understanding that science teachers integrate technology into their science teaching for a variety of reasons, how often each of these technologies is used to support teaching and learning are reported. Responses are delineated into using technology frequently, moderately, rarely, or never. Results shown in frequency, and percentage (n =433).

How often do you integrate the listed technology into the science teaching and learning in your classroom?	**Frequent Use**	**Moderate Use**	**Rarely Used**	**Never Used**
SMARTboards, Promethium boards, Mimio, iClickers	134 (31%)	85 (20%)	46 (11%)	168 (39%)
Tablet, Ipods, Itouch, and cell phones	9 (2%)	27 (6%)	26 (6%)	371 (86%)
Computer lab, media room	39 (9%)	308 (71%)	61(14%)	25 (6%)
Digital communication programs (ie. powerpoint, excel)	118 (27%)	187 (43%)	85 (20%)	43 (10%)
Simulation software (ie. Starry Night)	8 (2%)	98 (23%)	97 (22%)	230 (53%)
Digital probes and sensors(ie. Vernier Labquest, digital microscopes)	0 (0%)	49 (11%)	90 (21%)	294 (68%)
Digital photography and movie making (ie. Imovie)	13 (3%)	95 (22%)	171 (40%)	154 (36%)
Blogging, wikis, and online discussion boards	26 (6%)	47 (11%)	57 (13%)	303 (70%)
Podcasting	1 (0%)	10 (2%)	40 (9%)	382 (88%)

Table 3

Nature of Student Activities in Classroom Experiences

Most of the science activities and experiences in your classroom are:	Response Count	Response Percent
Teacher directed	206	48%
Student directed	10	2%
An equal amount of each of the above	217	50%

Table 4
Acknowledging Who Uses the Technology that is Accessible in the Class-Room

The use of technology in your science classroom is mostly:	Response Count	Response Percent
In your hands	188	43%
In the hands of the students	33	8%
Equally in your hands and in those of your students	212	49%

DISCUSSION

Reasons to Integrate Technology into Science Education

As shown in Table 1, of the thirteen most commonly reported reasons for integrating technology into the science teaching and learning in Manitoban K-12 science classrooms, promoting student engagement (56%), teaching 21st century skills as a way of the future (36%), using technology as best teaching practice (33%), to stay current (26%), for hands-on interactive learning (20%), to vary instructional methods (19%), and to perform labs and demonstrations (17%) were the most commonly cited reasons. The combination of responses on 'student engagement' and 'best teaching practice' speaks to teachers trying to improve the teaching and learning environment in their classrooms.

Promoting 21st century skills as a way of the future speaks to science teachers' concern about preparing their students for the ever changing, dynamic and diverse employment practices of the future. In Canada, a focus on the rapid expansion of the 21st century digital economy continues to grow in our classrooms. With this expansion comes the need for workers and citizens to be able "...to locate, organize, understand, evaluate and create information using digital technology" (Social Sciences and Humanities Research Council of Canada, 2011). Through the use of complex communications, systems thinking, and non-routine problem solving (Windschitl, 2009), we are in a position to develop student 21st century skills and influence the future of the digital economy.

In the light of the increasing value placed on safety concerns in the classroom (Zirkel & Barnes, 2011) which highlight the controversial use of chemicals in science classrooms due to the issues of safety hazards and liability; debate around the use of dissections (King, 2004; Oakley, 2009, 2012; Sapontzis, 1995) in relation to animal rights; and in an attempt to better demonstrate science concepts like the flow of blood through the circulatory system (Explore Learning, n.d.) or the movement of stars through the night sky (Starry Night, 2011); the ability to use technology to perform labs and demonstrations was stated as a reason to integrate technology into science education by 17% of all study respondents. Perhaps said best by one survey respondent about the reasons why technology integration is important for performing labs and demonstrations, it was stated, "because seeing is believing". When students are able to develop deeper conceptual understandings of science concepts, they are more likely to be able to communicate, problem-solve, reflect, and apply their knowledge within a wider frame of contexts.

Conversely, one of the least likely reasons teachers choose to integrate technology is because of divisional demands, cited by only 3% of respondents. While Manitoba Education, as well as school divisions and administrators, encourage technology integration in the classroom (Manitoba Education[b], n.d.), few teachers actually reported this as a reason why they integrate technology.

Technology Integrated in the K-12 Science Classroom

Within our study, frequent technology use is defined as use in every class or almost every class. Results found that the technologies most likely to be used frequently in science teaching and learning in Manitoba were SMARTboards, Promethium boards, Mimio, and iClickers (31% of teachers surveyed); as well as digital communication programs such as powerpoint and excel (27% of teachers surveyed). Upon reflection, these interactive whiteboard technologies and software are most often used in classroom presentations and teaching, and as such, it would suggest that these types of technologies would most often be used in the hands of the teachers.

In a study of exemplary middle and high school science teachers, conducted by Hakverdi-Can and Dana (2012), results indicated that science teachers seldom use technologies in teaching science. Furthermore, their study reported that the technologies that were in fact used were presentation and communication applications, digital data collection probes, and the internet for information retrieval; while problem-solving and modeling software were reported as the least frequent technologies integrated into the classroom. Our findings are consistent with that of Hakverdi-Can and Dana who found that merely a few computer applications were all that captured the essence of student use of technology in science classrooms. As we found in our study, and Hakverdi-Can and Dana noted, Type II applications that students learned with were almost completely excluded from the frequent use of exemplary teachers.

In our study, specifically, podcasting was reported as the least likely technology to be integrated in Manitoba science classrooms, as 88% of teachers surveyed had never used it in their science teaching and learning. These results are followed closely by tablets, Ipods, Itouch, and cell phones (never used in 86% of classrooms); blogging, wikis, and online discussion boards (never used in 70% of classrooms); digital probes, sensors, and microscopes (never used in 68% of classrooms), and simulation software (never used in 53% of classrooms). A generalization, though perhaps not true for each of these technologies individually, is that these types of technologies tend to be handheld or student input driven, and are therefore more likely to be used in the hands of students, rather than solely by educators. The fact that these technologies are never used in many Manitoban science classrooms is alarming considering the financial investments Manitoban school divisions are making to link science teaching and learning with 21st century skill development.

For the purposes of this study, moderate use of a particular technology is described as a technology being used a minimum of once a month, up to several times per month; but less than every class or almost every class. In some instances, moderate uses of technology in science teaching and learning are less likely to take place in the classroom, but instead in a school-based computer lab or media room, used moderately by 71% of teacher respondents. In addition, the use of digital communication programs such as Powerpoint and Excel, while used frequently by 27% of respondents, are also used moderately by an additional 43% of respondents. Other moderate uses of technology include simulation software (23% of respondents); digital photography or movie-making (22% of respondents); and SMART-boards, Promethium boards, Mimio, iClickers, which, in addition to being used every class or almost every class by 31% of teachers, are used moderately by an additional 20%.

Earle (2002) suggested that access to educational technology resources in the classroom is not enough to achieve integration. Although identified 10 years ago, this perspective is still relevant today, as our study is consistent with these findings. As such, Earle (2002) posits that focusing on access to hardware often comes at the expense of effective pedagogical practices (p. 3). Rather, the value of educational technologies is not simply access, but instead, the process of improving pedagogy; and thus, technologies can and should be used to support the learning, questioning, problem-solving, and communication practices of students (Earle, 2002; Emdin, 2011; Ertmer et al,. 2012; Ottenbreit et al,. 2010).

In identifying usage of specific technologies over how and why teachers' made these pedagogical selections, it seems that our study has fallen into that same trap as the aforementioned studies. Moving forward, we must consider current contexts for the application of technologies in the science classroom. Due to the relatively low-cost of many online present-day technologies (Ertmer et al., 2012), the broad access to the internet in most regions of Manitoba, and the availability of simulation software, digital content, and server-based applications (Ertmer et al., 2012) that address student-centered learning (Ottenbreit et al., 2010); student engagement through communication and collaboration can be achieved with technology (Ertmer et al., 2012) in science (Emdin, 2011).

Harris (2005) had difficulties with the assumption that student-centered technology integration constituted best practice in all teaching situations, and instead favoured a pluralistic approach where teachers remain responsible for determining the pedagogical practices that best suit their students and the learning environment of their classrooms. From the phrasing of our survey questionnaire, it is impossible to determine whether teachers felt that they were enacting best practice; or even, for that matter, what approaches each teacher valued for technology integration in the classroom. Therefore, while our results reflect the quantitative values of the pedagogical practice of technology integration in Manitoba, they do not offer further insight into the pedagogical orientations of teachers. It is perhaps the understandings of these orientations, and how they are reflected in daily practice, that may deepen our contextual grasp of the complexity in this field. As such, this is an area that will need to be explored with future research.

Regardless, recognizing the frequency of uses for specific technologies in the classroom is merely a first step in developing awareness for technology integration practices in K-12 science classes. The next step is to understand who is using the selected technologies in Manitoban classrooms.

Who is Using the Technology: Teachers or Students?

Approximately 43% of teachers report that most technology use in their classroom is in the teachers' hands, 8% report that it is mainly in students' hands, and the remaining 49% claim that technology use in their classrooms is used equally by both teachers and students. These percentages appear to be misleading when looking at the types of technologies that are frequently integrated in science classrooms. This suggests that in 49% of Manitoban science classrooms, students are using the technology half of the time. Seeing as 31% of daily technology use comes in the forms of interactive whiteboard technologies, and an additional 27% comes through using communication programs like Powerpoint, it is unclear how these would be used half of the time by students. In addition, when looking at the significant number of handheld, interactive, and online technologies that are never used in Manitoban science classrooms, it again brings this reported 49% into question. Consequently, this data seems to suggest that teachers over-report how often technology is used hands-on by students.

These findings make sense, according to Ottenbreit et al. (2010), Ertmer et al. (2001), and Judson (2006); who suggest that often teachers' descriptions of their technology uses do not align with their pedagogical practices. Instead, descriptions mimic expectations of student-centered learning currently considered to be best teaching practice, whereas pedagogical practices often do not achieve these standards (Ertmer et al., 2001; Judson, 2006; Ottenbreit et al., 2010). These results are supported by Graham et al. (2009) who found that teachers tend to use technologies themselves, but are less likely to put those technologies in the hands of students. Ottenbreit et al. (2010) posits that this occurs in large part due to a gap in understanding between those implementing professional development opportunities, and the lack of teacher input in the decisions about which of these opportunities best support their uses of technology in the classroom. Teachers need to be involved in the process of changing their pedagogical practices, beginning with internalizing value beliefs about the positive impact of technology integration on teaching and learning in the classroom (Ottenbreit et al., 2010). Furthermore, increasing computer access for students is "not sufficient to change teachers' technology practices especially if this increased access was not accompanied by a corresponding shift in teachers' pedagogical beliefs" (Ertmer et al., 2012, p. 424).

Ertmer et al., (2012) suggest that if technology integration is to be effective, it requires "that technology be placed in the hands of students, who are encouraged and enabled to utilize it in the same ways, and for the same purposes, that professionals do – that is, to communicate, collaborate, and solve problems" (p. 424). The extrapolation of this is to encourage school divisions to consider providing professional development opportunities for teachers to move towards handheld and interactive technologies that students can engage with, and also, for teachers to find ways to facilitate the successful integration of these types of technologies into the classroom.

In a study of Taiwanese grade 10 earth science students (n = 156)

Chang, Hsiao and Chang (2010) note “most students preferred learning in a classroom environment where student-centered and teacher-centered instructional approaches coexisted over a teacher-centered learning environment” (p. 136). Our study found that of the 433 teacher respondents, most of the science activities in classrooms are directed by teachers 48% of the time; by students 2% of the time; and equally by teachers and students 50% of the time. While this information supports ideal learning environments according to the findings of Chang, Hsiao, and Chang (2010), upon reflection, this survey question appears to be leading and the results are therefore not reliable. It makes sense that most science activities in the classroom would be directed by teachers, and occasionally also be directed by students, however, classroom science activities in Manitoba are also guided by government curriculum documents, divisional guidelines, and school-initiated practices. The response given by 50% of teachers that their classroom science activities are directed equally by teachers and students does not make sense in this context, and is seen as a flaw in the development of this particular question. This question was intended to explore the nature of technology integration through the basis of the types of inquiry-based activities implemented by the teacher, but did not reach this goal. We have revised the survey to better reflect our goal and are currently using it in an updated study.

FUTURE RESEARCH

Future research will uncover which technologies teachers most often use, and which are most often placed in the hands of students. In addition, research that seeks to understand barriers to technology integration and support technology integration practices will be pursued. Further, research designed to understand how teachers select specific technologies to integrate into science education in their classrooms, as well as why they have chosen to use them, will help inform fellow teachers, principals, superintendents, and policy-makers on how pedagogical practices affect technology integration in Manitoban classrooms. Thus, future studies will focus on uses of technology, barriers and support for technology integration for teachers, as well as matching specific technologies to appropriate science lessons to improve pedagogy and student understandings of science.

IMPLICATIONS OF RESULTS

The survey results identified reasons that teachers choose to integrate technology; who uses technology in the classroom; and calculates frequencies for how often teachers integrate specific technologies within Manitoban K-12 science classrooms. These findings explore and describe the current teaching experiences and practices of Manitoba K-12 inservice science teachers to inform a practical discussion for what this means for the teaching and learning of science in the province of Manitoba. The results of this study are both timely and crucial for government agencies, such as Manitoba Education, who, through "An Action Plan for Science Education in Manitoba" (n.d.), seek to improve science education in the province by instilling a "sense of wonder and curiosity about scientific and technological endeavors" ("Goals for Science Education," n.d.) in Manitoba science students by encouraging a 21st century skill development approach that focuses on student engagement ("A Rationale for the Action Plan," n.d.).

Understanding the technology integration practices of inservice teachers' classroom teaching and learning will help to inform and enable principals, superintendents, and government agencies to support technology integration practices at all levels. Specific to science education, the support of teachers' Information Communication Technology (ICT) practices will improve 21st century skills in today's youth. This should have a direct impact on student engagement and content-specific conceptual understanding. Over time, as technology integration in science education increases, the potential significance of this study will be to see an improvement in both Manitoba PCAP scores, as well as Canadian national PISA scores.

CONCLUSION

Considerable financial investments from school divisions pour into providing and improving the accessibility of technology in Manitoban K-12 science classrooms to develop 21st century skills in students with digital fluency. Unfortunately, even tech-savvy teachers, with positive intentions and beliefs about the value of technology integration for improving teaching and learning in classroom environments, often fall short of creating technology rich classrooms for their students. Teacher-led technologies such as interactive whiteboard technologies, as well as digital communication programs, are more frequently integrated; while student-driven handheld devices, online discussion boards, and simulation software are often passed over in pedagogical practices. Understanding teacher pedagogical practices for integrating technology in K-12 classrooms is a stepping-stone for learning to support teachers, ultimately promoting the effective use of educational technologies in the science classroom to improve teaching and learning.

References

Chang, C-Y, Hsiao, C-H, & Chang, Y-H. (2011). Science learning outcomes in alignment with learning environment preferences. *Journal of Science Education and Technology, 20,* 136–145. DOI 10.1007/s10956-010-9240-9

Creswell, J. (1998). *Qualitative inquiry and research design.* London: Sage.

Earle, R.S. (2002). The integration of instructional technology into public education: Promises and challenges. *ET Magazine, 42*(1), 5-13. Retrieved from http://bookstoread.com/etp/earle.pdf

Emdin, C. (2011). Dimensions of communication in urban science education: Interactions and transactions. *Science Education, 95*(1), 1-20.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25-39.

Ertmer, P. A., Gopalakrishnan, S., & Ross, E.M. (2001). Technology-using teacher: comparing perceptions of exemplary technology use to best practice. *Journal of Research on Technology in Education, 33*(5), 1–24.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers and Education, 59*(2), 423-435.

Explore Learning. (n.d.) Circulation System. Retrieved from http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=662

Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., Clair St., L., & Harris, R. (2009).TPACK development in science teaching: Measuring the TPACK confidence of inservice science teachers. *TechTrends, 53*(5), 70-79.

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers and Education, 57*(3), 1953-1960.

Haertel, G., Means, B., & Penuel, W. (2007). Technology tools for collecting, managing, and using assessment data to inform instruction and improve achievement. *Yearbook of the National Society for the Study of Education, 106*(2), 103–132.

Hakverdi-Can, M., & Dana, T.M. (2012). Exemplary science teachers' use of technology. *The Turkish Online Journal of Educational Technology, 11*(1), 94-112.

Harris, J. (2005). Our agenda for technology integration: It's time to choose. *Contemporary Issues in Technology and Teacher Education, 5*(2), Retrieved from http://www.citejournal.org/vol5/iss2/editorial/article1.cfm

Hofer, M., & Swan, K.O. (2006). Technological Pedagogical Content Knowledge in action: A case study of a middle school digital documentary project. *Journal of Research on Technology in Education, 41*(2), 179–200. Retrieved from http://www.eric.ed.gov/PDFS/EJ826092.pdf

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education, 13*, 277–302.

Judson, E. (2006). How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology and Teacher Education, 14,* 581–597.

King, L. A. (2004). Ethics and welfare of animals used in education: An overview. *Animal Welfare, 13*(SUPPL.), S221-S227.

Lei, J., & Zhao, Y. (2007). Technology uses and student achievement: a longitudinal study. *Computers and Education, 49*(2), 284–296.

Maddux, C. & Johnson, D. (2006). Type II applications of information technology in education: The next revolution. *Computers in Schools*, *23*(1/2), 1-5.

Manitoba Education[a]. (n.d.) An Action Plan for Science Education in Manitoba. Retrieved from http://www.edu.gov.mb.ca/k12/cur/science/action_plan/rationale.html

Manitoba Education[b]. (n.d.) Literacy with ICT. Retrieved from http://www.edu.gov.mb.ca/k12/tech/lict/

Mishra, P., & Koehler, M.J. (2007). Technological pedagogical content knowledge (TPCK): Confronting the wicked problems of teaching with technology. *Proceedings of Society for Information Technology and Teacher Education International Conference 2007.* 2214-2226. Chesapeake, VA: AACE. Retrieved July 6, 2012 from www.editlib.org/p/24919

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Moersch, C. (1995). Levels of technology implementation (LoTi): A framework for measuring classroom technology use. *Learning and Leading with Technology, 23*(4), 40-42.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509-523.

Oakley, J. (2009). Under the knife: Animal dissection as a contested school science activity. *Journal for Activist Science and Technology Education, 1*(2), 59-67.

Oakley, J. (2012). Science teachers and the dissection debate: Perspectives on animal dissection and alternatives. *International Journal of Environmental and Science Education, 7*(2), 253-267.

Odom, A.I., Marszalek, J.M., Stoddard, E. R., & Wrobel, J.M. (2011). Computers and traditional teaching practices: Factors influencing middle level students' science achievement and attitudes about science. *International Journal of Science Education, 33*(17), 2351-2374. Retrieved from http://dx.doi.org/10.1080/09500693.2010.543437

Ottenbreit-Leftwich, A.T., Glazewski, K.D., Newby, T.J., & Ertmer, P.A.(2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55*(3), 1321-1335.

Pan-Canadian Assessment Program (PCAPs). (n.d.). Retrieved from http://www.cmec.ca/302/Programs-and-Initiatives/Assessment/Pan-Canadian-Assessment-Program-%28PCAP%29/PCAP-2013/index.html

Pan-Canadian Assessment Program (PCAPs). (2011). *PCAP-2010 Report on the Pan-Canadian Assessment of Mathematics, Science, and Reading.* Retrieved from http://www.cmec.ca/Publications/Lists/Publications/Attachments/274/pcap2010.pdf

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon, 9*(5), 1–2. Available:www.marcprensky.com/writing/Prensky%20%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Programme for International Student Assessment (PISA). (2009). PISA Results: Canadian

Students Score High in Performance, Canadian Education System Scores High in Equity. Retrieved from http://cdnsba.org/all/education-in-canada/pisa-results-canadian-students-score-high-in-performance-canadian-education-system-scores-high-in-equity

Sandholtz, J.H., Ringstaff, C., & Dwyer, D.C. (1997). *Teaching with technology: Creating student-centered classrooms.* Teachers College Press, New York, NY.

Sapontzis, S. F. (1995). We should not allow dissection of animals. *Journal of Agricultural and Environmental Ethics, 8*(2), 181-189.

Social Sciences and Humanities Research Council of Canada (SSHRC). (2012). Digital Economy Priority Area. Retrieved from http://www.sshrc-crsh.gc.ca/funding-financement/programs-programmes/priority_areas-domaines_prioritaires/digital_research-recherche_numerique-eng.aspx

Starry Night (2011) Retrieved from http://www.starrynight.com/

Wang, E, Myers, M. D. & Sundaram, D. (2012) *Digital natives and the digital immigrants: Towards a model of digital fluency. ECIS 2012 Proceedings.* Paper 39.

Watson, G. (2006). Technology professional development: Long-term effects on teacher self-efficacy. *Journal of Technology and Teacher Education, 14*(1), 151–165.

Windschitl, M. (2009). Cultivating 21st century skills in science learners: How systems of teacher preparation and professional development will have to evolve. *National Academies of Science Workshop on 21st Century Skills.*

Zirkel, P.A., & Barnes, M.B. (2011). Negligence liability of K-12 chemistry teachers: The need for legal balance and responsible action. *Journal of Chemical Education, 88*, 1057-1061. dx.doi.org/10.1021/ed100869z

Acknowledgement

The data reported in this paper is based upon work supported by the University of Manitoba UM-SSHRC RGP under Grant No. 36259. We thank the teachers across Manitoba for participating in this study.