Jaipal-Jamani, K., & Figg, C. (2015). A case study of a TPACK-based approach to teacher professional development: Teaching science with blogs. *Contemporary Issues in Technology and Teacher Education*, *15*(2), 161-200.

A Case Study of a TPACK-Based Approach to Teacher Professional Development: Teaching Science With Blogs

Kamini Jaipal-Jamani and Candace Figg
Brock University
CANADA

Abstract

This paper presents a case study of a technology professional development initiative and illustrates how a workshop approach based on technology, pedagogy, and content knowledge (TPACK) was adapted for professional learning at a school site. The case further documents how three middle school science teacher participants developed knowledge about how to teach with technology as they planned and implemented a blog activity in science over a 4-week period. The design of the professional development was informed by the underlying assumptions of the TPACK framework and characteristics for effective professional development for science and technology-enhanced teaching. To obtain insights into the particular experiences of teachers as they participated in the onsite professional development, a naturalistic case study design was used. Data collection procedures included researcher field notes during workshop sessions and lessons, videotaped classroom observations, audiotaped interviews, and teacher and student lesson artifacts. Data on teachers' planning and lesson implementation of the blog activity to Grade 8 students were analyzed using content analysis. Overall, the results indicate that TPACK is developed through a combination of workshop experiences and immediate application of knowledge gained in the workshop into practice in the real-life teaching context.

Many of the characteristics of effective professional development (PD), such as collective participation of teachers, onsite facilitation, sustained period of time, and a focus on problems of practice, have been identified in the literature (Borko, Jacobs, & Koellner, 2010; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; DeMonte, 2013; Hargreaves, 2003; Hung & Yeh, 2013; Ingvarson, Meiers, & Beavis, 2005; Jaipal & Figg, 2011; Riveros, Newton, & Burgess, 2012). At the same time, concerns have been raised about teacher professional development, especially the need to deepen teachers' knowledge of the subjects being taught, while keeping up with developments in digital learning environments made possible through ubiquitous access to digital tools (DeMonte, 2013; Johnson et al., 2013).

These concerns point to the need to reexamine the nature of the PD approach as related to digital environments and the types of learning activities included in such PD. Limited by logistical and financial demands, school boards commonly choose a workshop approach to conduct technology professional development in order to meet the demands of changing digital learning environments. However, these technology workshops are of short duration and focus on the demonstration of technical skills—promoting tool use rather than technology-enhanced teaching (Carlson & Gadio, 2002; Trucano, 2005).

Such an approach to technology professional development most often leads to technology skills being learned out of the classroom context, with teachers finding it difficult to connect the technical skills learned to subject area content and classroom practice and leading to questions about the value of the technology-enhanced instruction (Harris & Hofer, 2009; McKenzie, 2001). Research has shown that a high degree of technical competence in teachers does not necessarily translate into teaching with technology (Jaipal & Figg, 2010; Mishra, Koehler, & Kereluik, 2009). Hence, for a workshop approach to effectively promote technology professional development—in a way that changes teaching practice—the type of learning activities presented in the workshop is key.

Professional development, where teachers are taught how to teach with an appropriate tool to meet content learning goals (referred to as technology-enhanced activities and instruction), is more effective than teaching teachers technical skills (Harris, 2005; Hughes, 2005; Jaipal & Figg, 2010; Keating & Evans, 2001; Kereluik, Mishra, & Koehler, 2010; Lundeberg, Bergland, Klyczek, & Hoffman, 2003; Margerum-Leys & Marx, 2002; Niess, 2005; Zhao, 2003). In other words, technology workshops should develop teachers' knowledge about teaching with the technologies to promote student learning of content in instructional contexts (Glazer, Hannafin, Polly, & Rich, 2009; Harris, Mishra, & Koehler, 2009; Larson et al., 2009).

For example, situating the learning of technical skills in an authentic learning activity, such as learning how to use a graphing calculator to illustrate the linear relationship between force and mass of an object in science, provides a concrete example of how to use the tool in teaching. This type of learning how to teach with technology is considered a content-centric approach, and the teacher knowledge developed through this approach is referred to as technological pedagogical content knowledge (or, more recently, technology, pedagogy, and content knowledge [TPACK]; Mishra & Koehler, 2006).

In a comparative case study examining the nature of teacher knowledge influencing technology integration in instruction among four English language arts teachers of varying years of teaching experience, Hughes (2005) found that "content-focused learning experiences yielded content-based technology integration in the classroom" (p. 295). Hughes's findings also revealed that experienced teachers with less technology experience drew on their professional knowledge to develop innovative, technology integrated activities because “veteran teachers’ expertise can offer a subject matter or pedagogical-based focus to technology explorations that beginning teachers may not be able to do independently” (p. 299).

In essence, the actual use of technology in instruction was found to be influenced by teachers’ perceptions of the usefulness of the technology for content and pedagogy purposes (Hughes, 2005). Teacher perceptions of the usefulness of technology is a factor proposed by the Technology Acceptance Model (TAM; Davis, 1989). The TAM model explains how users accept and use technology in terms of three factors: perceived usefulness of technology, perceived ease of use of technology, and attitude toward using the technology.

Davis (1989) explained that, when technology is perceived as useful (enhancing job performance) and as easy to use (requiring the least amount of effort), these perceptions result in positive attitudes and intentions to accept and use technology. Perception of usefulness was found to be the major factor influencing adoption (Davis, 1993). However, Teo (2008) demonstrated in his survey of 139 preservice teachers that their attitudes and intentions to use computers were more positive than their perceptions of control of the computer and its usefulness.

Teo’s finding appears to contradict Davis’ notion of perceptions of usefulness and ease of use leading to positive attitudes and intentions. A possible explanation for Teo’s finding is that, in education, unlike in other fields such as business, teachers in many educational jurisdictions have autonomy in the design of instructional activities to meet curriculum goals leading to more flexible job performance. Hence, while preservice teacher experiences in their teacher education program contribute to positive attitudes and intentions toward technology use, prior learning experiences and practicum experiences may affect their perceptions of control of technology (e.g., lack of access and technical support) and usefulness of the technology for content and pedagogical purposes (e.g., lack of technology modelling as a pedagogical strategy in content area teaching by associate teachers; Grove, Strudler, & Odell, 2004; Lei, 2009). How can perceptions of the usefulness and ease of use of technology be increased so as to instill positive attitudes and intentions toward technology that are translated into instructional practice? Based on her study findings, Hughes (2005) recommended the use of a PD approach that engages a small group of teachers in the same subject area in content-based technology inquiry as an effective way for teachers to learn how to teach with technology.

Such an approach to PD builds teacher knowledge about how to integrate technology in content areas (TPACK), demonstrating the usefulness of the technology as a pedagogical strategy to meet authentic curriculum learning goals. As well, delivering the PD in a short period of time, preferably onsite, demonstrates the ease of use of the technology within the specific context needs and constraints of teachers and school boards (e.g., covering of curriculum expectations, meeting special needs of learners, meeting school board strategic directives, negotiating constraints of rotary teaching, and limited access to digital resources).

Extending the work of Mishra & Koehler (2006), we developed the TPACK-based Professional Learning Design Model (TPLDM) for technology workshops—a sequence of four learning activities to facilitate a content-centric approach to learning how to plan and implement technology-enhanced instruction (Figg & Jaipal, 2012; Jaipal-Jamani & Figg, 2013). The purpose of this paper is to present a case study of a PD initiative to illustrate how the TPLDM approach was adapted for professional development at a school site in order to support teachers as they plan and implement technology-enhanced activities/instruction in science.

The term *technology-enhanced activity and instruction* refers to the design of instruction that integrates an appropriate technology, as perceived by teachers, to meet curriculum goals. Teachers make decisions to select a technology based on their understanding of the affordances of the technology in terms of its usefulness for meeting the content or pedagogy learning goals (Hughes, 2005). Knowledge of the affordances of the technology as perceived by the teacher may be gained from experiences such as past teaching practice or PD workshops.

Technology-enhanced activity and instruction does not imply that instruction with technology is more effective than instruction without technology. For example, an instructional strategy such as an inquiry, hands-on investigation may be more effective for student learning of the science process skills of observation and measuring than a technology-enhanced instructional strategy. Our study built upon the recommendations of Hughes (2005) and provided specific insights on how a small group of teachers teaching the same subject from one school site learned how to use blogs to address content curriculum learning goals, in this case related to the Grade 8 science topic of fluids.

The study was guided by the following research questions:

- What are teachers' perceptions of the efficacy of the TPLDM to develop knowledge about technology-enhanced science instruction?
- How did teachers use the TPACK gained to plan and implement a blog activity to Grade 8 students to meet science learning goals?
- How did implementing the blog activity in an authentic context support development of TPACK?

This case study, therefore, reports on (a) the process of establishing and supporting a subject matter, technology professional learning initiative of three science teachers over a short duration, (b) teacher perceptions of their PD experiences and the TPACK gained about how to teach a science topic with blogs, and (c) the impact of the PD on participants' teaching practices during the study.

Whether the technology-enhanced activity leads to effective technology-enhanced teaching depends on the way the teacher implements the technology-enhanced activity for increased student learning. This paper does not make claims about technology-enhanced teaching in relation to student learning and is a limitation explained in the limitations section. Nevertheless, while generalizations cannot be made from one case of teacher professional development, our study findings add to the literature by highlighting the complexities involved in developing teacher knowledge about teaching with technology through the inclusion of a specific TPACK-based workshop approach, the TPLDM Workshop approach. As well, insights gained from our study can be used to adapt the TPLDM Workshop approach for designing professional learning initiatives in similar settings.

A review of the literature follows, which highlights current trends in three areas that inform the design and results of the study: developing teacher knowledge for science instruction, developing teacher knowledge for integrating technology in science instruction, and blogs in science instruction.

Developing Teacher Knowledge for Science Instruction

The dominant lens through which the development of science teacher knowledge is framed in the literature is the construct of pedagogical content knowledge (PCK; McCrory, 2008). Lee Shulman (1986) described PCK as “ways of representing and formulating the subject that make it comprehensible to others” (p. 9), and it includes knowing what conceptions and preconceptions diverse learners have about the topic that may make learning it easy or difficult. PCK enables teachers to make decisions about how they will represent and present content so students will understand.

Science education researchers have explored how PCK develops in science teachers (Appleton, 2008; Lee, Brown, Luft, & Roehrig, 2007) and have identified PCK related to particular science topics (Loughran, Mulhall, & Berry, 2004). As well, given the varied interpretations of PCK in the literature, researchers acknowledge that PCK is a complex construct. Nevertheless, Guzey and Roehrig (2009) described two characteristics of PCK that Lee et al. (2007) found were common to all interpretations:

> (a) teachers’ knowledge of student learning to translate and transform content to facilitate students’ understanding and (b) teachers’ knowledge of particular teaching strategies and representations (e.g., examples, explanations, analogies, and illustrations). (p. 28)

In essence, these two common characteristics of PCK are consistent with and reinforce Shulman’s (1986) original definition of PCK. Research shows that PCK is developed from the practical experience of teaching and grows over time (Lee et al., 2007). Teachers do not enter the field with a developed sense of PCK; teachers learn about what issues, representations, analogies, and so forth, make a topic easy or difficult from their direct experiences teaching learners of diverse abilities and backgrounds. Therefore, Lee et al. (2007) suggested that professional development of PCK in science is more effective when situated onsite, within the teaching context.

Furthermore, since PCK is foundational for effective science teaching and develops in practice, a major component of science professional development that is successful in generating teacher change is “classroom support that enhances the teachers’ science PCK” (Appleton, 2008, p. 542). In Appleton’s study, elementary teachers were provided with onsite mentoring support and “according to the teachers, the more formal orientation sessions did little to influence their teaching, whereas the regular classroom support had a significant impact on helping them review and change their science teaching practice” (p. 538). The latter finding suggests that a critical component of any onsite PD approach is some form of mentoring during classroom implementation to facilitate tangible changes to teacher practice.

Besides mentoring during classroom teaching, Loughran et al. (2004) found that PD focused on developing teacher knowledge of how to teach a science topic (PCK) should take into account the individual and collective viewpoints of teachers in relation to the content. The PD they provided to science teachers in their study engaged teachers as individuals and as a group to discuss and plan pedagogical strategies to teach the science content. Their study revealed that PCK does not reside solely in individual teachers; different aspects of PCK are also revealed from the collective or groups of teachers. Hence, effective science PD provides opportunities for groups of teachers to share and develop PCK.

Research also shows that PCK is topic and context specific in science (McCrory, 2008). The representations and particular ways of presenting content are different for different topics and may also change, based on the needs of individual student learners (e.g., prior knowledge, misconceptions, and language abilities). As such, science PD that develops PCK around teaching a particular topic while considering the specific conditions of school context may be more effective than developing PCK about a variety of topics at the same time—an idea supported by evidence from research investigating teachers' PCK, in which teachers self-selected a specific content topic when discussing PCK development (Loughran et al., 2004).

In summary, the science education literature indicates that some of the characteristics for effective professional development of PCK in science teaching include onsite mentoring during teaching, individual and collective or group planning experiences, learning activities focused on teaching one topic, self-selection by teachers, and authentic teaching practice in classrooms.

Developing Teacher Knowledge for Technology-Enhanced Science Instruction

Mishra and Koehler (2006) described TPACK to highlight the integral role of content in teaching with technology in educational settings. Their model built upon Shulman's (1986; 1987) theory of teacher knowledge, in which teacher knowledge encompasses a number of categories of specific teacher knowledge (e.g., PCK; knowledge of learners and their characteristics; and knowledge of educational contexts). The knowledge required for successful technology-enhanced teaching (TPACK) is situated within PCK, "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (Shulman, 1986, p. 8).

The TPACK model proposes that teacher knowledge of the complex interactions between content, pedagogy and technology, referred to initially as technological pedagogical content knowledge, is necessary for effective teaching of content with technology. This model has resulted in technology educators and researchers reconceptualizing how knowledge about technology-enhanced teaching is learned. For example, Harris et al. (2010) developed a categorization of activity types that link learning activities specific to different subject areas with appropriate technologies, providing knowledge about lesson design of technology integration in teaching in different content areas. An illustration of an activity type identified in science is data analysis, executed by technology such as spreadsheets.

In science education contexts, Jimoyiannis (2010) applied the TPACK framework to science content to develop the TPASK curriculum (*content* replaced by *science*). The TPASK curriculum represented the knowledge components specific to science (e.g., technological science knowledge [TSK] and technological pedagogical science knowledge [TPASK]) needed to integrate technology in science education. This curriculum was taught in an in-service PD course over a 4-month semester to prepare high school teacher mentors to integrate technology in science instruction.

The effectiveness of the curriculum to develop TPASK was evaluated by interview data from four specialist high school teacher participants. Engaging in an authentic classroom task led these teacher participants to progress beyond "viewing technology integration through a simple skill based lens (e.g., presentation of simulations or other tools through a video-projector)" to thinking about how to effectively integrate technology into science content for student learning (Jimoyiannis, 2010, p. 1267). This finding reinforces the notion of a content-centric approach being an effective way to develop technology-enhanced teaching in content areas (Mishra & Koehler, 2006; Niess, 2005).

Another important finding of the study by Jimoyiannis (2010) was that the difficulties the secondary science teachers experienced integrating technology in practice was influenced by the educational context (e.g., curriculum coverage, exams, and insufficient prep time). Hence, the author proposed the addition of a fourth component, educational context be added to the TPASK model and be considered when designing technology PD for science teachers.

McCrory (2008) proposed another approach to technology professional development in science contexts. She identified four different types of knowledge relevant to developing TPACK for teaching science with technology: knowledge of science, students, pedagogy, and technology. Using McCrory's framework, Guzey and Roehrig (2009) conducted a case study of a professional development initiative to develop TPACK among in-service science teachers. Data were collected from four of the science teachers who participated in a 2-week summer course. Teachers then completed an online action research course, which included online discussions and face-to-face, off-school-site meetings through the school year.

Guzey and Roehrig (2009) found that two critical factors, school context and pedagogical reasoning, affected teachers' development of TPACK. Examples of contextual constraints in their study were availability of technology tools and student characteristics. Teachers' pedagogical reasoning (reasons for instructional decisions) was reflected in their practice and was influenced by knowledge of instructional strategies and students, purposes for teaching, and conceptions of science. The researchers noted a limitation of the study was not being able to address issues related to school context during the summer course. Guzey and Roehrig found it was "necessary to provide teachers follow-up assistance during the time when they were designing and implementing their technology-enriched lessons and action research projects" (p. 41). In their study, this support was provided through online and some face-to-face meetings during the action research course.

In light of the discussion on characteristics of effective science PD, Guzey and Roehrig's findings reinforce the importance of mentoring during the classroom implementation process for technology PD as well. In this way, issues related to school context and technology are considered by teachers when pedagogical decisions are made about how to teach science with technology to meet the needs of their particular learners. Other research (Appleton, 2008; Higgins & Spitulnik, 2008) has shown that onsite social supports, such as mentoring and facilitated work groups, also foster teacher conversations and teacher collaboration and support teachers in the integration of technology effectively in science instruction.

In summary, the literature shows that effective PD for technology-enhanced science instruction is characterized by the following components:

- Adapting for the educational and school context in which the instruction will take place (such as school board directives, curricular constraints, access to tools, and student diversity/meeting needs of students).
- Providing an authentic technology-enhanced, content-based task (e.g., a task that promotes learning goals for students and uses technology available in the school).
- Providing individual and group mentoring to teachers as they plan and implement the technology-enhanced activity (building TPACK through sharing as the teachers plan and implement).
- Conducting professional development onsite (e.g., at the school to facilitate planning that takes into account the school and teaching context and enables reflective feedback during the implementation).

These characteristics were taken into consideration when designing the PD initiative we carried out in this study.

Blogs in Science Instruction

The call for instruction that engages students in learning activities that enable them to collaborate, construct, and communicate knowledge is articulated in the most recent report from the United States, entitled *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* (National Research Council [NRC], 2012). This NRC report outlines new standards or a"vision of the scope and nature of the education in science, engineering,and technology needed for the 21st century" (p. 8). The essential practices for science education outlined include asking questions, constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Additionally, some of the skills identified as necessary for competence in the 21st-century workplace include collaborative knowledge building, skilled communication, skilled use of ICTs (information and communication technologies), collaborative team work, critical thinking, and innovative real-world problem solving (Microsoft Partners in Learning, 2011; Partnership for 21st Century Skills, 2011).

To promote the development of the recommended practices of science and 21st-century learning skills, the affordances of Web 2.0 tools such as blogs can be harnessed (Luehmann & Frink, 2009). Many affordances of blogs for student learning in K-12 and higher education contexts have been espoused in the literature. Robertson (2011) viewed blogs as supporting students' writing by providing a safe "learning community," which offers "opportunities for collaborative learning" (p. 1628).

Ferdig and Trammel (2004) purported that blogs "provide a space for students to reflect and publish their thoughts and understandings. And because blogs can be commented on, they provide opportunities for feedback and potential scaffolding of new ideas" (p. 2). Huffaker (2005) illustrated how students in elementary and high schools used blogs to practice reading and writing to support the development of language skills.

Within science education, Sawmiller (2010) explained the many ways that blogs can be used to support science learning, including providing opportunities for collaboration, increasing motivation, enhancing critical thinking skills, and supporting differentiated instruction. Brownstein and Klein (2010) proposed a set of procedures for effective implementation, which included having a clear purpose for the blog (e.g., constructing knowledge, commenting, or writing), having structure in the form of clear guidelines often provided by assessment rubrics, and providing examples. Additionally, Luehmann and Frink (2009) outlined several learning affordances of blogs for science teaching developed from a literature review that included supporting construction of scientific explanations and using peer feedback to develop scientific explanations. This literature described the affordances of blogs and benefits for learning subjects like language and science. However, these reports have not provided empirical evidence to illustrate claims about the effectiveness of blogs for learning in classrooms. A few recent studies have sought to examine the effectiveness of blogs for student learning.

Du and Wagner (2007) investigated the effect of weblog use on learning in a university undergraduate business course. Their findings showed that the "weblog performance can be a significant predictor of the students' learning outcome (i.e., exam performance) and possibly a better predictor than traditional coursework." (p. 10). Their findings also suggested that written posts and comments provided explicit evidence of students' cognitive and social construction efforts and, hence, weblogs could be used to assess student learning of course content.

In another study on the value of blogs for student learning, Deng and Yuen (2011) proposed a constructivist-based learning framework to analyze the affordances of blogs for supporting learning. Participants were bachelor of education degree students at a university in Hong Kong majoring in English. Deng and Yuen’s framework described learning as involving four processes: self-expression, self-reflection, social interaction, and reflective dialogue. Accordingly, they investigated how blogs supported these social and cognitive processes during a teaching practicum. Their findings indicated that blogs fostered emotional and social self-expression and self-reflection. However, blog commenting was characterized by more social support rather than reflective dialogue. A possible explanation for the latter finding may be that in this study students received minimum guidelines on how to structure responses.

In a recent quasi-experimental study on blogs and writing, with and without instructional support through prompts, Petko, Egger, and Graber (2014) found that the group provided with prompts achieved greater learning gains than the group writing without prompts. Additionally, they found that a larger number of those writing from the prompt group revealed the use of metacognitive and cognitive strategies. Petko et al.’s findings suggest, that while blogs afford a shared space for writing, sharing ideas, and receiving feedback on ideas, producing writing to reflect learning and understanding of content is enhanced through the use of instructional prompts. Hence, these findings point to the need for teachers to incorporate pedagogical strategies during blog activities, to help students focus on relevant information and organize their ideas into coherent forms of knowledge. Petko et al.’s findings are consistent with the results of a meta-analysis of scaffolding research showing that scaffolding instruction is effective for student learning (van de Pol, Volman, & Beishuizen, 2010).

Methods

Since the intent of this study was to gain insights into how participants experienced learning to design and teach with technology through a TPACK-based professional development approach at a particular school site, a naturalistic case study design was used (Creswell, 2009; Erlandson, Harris, Skipper, & Allen, 1993; Yin, 2009).

Yin (2009) stated that “a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context” (p. 18). He further explained that cases can be of individuals, processes, programs, or events and often highlight a decision, or set of decisions, related to the phenomenon, such as the process teachers underwent to build knowledge about teaching with technology, as explored in this study.

The purpose of the case is not to generalize findings to a larger population, but to present a rich description of the phenomenon under study from which others can examine and draw inferences. The case is not a sample, and as Merriam (2002) asserted, “The general lies in the particular; what we learn in a particular situation we can transfer to similar situations subsequently encountered” (p. 28). Hence, “reader or user generalizability” is one way of how case study findings can be applied to other contexts (p. 28). Another way to generalize from a case study is when findings “expand and generalize theories (analytic generalization)” (Yin, 2009, p. 15).

Thus, the development of theoretical propositions or frameworks supports case study research because it guides data collection and analysis (Yin, 2009). Validity or credibility of case study research is achieved through triangulation methods such as multiple data sources and multiple investigators (Merriam, 2002) rather than a large sample size.

The bounded case in our study was the TPACK-based professional development initiative that occurred over a period of 4 weeks at the school site. The inner-city school had a culturally diverse student population. Teacher participants were three female Grade 8 teachers; two teachers taught science in English and one taught science in French. All teachers were in their first 5 years of teaching, with some to limited experience with using blogs for classroom instruction. The professional development initiative, which was facilitated by an educational technology educator (author Candace Figg) and a science educator (author Kamini Jaipal-Jamani), consisted of the following:

- Two just-in-time workshops (support based on participant learning needs) at the school site for teacher participants (the authors with three teacher participants in 3-hour sessions each).
- Mentoring and feedback sessions, prior to, during, and after classroom implementation of blogs in science instruction (university facilitator observed each participant teaching two 80-minute sessions each, and coached during, before, and after lessons).
- Teacher collaborative planning sessions during lunch and after school (with only the teacher participants in three, 2-hour sessions).

The three teachers made a collaborative decision to develop an instructional activity where blogs could be used to research and explore the applications of fluid mechanics, the next topic they were to teach.

Data Collection and Analysis

Qualitative methods were used to collect data (Creswell, 2009), and the appropriate ethics approvals to conduct research with human participants were obtained. We recorded field notes during the two face-to-face professional learning sessions and audiorecorded selected portions of the facilitation and discussion. Field notes were also recorded during the six classroom observations, and selected excerpts of lessons were video recorded.

Informal discussions with teachers before lessons and debriefing sessions after lessons were audio recorded. Individual preinterviews and a final, individual postinterview were conducted with the three teachers, and three focus group interviews were conducted with 12 students in total. Finally, teacher planning resources and artifacts and student blog entries were collected. These multiple sources served to triangulate data and provide validity for participants' views and actions. Some of the classroom observations and all formal interviews with teachers were conducted by a research assistant to minimize the effect of researcher-participant power relations.

According to Yin (2009), an analytic strategy should guide the development of the case report. We used theoretical propositions from the literature to create a list of codes, such as school context (resources to be used and school directives such as literacy across the curriculum), process (how the activity was planned and implemented), and social relationships (collaborative elements and individual interpretation), from which the data were unitized (Creswell, 2009). This strategy allowed us to identify common patterns, or categories, related to the codes. The actual process involved each of us (the authors) independently reading transcripts of field notes and interviews and coding using the a priori list of codes. Themes were then derived from the categories that emerged and used to construct the case report. The process of coding for themes independently by each of us provided intercoder reliability (Creswell, 2009).

As with any research study, there were methodological limitations to this study. The use of one school site did not enable cross case analysis. However, we chose to work at one site for this first adaptation of the workshop approach to a school site. The study served as the pilot for future large-scale studies. The PD was not sustained over a long period as recommended by the literature, because the duration of the study was limited to the length of the blog activity, which took place over a period of 4 weeks. As such, the PD was conducted to follow through on the planning, implementation, and reflection of the blog activity.

As well, the number of onsite PD sessions was determined by the needs and contextual constraints of the teachers. Teachers indicated that they did not require further formal workshop sessions, as they preferred to complete their planning by collaborating with each other after school. They were also constrained by the need to complete other learning goals in the science curriculum so could give up class time only to attend two formal PD sessions. However, mentoring with teachers occurred more informally as we observed and engaged in discussions during the blog implementation over the 4-week period.

The TPLDM Workshop

In a series of longitudinal studies we identified characteristics and actions that teachers used during elementary teaching practice to demonstrate TPACK (Figg & Jaipal, 2011; Figg & Jaipal, 2012; Jaipal & Figg, 2010).

We found that the main characteristics and actions demonstrating TPACK in the practice of teaching (Jaipal-Jamani & Figg, 2015, as summarized in Table 1) were related to the following three components of the TPACK model:

- Technological pedagogical content knowledge (TPCK): the interaction of technological knowledge (TK) with pedagogical content knowledge (PCK).
- Technological content knowledge (TCK): the interaction of TK with content knowledge (CK).
- Technological pedagogical knowledge (TPK): the interaction of TK with pedagogical knowledge (PK).

Our research further indicated that teaching the specific characteristics and actions of these three knowledge components to teachers promoted transfer of knowledge into teaching practice (Jaipal-Jamani & Figg, 2013; see Table 2) and is similar to what other studies have found (Angeli & Valanides, 2008; Lock & Redmond, 2010). We also found that four different types of workshop learning activities were particularly useful in promoting the learning of these characteristics in practice (Figg & Jaipal-Jamani, 2013).

Table 1
The Components of TPACK-in-Practice

Component	Characteristics and Examples of Teacher Actions in Practice
Technological Pedagogical Content Knowledge (TPCK-in-Practice)	Knowledge to match models of teaching appropriate for content to appropriate technology. Two characteristics supporting this are: 1. Knowledge of a Repertoire of Technology-Enhanced Activity Types such as WebQuests, spreadsheets, simulations to represent different Content Knowledge and skills. Teacher Action: to select most appropriate activity type to teach and represent the content learning outcome. 2. Knowledge of Content-based Models of Teaching such as inquiry or problem based model appropriate for the technology-enhanced Activity Types. Teacher Action: select appropriate model of teaching for technology enhanced instruction
Technological Content Knowledge (TCK-in-Practice)	Knowledge to use content-appropriate technologies or cross-disciplinary technologies in instruction, and the personal competence to use these technologies to achieve specific subject matter goals or learning outcomes. Characteristics are: 1. Knowledge of content-appropriate technologies. Teacher Action: Match appropriate technology or repurpose technology to achieve content learning goals. 2. Competence with content –appropriate technologies. Teacher Action: Identify technical skills and personal competence for effective technology use
Technological Pedagogical Knowledge (TPK-in-Practice)	Knowledge of practical teaching competencies (i.e., activity choices, organization, assessment, differentiation, classroom management) <u>during planning and implementation of tech-enhanced lessons</u>. Examples of some characteristics are: 1. Activity choices. Teacher Action: select technology-enhanced activity types based on content learning outcomes. 2. Sequencing. Teacher Action: include technology and content skills into the lesson and unit. 3. Differentiation for technical competence. Teacher Action: introduce few technical skills in a lesson. 4. Modelling technology use to and for students. Teacher Actions: model technology use through teacher created exemplars and student modeling of skills in content examples.

Table 2
Discussion Phase: TPK Aspects to Consider When Planning

Questions To Consider When Designing the Science Task	Examples
What is the most appropriate activity type to meet the science learning goal (concepts, skills, tasks) that you want students to focus on?	Internet research and blog comments to explain applications of content and communicate through writing, online lab simulation and wiki group report to demonstrate inquiry skills and data charts
How do you want students to communicate, organize or sequence their responses using the technology?	Written posts, diagrams, symbols, simulations, pictures, hyperlinked websites
How will you differentiate for student learning when using the technology?	Add information links, post technical tutorials, use graphics, add series of questions
How will you assess student learning using technology?	Rubric, checklist

Other studies have also shown that these four activities support knowledge building around teaching with technology, so that teachers are able to transfer what they learn and adapt it for their own teaching situations and student learning needs (Angeli & Valanides, 2009; Niess, 2011). For example, Angeli and Valanides (2009) found that authentic tasks developed TPACK. We combined the four learning activities into a four-stage, professional development workshop, the TPLDM approach (Figg & Jaipal-Jamani, 2013).

The four activities, or stages, are as follows:

- Modeling a technology-enhanced activity type (learning with the tool) to set the context and purpose for tool use,
- Integrating pedagogical dialogue in a modeled lesson (discussion of pedagogical and context factors such as student needs, management, and access to technology),
- Developing activity-specific technical skills through short tool demonstrations, and
- Applying TPACK to the design of an activity adapted to a specific content area or teaching context.

Examples of how each stage can be applied in a PD workshop are discussed in the case report that follows.

Findings

This case study report begins with a description of the professional development setting and the four learning activities of the TPLDM Workshop approach, as adapted for teaching science content in this school context. We then report teacher perceptions of the knowledge they gained through participation in the TPLDM-based PD learning activities with supporting evidence. Finally, the professional learning experienced by the three teachers as they implemented the blog activity is presented. The complex nature of PD—including the successes, frustrations, and knowledge learned about how to teach science with blogs—is highlighted.

Professional Development Setting and Learning Experiences

The importance of adapting any type of professional development to meet the needs of the teaching context (including curricular needs, directives from the school boards or school sites, and learning needs of the participants' own students) has been clearly established by the research. Therefore, when designing the professional development for the in-service teachers participating in this study, the TPLDM Workshop approach was adapted to address the unique contextual features experienced by this group of teachers. For example, the development of literacy and numeracy across the curriculum, one of the Ontario Ministry of Education's (Ontario Ministry of Education , 2015) strategic directives, was emphasized by the school board as a top priority for all teachers. Therefore, the teachers in this study were looking for science professional development on a technology that would address both science and literacy learning goals.

The participants in this study were familiar with ways blogs could be used to support literacy goals, especially the affordances of blogs to communicate ideas by writing and publishing and to enable the reading of other students' writing. We provided participants with articles on blogs to further their knowledge of the affordances of blogs, in general, and in science (Brownstein & Klein, 2010; Huffaker, 2005). Based on this background reading and discussions with us, the blog was selected because of its affordances for ease of use for researching topics and usefulness for enabling the sharing of information and provision of feedback in one shared classroom online space. Blogs were also seen as logistically feasible to use because of the accessibility from multiple sites and the availability of hardware resources at the school. Teachers had access to laptops for pairs of students to use in class, and the majority of students had access to the Internet at home.

Another consideration for the adaptation of the TPLDM Workshop approach was that the workshop be conducted at the school site. Teachers preferred to have the workshops conducted during the time when they were going to plan and teach this curriculum and at a time and place convenient for all three teachers to learn collaboratively without losing teaching time with their students. A more formal workshop presentation usually occurring for a larger group of teachers on a PD day was adapted for a smaller audience in a more informal setting—a computer classroom at the school.

Professional Workshop Session 1. The four learning activities of the TPLDM Workshop approach were adapted for the first professional workshop session, as follows:

Phase 1: Modelling a technology-enhanced activity type. Our prior research showed that modelling a repertoire of technology-enhanced activity types developed knowledge of how to teach content with technology (Figg & Jaipal-Jamani, 2013; Jaipal-Jamani & Figg, 2015). We first showed participants a variety of activity types (e.g., blog-based journaling activities, Internet research activities, article critique activities, or project showcasing activities) to meet different learning goals. As the participants in this study were somewhat familiar with the capabilities of blogs in literacy, the science educator discussed how blogs were used in science instruction (e.g., to meet the science learning goals of communication and application skills) and modeled one blog activity for teaching content in a Grade 5 science class that could be adapted for Grade 8. Teachers were also provided with examples of other authentic classroom applications for the use of blogs in teaching science content.

Phase 2: Engaging in pedagogical dialogue. This phase of the workshop involved a discussion of how pedagogy and technology interacted when planning and implementing a technology-enhanced science activity. Questions engaged participants in a discussion of aspects and issues to consider when teaching science with blogs in the classroom in order to develop their TPACK. The questions specifically targeted teacher actions while teaching with technology, which were representative of the components TCK, TPK and TPACK (Jaipal-Jamani & Figg, 2013). For example, the discussion highlighted TCK about how blogging tools would support the science Grade 8 learning goals, TPK about classroom management strategies for students during the classroom implementation of the blogging activity and ways to differentiate and assess this type of instruction, and TPACK about how to design an appropriate technology-enhanced activity that promotes science concept learning while developing literacy skills. The discussion was guided by four questions (as shown in Table 2 with sample responses).

Phase 3: Tool demonstration. The pedagogical discussion in the previous phase acted as a segue to the activity in the workshop, where the technology educator demonstrated, step by step, the skills required to use blogs effectively. Participants were taught the minimum technical skills required, which were creating a blog, linking to articles and websites, linking within message posts, writing posts, and commenting on posts. Then, participants created a blog for the science activity and learned technical skills in an authentic context (TCK).

Phase 4: Collaborative planning to develop a practice task. Teachers were then given time to collaborate and make decisions about what the common blog-enhanced science activity would be that they would implement in all of their Grade 8 classes. We supported teachers in this process. Using the Grade 8 curriculum and science textbook, teachers selected specific content learning outcomes and a task or activity that would lead to the learning outcomes. Within the Grade 8 fluid mechanics unit, the learning outcomes selected were (a) investigating applications of fluid mechanics and (b) communicating scientific information. The task agreed upon by teachers was guided Internet research to explain the application of fluid mechanics in an industry to be communicated through a blog post.

Thereafter, teachers worked individually on computers to research resources related to the task, such as websites and articles that could be shared with students in blog posts. To prompt reflection about how technology, pedagogy, and content interact, teachers used a written planning guide to plan and develop the technology-enhanced science activity (see Appendix A).

Professional Workshop Session 2. The second session took place a week after the first professional learning session. In the interim, teachers had worked collaboratively after school to discuss lesson design. For example, teachers agreed on a common question that would guide student research and, based upon prior teaching experience with a range of students with diverse learning needs, agreed to use a graphic organizer to assist students in organizing ideas that would become the content of the blog comment task. Teachers also agreed on the rubric they would use to assess both science content learning and literacy skills.

During the second professional learning session, teachers worked independently to build their individual class blog sites, writing the message posts to guide student research, importing pictures and videos, and creating resources hyperlinks (see appendixes B, C, and D). In this workshop, we were present as facilitators to provide pedagogical and technical support as teachers required assistance. Teachers also got feedback from each other on blog design.

Mentoring and Debriefing Teachers' Classroom Implementation. Short debriefing sessions with teachers occurred before and after their teaching of the blog activity to engage teachers in pedagogical reasoning about their decisions for the lesson design. During classroom teaching, we were available to support the implementation process as needed. Feedback on the lesson after implementation provided an opportunity for teachers to reflect on the lesson and discuss any issues that arose, as well as any subsequent modifications needed.

Teacher Perceptions of the Efficacy of the TPLDM Workshop Experiences

Three main themes emerged about teachers' perceptions of the knowledge they gained about technology-enhanced science teaching from their experiences in the TPLDM Workshop PD.

Theme 1. Authentic, content-focused learning experiences within the TPLDM Workshop transformed theoretical ideas into practical understandings. The TPLDM Workshop was valued by participants because it engaged them in authentic, content-focused learning experiences about technology-enhanced teaching in three ways. First, teachers indicated that modelling of technology-enhanced science activity types for classroom use that are appropriate for accessing through a blog—such as resource exploration activities, Internet research activities, and article critique activities—by workshop facilitators was important for building their knowledge of how to teach with blogs.

When asked to explain the most important knowledge they gained from the professional development sessions, they stated that knowledge related to the practical application of blogs in the science classroom for student learning was most beneficial.

> Having the [modelling activity] was the most beneficial or most helpful because...[there was] someone telling me, "You can do this; here's how; here's some examples." (Daley)

> The most important knowledge and skills I gained are to be able to set up a blog, [and] know how my kids can use it. Because again it can be conceptual, like, "Oh yes, I'd like to do that," but I don't know how it's going to work in my class. I don't know what it's going to look like, and can the kids access it well and really know what to do, and all of that sort of thing. So it wasn't just a theoretical idea. (Pat)

> Second, modelling a repertoire of blog-based science activities provided an authentic context for the next phase of the workshop. Discussion of the pedagogical issues related to planning and implementing blogs as a technology-enhanced science activity occurred around real applications of blog activities in a science classroom, as opposed to a hypothetical general class. Topics in the discussion targeted practical pedagogical issues, such as classroom management and grouping of students associated with a science classroom. This discussion enabled them to analyze how they would implement their own science lesson design that incorporated blogs.

> I think realizing how it's useful in the classroom setting and all of us being together throwing ideas off one another—that was all important—and focusing specifically on how to use it for the classroom. I think that was probably new knowledge and understanding. (Daley)

> I thought through what the students would need to know to be success [sic], what I was looking for from them, what my expectations were, so that they would be clear on what they were to produce and how they were going to engage in the activity. (Pat)

Finally, the third phase of the workshop involved learning the technical skills required to create the blog-based activity. During the technical skill demonstration phase, the sequencing of a few, just-in-time technical skills in step-by-step, doable chunks was perceived as useful.

Both the professors definitely guided us through the whole thing and helped us figure out how to make a blog, which blog to use or which blogspot to use. As well, the process was very simple, and it was easy enough for me to follow along to be able to create a blog, which was great. So it was a step-by-step process, and I thought it was really well communicated and easy to follow. (Sharon)

Overall, the vibe was so positive, like, "You can do it. It's okay." I didn't feel that our questions were too elementary or we should have known more. I really appreciated being taken where I was at—"Okay, I don't really know anything about this"—and being led through the process. (Pat)

These responses suggest that for these participants the sequence of the phases of the TPLDM Workshop approach, especially the modelling of authentic, science classroom-based blog activities, scaffolded learning about how to design and implement blog activities in their science instruction.

Theme 2. **Onsite professional learning supported collaborative coplanning and individual implementation.** Workshops were held at the school site. Participants indicated that holding professional development workshops onsite enabled all of the science teachers to participate and collaborate together. Participants felt that opportunities for guided, collaborative discussions assisted them in coplanning and making decisions about the types of activities, resources, and content learning outcomes that would work well with blogging technology.

> I really just enjoyed trying to figure out which blog would probably work best for our activity, so making sure that there was a blog that enabled the kids to be able to comment on each other, as well as even just going over the articles as a group to figure out which articles would probably be best suited for the students, that was very helpful because we didn't even know where to start from that point. (Sharon)

Although the teachers planned a common blog learning activity, the relationship that existed between them due to teaching at the same school site and in the same subject area gave them a comfort level that allowed them to individualize and implement the activity for their own classes and according to their individual teaching styles: "We put our heads together in coming up with the blog site that we were going to use and the assignment itself but how we were going to instruct it—from there we did on our own" (Pat).

Participants indicated that the professional learning experience was relevant to the situations in which they taught. Hence, participation in the PD experience that was onsite supported collaborative coplanning and individual implementation.

Theme 3. Just-in-time technical, pedagogical, and content mentoring enabled transfer of new TPACK immediately into participants' practice. Teachers stated that their participation in a hands-on application task (Phase 4: Collaborative planning to apply TPACK in a practice task) with facilitator support was "hugely" beneficial.

> It was great to be able to be hands on with it all. It would not have been as beneficial, I think, had it just been presented as, "Here's what you can do and here's some ideas and here's some examples." (Pat)

> I found that you both really sold the blogging to us. You made us go online. I really like that because we went right onto the computers while you were there, and you had us get started. Just that was very helpful because afterwards, when we had the articles found and when we were on a roll, then it was much easier. (Sharon)

The depth of knowledge developed from the experience was enhanced with pedagogical mentoring. During this time, teachers used the written planning guide (see Appendix A) to discuss ideas on lesson planning and worked on computers to create their science blog lesson activity. Any science content support required was provided by the science educator and other science teachers, and technical support was provided by the technology educator.

> It made it doable instead of it being an idea like, "Oh yeah, I should do that, but there is so much to learn. I don't know how to get started. I don't know what to use." And then it becomes, "Okay, I'll get to that sometime when I have time." So having someone hands on for a period of time, being released for that time and actually being able to get set up and started is huge. (Pat)

> For sure to have professional development time—we had the afternoon basically where someone was walking us through how practically to create a blog. I think with all of that—we were given a lot of tools in that afternoon—and just even time was a huge tool. [It] was most beneficial to have people kind of standing behind you as you're creating and as you're in there trying to create your blog. That was the most helpful part, I would say. (Daley)

Just-in-time technical, pedagogical, and content support during the workshop and applying that knowledge through creating a technology-enhanced learning activity to be used with their students transformed an abstract teaching idea into a doable plan in practice. Additionally, engaging in a concrete activity assisted teachers in making the connection between the abstract TPACK and teacher actions in practice.

Professional Learning Through the Practice of Teaching: Three Teachers' Experiences

The following section describes the professional learning participants' experienced through the act of teaching the technology-enhanced blog activity, planned during the workshops. Although the three teachers designed the lesson activity collaboratively, implementation of that lesson design differed between the teachers. In this section, we first describe how each teacher implemented the blog activity. Then, we present a thematic analysis of their perceptions of the knowledge about technology-enhanced teaching they developed through this process.

Teaching the Blog Activity: Pat's Experience. Pat began her introduction to the blog activity by asking students about their prior experiences with blogs. She explained the blog to them as "a diary on the Internet." While students logged into the school portal using laptops provided to each student, she showed an advanced organizer on the SMART Board which read "WALT" (What are we learning today?) to introduce the topic, Application of Fluid Mechanics. The slide had pictures linked to videos showing fluids in action in real life, such as a speedboat and flying golf balls.

Students were excited and responded with comments such as, "Wow," and "Check this out." She also showed the relevance of these applications to careers. Then, she introduced the second learning goal for the lesson, Communicating Scientific Information, with the audience being the class members communicating via a blog.

She introduced "WILF" (What am I looking for?), which consisted of the expectations for the blogging activity—researching the topic to be able to respond to questions on her blog through comments. She showed them the questions on her blog and told them to read her blog post and answer the questions there by replying. Next she introduced "HOWDI" (How will I do it?) and had originally planned to introduce three steps students would complete during this period. However, prior to the lesson and after talking to author Jaipal-Jamani, she made the decision to introduce only two steps in the process during this class period, as the three steps of the process would have been too many for students to comprehend and complete.

First, she explained to students that they would be using a graphic organizer (provided on a handout) to collect information about applications of fluids and related industries. She provided examples for many of the industries students could research (e.g., medicine, construction, aeronautics, sports, and food) and modeled how to fill in the graphic organizer for the students with an example she had prepared (in which the industry was medicine and blood flow was the application).

The second step of the learning activity was for students to log into her blog site and post a comment in response to the questions on the blog (see Appendix B). She then showed them an example post she had already added to the blog to show how to change the information (called jot notes), collected through the five areas of the graphic organizer, into five paragraphs that were posted as a response to the questions on the blog.

For the rest of the class period, students then individually chose an industry from the list she provided, used the hyperlinks on the blog related to that application/industry for three areas of interest in that application and related careers, and filled in the graphic organizer by jotting down notes onto the print copy of the graphic organizer (to prevent plagiarizing by cutting and pasting).

Students continued with the activity in a second, follow-up period, completing the graphic organizer and posting to the blog. Pat moderated the posts (reviewed the messages) before they could be published on the blog. The activity continued into a third period, where replying to posts was introduced.

Teaching the Blog Activity: Sharon's Experience. Sharon's lesson started with a question to students asking if they were familiar with blogs. She discussed how a blog was similar to YouTube, with respect to posting comments to videos uploaded by other people. She reviewed knowledge discussed in the previous class about the properties of fluids and, as an example, explained how fluids affect artificial hearts.

An LCD projector was used to project her blog that she created for this activity, and she introduced the blog by having students read the information on fluids aloud. Then she explained the task students would be completing by going over the content questions posted on her blog and pointed to the links on the blog of the different applications of fluids. The link to information to the artificial heart was used to illustrate two careers related to this application (e.g., the heart surgeon and the industry that makes the artificial hearts). She also explained what they were required to do: create a post and reply to messages posted by two other classmates. Posts would also be approved before they could be displayed on the site.

Students were then given a print graphic organizer (a series of questions) and told to use it to summarize the information learned from their research. Sharon then went on to demonstrate how to fill in the organizer by retrieving information about the application of a water blaster from a link on her blog. Students were asked to use MS Word to summarize their jot notes into a good post.

Sharon modeled the content expectations and technical skills required for the task by showing an example of an appropriate message that she had created on her blog about the application of body armor/protection. She then showed an example of replies to her post and demonstrated how to reply using the reply tab.

Students worked on their laptops individually to research applications from the list presented on her blog and spent the remainder of the period filling in their organizer and creating draft posts. Toward the end of the period, Sharon realized that students did not have enough time to complete researching, writing a post, and replying to posts from classmates. She modified her instructions to students, telling them to focus on researching their topic and creating their post. She also explained that they should create their posts directly on her blog, rather than writing it out in MS Word and cutting/pasting. In the second lesson, Sharon retaught how to create a post as well as how to reply to classmates' posts. Students worked during the second class session completing the activity.

Teaching the Blog Activity: Daley's Experience. Daley taught science in the French language, and all written information and oral instructions were communicated in French to students. Daley provided additional scaffolds for her beginning French students by placing posters around the classroom describing fluids and blogs. She introduced students to the topic of fluids through an English language YouTube video titled "How many fluids do you use in a day?" As the video played, Daley asked students if they did the activities being displayed in the video to connect the topic to their own lives. She then displayed her blog and explained what a blog was. A student then read the introductory paragraph from her blog. Daley used the activity questions on the blog to explain the learning task and drew students' attention to the visual links (using hyperlinked pictures rather than links alone) listed on the blog that would be used to research the applications of fluids and related careers. She then reiterated that students would be using the links to research and write a post that summarizes the information they learned and then reply to classmates' posts.

She displayed the graphic organizer (the concept map) and explained how they should use the graphic organizer, if they felt they needed it, to gather information they needed to answer the questions listed on the blog. An additional question incorporated into her blog asked how the applications chosen were used in students' personal lives. She shared the marking rubric with them.

Students were then asked to work independently on their laptops to do the research and fill in the organizer if required. Daley walked around the classroom to assist students as needed. Students asked a lot of questions of what they were expected to do and how to do it. Daley redirected students to the blog to reread the questions, and she explained the applications again, this time in English. Students worked individually, and after facilitating for a while, Daley redirected their attention to the graphic organizer and verbally explained how to complete the components of the concept map, again in English.

Finally, Daley realized a number of students required a visual model, so she sketched the graphic organizer on the whiteboard and used the example of hydropower to demonstrate how the graphic organizer should be filled. She also modified her instruction and asked that all students complete the organizer. She suggested to students that, if they were ready to post, they should first go to MS Word and write out their post (to enable them to edit and spellcheck their work).

Students spent the remainder of the class period researching, completing the organizer, and writing a post. In the following class, students continued creating their post by translating from English to French and posting it to the blog, with Daley's assistance.

Development of TPACK During Science Instruction

The pedagogical decisions teachers made about TPACK-related characteristics and actions are discussed next in relation to activity choices, sequencing, differentiation, and modelling of the technology. These four characteristics have been identified as integral aspects of effective teaching with technology (Jaipal & Figg, 2010).

Activity Choices. Teachers who make choices by selecting the technology-enhanced activity most appropriate to meet learning goals demonstrate TPACK. The teachers in this study selected the blog as the most appropriate technology because of its usefulness to achieve their immediate science curriculum expectations of understanding the application of fluid mechanics and, at the same time, satisfy the literacy expectation of communicating information. Teachers then selected an Internet research activity communicated through the blog.

> So I picked two curriculum expectations, one being investigating the application of fluid mechanics and the other one is communicating scientific information for a variety of purposes for a variety of audiences using a variety of things. So those are my two expectations, those are the things I'll be assessing. (Pat)

> One of the language requirements is that they read multiple styles of writing and this would go with that because blogging is a style on its own and even writing-wise, they have to write in a variety of genres, and this was sort of research writing versus not persuasive, not letter writing, or anything like that. (Daley)

Additionally, the design of the blog activity, which asked students to research, select, and construct a paragraph communicating knowledge learned (as illustrated in appendixes B, C, and D) contributed to the development of broader science learning goals (NRC, 2012), which in this instance were constructing scientific explanations; obtaining, evaluating, and communicating information; and building collaborative knowledge by individually contributing to the blog document. Commenting on other students' posts supported the development of 21st-century learning skills, such as collaborative knowledge building, critical thinking, and information and communications technology skills development.

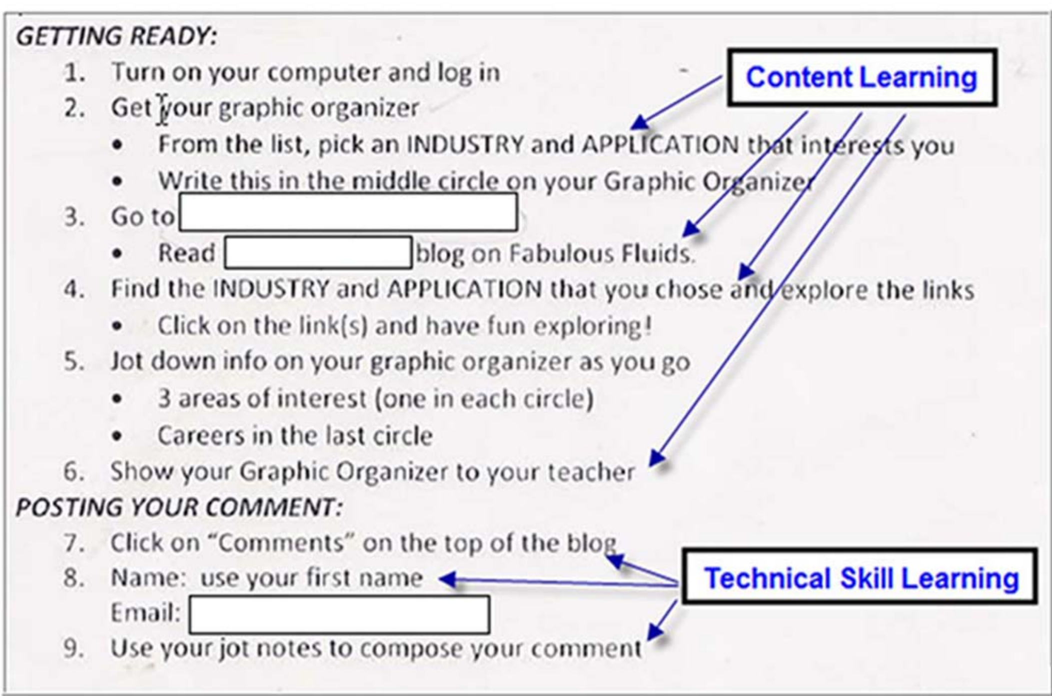
The following is an example of a student's comment on another student's scientific explanation about the application of artificial hearts in health and medicine and illustrates collaborative knowledge building.

> Hi Ben, awesome info about the human heart. One of my mum's friends was going in for heart surgery, but he was actually having a pig heart installed. FACT** pig hearts are the closest genetic animal to humans** (monkeys are very similar dna wise) hopefully we can save many lives with this technology. -Tony
> ps look after your heart!

Hence, the activity choice of Internet-based research task communicated as a blog post on a teacher-created blog met the science and literacy curriculum learning goals and contributed to broader science education and 21st-century learning goals.

Sequencing. This characteristic refers to decisions made about how to sequence the learning activities so that the required technical skills are developed through teaching content, rather than isolating technical skill instruction. The three teachers planned their blog activity to sequence both content and technical skill learning within the science lesson, as demonstrated in the case reports. All three participants began the lesson by introducing the science content (fluids). Technical skills were shown or explained during the teaching of the content.

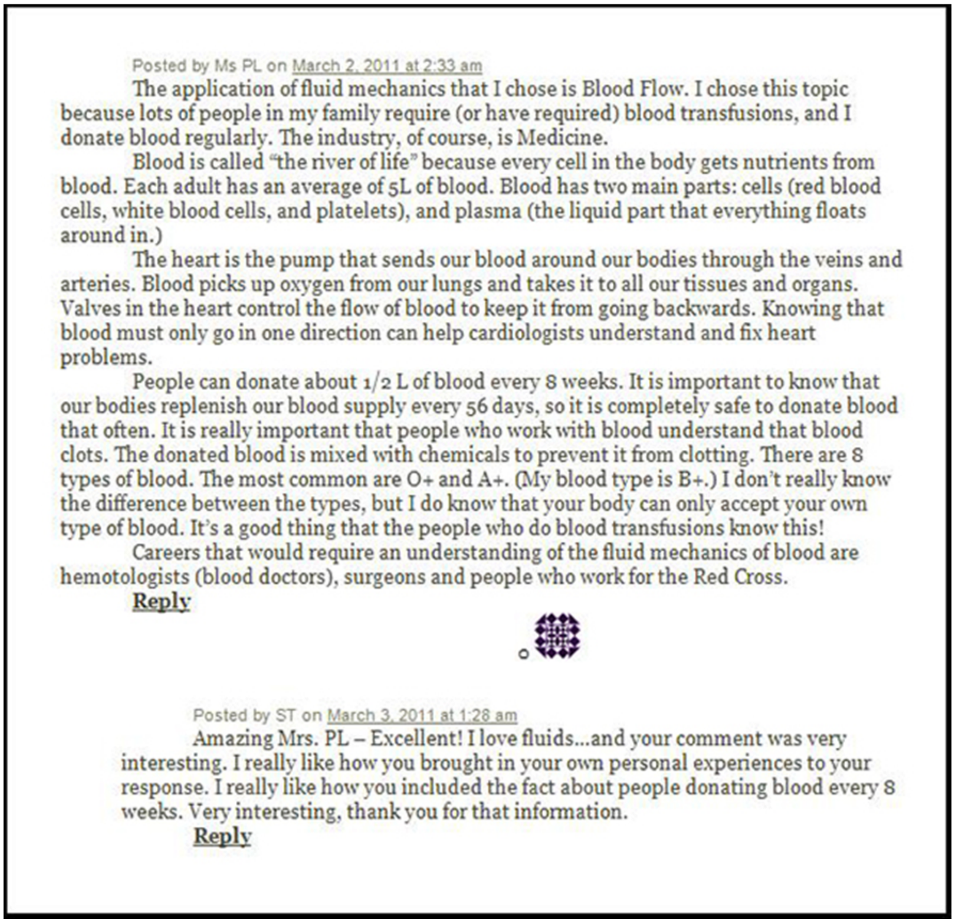
For example, Pat provided students with a written handout that was used to structure the learning so that the focus remained on the content learning while the technical skills were introduced. The instructions on the worksheet show how she embedded technical learning within content learning (Figure 1).


GETTING READY:
1. Turn on your computer and log in
2. Get your graphic organizer
   - From the list, pick an INDUSTRY and APPLICATION that interests you
   - Write this in the middle circle on your Graphic Organizer
3. Go to
   - Read blog on Fabulous Fluids.
4. Find the INDUSTRY and APPLICATION that you chose and explore the links
   - Click on the link(s) and have fun exploring!
5. Jot down info on your graphic organizer as you go
   - 3 areas of interest (one in each circle)
   - Careers in the last circle
6. Show your Graphic Organizer to your teacher

POSTING YOUR COMMENT:
7. Click on "Comments" on the top of the blog
8. Name: use your first name
   Email:
9. Use your jot notes to compose your comment

Figure 1. *Embedding technical skill learning within content instruction.*

Modelling Technology Use for Students. This characteristic refers to modeling best practices for technology use and providing exemplars and examples. Participants used a teacher-created blog site to model how to use a blog. Students were shown basic blogging skills through the content-based blogging task (blog posting and replying). Teachers modelled posting and replying skills using a teacher-created exemplar of a post about a fluid application, and a reply to that post (see Figure 2).


Posted by Ms PL on March 2, 2011 at 2:33 am

The application of fluid mechanics that I chose is Blood Flow. I chose this topic because lots of people in my family require (or have required) blood transfusions, and I donate blood regularly. The industry, of course, is Medicine.

Blood is called "the river of life" because every cell in the body gets nutrients from blood. Each adult has an average of 5L of blood. Blood has two main parts: cells (red blood cells, white blood cells, and platelets), and plasma (the liquid part that everything floats around in.)

The heart is the pump that sends our blood around our bodies through the veins and arteries. Blood picks up oxygen from our lungs and takes it to all our tissues and organs. Valves in the heart control the flow of blood to keep it from going backwards. Knowing that blood must only go in one direction can help cardiologists understand and fix heart problems.

People can donate about 1/2 L of blood every 8 weeks. It is important to know that our bodies replenish our blood supply every 56 days, so it is completely safe to donate blood that often. It is really important that people who work with blood understand that blood clots. The donated blood is mixed with chemicals to prevent it from clotting. There are 8 types of blood. The most common are O+ and A+. (My blood type is B+.) I don't really know the difference between the types, but I do know that your body can only accept your own type of blood. It's a good thing that the people who do blood transfusions know this!

Careers that would require an understanding of the fluid mechanics of blood are hemotologists (blood doctors), surgeons and people who work for the Red Cross.

Reply

Posted by ST on March 3, 2011 at 1:28 am

Amazing Mrs. PL – Excellent! I love fluids...and your comment was very interesting. I really like how you brought in your own personal experiences to your response. I really like how you included the fact about people donating blood every 8 weeks. Very interesting, thank you for that information.

Reply

Figure 2. *Example of teacher blogging of commenting and replying for students.*

Differentiation for Student Learning of Content and Technical Skills. All three teachers successfully structured the learning activities so that content development in science and writing skills for communication were promoted. Student learning was guided by questions and graphic organizers.

> Because I don't want them cutting and pasting...[students] will use this [concept map] to make jot notes, and then they will write their comment from their jot notes, and I have a rubric for them so they can see what I'm expecting and what I'm marking. (Sharon)

Teachers also incorporated specific modifications to cater to special learning needs of various students. For example, Pat provided the English as a second language (ESL) teacher with a copy of her blog for translation into Arabic to meet the needs of her ESL learner.

> I talked to the ESL teacher ahead of time, and I asked him to take the blog and try to translate it into Arabic using the translator...to see if it made sense to him, so [the student has] already had hands-on [practice] with it yesterday and has already written five sentences....The ESL teacher won't be here today, but at least [the student] will have a little bit of knowledge and will know how to translate it [the blog] into Arabic.
>
> I've talked to the homeroom teacher about who's a good buddy for her to work with so I have a buddy in place for her [the student with mild intellectual disability (MID)] as well as for my deaf/hard-of-hearing student, who has a learning disability as well. For MID students I won't require them to do the complete graphic organizers. Even if they do one circle for me, that's what I will assess.

However, all three teachers planned their lessons to teach students all of the technical skills in the first lesson: using the blog to research Internet information, posting a blog message summarizing what they had learned, and replying to a post uploaded by another student.

The realization that technical skills also needed to be taught in increments dawned on the teachers at different times during their teaching. Sharon and Daley introduced all of the skills in the first lesson. As the lesson progressed, these two teachers realized that students were not able to complete all the content and technical tasks in the one lesson. They, therefore, revised lesson expectations on the fly as the lesson progressed and asked students to write the research post only. They then retaught posting and replying to posts in the next lesson. The following comment by one teacher shows that this element of TPACK—teaching technical skills in increments—was learned as she taught the technology-enhanced lesson.

> Maybe not going so much into it [blogging skills] for that one session and making sure that I block time off for each section, because it can be overwhelming for me and for the kids knowing all the things about the blog. (Sharon's postlesson interview)

Likewise, Pat voiced her concerns about the amount of technical skills being taught in the lesson a few minutes prior to teaching the lesson, and with feedback from author Jaipal-Jamani, modified her plans. She did not teach how to reply to posts in the first lesson.

> This lesson is 100 minutes, and I expect that I will be able to go through the instructions, that they will be able to pick their topic, that they will be able to research their topic and complete their jot notes. My hope is that they will be able to complete their comment; my doubt is that they will be able to comment on someone else's comment. (Pat's prelesson conversation)

As a result of this study, all three teachers realized that differentiation for technical skill learning is also essential when teaching with technology. Teachers realized that the Internet researching activity plus the skills of posting and replying to another post were too many tasks (technical and content) for one lesson.

Discussion

Our findings provide insights into professional learning as experienced by three teachers who participated in a PD initiative, consisting of TPLDM Workshop sessions and mentoring during the teaching of a technology-enhanced blog activity planned during the workshops. The TPLDM Workshop engaged teachers in a series of learning activities designed to promote the development of teacher knowledge about how to meet content-learning goals through integration of technology in science teaching.

Participants reported that the workshop was beneficial because the activities of the workshop transformed their theoretical knowledge about teaching science with blogs into understandings of how to teach with blogs in their classroom practice. For example, participants found that engagement in authentic, content-focused learning experiences for teaching science content and literacy skills, which included the modelling of relevant technology-enhanced activity types during the workshop session, helped them develop teacher knowledge to design their activity.

In the study, we modeled a blog posting of a science article critique, which participants described as an important experience for developing their understanding of teaching with blogs in science. As well, participants indicated that engaging in a pedagogical dialogue about the unique affordances of the particular technology for practical classroom implementation and receiving just-in-time technical, pedagogical, and content support during planning and implementation were highly beneficial for professional learning. These findings support other findings in the literature that highlight the importance of professional development that includes authentic classroom tasks (Glazer & Hannifin, 2006; Jimoyiannis, 2010) and modelling preferred instructional practices (Borko et al., 2000).

Although the literature (Darling-Hammond & McLaughlin, 1995; Sparks & Hirsh, 2000) emphasized the importance of reflection to develop teacher knowledge, the type of teacher reflection engaged in during the workshop sessions, which we call pedagogical dialogue, refers to a structured reflection about the pedagogical aspects associated with teaching an authentic, technology-enhanced, content activity. For example, the pedagogical discussion might include ideas about how to sequence technical skills within content learning and manage students and computers for a particular content lesson (Figg & Jaipal-Jamani, 2013). Hence, our study extends the literature by proposing a specific type of teacher reflective practice as an essential component of professional development for technology-enhanced teaching.

Unlike the technocentric professional development models in which participants are first taught the skills for using a technology (Papert, 1987), the TPLDM Workshop approach promotes teacher understanding of technical skills through just-in-time technical support. Our findings reinforce the notion that the learning of technical skills is effective when situated in an authentic learning activity (content-centric), which is consistent with current approaches to technology professional development calling for technology skill instruction to be embedded within the learning of content skills and knowledge (Harris et al., 2009; Kereluik et al., 2010). The PD in our study provided teachers with technical skill knowledge while they engaged in the design of technology-enhanced instruction to meet specific science curriculum goals.

Teacher participants showed evidence of developing TPACK (knowledge of technology-enhanced teaching) through their choice of activities, sequencing of tasks and technical skills within the science content task, modelling technology use for students, and differentiating for student learning needs during implementation of the blog activity.

With regard to differentiating for students' needs, scaffolding learning with prompts and graphic organizers is recommended as a best practice pedagogy for supporting learning in any classroom context (Petko et al., 2014; van de Pol et al., 2010). As well, the benefit of scaffolding for student learning is well exemplified in this excerpt from a student blog comment: "I studied up on blood flow. It is a VERY interesting topic. I used the graphic organizer you gave and made these four general topics: Blood Flow through the Heart, Donating Blood, Careers Involving Blood Flow, and Fun Facts!"

The question prompts on the teacher blog and the graphic organizers were used by all students in some way to organize and develop their scientific explanations. Our findings on the benefits of a TPACK-based, content-centric approach for developing teacher knowledge reinforce similar findings in the literature (Angeli & Valanides, 2009; Harris et al., 2009; Niess, 2005; 2011).

Participants in our study also noted other characteristics of the PD that supported them in their professional learning about how to teach science with blogs. First, onsite professional development fostered collaborative coplanning and individual implementation, which are characteristics of effective professional development (Hughes, 2005; Hung & Yeh, 2013; Joyce & Showers, 2002). Unlike other recent initiatives where PD supporting technology-enhanced science instruction was delivered through formal courses or workshops (Guzey & Roehrig, 2009; Jimoyiannis, 2010), our PD design addressed the contextual needs of the teachers, meeting real-time instructional needs and time constraints of teachers' schedules.

In the two PD studies previously cited, a variety of general technologies specific to science were introduced to teachers. As a result, these researchers found that some participants required follow-up assistance because they were unable to connect how the technologies presented in the course could be adapted for their instructional contexts. The just-in-time, need-to-know approach of the TPLDM-based PD, with a focus on a particular technology, addressed the concerns raised in the literature about contextual issues.

Second, professional learning was supported by the collaborative engagement of teachers in an authentic task with a common purpose (common content learning goals). In our study, the participants were Grade 8 science teachers. They were able to select common curriculum content outcomes, which enabled them to codesign a learning activity collaboratively around common student learning goals. Collaborative planning on how to use a specific technology (blog) to teach specific content knowledge (application of fluids) provided this common and concrete application for implementation in their actual practice.

As Glazer et al. (2009) observed in their study, shared planning and shared curriculum positively influenced interactions and professional learning among teachers. Other studies have also shown that teachers codesigning learning activities promoted collaborative professional learning (Hughes, 2005; Hung & Yeh, 2013; Glazer, Hannafin, & Song, 2005). However, Glazer et al. (2009) cautioned that the development of "shared repertoire was jeopardized when subject-area differences surfaced" (p. 35). The experiences of teachers in our study support the notion that when PD is provided to participants who teach in one subject area, they are able to share common curricular content, promoting collaborative professional learning (also reported by Hughes, 2005).

A third characteristic of the PD that supported professional learning was the mentoring of teachers during the implementation phase of the PD, which is consistent with the findings of Appleton (2008). Our study adds to the literature by providing insights on the importance of having access to mentors during the implementation phase for both content and technology areas. Mentoring should occur not only during the planning of the technology-enhanced activity and instruction, as is the case with many technology PD initiatives that provide support through courses or short workshops.

Our findings suggest that mentoring during implementation developed teacher knowledge by prompting reflection that resulted in modifications to the lesson in response to learners' actual classroom needs. Participants in our study had at least 2 years of experience teaching science, and they exhibited evidence of developed levels of PCK in some areas. For example, the use of graphic organizers, scaffolding questions, and science content visuals were used to scaffold student learning of science content. In the TPLDM Workshops, they were shown how to select technology-enhanced activities for learning goals and how to incorporate content and technology learning in science instruction and were taught the importance of sequencing both content and technical skills. Yet, only through directly teaching the activity in the classroom did teachers develop the TPACK of sequencing technical skills into manageable units.

Teachers learned through the practice of teaching that they also had to gauge how many and in what sequence to present technical skills so as not to impede students' learning of content. As discussed in the findings, Sharon and Daley realized that students were overwhelmed with the tasks of researching, posting, and replying. Student learning was not seamless, and learning was interrupted by students struggling to complete all the tasks. Hence, these teachers responded during lesson implementation by adapting the lesson on the fly–breaking the task into two manageable units to be carried out over 2 days.

This learning about how to teach with technology during the practice of teaching is consistent with the literature on effective teaching. Darling-Hammond (2012) stressed that effective teaching is characterized by teachers becoming adaptive experts—having the ability to figure out problems during teaching and adapting teaching strategies or supports accordingly. As such, developing teacher knowledge involves "preparing teachers who can learn from teaching, as well as learning for teaching" (p. 11). In relation to PD initiatives, the latter statement suggests that effective teacher PD should include experiences that promote learning from the practice of teaching and learning about how to teach (such as from workshops or courses). In our study, participants developed TPACK from workshops and from reflection during teaching. This particular instance of teacher reflection and modification also reinforces the importance of sequencing technical skills into small doable chunks, which has been identified as one of the effective characteristics of technology-enhanced teaching in the literature (Angeli & Valanides, 2009; Figg & Jaipal, 2012).

Overall, the TPLDM Workshop was effective at developing some aspects of TPACK, such as activity choice; other aspects such as sequencing of technical skills, which is highly learner and context dependent, developed during the practice of teaching with the technology. Similar findings have been noted in the literature about how PCK is developed from the practical experience of teaching over time (Lee et al., 2007).

Our findings have implications for how technology PD should be designed. It suggests the need to provide an immediate application-in-teaching practice phase to help teachers transfer the knowledge introduced in a workshop into real-time teaching practice and to further develop their TPACK from teaching in relation to the actual needs of the learners. Therefore, our findings contribute to the theoretical base of how teacher knowledge, specifically TPACK, develops, and it provides a practical illustration of how to prepare teachers to learn about teaching and learn from teaching (as recommended by Darling-Hammond, 2012).

Another characteristic of effective professional development noted in the literature is ongoing and sustained professional learning experiences (Borko et al., 2010). In our study, provisions were not made for sustaining the PD because of faculty and teacher workload commitments and financial constraints. While we were not able to sustain the professional learning onsite at that school, we found other ways to apply the TPLDM Workshop to impact teacher practice at a systemic level. As part of the collaboration between our university and the school board, we provided workshops to board technology consultants on the TPLDM Workshop.

We have evidence that many of these technology consultants have adopted a TPACK-based, content-centric model of technology professional development, as opposed to a focus on teaching technical skills in decontextualized contexts. These consultants presented technology workshops to our university faculty members that incorporated components of the TPLDM Workshop, and we hope that continued use of this professional development approach to provide technology professional development for practicing teachers in the local school board will impact the field.

Limitations

The findings reported in this paper are limited in the following ways. The focus of the PD was limited to teachers learning about one type of technology, the blog, in response to their contextual needs—in their case, the Ministry of Education strategic goals of literacy. The paper does not report on the effectiveness of blogs on students' learning, as the focus of this paper is on teacher professional development. Reporting on the effectiveness of blogs for student learning requires presenting a framework of analysis and conducting content analysis to provide evidence that was beyond the scope of this paper. However, teacher and student interview data provide preliminary evidence that blogs supported construction of science explanations among students.

In response to the interview question, "What evidence do you have to show that learning occurred using this blog teaching strategy?" Pat's response was, "The evidence is in the blogs." Sharon explained how the principal and other colleagues who had looked at the blog entries commented, "Wow, some of these kids who don't usually do any work or who are just not into school, they put their effort forward and did their best on their comments." Sharon commented further:

> [Students] did put a lot of effort into their work, and they tried their best to incorporate their [personal] connections to them, as well. I was really impressed, because sometimes you don't even get that much out of them in normal work. That says a lot just on its own.

Similar comments were echoed by Daley.

The study findings also do not report on the long-term impact on teachers' practice, as this data is not available and would require a follow-up study with necessary ethics approvals from the university and school board. It should also be noted that Pat was promoted to a consultant position with the school board the following year, hence could not be involved in classroom teaching to follow-up with blog integration in her practice. However, during the year the study was conducted, Daley used blogs for further activities in her English and French classes at other times in the year. The other two teachers articulated intentions to use blogs. Pat stated, "I would have liked to use it again for 'water systems,' which is what I am doing now but...Our computer cards went on the fritz. We haven't had our computers for about three or four weeks, so that didn't happen."

Sharon explained, "Unfortunately, and not because I don't want to. It's just been such a chaotic year for me, and it was really difficult with our computer labs being down."

Conclusion

The purpose of this paper was to illustrate how the TPLDM Workshop approach for technology workshops was adapted for professional development at a school site and to explore teacher perceptions of the efficacy of the workshop model and how they developed TPACK as they planned and implemented a technology-enhanced activity in science. Our findings suggest that a TPLDM Workshop approach to technology professional development enabled teachers to see and experience the ways in which technology, content, and pedagogy interact in an authentic context, promoting the development of some aspects of TPACK.

Overall, the findings show that content-centric technology professional development that involves collaboration among a small group of teachers around a common content area and an authentic classroom activity, with technical and content area support from experts, supports the transformation of teachers' theoretical teaching ideas and hypothetical teaching activities into actual teaching practice. This paper makes a theoretical contribution by proposing that TPACK is developed through a combination of workshop experiences and immediate application of knowledge gained in the workshop into practice in the real-life teaching context. The unique insights gained from this study can inform the design of future PD initiatives conducted by other researchers and professional development facilitators.

This paper makes a contribution to the practice of technology-enhanced teaching by presenting a case of how the TPLDM Workshop approach was applied in a real teaching context and could inform the work of faculty interested in conducting similar PD. For teachers in such a study, the research provides professional development in action, and findings provide research-based evidence for instructional decision-making purposes. Such findings also provide school administrators with data to inform professional development and curriculum decisions for science instruction. Directions for future research include adapting the TPLDM Workshop approach to multiple school sites and different subject areas to enable cross-case comparisons, which may lead to refinement of the TPLDM Workshop approach.

References

Angeli, C., & Valanides, N. (2008, March). *TPCK in pre-service education: Preparing primary education students to teach with technology*. Paper presented at the annual meeting of the American Educational Research Association. Retrieved from Punya Mishra's website: http://punya.educ.msu.edu/presentations/AERA2008/AngeliValanides_AERA2008.pdf

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers and Education, 52*(1), 154-168.

Appleton, K. (2008). Developing science pedagogical content knowledge through mentoring elementary teachers. *Journal of Science Teacher Education, 19*(6), 523-545.

Borko, H., J. Jacobs, & Koellner, K. (2010). Contemporary approaches to teacher professional development. *International Encyclopedia of Education, 7*, 548-556.

Brownstein, E., & Klein, R. (2006). Blogs: Applications in science education. *Journal of College Science Teaching, 35*(6), 18-22.

Carlson, S., & Gadio, C.T., (2002). Teacher professional development in the use of technology. In J. Sikula (Ed.), *Handbook of research on teacher education* (pp. 978-1029). New York, NY: Macmillan.

Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, CA: SAGE Publications.

Darling-Hammond, L. (2012). *Powerful teacher education: Lessons from exemplary programs*. San Francisco, CA: John Wiley & Sons.

Darling-Hammond, L., & McLaughlin, M. W. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan*, *76*(8), 597-604.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Washington, DC: National Staff Development Council.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319 - 340.

Davis, F. D. (1993). User acceptance of information technology: System characteristics, user perceptions and behavioral impacts. *International Journal of Man-Machine Studies*, *38*(3), 475-487.

DeMonte, J. (2013, July 15). *High-quality professional development for teachers: Supporting teacher training to improve student learning.* Retrieved from the Center for American Progress website: http://www.americanprogress.org/issues/education/report/2013/07/15/69592/high-quality-professional-development-for-teachers/

Deng, L., & Yuen, A. H. (2011). Towards a framework for educational affordances of blogs. *Computers & Education*, *56*(2), 441-451.

Du, H. S., & Wagner, C. (2006). Weblog success: Exploring the role of technology. *International Journal of Human-Computer Studies, 64*(9), 789-798.

Erlandson, D. A., Harris, E. L., & Skipper, B. L. Allen. SD (1993). *Doing naturalistic inquiry: A guide to methods*. Thousand Oaks, CA: Sage Publications.

Ferdig, R. E., & Trammell, K. D. (2004). Content delivery in the 'blogosphere.' *THE Journal*, *31*(7), 12-20.

Figg, C., & Jaipal, K. (2011). Developing a survey from a taxonomy of characteristics for TK, TCK, and TPK to assess teacher candidates' knowledge of teaching with technology. In M. Koehler & P. Mishra (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2011* (pp. 4330-4339). Chesapeake, VA: Association for the Advancement of Computing in Education

Figg, C., & Jaipal, K. (2012). TPACK-in-practice: Developing 21st century teacher knowledge. In P. Resta (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2012* (pp. 4683-4689). Chesapeake, VA: Association for the Advancement of Computing in Education.

Figg, C., & Jaipal-Jamani, K. (2013). Transforming classroom practice: Technology professional development that works! *Teaching & Learning, 8*(1), 87-98. Retrieved from http://brock.scholarsportal.info/journals/teachingandlearning/home/article/view/431/384

Glazer, E. M., & Hannafin, M. J. (2006). The collaborative apprenticeship model: Situated professional development within school settings. *Teaching and Teacher Education, 22*(2), 179-193.

Glazer, E., Hannafin, M.J., Polly, D., & Rich, P. (2009). Factors and interactions influencing technology integration during situated professional development in an elementary school. *Computers in the School, 26*, 21-39.

Glazer, E., Hannafin, M. J., & Song, L. (2005). Promoting technology integration through collaborative apprenticeship. *Educational Technology Research and Development, 53*(4), 57-67.

Grove, K., Strudler, N., & Odell, S. (2004). Mentoring toward technology use: Cooperating teacher practice in supporting student teachers. *Journal of Research on Technology in Education, 37*(1), 85-109.

Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education, 9*(1), 25-45. Retrieved from http://www.citejournal.org/vol9/iss1/science/article1.cfm

Hargreaves, A. (2003). *Teaching in the knowledge society: Education in the age of insecurity*. New York, NY: Teachers College Press.

Harris, J. (2005). Our agenda for technology integration: It's time to choose. *Contemporary Issues in Technology and Teacher Education, 5*(2). Retrieved from www.citejournal.org/articles/v5i2editorial1.pdf

Harris, J., & Hofer, M. (2009). Instructional planning activity types as vehicles for curriculum-based TPACK development. In C. D. Maddux, (Ed.), *Research highlights in technology and teacher education 2009* (pp. 99-108). Chesapeake, VA: Society for Information Technology in Teacher Education. Retrieved from https://chathamcat.pbworks.com/f/HarrisHofer-TPACKActivityTypes.pdf

Harris, J. B., Hofer, M., Schmidt, D. A., Blanchard, M.R., Young, C.Y., Grandgenett, N. F., & Van Olphen, M. (2010). "Grounded" technology integration: Instructional planning using curriculum-based activity type taxonomies. *Journal of Technology and Teacher Education, 18*(4), 573-605.

Harris, J. B., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education, 41*(4), 393-416.

Higgins, T. E., & Spitulnik, M. W. (2008). Supporting teachers' use of technology in science instruction through professional development: A literature review. *Journal of Science Education and Technology*, *17*(5), 511-521.

Huffaker, D. A. (2005). The educated blogger: Using weblogs to promote literacy in the classroom. *AACE Journal*, 13(2), 91-98.

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education, 13*(2), 227-302.

Hung, H. T., & Yeh, H. C. (2013). Forming a change environment to encourage professional development through a teacher study group. *Teaching and Teacher Education*, *36*, 153-165.

Ingvarson, L., Meiers, M., & Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes & efficacy. *Education Policy Analysis Archives, 13*(10). Retrieved from http://epaa.asu.edu/ojs/article/view/115

Jaipal, K., & Figg, C. (2010). Unpacking the "Total PACKage": Emergent TPACK characteristics from a study of preservice teachers teaching with technology. *Journal of Technology and Teacher Education, 18*(3), 415-441.

Jaipal, K., & Figg, C. (2011). Collaborative action research approaches promoting professional development for elementary school teachers. *Educational Action Research*, *19*(1), 59-72.

Jaipal-Jamani, K**.,** & Figg, C. (2013). The TPACK-in Practice Workshop approach: A shift from learning the tool to learning about technology-enhanced teaching. In E. Ivala (Ed.), *Proceedings of the 8th International Conference on e-Learning* (Vol. 2; pp. 215-223). Reading, UK: Academic Conferences and Publishing International Ltd.

Jaipal-Jamani, K., & Figg, C. (2015). A framework for TPACK-in-Practice: Designing technology professional learning contexts to develop teacher technology knowledge (TPACK). In C. Angeli & N. Valanides, N. (Eds.) *Exploring, developing, and assessing TPCK* (pp. 137-164). New York, NY: Springer Publications.

Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers' professional development. *Computers & Education, 55(*3), 1259-1269.

Johnson, L., Adams Becker, S., Cummins, M., Estrada, V., Freeman, A., & Ludgate, H. (2013). *NMC Horizon report:2013 Higher education edition*. Retrieved from The New Media Consortium website: http://www.nmc.org/pdf/2013-horizon-report-HE.pdf

Joyce, B., & Showers, B. (2002). *Designing training and peer coaching: Our needs for learning*. Alexandria, VA: ASCD.

Keating, T., & Evans, E. (2001). Three computers in the back of the classroom: Preservice teachers' conceptions of technology integration. In J. Price et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference*

2001 (pp. 1671-1676). Chesapeake, VA: Association for the Advancement of Computing in Education.

Kereluik, K., Mishra, P., & Koehler, M. (2010). Reconsidering the T and C in TPACK: Repurposing technologies for interdisciplinary knowledge. In D. Gibson & B. Dodge (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 3892-3899). Chesapeake, VA: Association for the Advancement of Computing in Education.

Larson, L., Kuhn, C., Collins, R., Balthazor, G., Ribble, M., & Miller, T. (2009). Technology instruction: Fixing the disconnect. *Principal Leadership, 10*(4), 54-58.

Lee, E., Brown, M. N., Luft, J. A., & Roehrig, G. H. (2007). Assessing beginning secondary science teachers' PCK: Pilot year results. *School Science and Mathematics, 107*(2), 52-60.

Lei, J. (2009). Digital natives as preservice teachers: What technology preparation is needed? *Journal of Computing in Teacher Education*, *25*(3), 87-97. Retrieved from http://jeffmacleodtechnologyintegrationportfolio.yolasite.com/resources/teachers_as_digital_natives.pdf

Lock, J.V. & Redmond, P. (2010). Transforming pre-service teacher curriculum: Observation through a TPACK lens. In *Proceedings of ASCILITE - Australian Society for Computers in Learning in Tertiary Education Annual Conference 2010* (pp. 559-564). Tugun, QLD: Australasian Society for Computers in Learning in Tertiary Education.

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching, 41*(4), 370-391.

Luehmann, A. L., & Frink, J. (2009). How can blogging help teachers realize the goals of reform-based science instruction? A study of nine classroom blogs. *Journal of Science Education and Technology*, *18*(3), 275-290.

Lundeberg, M. A., Bergland, M., Klyczek, K., & Hoffman, D. (2003). Using action research to develop preservice teachers' beliefs, knowledge and confidence about technology. *Journal of Interactive Online Learning*, *1*(4), 1-16. Retrieved from http://www.ncolr.org/jiol/issues/pdf/1.4.5.pdf

Margerum-Leys, J., & Marx, R. W. (2002). Teacher knowledge of educational technology: A case study of student/mentor teacher pairs. *Journal of Educational Computing Research, 26*(4), 427-462.

McCrory, R. (2008). Science, technology and teaching: The topic-specific challenges of TPCK in science. In B. Cato (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 193-206). New York, NY: Lawrence Erlbaum.

McKenzie, J. (2001). How teachers learn technology best. *The Educational Technology Journal, 10*(6). Retrieved from http://fno.org/mar01/howlearn.html

Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco, CA: Jossey-Bass.

Microsoft Partners in Learning. (2011). *ITL 21st century learning design: 21CLD learning activity rubrics*. Retrieved from http://www.itlresearch.com/itl-leap21

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

Mishra, P., Koehler, M. J., & Kereluik, K. (2009). The song remains the same: Looking back to the future of educational technology. *TechTrends*, *53*(5), 48-53.

National Research Council. (2012). *A framework for k-12 science education: Practices, crosscutting concepts, and core ideas.* Retrieved from The National Academies Press website: http://www.nap.edu/openbook.php?record_id=13165&page=R1

Niess, M. L. (2005). Scaffolding math learning with spreadsheets. *Learning and Leading With Technology*, *32*(5), 24–25.

Niess, M. L. 2011. Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research, 44*(3), 299-317.

Ontario Ministry of Education. (2015) Elementary: Elementary education. Retrieved from http://www.edu.gov.on.ca/eng/elementary.html

Partnership for 21st Century Skills. (2011). *Framework for 21st century learning*. Retrieved from http://www.p21.org/storage/documents/1.__p21_framework_2-pager.pdf

Papert, S. (1987). *A critique of technocentrism in thinking about the school of the future.* Retrieved from http://www.papert.org/articles/ACritiqueofTechnocentrism.html

Petko, D., Egger, N., & Graber, M. (2014). Supporting learning with weblogs in science education: A comparison of blogging and hand-written reflective writing with and without prompts. *Themes in Science and Technology Education*, *7*(1), 3-17.

Riveros, A., Newton, P., & Burgess, D. (2012). A situated account of teacher agency and learning: Critical reflections on professional learning communities. *Canadian Journal of Education*, *35*(1), 202-216.

Robertson, J. (2011). The educational affordances of blogs for self-directed learning. *Computers & Education, 57,* 1628–1644.

Sawmiller, A. (2010). Classroom blogging: What is the role in science learning? *The Clearing House*, *83*(2), 44-48.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-23.

Sparks, D., & Hirsh, S. (2000). Strengthening professional development. *Education Week, 1*9(37), 42, 45.

Teo, T. (2008). Pre-service teachers' attitudes towards computer use: A Singapore survey. *Australasian Journal of Educational Technology*, *24*(4), 413-424. Retrieved from: http://www.ascilite.org.au/ajet/ajet24/teo.html

Trucano, M. (2005). *Knowledge maps: ICTs in education*. Washington, DC: Information for Development Program.

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher-student interaction: a decade of research. *Educational Psychology Review, 22*,271-296.

Zhao, Y. (Ed.). (2003). *What should teachers know about technology? Perspectives and Practices* (Vol. 2). Charlotte, NC: Information Age Publishing.

Yin, R. (2009). How to do better case studies. In L. Bickman & D. J. Rog's (Eds.), *The SAGE handbook of applied social research methods* (pp. 254-282). Thousand Oaks, CA: SAGE Publications.

Author Notes

Kamini Jaipal-Jamani
Department of Teacher Education
Brock University
CANADA
Email: kjaipal@brocku.ca

Candace Figg
Department of Teacher Education
Brock University
CANADA
E-mail: cfigg@brocku.ca

Appendix A
Designing Your Blog/Wiki Activity to Enhance Science Learning: Science Teacher Technology Workshop

PLANNING upcoming lesson(s) that Integrate Blog/Wiki

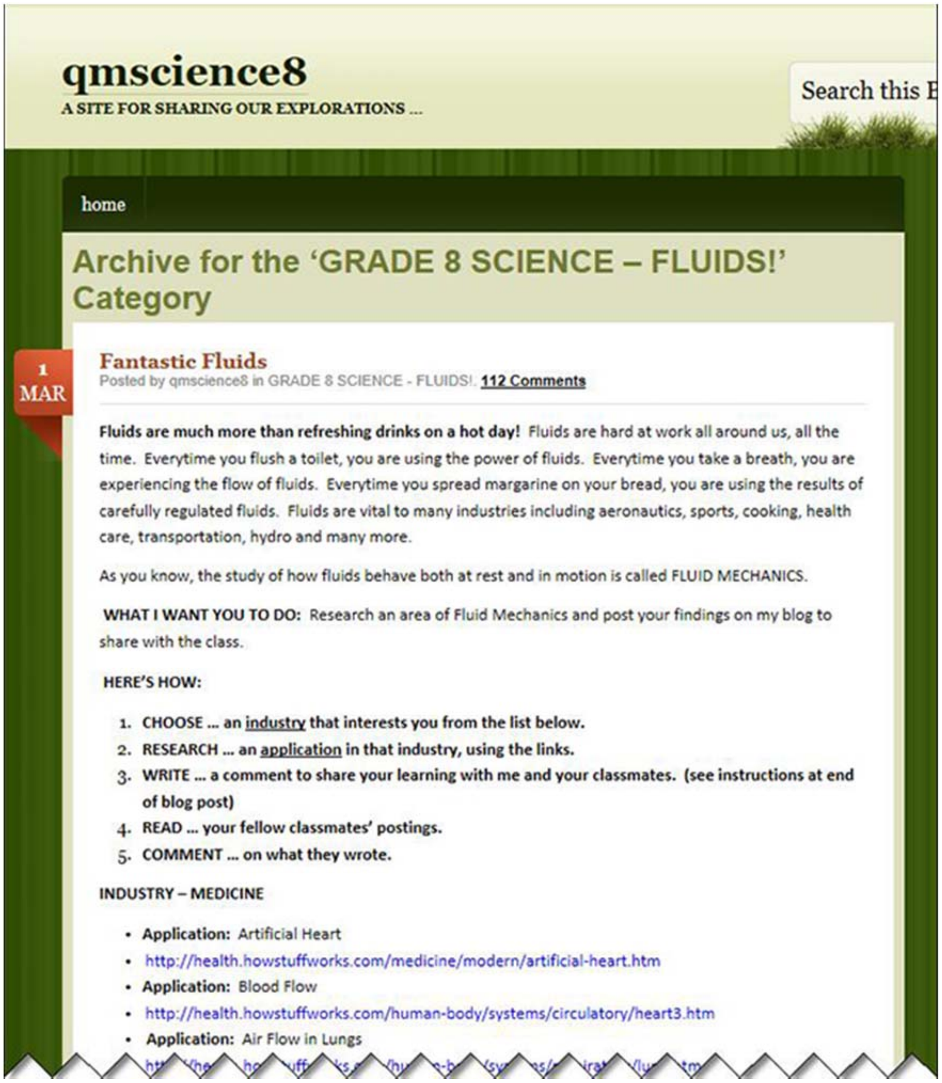
- What is your content learning outcome?
- What is the task/activity and how will you sequence multiple activities in a lesson to scaffold learning?
- How do you want students to communicate this outcome to you?
- How will you differentiate for student learning?
- How will you assess student learning?

Outcome	**Appropriate Task/Activity**	**Communication Mode On Blog**	**Differentiation Considerations**	**Assessment Focus**
1. Project-based (slideshow presentation, laboratory report, data tables, graphic organizers or graphs, models, poster, article or story, podcast, video)	Student will create the project. What is the process for creating the project? (conduct a lab inquiry and create report, interpret databases and construct graphs, read an article and evaluate)	Written blog post with embedded multimedia components (video, podcast, slideshow, Google Docs link, images/photos, diagrams converted to images)	Prior knowledge of content, Technical skills, Language abilities, Scaffolded instructional strategies e.g., add links to sites for definitions/notes e.g., post tutorials on how to do technical aspects e.g., create a glog/podcast e.g., different instruction, questions or graphics e.g., add series of questions	Rubric (specifically covers knowledge and understanding of content, oral, written, and visual communication)
2. Issues-Based	Student will analyze and/or evaluate issue for decision-making (conduct research online, read an online article, evaluate online databases)			
3. Research and Share	Student will locate resources/information on topic to share with class (posting resources on the blog, commenting on resources)			Checklist (online participation, frequency of on-task posts/comments, number of resources shared)
4. Reflect on Learning	Student will journal reflections on learning, explaining their thinking and reasoning of class discussions, give feedback on lesson activities)			

IMPLEMENTING upcoming Lesson(s) that Integrate Blog/Wiki

- What do you need to prepare to implement the lesson successfully?
- What type of technology is needed (hardware/software)?
- What is your backup plan if technical issues arise?
- What types of resources do your students need to do the lesson (e.g., handouts, online articles, databases, image collections)?
- How will you make these accessible to your students during the lesson (e.g., embedded in the blog, links from Google Docs, hardcopies)?
- How will you group your students (pairs, individual work with partner sharing)?
- When and how will you model using the blog for students (brief handouts, demonstrating techniques – NetSupport/LCD projector in class)?

Appendix B
Website Created by Pat



qmscience8
A SITE FOR SHARING OUR EXPLORATIONS ...

Search this B

home

Archive for the 'GRADE 8 SCIENCE – FLUIDS!' Category

1 MAR

Fantastic Fluids
Posted by qmscience8 in GRADE 8 SCIENCE - FLUIDS!. 112 Comments

Fluids are much more than refreshing drinks on a hot day! Fluids are hard at work all around us, all the time. Everytime you flush a toilet, you are using the power of fluids. Everytime you take a breath, you are experiencing the flow of fluids. Everytime you spread margarine on your bread, you are using the results of carefully regulated fluids. Fluids are vital to many industries including aeronautics, sports, cooking, health care, transportation, hydro and many more.

As you know, the study of how fluids behave both at rest and in motion is called FLUID MECHANICS.

WHAT I WANT YOU TO DO: Research an area of Fluid Mechanics and post your findings on my blog to share with the class.

HERE'S HOW:

1. **CHOOSE ... an industry that interests you from the list below.**
2. **RESEARCH ... an application in that industry, using the links.**
3. **WRITE ... a comment to share your learning with me and your classmates. (see instructions at end of blog post)**
4. **READ ... your fellow classmates' postings.**
5. **COMMENT ... on what they wrote.**

INDUSTRY – MEDICINE

- **Application:** Artificial Heart
- http://health.howstuffworks.com/medicine/modern/artificial-heart.htm
- **Application:** Blood Flow
- http://health.howstuffworks.com/human-body/systems/circulatory/heart3.htm
- **Application:** Air Flow in Lungs

Appendix C
Website Created by Sharon

Fluids In Our Everyday Life

Filed under: Uncategorized — 34 Comments

March 3, 2011

Fluids are essential to our everyday living. We use fluids in many different ways. Not only do our bodies contain mostly fluid, but we have many other examples of fluids in our lives around us. Scientists use fluid mechanics in many ways, the industries are aeronautics, sports, cooking, healthcare, transportation and hydro. such as designing aircrafts, improving food products, building dams and controlling blood flow. Every time you take a full breath, use your sink faucet, flush your toilet, use an eavestrough and produce food, you are experiencing the the way fluids behave at rest and when moving. This helps you to understand how fluids can help with everyday living and create a more efficient and safe workplace and environment.

Create a **REPLY** to my **BLOG**

In your ***reply to my blog***, this is **(What I'm Looking For)**

Answer **ALL** of the questions below:

1. Identify an **industry** that interests you from the list below and **why you chose the industry?**

2. ***Research your related application using the websites provided for you. What*** is the related **application** you chose?

3. **Create a comment to answer the following questions**:

- What fluids are being used?
- What do the fluids do?
- How do the fluids work specifically for your application?
- Why do you think it is important to understand why fluids behave the way they do in your related application?
- Identify **2 or 3 related careers** that would ***relate to fluid mechanics in the industry you picked.***

Share any other interesting information you feel would be educational for me and your classmates on your related application

4. Be sure to **view** and **read** at ***least 2 other postings from students*** in your class and comment on their industry and application. Make sure to ***comment on what they wrote.*** You should comment on the comment's ***of a minimum of 2 students***, but more comments would be great. Take your time and create a positive and reflective comment rather than creating many small posts. Share your experiences, your knowledge and your opinions on their comment.

INDUSTRY

****TOYS****

Application: High Pressure Washer/Cutter

...://w... hows...fwork...om/w...er-bl...r.htm

Appendix D
Website Created by Daley

8F2 Fluides et Le Monde

22

Posted: March 9, 2011 in **Uncategorized**

Nous savons qu'on utilise les fluides chaque jour en nos vies en beaucoup de différentes façons. L'eau pour brosser les dents, le pétrole en nos voitures même le sang en nos corps.
MAIS voici le question du jour:
Quand nous pensons des mécaniques des fluides, **COMMENT** est-ce que les fluides sont utilisent en le monde autour de nous?

SAVEZ-VOUS que les fluides sont une partie de chaque facette de nos vies? Il y a l'industrie, les médecines, les sports, la construction, l'énergie et les mécaniques hydrauliques. Mais exactement COMMENT est-ce que les fluides sont une partie de tout ceci? Ça c'est exactement qu'est-ce que vous voyez rechercher au'jourdhui!

LE PROJET

Recherchez une partie des fluides mécaniques dans une industrie qui t'intéresse. En bas, il y a trois sites qui peuvent t'aider et aussi le blog de Mme Willis. Les utilisez pour vos recherche. Après que vous avez lu les sites, vous devez suivre les quatre étapes ici;

1. **Identifiez** l'industrie que tu as choisir. **Pourquo**i est-ce que tu as le choisir?

2. **Récherchez** plus avec les sites en bas. Qu'est-ce que c'est l'application mécanique que tu as choisir? Quel fluides est-ce qu'il emploie pour ce type d'application? Qu'est-ce que ce fluide doit faire pour ce type d'emploi mécanique?
3. **Créer** une annotation (comment) qui répondait aux questions suivantes:
QUEL fluides sont utiliser pour ce application?

COMMENT est-ce que ce fluide fonction dans l'application?

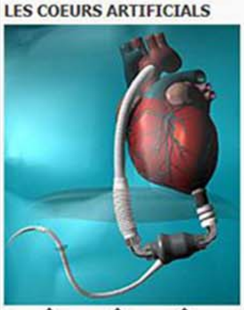
POURQUOI est-ce que qu'on doit comprendre comment les fluides fonction pour cette application spécifique?

NOMMEZ deux carriers (careers) qui peuvent utiliser pour ce type d'application mécanique des fluides.

PARTEGEZ d'autre information qui t'a intéresse

4. **Lire** deux autres annotations que les autres étudiants ont écrit et préparez, au minimum, deux réponses aux annotations d'autres élèves. Écrivez seulement des annotations qui sont pensive (***thoughtful***) et gentil en relation à ce que tu as lu.

VOICI LES SITES QUI PEUVENT T'AIDER!
LES COEURS ARTIFICIALS



Che[illegible]ez po[illegible]lus d'[illegible]orma[illegible] ici: h[illegible]/heal[illegible]owstu[illegible]rks.c[illegible]medic[illegible]moder[illegible]tificial[illegible]rt1.h[illegible]