A Comparative Study of STEM Educators' Views of Technology: A Case of Canada, China and Korea

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Abstract: *This paper describes the results of a pilot quantitative international comparative study that investigated how STEM educators in Canada, China and Korea view the roles of technology in their teaching. The study incorporated the Technological Pedagogical Content Knowledge and Deliberate Pedagogical Thinking with Technology frameworks to emphasize that in addition to the relevant knowledge necessary for effective use of educational technologies, teachers have to acquire positive attitudes towards its impact on student learning. The results of this pilot indicate that according to the self-reports of 195 Canadian, Chinese and Korean STEM educators who participated in this research , they have significantly different levels of pedagogical, content and technological knowledge, as well as are offered significantly different opportunities for incorporating technology in their teaching. The opportunities for support and technology-related professional development for STEM teaching also vary dramatically among the participants. Most importantly, STEM educators in these countries have disparate perceptions of the role of technology in STEM: Canadian educators focus on technology as a tool to promote individualized student learning, Chinese educators view the main goal of technology use as improving documentation of student learning, and Korean educators view technology as a tool to promote student content knowledge. While the sample of this pilot was rather limited, this study identified directions for the future study. This paper reports on the first pilot project in a forthcoming series of international comparative studies that will investigate how teachers in Canada, China and Korea view and utilize technology to promote their pedagogical goals.*

Keywords: Deliberate pedagogical thinking with technology, teachers' attitudes about technology, teachers' views on limitations of technology use, TPCK (TPACK)

1. Introduction and Theoretical Framework

At the dawn of the third millennium, many notable educational researchers had questioned schools' investment in technology, claiming that computers have been "oversold and underused" (Cuban, 2001). While, few educators today contest the need for the computer presence in schools, the question of *how* digital technologies are being utilized by 21st century teachers in science, technology, engineering and mathematics (STEM) fields still remains widely open (Shelton, 2015; Spector, 2015).

It is estimated that as of October 2011, there were nearly 1.2 billion of personal computers worldwide, and in 2015, the number of personal computers reached a 2 billion mark (one computer on average per four people). At present, personal computers today represent only a small slice of the digital tools' landscape available to teachers and students, as personal devices such as smart phones, tablets, iPads, have found multiple applications in modern STEM classrooms (Carr, 2012; Galligan, Loch, McDonald, & Taylor, 2010). Today, it is inconceivable to imagine an educator, a student, or a parent whose knowledge of the world has not been ultimately affected by various forms of digital technologies. However, it is still unclear if modern educators are able to tap into the full potential of educational technologies for the purpose of promoting meaningful student STEM learning (DeVane & Squire, 2012; Ge, Ifenthaler, & Spector, 2015; Jonassen & Land, 2012; Milner-Bolotin, 2015; Spector, 2015).

There is ample research evidence that the mere presence of digital technologies in STEM classrooms does not guarantee improved learning, unless teachers possess relevant Technological Pedagogical Content Knowledge (TPCK or TPACK) (Koehler & Mishra, 2009) and are willing and capable of harnessing the power of technology in order to facilitate meaningful student engagement (DeVane & Squire, 2012; Jonassen & Land, 2012; Milner-Bolotin, 2015). TPCK concept was born as an extension of the original *Pedagogical Content Knowledge* (PCK) framework proposed by Shulman in 1986. In his famous American Educational Research Association presidential address, Shulman emphasized that teaching as a profession is built on teachers' knowledge of relevant content matter and of the pedagogical strategies teachers can employ to support students in learning (Shulman, 1986). Later Kohler and Mishra expanded Shulman's original framework adding to it teachers' Technological knowledge, thus forming a TPCK framework widely adopted by the researchers and used in this paper (Koehler & Mishra, 2015).

However, what these frameworks do not emphasize, is the importance of teachers' positive attitudes about the role of technology in their teaching. Teachers' TPCK and their positive attitudes about the use of technology to promote student STEM learning are both crucial for harnessing the power of digital technologies (Banas, 2010; Doering, Veletsianos, Scharber, & Miller, 2009; Jimoyiannis, 2010; Lee & Tsai, 2010). This requires teachers to develop what we have called elsewhere, *deliberate pedagogical thinking with technology* (Milner-Bolotin, 2016). This combination of TPCK and positive attitudes about technology will serve the overarching theoretical framework for the current study.

The problem of technology use in promoting learning in universal, yet as far as we know, there is a lack of international comparative studies that examine how STEM educators in different countries view the role of technology in promoting student learning. It is especially interesting to compare countries that demonstrate high student STEM performance but have rather dissimilar education cultures, such as Canada, China and Korea (OECD, 2014). The current study will address this gap in the research literature by answering the following questions in the context of Canadian, Chinese and Korean STEM educators:

1. What are these educators' perceptions of their own TPCK?
2. How do these educators view the goals of technology use in their teaching?
3. How do these educators perceive the limitations of technology use in their teaching?

In the following section we discuss the methodology of the study chosen to answer these questions.

2. Methodology

This study is the first step in a multi-year international collaboration. In this pilot, we chose a quantitative approach, as it allowed us to conduct an initial investigation and chart the course for future research. The survey described below was used to collect self-reported information from the participants.

2.1. Participants

Participants of the study were STEM teachers and teacher-educators in Canada, China and Korea. Both elementary and secondary STEM educators were invited to take part in the study. The description of study participants in provided in Table 1. In Canada and Korea, the participants were STEM educators who responded to an online invitation to take part in the study. In China, the participants were Beijing teachers who were chosen by their school district to take part in a STEM professional development event delivered by the first author. They responded to a paper survey translated to Mandarin.

Table 1. Description of study participants and their teaching environments.

	Descriptions	**Canada**	**China**	**Korea**
Designation	In-service teachers	81	51	185
	Teacher educators	9	0	10
Main teaching expertise	Elementary	9	11	0
	Secondary	81	40	195
Teachable subject (all that apply)	Math	66	19	108
	Physics	66	9	30
	Chemistry	27	4	27
	Biology	12	18	33
	Earth science	27	2	9
	General science	66	2	33
Teaching experience	1-5 years	18	16	18
	6-10 years	30	12	30
	11-15 years	9	10	30
	16-20 years	9	5	42
	20+ years	24	8	75
Average number of students in a classroom	1-10	0	0	9
	11-20	24	2	12
	21-30	57	31	60
	31+	9	18	114

Participation in professional development events	Never	3	3	30
	Once in a few years	30	18	84
	1-2 times a year	39	23	75
	3-5 times a year	18	6	6
	6-8 times a year	0	0	0
	9+ times a year	0	1	0
Total				**195**

2.2. Instruments: A Questionnaire

In order to answer these research questions, we developed a study questionnaire (Table 2) that was verified by five independent experts. Three of them were mathematics and science teachers, another one was a technology teacher, while the last one was a researcher in the field of educational statistics. A pilot questionnaire study was conducted to test and consequently improve the tool. In order to comply with the university Ethics Review Board requirements, the questionnaire was hosted on a designated Canadian university server. The questionnaire was administered online for Canadian and Korean educators (in English and in Korean respectively) and in a paper form for Chinese teachers.

Table 2. General description of questions included in the survey.

Factors	**Answers**	**Number of questions**
Demographic characteristics and teaching info	Multiple choice	9
Self-reported competency in their TPCK	5-point Likert scale	6
Purpose of technology use	5-point Likert scale	10
Limitation of technology use	5-point Likert scale	7
Descriptive information specific technology use	8-point Likert scale	9
The goals and methods of specific technology use	Choose all	9
Importance/confidence of specific technology use	5-point Likert scale	18
Teaching philosophy	5-point Likert scale	20
Total number of questions		**88**

2.3. Statistical Methodological Approach

In order to analyze the results of the online and paper-based questionnaire administration, t-tests, one-way ANOVA and Importance-Practice Analysis were used. All the answers were initially translated into English and combined into one database. SPSS statistical package was used for the combined analysis.

3. Results and Discussion

The goals of the study were to answer the following three research questions in the context of Canadian, Chinese and Korean STEM educators:

1. What are these educators' perceptions of their own TPCK?
2. How do these educators view the goals of technology use in their teaching?
3. How do these educators perceive the limitations of technology use in their teaching?

Below we will provide a brief description of the preliminary results of the current study.

3.1. STEM Educators' Perceptions of their Own TPCK

Not surprisingly, we found significant differences between the Canadian, Chinese and Korean educators' own perceptions of their TPCK and the importance their attribute to each one of the TPCK components. Chinese teachers viewed the Content Knowledge as the most important aspect of TPCK and it was significantly more important as compared to Canadian and Korean educators (F=3.708*). Canadian and Chinese teachers also attributed significantly higher value (more importance) to their pedagogical knowledge than their Korean counterparts (F=10.147*). Interestingly, Korean teachers attributed significantly lower value to their technical knowledge, than their Canadian and Chinese colleagues (F=4.534**). There were significant difference in the self-reported confidence of the teachers in the different aspects of their TPCK. Canadian teachers evaluated themselves as having consistently significantly (at p=0.05 level) higher confidence in their content, pedagogical and technological knowledge, as compared to their international colleagues: $F_{content}$=4.534**, $F_{pedaoggical}$=5.908**, $F_{technological}$=7.843** respectively. Additional t-test analyses have shown that there were significant gaps in teachers' views of importance of different aspects of TPCK and their confidence in their own TPCK knowledge. These results indicate that teachers in these three countries need more support in helping them develop their TPCK and close the gap between their own TPCK and the value they attribute to it.

3.2. STEM Educators' Views of the Goals of Technology Use in their STEM Teaching

Our results indicate that the teachers hold discrepant views on the roles of technology. These differences stem from different cultural norms and different educational goals in these countries. Table 3 uses color-coding to indicate the correspondence between different roles teachers attributed to technology. It is interesting to note that Chinese teachers, whose teaching outcomes are much more test-driven than for their Canadian counterparts, value the documentation of student learning as the most valuable role technology can play in their teaching. On the other hand, Canadian teachers, did not view improving social interactions among students as one of the top roles played by technology. We also found significant differences in the other goals of technology use among the Canadian, Chinese and Korean educators, such as developing student critical thinking skills, student STEM engagement, etc.

Table 3. Three most important goals of technology use in STEM classrooms as viewed by the teachers.

Canada	China	Korea
1. Improve independent student learning 2. Improve communication between teachers, students and parents 3. Develop student content knowledge	1. Improve (a) documentation of student learning; (b) communication between teachers, students and parents 2. (a) Improve independent student learning; (b) Develop student content knowledge 3. Improve social interactions among students	1. Develop student content knowledge 2. Improve independent student learning 3. Improve social interactions among students

3.3. STEM Educators' Perceptions of their Own Limitations of Technology Use in STEM Teaching

Canadian, Chinese and Korean educators showed common concerns about the limitations of technology use (Table 4). In all three countries, teachers indicated the lack of technical support as their top limitation in using technology. The inadequate access to computers at school, the lack of software and inadequate teachers' Technological knowledge were recurring concerns. Only Chinese teachers ranked their lack of comfort with technology in general as one of their top concerns.

Moreover, there were other significant differences between the countries. Canadian teachers' levels of access to internet and to a computer projectors were surprisingly significantly lower than for Chinese or Korean teachers (F=19.463** and F=28.254** respectively). Both Canadian and Chinese teachers also indicated significantly lower access to relevant software, than their Korean counterparts (F=18.240**). Canadian teachers indicated their lack of comfort with the subject-specific technology as a much more significant concern than did their international counterparts (F=54.507**).

Table 4. Top three limitations reported by teachers for technology use in STEM teaching.

	Canada	China	Korea
1	Lack of technical support	Lack of technical support	Lack of technical support
2	Insufficient or inadequate access to computers	Lack of my comfort with technology in general	Insufficient or inadequate software
3	Insufficient or inadequate software	Insufficient or inadequate software	Insufficient or inadequate access to computers

4. Conclusions

This pilot study aimed at investigating how Canadian, Chinese and Korean STEM educators perceive the role of technology in their classrooms and what obstacles they face in order to successfully incorporate technology in their teaching. While the same of the study was somewhat limited (N=195 participants) and we cannot yet draw large-scale generalizations, the study has uncovered interesting findings and potential themes for future research. One finding is the interplay between the educational goals, opportunities and teacher support that needs to be taken into account while scaffolding teachers in successful technology use in their STEM classrooms. The second finding is the misleading perception that the issue of access to technology has been resolved in the developed countries (our results indicate that teachers in Canada have often limited access to technology). The third finding is the lack of consistent professional development and technical support. The fourth finding is the lack of support for STEM teacher-educators in effective technology use, as a number of them indicated significant challenges in incorporating technology in their own teacher education programs.

In addition, some of the results of the study are rather surprising and might be caused by a relatively small sample or by the selection bias. It is important to clarify these results in the follow-up study.

One of the goals of international education comparative studies is sharing pedagogically effective practices and learning from each other. This study highlighted important differences and commonalities between the three countries and opened new opportunities for international collaborations.

5. Study Limitations and Future Directions

This was a pilot project that aimed to build a background for conducting a more comprehensive comparative research focused on Canadian, Chinese and Korean STEM educators' views about the roles of technology in their teaching. As a pilot project, we purposefully decided to use a very limited sample of convenience, such as only teachers who participated in the professional development event in China or only educators who chose to participate in an online questionnaire. The relatively narrow sample obviously limits the results of the study and doesn't allow us to draw wide generalizations. Yet, this study opened doors for future research and showed that a survey, such as the one developed here is a viable tool to use in an international comparative research. However, this tool has to be improved and administered on a random sample of STEM educators. This will be the goal of the second stage of this research. In addition, we will develop a qualitative portion of the study (semi-structured interviews) that will allow us to better interpret and clarify the quantitative results and draw meaningful conclusions.

Acknowledgements

We thank UBC Teaching and Learning Enhancement Fund for supporting this research in 2012-2015.

References

Banas, J. R. (2010). Teachers' attitudes toward technology: Considerations for designing preservice and practicing teacher instruction. *Community & Junior College Libraries*, *16*(2), 114-127.

Carr, J. M. (2012). Does math achievement h'APP'en when iPads and game-based learning are incorporated into fifth-grade mathematics instruction? *Journal of Information Technology Education: Research*, *11*, 269-286.

Cuban, L. (2001). Oversold and underused: Computers in the classroom. *Harvard University Press Review*.

DeVane, B., & Squire, K. D. (2012). Activity Theory in the Learning Technologies. In D. Jonassen & S. M. Land (Eds.), *Theoretical Foundations of Learning Environments* (Second ed., Vol. 1, pp. 242-267). New York: Routledge.

Doering, A., Veletsianos, G., Scharber, C., & Miller, C. (2009). Using the Technological, Pedagogical, and Content Knowledge Framework to Design Online Learning Environments and Professional Development. *Journal of Educational Computing Research, 41*(3), 319-346.

Galligan, L., Loch, B., McDonald, C., & Taylor, J. A. (2010). The use of tablet and related technologies in mathematics teaching. *Australian Senior Mathematics Journal*, *24*(1), 38-51.

Ge, X., Ifenthaler, D., & Spector, J. M. (Eds.). (2015). *Emerging Technologies for STEAM Education: Full STEAM ahead*. New York: Springer.

Jimoyiannis, A. (2010). Designing and Implementing an Integrated Technological Pedagogical Science Knowledge Framework for Science Teachers Professional Development. *Computers & Education, 55*(3), 1259-1269.

Jonassen, D., & Land, S. (Eds.). (2012). *Theoretical foundations of learning environments* (2nd ed.). New York, NY: Routledge.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

Koehler, M. J., & Mishra, P. (2015). Technological Pedagogical Content Knowledge. In M. J. Spector (Ed.), *The SAGE encyclopedia of educational technology* (Vol. 2, pp. 782-785). Los Angeles: SAGE Publications.

Lee, M.-H., & Tsai, C.-C. (2010). Exploring Teachers' Perceived Self Efficacy and Technological Pedagogical Content Knowledge with Respect to Educational Use of the World Wide Web. *Instructional Science*, *38*(1), 1-21.

Milner-Bolotin, M. (2015). Learning physics teaching through collaborative design of conceptual multiple-choice questions. *The Canadian Journal of Action Research, 16*(2), 22-41.

Milner-Bolotin, M. (2016). Promoting Deliberate Pedagogical Thinking with Technology in physics teacher education: A teacher-educator’s journey. In T. G. Ryan & K. A. McLeod (Eds.), *The Physics Educator: Tacit Praxes and Untold Stories* (pp. 112-141). Champaign, IL: Common Ground and The Learner.

OECD. (2014). PISA 2012 Results: What students know and can do – student performance in mathematics reading and science (Vol. I, Revised Edition February 2014). Paris: OECD.

Shelton, B. E. (2015). TPCK (Technological Pedagogical Content Knowledge): Implications for 21st century teacher education. In M. J. Spector (Ed.), *The SAGE encyclopedia of educational technology* (Vol. 2, pp. 785-790). Los Angeles: SAGE Publications.

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

Spector, J. M. (Ed.). (2015). *The SAGE encyclopedia of educational technology*. Los Angeles: SAGE Publications, Inc.