Training Teachers to Use Educational Technologies in STEM Using Field Experience at a Community-Based Organization

Stephen Adams, Elaine Bernal, Monica Cole-Jackson, Lisa Martin-Hansen
California State University, Long Beach
USA
Stephen.Adams@csulb.edu

Abstract: This presentation highlights the evaluation of a model for training credentialed teachers to use educational technologies in science, technology, engineering, and mathematics (STEM). The model includes a 3-unit summer university course with a field experience project at a community-based organization. Teachers worked in teams of four to plan a set of four 2-hour workshops for youth in the organization. Data sources included questionnaires at the beginning and end of the course that included a TPACK survey plus an end-of-course interview. A total of 17 teachers participated in the course and 12 agreed to participate in the study. There were statistically significant increases in the mean scores related to Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical and Content Knowledge (TPACK), as well as in individual items of other categories. We will report on analyses of complementary interview data.

Introduction

We present an evaluation of a professional development model designed to support teachers in using technology in instruction in Science, Technology, Engineering, and Mathematics (STEM). The approach incorporates a 3-unit university course for credentialed teachers. It aims to strengthen teachers' teaching in STEM subjects by introducing them to innovative pedagogical approaches possible with technology and by offering field experiences. Field experiences with support and reflection after practice are important, since they can help teachers move toward more reform-based practices (Goldstein, Goldstein, & Lake, 2003; Roehrig & Luft, 2006). A further part of the model involves using technology to support and strengthen professional networking among teachers.

The approach strongly emphasizes teacher collaboration in using technology in a field setting (Adams, 2005). In this way, it aims to support teachers' understanding of pedagogy in connection to content and technology, that is, their Technological Pedagogical and Content Knowledge (TPACK) (Koehler & Mishra, 2008, 2009). The course is part of an overall professional development project for teachers, Transforming Teaching and Learning through Technology (Adams, 2013).

The course was first piloted in Spring, 2013. At this time, a majority of participants (63%) had more than three years of previous teaching experience. Initially, the field experience component was done in teachers' own classrooms. However, in the present project, we changed the approach and the field experience was based not in teachers' existing classrooms, but at a community-based organization. The community-based organization offers afterschool and summer programming for youth from underserved populations.

There were several reasons to consider such a change, some related to the teachers and some related to the students at the community-based organization. From the point of view of the teachers, one reason for the change was to position the course to serve a greater proportion of recently credentialed teachers, including teachers with credentials who may not have their own classrooms. Veteran teachers were still invited to participate, creating a collaboration between teachers with differing amounts of experience who worked in teams. With none of the teachers teaching in their own classrooms, no single teacher was in charge of the instructional situation. Also, the setting at the community-based organization meant that the teachers were freed of the constraints of a traditional school setting, including testing and scheduling. Also, the instructional setting was not compulsory for the youth participants. As a result, teachers were advised that the activities needed to be engaging, lest the students decide to stop participating.

A further reason for the change was to provide STEM training for the youth at the community-based organization. We decided to offer the course in the summer, at a time when teachers are not teaching in their regular classrooms and a time at which additional training for youth at the community-based organization could be especially helpful. For K-12 students, a substantial part of the achievement gap between relatively more and less advantaged students can be attributed to a loss of learning during the summer months (Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996; Heyns, 1987). With explicit, engaging instruction in science at informal science settings, gains can be made in science knowledge as well as attitudes about science (Brossard, Lewenstein, & Bonney, 2005). Studies have found a correlation between time spent on instruction and learning (e.g., Blank, 2012).

Many efforts at STEM education reform have focused on K-12 students, as students in the United States have fallen behind in math and science aptitude compared with their international peers (Barker, Nugent, & Grandgenett, 2014). Efforts to combine STEM education professional development and informal learning activities have become a promising avenue to encourage teachers to enter STEM education and students to consider viable STEM careers ("The ASM-Materials Camp© Program for Professional Development of Teachers," 2011). However, there is a lack of empirical data showing the effectiveness of informal learning programs (Barker et al., 2014).

The present study provides further information about the pedagogical model, with its informal learning component. We provide an evaluation of the effort from the point of view of the teachers, focusing on their responses to a survey of TPACK. Helping teachers develop their TPACK is an aim of the project (Adams, 2013), and this study is the project's first evaluation to use a TPACK survey. An evaluation is also underway focusing on the experiences of the youth who participated in the workshops at the community-based organization, but this is beyond the scope of the present study.

The Teacher Training Model

The course took place over a 9-week period in Summer, 2014. The format combined face-to-face instruction, online instruction, and field experience at the community-based organization. It included material on strategies for using educational technology in STEM subjects. It culminated with a team project to plan and conduct STEM workshops at a community-based organization. Teachers were grouped into four teams, with approximately four participants each. Each team of four teachers was given the problem of planning and conducting a STEM workshop for a group of 20 students at the community-based organization. There were two student groups composed of 20 students each in grades 3-5, and two groups were composed of 20 students each in grades 6-8. Thus, altogether, four teams of teachers worked with a total of 80 students, being assigned either to a group of 20 students in grades 3-5 or a group of 20 students in grades 6-8. The STEM workshops consisted of 4 sessions of two hours each, meeting once a week for four weeks. As a starting point, the teacher teams were offered the option to use curriculum kits from the Engineering is Elementary / Engineering is Everywhere series of the Museum of Science, Boston (http://www.eie.org/). A set of 10 iPads was also made available to the group. Teachers were encouraged to use the iPads to support their instructional goals.

This approach had some interesting characteristics. The teacher teams were formed so that they were heterogeneous in terms of their prior teaching experience. Also, since each group had four teachers for every 20 students, this meant there was a ratio of one teacher for every five students. This gave the teachers the opportunity to work with the students in small groups. Teachers worked together to plan and conduct the workshops. Every week during the workshop, teachers used an electronic discussion board to post and discuss reflections regarding the instructional process. They also prepared reflections regarding the process.

The Study

Participants in the course were 17 credentialed teachers with at least a B.A.. Approximately half of the teachers (53%) had one year or less of prior teaching experience, but the group also included experienced teachers, with 41% of the group having five or more years' experience. Each participant completed a 40-question TPACK survey at the beginning and the end of the course that was based on a previously published instrument (Schmidt, Baran, Thompson, Koehler, Mishra, and Shin, 2009). TPACK has seven categories such as "Pedagogical Content Knowledge"; the survey had 4 to 9 questions for each category. Because the curriculum focused on STEM and in particular, engineering, we made some changes that included creating three new questions that mentioned engineering. These were modeled on existing TPACK questions. For example, a survey question, "I know about technologies that I can use for understanding and doing *science*," served as a model for creating our own question, "I know about technologies that I can use for understanding and doing *engineering*" (italics added).

Participants gave responses on a 5-point Likert scale, with “strongly disagree” scored as a 1, and “strongly agree” scored as a 5. Participants also took an additional survey at the end of the course with further questions. Semi-structured interviews were conducted, based on a general interview protocol with open-ended questions. Each interview was conducted in a period of 20 to 30 minutes, and consisted of six questions. Each question was designed to explore participant experiences, including areas that either posed challenges or helped facilitate their learning. Follow-up probes were used to encourage participants to clarify their responses and to elaborate their ideas. The interviews were completed online using Blackboard Collaborate, which was software students were already using as the course was taught in a hybrid format. These sessions were recorded. Students were given the opportunity to review their interview recordings. Institutional Review Board Certification was obtained. Of the 17 teachers in the course, 14 signed consent forms, and 12 were legible. Complete sets of TPACK pre- and post-surveys were available for 9 teachers.

Results

Teachers’ responses for each category of TPACK were averaged to arrive at an overall score for that category. For each category, the difference between the pre-test and post-test scores was calculated to serve as an indicator of the overall change for that category. Also for each TPACK category, a paired-samples t-test was conducted to compare the pre-test and post-test means. As shown in Table 1, there were statistically significant increases in the mean scores of three of the seven categories of TPACK. These were Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical and Content Knowledge (TPACK).

An example of a question related to the first of these three areas, Technological Pedagogical Knowledge (TPK), was “I am thinking critically about how to use technology in my classroom.” Scores on this question increased from 3.78 on the pre-test to 4.44 on the post-test, an increase which is statistically significant ($p=.004$). An example of a question related to the second area that changed significantly, Pedagogical Content Knowledge (PCK), was “I can select effective teaching approaches to guide student thinking and learning in engineering.” Scores on this question increased from 2.89 on the pre-test to 4.00 on the post-test, which is statistically significant ($p=.021$). An example of a question related to the third category that changed significantly, Technology Pedagogy and Content Knowledge (TPACK), was “I can teach lessons that appropriately combine engineering, technologies, and teaching approaches.” Scores on this question increased from 2.56 on the pre-test to 3.56 on the post-test, which was statistically significant ($p=0.028$).

In three further TPACK categories, although the means of the pre-test and post-test scores in the overall category did not change significantly, there were statistically significant changes on individual questions within the category. We report the specific items for these three areas. For the category of Technology Knowledge (TK), there were statistically significant increases on two questions. On the question, “I have the technical skills I need to use technology,” mean ratings were 3.44 on the pre-test and 4.22 on the post-test, an increase that was significant ($p = 0.008$). On the question, “I frequently play around with technology,” scores were 3.33 on the pre-test and 4.11 on the post-test, an increase that was significant ($p = 0.043$).

For the category of Technological Content Knowledge (TCK), there were statistically significant increases on one question, “I know about technologies that I can use for understanding and doing technology.” Mean ratings on this question changed from 3.33 on the pre-test to 4.33 on the post-test, an increase that was significant ($p = 0.009$). In the category of Content Knowledge (CK), there were statistically significant increases for one question, “I have various ways and strategies of developing my understanding of mathematics,” which had a mean of 3.67 on the pre-test and 4.56 on the post-test, a significant increase ($p = 0.009$). In the category of Technological Content Knowledge (TCK), there were statistically significant changes for one question, “I know about technologies that I can use for understanding and doing technology.” Mean ratings on this question were 3.33 on the pre-test and 4.33 on the post-test, a significant increase ($p = 0.009$). Lastly, there were no statistically significant changes on any items in the category of Pedagogical Knowledge (PK). This was the sole category for which no statistically significant changes were observed.

		Pre-Test		Post-Test			
TPACK Area	**Items**	**Mean**	**SD**	**Mean**	**SD**	**t(8)**	**p**
Technology Knowledge (TK)	6	3.630	0.767	3.963	1.081	1.922	0.091
Content Knowledge (CK)	6	3.963	0.582	4.352	0.914	1.960	0.086
Pedagogical Knowledge (PK)	7	4.317	0.597	4.429	0.857	0.589	0.572
Pedagogical Content Knowledge (PCK)	4	3.668	0.500	4.306	0.480	2.588	0.032
Technological Content Knowledge (TCK)	4	3.473	1.064	4.140	0.254	2.138	0.065
Technological Pedagogical Knowledge (TPK)	9	3.642	0.919	4.432	1.533	2.521	0.036
Technological Pedagogical and Content Knowledge (TPACK)	4	2.111	0.719	2.918	0.780	2.612	0.031

Table 1. Comparison of TPACK Pre-test and Post-test Results by Area
(1 = Strongly Disagree, and 5 = Strongly Agree)

Discussion

This teacher training model placed emphasis on teaching with technology in STEM, with field experience at a community-based organization. Interestingly, the most significant changes on the TPACK survey were not in single categories such as Pedagogical Knowledge (PK), but in composite categories such as Technological Pedagogical and Content Knowledge (TPACK) or Technological Pedagogical Knowledge (TPK). A limitation of the study concerns the sample size, and there is potential for a sampling bias. With that caveat, these results suggest that professional development program was effective in helping participants increase their knowledge in multiple areas of TPACK. We plan to continue to develop and evaluate this pedagogical model. To better understand teachers' experiences in relation to these findings, we are currently analyzing end-of-course interviews and other qualitative data and will report on these complementary analyses.

References

Adams, S. (2005). A strategy for technology training as part of a Master's program conducted at a school site. *Journal of Technology and Teacher Education*. 13 (3), pp. 493-514. Norfolk, VA: AACE.

Adams, S. (2013). A field test of a model for training teachers to use technology in mathematics and science teaching. In *Edulearn 13 Proceedings: The 5th Annual International Conference on Education and New Learning Technologies* (p. 1069). International Academy of Technology, Education, and Development: Barcelona, Spain.

The ASM-Materials Camp© Program for Professional Development of Teachers. (2011). *Advanced Materials & Processes, 169*(10), 36-39.

Barker, B., Nugent, G., & Grandgenett, N. (2014). Examining fidelity of program implementation in a STEM-oriented out-of-school setting. *International Journal of Technology and Design Education, 24*(1), 39-52. doi: 10.1007/s10798-013-9245-9

Blank, R. K. (2012). What is the impact of decline in science instructional time in elementary School. Noyce Foundation. Available at: www. csss-science. org/downloads/NAEPElemScienceData. pdf.

Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education*, 27(9), 1099-1121.

Cooper, H., Nye, B., Charlton, K., Lindsay, J., & Greathouse, S. (1996). The effects of summer vacation on achievement test scores: A narrative and meta-analytic review. *Review of Educational Research*, 66(3), 227-268.

Goldstein, K., Goldstein, L. S., & Lake, V. E. (2003). The impact of field experience on preservice teachers' understandings of caring. *Teacher Education Quarterly,* 115-132.

Heyns, B. (1987). Schooling and cognitive development: Is there a season for learning?. *Child Development*, 1151-1160.

Koehler, M. & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Eds.). *Handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-29). New York: Routledge.

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

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *Journal of Educational Research, 106*(2), 157-168. doi: 10.1080/00220671.2012.667014

Roehrig, G. H., & Luft, J. A. (2006). Does one size fit all? The induction experience of beginning science teachers from different teacher preparation programs. Journal of Research in Science Teaching, 43(9), 963-985.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123-149.

Acknowledgements

This project was made possible with support from the Fluor Corporation, Chevron, and the Packard Foundation.