

Facilitating Teachers' Integrated Technological Pedagogical Content Knowledge

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Abstract: The study reports on how three science teachers develop integrated knowledge over time to guide their students to learn science concepts using technologies. The professional development supporting the teachers employed a co-design partnership. The results indicate better student learning outcomes and more integrated teachers' technological pedagogical content knowledge after the professional development in the first year.

Introduction

Modern technologies offer transformative opportunities for instruction and learning. However, teachers need long-term professional development to support them in developing expertise that leads to effective student learning with technologies (Gerard, Varma, Corliss, & Linn, 2011). The professional development of this study established a long-term, co-design partnership (Slotta & Linn, 2009), including science teachers and university researchers working collaboratively to customize science units in the Web-based Inquiry Science Environment (WISE, Slotta & Linn 2009). During the professional development activities teachers and researchers met on a regular basis to customize WISE units, discuss student learning difficulties and instruction dilemmas. This study analyzed how three science teachers who so far participated all of the professional development meetings developed integrated technological pedagogical content knowledge (I-TPCK) over time. Student learning outcomes between the pilot and first-year cohorts were compared to indicate the impact of the teachers' professional development on student learning. While continuing to conduct professional development and collect data in the second year, this study proposes an analysis framework that is initially validated by the first-year data, with the aim to develop an analysis scheme that may be used to formatively assess teachers' development of expertise in science instruction using technology.

Theoretical Background

Researchers propose teachers' "Technological Pedagogical Content Knowledge" (TPCK or TPACK, e.g., Jimoyiannis, 2010) frameworks to discern the types of the knowledge necessary for effective technology-enhanced teaching and learning. In addition to the constructs within the TPCK framework such as assessment, learner, representation and pedagogy (Angeli & Valanides, 2009), how to assess the status and development of teachers' TPCK is a major issue. Surveys have been developed to measure teachers' TPCK confidence (e.g., Graham, Burgoyne, Cantrell, Smith, St. Clair, & Harris, 2009). Surveys provide quantitative results to indicate teachers' self-reported confidence but address little teachers' knowledge status based on qualitative data such as classroom observations or interviews. This study applies a Knowledge Integration framework (Lee, Liu & Linn, 2011) that has been used to assess students' knowledge integration, and proposes an analysis scheme to identify or formatively assess teachers' knowledge integration levels of TPCK (Table 1 shows an example). The study has used the scheme to analyze qualitative data including observations and interviews to reveal how the teachers developed their integrated knowledge over time as a result of the professional development.

Methods

The study focuses on three science teachers and their 231 eighth-grade students at two public junior high schools in South Taiwan. The three teachers attended all of the professional development of this study including two summer three-day workshops (with about 15 teachers in total for each workshop) and six discussion meetings during Year 1 (Table 2). The professional development activities engaged the teachers in working collaboratively with three educational researchers to customize WISE units, discuss predicted and actual student learning difficulties and instruction dilemmas, brainstorm teaching strategies and reflect on the implementations. The activities were explicitly designed to foster teachers' knowledge integration that research calls for (Gerard et al., 2011). The three teachers are selected to be the focus of this study based on the fact that first, due to their persistent attendance they have become core members of the professional development; second, they are all highly motivated to use technology in their classrooms; third, they have been working on the same WISE unit on thermodynamics; and forth, they have different teaching experiences (4, 8 and 18 years of teaching science, respectively). It is of interest to examine whether the three motivated teachers with different teaching experiences developed integrated TPCK through similar or different trajectories.

Data collected include transcripts of the discussions during the professional development activities, the pre- and post-unit implementation interviews for the three teachers, teacher implementations of the WISE units, and students' pre- and posttest scores. An integrated TPCK analysis scheme is proposed, and will be discussed in detail during the poster session, with regard to how the scheme is used to reveal teachers' knowledge integration levels at different time points during the professional development phases (Table 1). NVivo is used to facilitate the coding and triangulating processes. Students' pre- and posttest scores between the pilot and first-year cohorts of the teachers were also analyzed to indicate the impact of the first-year professional development. The test items are all identical. A multiple regression model was used, with the pretest score, teacher and cohort variables as the predictors, and the posttest score variable is the outcome variable.

Table 1: Data collection and time points to assess teachers' integrated TPCK (I-TPCK) and students' outcomes

	Year 0			Year 1					Year 2
	Pre-Interview	Pilot Unit Implementation	Post-Interview	Three-day Workshop	Six PD Meetings	Pre-Interview	Unit Implementation	Post-Interview	Three-day Workshop
I-TPCK analysis	Event 1 ● N=3	Event 2 ● N=3	Event 3 ● N=3	Event 4 ● N=3	Event 5 ● N=3	Event 6 ● N=3	Event 7 ● N=3	Event 8 ● N=3	Event 9 ● N=3
Students' test-score analysis		Pretests Posttests N _{cohort0} =124					Pretests Posttests N _{cohort1} =107		

Results

The multiple regression result indicates that all three variables, including pretest, teacher and cohort, are significant predictors of students' posttest scores. The model explains 42.1% of variance in students' posttest scores. The mean posttest score of the eighth-grade students right after the pilot implementation (Cohort 0 in Year 0) is 9.22 (S.D.=3.60), and the mean posttest score of another cohort of eighth-grade students right after the Year 1 implementation is 12.01(S.D.=5.43). The difference in posttest score between Cohort 0 and Cohort 1, even after controlling for teacher and pretest score differences, was statistically significant. The result provides evidence for more effective teaching and learning with technology from Cohort 0 to Cohort 1.

Initial qualitative analysis of the three teachers' integrated TPCK at eight points in Year 0 and Year 1 reveals improved levels of integrated TPCK with various trajectories in different aspects. For example, the teacher with 4-year teaching experience demonstrated most integrated TPCK between learner and pedagogy during the post-interview in Year 1. Future professional development will address the teacher's need for developing integrated TPCK in assessment and also complex links among the aspects. Trajectories of how the three teachers developed integrated TPCK will be discussed, providing insight into the role of teaching experience and the impact of the professional development activities to facilitate teachers' integrated TPCK.

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