Using lesson plans as a proxy for teacher technology integration practices in math and science using TPACK: A transferrable research design

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Abstract

The purpose of this paper is to describe a novel approach to measuring teacher technology integration practices in the context of lesson plans using the TPACK framework. We first describe the Technological Pedagogical Content Knowledge (TPACK) framework in light of lesson plans as a proxy for teacher practices. We then describe a systematic and rigorous procedure for analyzing the lesson plans for evidence of TPACK. We used this method on a large cross-sectional sample of teacher lesson plans in the context of math and science lesson plans. We believe this approach is a novel way to gauge teacher technology integration practices beyond self-report measures, observation, and case study. Significance and caveats to this approach are described in light of our experiences.

Introduction

Teachers play a critical role in the ways technology is used in classrooms and their classroom practices influence student outcomes for better or for worse (Darling-Hammond, 2010; Wenglinsky, 2005). Early research in teacher technology integration practices used survey methodology to paint a broad picture of teacher technology integration practices (Becker, 1991; Becker 1994; Hadley & Sheingold, 1993) and this practices continues today (Lei, 2010; Russell, Bebell, O’Dwyer & O’Conner, 2003). Despite the continued popularity of survey research to study teacher technology integration practices, its primary limitation is reliance on self-reported data (Mayer, 1999). Others have studied teacher technology practices through observation which, in contrast to surveys, rely on direct evidence of teacher practices (Kozma, 2003; Dawson, Cavanaugh & Ritzhaupt, 2008). However, classroom observations are often time-intensive, resource-intensive, intrusive to teachers and plagued by potential researcher bias. Case study methodology is also a common strategy for studying teacher technology integration practices (Dawson & Heinecke, 2004; Cuban, 2001; Warschauer, 2008). These studies provide important snapshots of what is happening in a small number of classrooms but do not provide sufficient data to generalize beyond the localized context.

Recently, we implemented a large-scale study of teacher technology integration practices in math and science using lesson plans as our data source and TPACK as our methodological framework (Dawson, Ritzhaupt, Liu, Rodriquez & Frey, 2013). The purpose of this paper is to describe the method we used and provide guidance to others wishing to replicate this method in other settings.

Methodological Framework

We used TPACK as the methodological framework for our research design. This framework organizes the types of knowledge needed in order to integrate technology in teaching and learning as illustrated in Figure 1. This framework builds on the notion of pedagogical content knowledge (Shulman, 1986) and provides a way of thinking about the complex relationship among content, pedagogy and technology in K-12 contexts (Mishra & Koehler, 2006). TPACK has previously been used as a framework to support research on technology integration including case studies of mathematics teachers involved in a learner-centered professional development project (Polly, 2011) and mathematics and science preservice teachers enrolled in methods courses (Niess, 2005), survey research to ascertain K-12 online teachers perceptions of their TPACK knowledge (Archambault & Crippen, 2009), interpretive research examining growth of TPACK knowledge exhibited by inservice teachers enrolled in an online graduate course (Niess, van Zee & Gillow-Wiles, 2010)and design-based research to support TPACK development in preservice teachers (Mishra & Koehler, 2006).
We were not able to locate other studies using TPACK as a framework for analyzing teacher lesson plans. While somewhat novel in educational technology research there is a precedent for using lesson plans and other classroom artifacts as proxies for teacher practices (Darling-Hammond, 2010; Silk, Silver, American, Nishimura & Boscardin, 2009; Silver, Mesa, Morris, Star & Benkin, 2009; Jacobs, Martin & Otieno, 2008). Previous work also suggests a strong connection between teacher knowledge and teacher practice which lends credence to using a framework based on teacher knowledge (i.e. TPACK) to study teacher practices (Cochran-Smith & Lytle, 1999).

**Research Design**

We used a pre-post research design in our study (Gall, Borg & Gall, 1996). Math and science teachers were asked to submit their best lesson using technology prior to a year-long, statewide technology integration initiative and then again at the end of the initiative. The lesson plans were submitted online and timestamps were used to identify pre and post lessons. Researchers in other contexts may find other overarching designs more appropriate. It is how we analyzed the lesson plans using TPACK as a framework that is transferrable to a variety of contexts.

**Lesson Plan Structure**

Each teacher submitted lesson plans using an online template in which teachers were asked to provide the lesson title, grade level, content area, estimated time, objectives/standards, procedures and assessments.

**Coding Criteria**

Teacher knowledge and teacher practices are closely linked in what is often referred to as teachers’ knowledge-in-practice (Cochran-Smith & Lytle, 1999). That is, what a teacher knows becomes evident in her practices. In our research design, lesson plans are used as proxies for teacher practice and the components of teacher knowledge articulated through the TPACK framework are used to identify teacher practices expressed in the lesson plans.

While the TPACK framework is inherently complex and contextually bound (Mishra & Koehler, 2006), this study separates the components in order to explore teacher technology integration practices in a way that is consistent and reliable across multiple lesson plans and multiple reviewers. We recognize our design are limited by the information on which we choose to focus and we have countered this limitation by defining our criteria based on literature in the related fields of science education, mathematics education and educational technology. We also countered this limitation by including a mathematics educator and a science educator on our research design team.
The following sections and Table 1 detail coding criteria for each of the seven TPACK components.

Table 1. Coding criteria in TPCK framework.

<table>
<thead>
<tr>
<th>TPCK Construct</th>
<th>Review Criteria</th>
<th>Supporting Literature</th>
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<tbody>
<tr>
<td>Content Knowledge (CK)</td>
<td>Math Topics</td>
<td>NCTM, 2000</td>
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<tr>
<td></td>
<td>Science Topics</td>
<td>FLDOE, 2010</td>
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<td></td>
<td>Assessment practices</td>
<td>Morrison, Ross &amp; Kemp, 2008; Wiggins, 1990</td>
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<tr>
<td>Pedagogical-Content Knowledge (PCK)</td>
<td>Math practices (NCTM, 2000)</td>
<td>NCTM, 2000</td>
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<tr>
<td></td>
<td>Science practices</td>
<td>Michaels, Shouse, &amp; Schweingruber, 2008</td>
</tr>
<tr>
<td></td>
<td>Cognitive demand for content area learning</td>
<td>Silver, Mesa, Morris, Star &amp; Benken, 2009</td>
</tr>
<tr>
<td>Technological Knowledge (TK)</td>
<td>Software</td>
<td>Hogarty, Lang &amp; Kromrey, 2003; Lowther &amp; Ross, 2001</td>
</tr>
<tr>
<td></td>
<td>Hardware</td>
<td></td>
</tr>
<tr>
<td>Technological Content Knowledge (TCK)</td>
<td>Math Software</td>
<td>Kersaint, Horton, Stohl &amp; Garofalo, 2003</td>
</tr>
<tr>
<td></td>
<td>Science Software</td>
<td></td>
</tr>
<tr>
<td>Technological Pedagogical Knowledge (TPK)</td>
<td>Level of Integration (ACOT Continuum)</td>
<td>Sanholtz, Ringstaff &amp; Dwyer, 1997</td>
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</tbody>
</table>

**Content Knowledge (CK)** was represented by the content identified by teachers in the lesson plans. The list of math topics was modified slightly from the Common Cores State Standards for Mathematics (NCTM, 2000) while the list of science topics came from Florida’s Next Generation Sunshine State Standards (FDLOE, 2010). Reviewers retrieved this information only from the Objectives and Standards sections of the lesson plan. They did not infer content from other areas of the lesson plan. For example, if a science lesson had students conducting measurements but mathematics standards/objectives were not listed, they did not identify Measurement as a math topic.

**Pedagogical Knowledge (PK)** was represented by the attributes of meaningful learning identified in the lesson plans. Specifically, reviewers looked for evidence of four attributes of meaningful learning - active, constructive, authentic and collaborative (Jonassen, Howland, Moore & Marra, 2003). These attributes are not mutually exclusive and reviewers selected as many attributes as were evident in the lesson. Active refers to students learning by interacting within their environment. Constructive refers to students articulating, synthesizing, interpreting or evaluating what they know through the creation of artifacts. Authentic means learning that is situated within a context rather than being oversimplified or presented in isolation. Finally, cooperative refers to socially negotiated understandings.

**Pedagogical Knowledge (PK)** was also represented by the assessment methods articulated in the lesson plan. Reviewers retrieved this information from the Assessment section of the lesson plan only. Options included short response tests (i.e. Multiple Choice, True/False, Matching, Fill in the Blanks etc.), extended response tests (i.e. Short or long essay tests; responding to prompts), performance-based assessment (i.e. digital artifact, portfolio, skits, etc.), student-self assessment, peer assessment, group assessment, use of rubrics and teacher observation (Morrison, Ross & Kemp, 2008; Wiggins, 1990).

**Technological Knowledge (TK)** was represented by the general hardware and software used in the lesson plans and coding categories were modified from two valid and reliable instruments used in previous studies of technology use (Hogarty, Lang & Kromrey, 2003; Lowther & Ross, 2001).
Pedagogical Content Knowledge (PCK) was represented by the cognitive demand of the lesson in terms of content area learning. Cognitive demand is the kind and level of thinking required of students during a learning experience. Low demand tasks involve skills such as recalling, remembering or applying facts/procedures while high demand tasks involve skills such as analyzing, creating, evaluating and being metacognitive. Criteria for low and high demand tasks aligned with another study using lesson plans as proxies for teacher practices (Silver et. al., 2009).

Pedagogical Content Knowledge (PCK) was also represented by the math and science practices articulated in the lesson plans. Reviewers looked for evidence of the following practices often associated with exemplary mathematics teaching according to NCTM (2000): students engage in problem solving, students engage in mathematical reasoning, students communicate mathematical ideas, students use multiple mathematical representations and students connect mathematical ideas. Science practices were based on the following practices often associated with inquiry-based science (Michaels, Shouse, & Schweingruber, 2008; NRC, 2000): lesson involves a scientifically-oriented question or problem, students collect evidence, students make claims, and students engage in reasoning.

Pedagogical Content Knowledge (PCK) was represented by the content specific hardware and software articulated in the lesson plans and coding categories were developed based on previous work with math-specific content (Kersaint, Horton, Stohl & Garofalo, 2003) and with input from the science educator on our team.

Technological Pedagogical Knowledge (TPK) was represented using the five-level continuum for technology integration initially developed during the Apple Classrooms of Tomorrow (ACOT) study (Sandholz, Ringstaff & Dwyer, 1997): entry, adoption, adaptation, infusion and transformation. Criteria for each level were developed using descriptions within a technology integration resource and observation tools (Allsopp, Hohlfield & Kemker, 2007). It is possible for multiple levels of integration to be present in a lesson and reviewers identified the highest level of integration articulated in the lesson plans.

Interrater Reliability of Lesson Plan Reviewers
A cohort of trained reviewers analyzed the lesson plans in dyads. A dyad consisted of a math or science expert and an educational technology expert. 14 reviewers were divided into 7 dyads (4 science/educational technology and 3 math/educational technology). The reviewers were doctoral students in their respective subject areas and had extensive experience in K-12 education.

All reviewers attended a 6-hour training session conducted by members of the research team. The training sessions served several purposes. First, it allowed the reviewers to be introduced to each other and the project in a formal setting and allowed the reviewers to select their dyad partner based on scheduling preferences. Second, it allowed the research team to formally prepare the reviewers to code the lesson plans following a 14-page manual that was also developed by the research team. The manual included the purpose, framework, review criteria, review process, guiding principles, and definitions of the criteria for the reviewers to follow. Third, we collected data for calculating the inter-rater agreement across the technology/content dyads during the training session.

The reviewer training was executed in three iterations using a gradual release of responsibility model in which strong scaffolds were gradually decreased to the point at which reviewers were independently analyzing the lesson plans (Pearson & Gallagher, 1983): 1) independent staged walkthrough, 2) dyad staged walkthrough, and 3) coding simulation. Each stage will be described in detail in the full paper. Inter-rater agreement was calculated for each item and scoring differences for inter-rater agreement below 80% were resolved through dialogue among reviewers and researchers. The cumulative inter-rater agreement for both math dyads and science dyads was .94. After the training, the reviewers worked in their dyads to code each of the lesson plans within three weeks of the training session.

Data Analysis
Data from the online rubric was exported into IBM SPSS Statistics 19. Descriptive statistics analysis was conducted including frequencies such as the number of math/science topics, the number of certain level of technology integration, and the percentage of specific technologies utilized in the lesson plans were
calculated. Chi square was used to compare the counts in different categories of the lesson plans and to compare differences between pre and post lessons.

**Significance**

New approaches to educational inquiry are needed to gain insights into teacher technology integration practices (Culp, Honey & Mandinach, 2005; Dawson & Ferdig, 2006; Lei, 2007; Lei, 2010). These approaches should help “identify and develop themes and constructs that would apply across diverse cases and examples of practice” (Mishra & Koehler, 2006, p. 1018). The research design described here represents one plausible way to meet this need. The high level of interrater agreement achieved in our original study suggests our coding criteria and our associated reviewer training procedures may be of value to others seeking to study the technology integration practices of math and science teachers.

While our work specifically focused on math and science teachers, our general design can be adapted for other content areas through collaborations between educational technologist and content area specialists such as reading educators, English educators or social studies educators. Our design is also transferrable to preservice teacher education contexts.

Our research design also contributes to the larger need for codebooks or heuristics that can guide theoretically grounded research into teacher technology integration practices (Dawson & Ferdig, 2006; Mishra & Koehler, 2006). Finally, the large-scale nature of our original work (672 lesson plans) suggests the design is a reasonable way to collect data from teachers without disrupting their classroom work. Additional studies using this design will help us identify commonalities and distinctions across contexts and help build a better understanding of what is happening in classrooms related to technology integration.

**Caveat**

While our goal for this paper is to share a research design we believe is transferrable to numerous contexts in which the goal is to study teacher technology integration practices, the data were never associated with individuals nor were decisions about performance or competence made. A study associating lesson plans with individuals may be useful as a formative measure to inform individual professional growth and to study the effectiveness of a professional development at a teacher level; however, studies with high-stakes consequences for teachers should involve a variety of data points (Haertel & Means, 2003).

**References**


Florida Department of Education. (2010). *Florida next generation sunshine state standards.* Tallahassee, FL: FLDOE.


