Teacher beliefs and technology integration

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HIGHLIGHTS

- Teacher beliefs (i.e., epistemology and conceptions of teaching) were examined.
- The goal was to understand why technology is integrated differently among teachers.
- Such beliefs were related to teachers’ technology integration practice.
- Teacher beliefs need be considered in order to facilitate technology integration.
- Several suggestions for positive changes in teachers’ beliefs are provided.

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ABSTRACT

The purpose of this exploratory mixed methods study was to investigate how teacher beliefs were related to technology integration practices. We were interested in how and to what extent teachers’ (a) beliefs about the nature of knowledge and learning, (b) beliefs about effective ways of teaching, and (c) technology integration practices were related to each other. The participants were twenty-two teachers who have participated in a four-year professional development project funded by the U.S. Department of Education. Specific relations between teachers’ beliefs and technology integration practices are presented. The implications for professional development and suggestions for teacher belief change and technology integration are discussed.

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1. Introduction

As an international phenomenon, technology is an important part of our everyday lives and efforts to improve teaching and learning (Sandholtz, Ringstaff, & Dwyer, 1997; Voogt, Tilya, & van den Akker, 2009; Williams, Linn, Ammon, & Gearhart, 2004). With the importance of technology in education, technology integration has been greatly emphasized in teacher training and professional development (Lawless & Pellegrino, 2007). However, it has been criticized that teachers have not been provided with adequate support that goes beyond learning specific technology skills (e.g., using a particular tool or software program) (Llorens, Salanova, & Grau, 2002).

In recent years, technological pedagogical content knowledge (TPACK; changed from TPCK in Thompson & Mishra, 2007) has been studied to understand what knowledge and skills teachers lack and what professional development ought to target in order to systemically improve effective use of technology in teaching (Koehler & Mishra, 2009; Mishra & Koehler, 2006). Many argue that teachers’ integrative knowledge of technology, pedagogy, and content that goes beyond specific technology skills should be emphasized in teacher development (e.g., Niess, 2005; Polly, McGee, & Sullivan, 2010). Although teachers’ TPACK is a strong enabler for effective technology integration, still this does not explain why teachers with sufficient knowledge utilize technology differently. For example, some use an interactive whiteboard only to project content while others use the board to support interactive student inquiry processes (Hall, 2010). Using an interactive whiteboard just to present information without any interaction has no real pedagogical advantages over traditional whiteboards. However, with the functionality that an interactive whiteboard allows, immediate, dynamic changes in pedagogical decisions and actions that are contingent on students’ input are possible (Kennewell & Beauchamp, 2007). Interactive use of interactive whiteboards to actively engage students with the subject matter.
through the technology would probably justify the additional expense compared to the cost of a traditional whiteboard, and schools are already widely equipped with interactive whiteboards in the U.K., the U.S., Australia, South Korea, and elsewhere.

In an attempt to understand why technology is differently (or not at all) integrated into teaching among teachers who are equipped with relevant knowledge, two sets of barriers are often discussed (Ertmer, 1999, 2005; Hew & Brush, 2007): (a) first-order barriers concern factors such as environmental readiness (e.g., computers, the Internet access) and teacher knowledge (e.g., TPACK); (b) second-order barriers include factors such as teachers’ beliefs (Ertmer, 1999, 2005; Hew & Brush, 2007). Second-order barriers, defined as the intrinsic factors that hinder technology integration, can interfere with teachers’ technology integration even when first-order barriers are overcome (Ertmer, 1999). It has been well documented that technology availability creates the possibility of effective technology integration (e.g., Norris, Sullivan, & Poirrot, 2003) but knowledge pertinent to pedagogy and content are required to realize the full potential of teaching technologies to improve learning and instruction (e.g., Mishra & Koehler, 2006; Shulman, 1987). Nonetheless, the acquisition of technology and knowledge does not always lead to effective technology integration (Polly, Mims, Shepherd, & Inan, 2010). Teachers’ persistent beliefs about their current practices are recognized as second-order barriers that delay or inhibit technology integration (Ertmer, 2005). Even when technology and technical knowledge are in place (i.e., when first-order barriers are overcome), effective technology integration requires teachers’ beliefs in “new ways of both seeing and doing things” (Ertmer, 2005, p. 26). Teachers’ beliefs predict, reflect, and determine their actual teaching practice (Kagan, 1992; Pajares, 1992; Wilkins, 2008). For instance, research has shown that the ways of teaching can be different depending on teachers’ different beliefs even when the teachers have similar knowledge and skills (e.g., Ernest, 1989). Teacher beliefs are considered even more influential than teacher knowledge (Pajares, 1992), Understanding of teachers’ beliefs that make technologies differently integrated into teaching would be helpful in improving technology integration trainings.

In short, to promote teachers’ technology integration practice in the classroom, it has been suggested that second-order barriers to technology integration should be identified and overcome; positive changes in teacher beliefs could help surmount second-order barriers (Ertmer, 2005; Hew & Brush, 2007). Thus, we examined how teachers’ beliefs are related to their technology integration practices. In doing so, first, we reviewed the literature to determine the teacher beliefs that should be examined. Second, we examined teachers’ (a) beliefs about the nature of knowledge and learning, as well as (b) beliefs about effective ways of teaching. Last, we investigated how such beliefs are related to teachers’ technology integration practice. Throughout the investigation, it was expected that information about relationships between teacher beliefs and technology integration would suggest how to take teacher beliefs into consideration so as to facilitate technology integration.

2. Theoretical framework

2.1. Teacher beliefs

2.1.1. Defining teacher beliefs in relation to technology integration

Teacher beliefs have been studied to understand teaching practices (Pajares, 1992) since beliefs influence behaviors (Ajzen & Madden, 1986). Teacher beliefs are considered an indicator for certain behaviors in class because of the mediating effects of beliefs on the ways of teaching via their impact on decision making (Kagan, 1992; Kane, Sandretto, & Heath, 2002; Ng, Nicholas, & Williams, 2010; Pajares, 1992). For instance, teachers who believe that learning in collaboration brings about greater benefits than learning alone would tend to include more group work than teachers who see little or no learning value in collaboration.

Teacher beliefs are regarded as one of the most valuable constructs for teacher education (Kagan, 1992; Pajares, 1992). Teacher beliefs have been studied in the U.K. (e.g., Blay & Ireson, 2009; Florian & Rouse, 2009), Spain (e.g., Cano, 2005), Greece (e.g., Matthoudakis, 2007), Portugal (e.g., Fonseca, Costa, Lencastre, & Tavares, 2012), Israel (e.g., Shechtman & Or, 1996; Zohar, Degani, & Vaaknin, 2001), the Netherlands (e.g., Meirink, Meijer, Verloop, & Bergen, 2009; Tillema, 1994; Zantinga, Verloo, & Vermunt, 2001), Turkey (e.g., Isikoglu, Basturk, & Karaca, 2009; Özgün-Koca & Şen, 2006), China (e.g., Correa, Perry, Sims, Miller, & Fang, 2008), South Korea (e.g., Lee, Baik, & Charlesworth, 2006), Japan (e.g., Underwood, 2012), Singapore (e.g., Lim, 2010), Australia (e.g., Mansfield & Volet, 2010; Ng et al., 2010), the U.S. (e.g., Brousseau & Freeman, 1988; Sanger & Ogusortho, 2011; Stipek, Givvin, Salmon, & MacGyvers, 2001), Canada (e.g., Jordan, Glenn, & McGieh-Richmond, 2010), and the list goes on. However, the term ‘teacher beliefs’ has been used inconsistently and previous studies focused on a variety of beliefs such as teacher expectation of learner success (i.e., self-fulfilling prophecy; e.g., Harackiewicz & Juvani, beliefs, self-efficacy to use their inability to teach; i.e., teacher efficacy; e.g., Tschanne-Moran & Woolfolk Hou, 2001), beliefs about the value of specific teaching strategies or materials (e.g., computer use; Park & Ertmer, 2008), content-specific beliefs (i.e., different views on how to be taught per content; Kagan, 1992), and so on.

Defining teacher beliefs in relation to technology integration has no consensus as well. However, in many studies, what beliefs are about is specified, as Pajares (1992) recommended. Some researchers regard teacher beliefs as beliefs about the value of technology for student learning (e.g., Polly et al., 2010); some regard teacher beliefs as self-efficacy regarding technology use (e.g., Abbitt, 2011; Wang, Ertmer, & Newby, 2004); and some regard teacher beliefs as a combination of self-efficacy, beliefs about the value of technology, and beliefs about teaching and learning with technology (e.g., Park & Ertmer, 2008).

One difference that we noticed in research on teacher beliefs in technology integration contexts is that the view on beliefs is narrower than in research on teacher beliefs in general. In other words, it appears that researchers examined beliefs only associated with technology although there should be fundamental beliefs that are associated with teacher beliefs in relation to technology. For example, a teacher believes that the value of technology for student learning is high because an interactive whiteboard allows her to promote active participation of students. In contrast, another teacher believes that the value of technology for student learning is high because an interactive whiteboard allows him to deliver content more efficiently by projecting online resources on the board. Although both teachers perceive the value of interactive whiteboard technology to be equally high, their beliefs about the value of the technology do not explain their different uses of that technology. In order to understand why technology is integrated differently among teachers, their fundamental beliefs about what is important in student learning and thus teaching (regardless of technology use) should be understood.

We are not arguing that self-efficacy, beliefs about the value of technology, and beliefs about teaching and learning with technology should not be studied. We do recognize that if teachers do not have self-efficacy beliefs in their ability to use their interactive whiteboard, for example, it is unlikely that they will integrate such a technology into teaching. We are arguing that fundamental beliefs (regardless of the technology involved) that teachers bring into teaching should be studied in order to understand how
differently (or not at all) technology is integrated. For example, after teachers attended a professional development training together, acquired necessary knowledge and skills with confidence, and are convinced to use their interactive whiteboard, why do they use their interactive whiteboards differently? In this study, our core interest is in teachers’ fundamental beliefs that may play a critical role in making a decision on how to use a particular technology to support learning. Thus, we decided to investigate teacher beliefs about the nature of knowledge and learning (i.e., epistemology; e.g., Schommer, 1990) and about effective ways of teaching (i.e., conceptions of teaching; e.g., Chan & Elliott, 2004), regardless of any particular technology. More specific descriptions of teachers’ epistemology and conceptions of teaching are provided in the following sections as well as the rationale for our choice for these two beliefs.

2.1.2. Teacher beliefs about the nature of knowledge and learning (epistemology)

One’s beliefs about the nature of knowledge and learning are directly or indirectly related to performance mediated by cognitive processes, motivation, attitudes, behavior, efforts, and so forth (Schommer, 1990). Most of the research on these beliefs has focused on epistemological beliefs. Schommer has conceptualized and refined a framework of epistemological belief research (Schommer, 1998; Schommer-Aikins, 2002; Schommer-Aikins & Hutter, 2002). Schommer (1990) argued that one’s epistemological beliefs consisted of multidimensional beliefs, which were to some degree independent of each other (Schommer, 1990). Her five dimensions of beliefs about knowledge acquisition and learning consist of: 1) the structure of knowledge, ranging from isolated pieces to integrated concepts, 2) the source of knowledge, ranging from authority to reasoning, 3) the stability of knowledge, ranging from certain knowledge to changing knowledge, 4) the speed of learning, ranging from quick learning to gradual learning, and 5) the ability to learn, ranging from fixed at birth to improvable (Schommer, 1998; Schommer-Aikins, Duell, & Hutter, 2005). She indicated that “unspoken and sometimes unconscious beliefs about the nature of knowledge and learning play a critical role” in guiding a person’s thinking (Schommer-Aikins & Hutter, 2002, p. 13) and affect reasoning and decision making in learning and teaching environments. For example, if a teacher believes that the source of knowledge is authority, that teacher may not use a relatively open-ended approach such as a WebQuest (Dodge, 1997) that encourages students to explore a variety of sources (e.g., Google search, library, etc.) and construct answers to a given problem or complete a certain task. Instead, that teacher may just show answers on an interactive whiteboard, which is not so different from showing content on a traditional blackboard.

2.1.3. Teacher beliefs about effective ways of teaching (conceptions of teaching)

Teacher beliefs about effective ways of teaching are conceptions of teaching associated with teacher-centered and student-centered approaches to instruction (Chan & Elliott, 2004). Teacher-centered approaches tend to emphasize the activities that a teacher uses to promote learning. Student-centered approaches tend to emphasize the activities in which a student is engaged. Associated with these two approaches is a continuum from structured, directed learning environments to unstructured, open-ended learning environments. For example, if a teacher believes that teaching is about letting students search around for answers rather than explaining the answers directly, that teacher may use a relatively open-ended approach such as a WebQuest (Dodge, 1997). Technology integration goes beyond the use of any particular technology, and it can be tightly connected with teachers’ beliefs about effective ways of teaching to support learning and instruction. Student change (e.g., surface and deep learning approaches) and achievement are dependent on teachers’ conceptions of teaching (Cano, 2005).

3. Research questions

The purpose of this study was to examine the relation of teachers’ beliefs to their technology integration practices. The context for the study was a four-year professional development project. The goal of the professional development project was to increase the technology capacity and competency of teachers in poorly performing rural schools and to improve the quality of participating teachers’ integration of technology in their classrooms to support specific learning objectives and students’ mastery of skills and competencies described in the states’ standards. It was reasonable to consider that first-order barriers to technology integration were overcome in this group of teachers since extrinsic factors (e.g., access to resources and sufficient technology skills and knowledge) were appropriately functioning. We do not claim that all first-order barriers were overcome because teachers’ integrated knowledge of technology, pedagogy, and content was not specifically examined in this study. However, it was worth investigating second-order barriers, especially teacher beliefs, not only because of environmental readiness but also because of teachers’ technology skills and knowledge that were used in technology integration combined with their existing knowledge of content and pedagogy. Consequently, our research questions focused on teacher beliefs. We were specifically interested in how and to what extent teachers’ (a) beliefs about the nature of knowledge and learning, (b) beliefs about effective ways of teaching, and (c) technology integration practices are related to each other. The following research question was addressed: How do teacher beliefs about the nature of knowledge and learning as well as effective ways of teaching relate to their technology integration practices?

4. Context and methodology

4.1. Participants

The participants were among the teachers who have participated in our four-year Comprehensive School Reform program funded by the U.S. Department of Education. Among a total of 42 teachers involved in our project over its four-year duration, 22 teachers were selected for this particular research, using these two criteria: (a) taught in class during the project years (e.g., school library media specialists were excluded from the data collection), and (b) participated in the project for at least two consecutive years from 2007 to 2010. In short, the selection of only 22 of the 42 teachers was to intentionally focus on those teachers who were actually in classrooms most of the time during the project. Among the 22 teachers, 5 taught 4th graders, 4 taught 2nd graders, 4 taught 6th graders, 3 taught 5th graders, 2 taught 3rd graders, 2 taught 8th graders, 1 taught 1st graders, and 1 taught 7th graders.

The primary goal of our project was to improve the use of technology in poorly performing rural K-8 schools in the Southeast in the United States by providing (a) new technologies, (b) professional development workshops, and (c) technical and pedagogical assistance. The technologies included laptops, interactive whiteboards, digital cameras and recorders, and other technologies selected in collaboration with participating schools. Professional development workshops included intensive, week-long summer training workshops each year as well as workshops on demand during the school year. Training sessions included such topics as integrating Web resources into lessons (e.g., the use of GeoGebra allowing the dynamic manipulation of equations along with
automatic visualization to learn both geometry and algebra; Hohenwarter, Hohenwarter, and Lavicza (2009)), video recording and editing, maintaining a Web-based knowledge sharing system, using video-conferencing, and so on. Technical and pedagogical assistance was given to teachers face-to-face, by phone, and by video-conference. The eight participating elementary and middle schools in Alabama, Florida and Georgia received approximately 40% of the total grant to support technology upgrades and teacher professional development training. The schools had voice and choice in selecting which technologies to acquire, although these technologies had to be consistent with project goals and used by participating teachers.

4.2. Data collection

4.2.1. Teacher beliefs about the nature of knowledge and learning (epistemology)

Teacher beliefs about the nature of knowledge and learning were measured using Schommer’s (1990) Epistemological Belief Questionnaire (EBQ). The questionnaire consists of 63 questions with regard to five multidimensional beliefs, which are to some degree independent of each other, as follows: 1) the structure of knowledge; 2) the source of knowledge; 3) the stability of knowledge; 4) the speed of learning; and, 5) the ability to learn. Table 1 shows sample questions for each belief. Reliability scores on the sub-scales of EBQ (its adult version) range from .63 to .85 and validity has been verified in a variety of settings (Chan & Elliott, 2004; Schommer-Aikins et al., 2005). Scale reliabilities in this study were .40 for the structure of knowledge, .22 for the source of knowledge, .36 for the stability of knowledge, .65 for speed of learning, and .50 for ability to learn.

4.2.2. Teacher beliefs about effective ways of teaching (conceptions of teaching)

Teacher beliefs about effective ways of teaching were measured using part of the Teaching, Learning, and Computing (TLC) survey developed under projects funded by the National Science Foundation and the U.S. Department of Education (Becker, 2001). We used three scales from the survey (J1, J2, and J3) to figure out where teachers’ conceptions of teaching are along a teacher-centered and student-centered continuum. The rationale for our choice was to investigate teachers’ beliefs about effective ways of teaching regardless of technology by asking about their beliefs regarding class discussions (J1), learning process (J2), and teacher role (J3). For example, the items with regard to class discussions questioned teachers’ perspectives on how open-ended the class discussions should be (see Fig. 1 for sample questions). Reliability score on the sub-scales of TLC was .83 (Becker, 2001) and validity was verified using interviews and classroom observations (Ravitz, Becker, & Wong, 2000). Scale reliabilities in this study were .92 for class discussions (J1), .76 for learning process (J2), and .33 for teacher role (J3).

4.2.3. Technology integration

Technology integration was measured using (a) classroom observations and (b) teacher interviews. For classroom observations, the Classroom Lesson Observation (CLO) survey of CITERA (Comprehensive Information Technology Education in Rural Appalachia, funded by the National Science Foundation; http://www.theedventuregroup.org/citerawv/) was used. We used two scales from CLO to rate the design and implementation of teachers’ lessons that incorporated technologies, ranged from teacher-centered (highly structured, directed learning) to student-centered (mostly unstructured, open-ended learning). CLO has been utilized in middle and high school contexts to see the impact of technology integration professional development on classroom teaching (Darrah & Blake, 2009). For the teacher interview, a semi-structured interview protocol was used to examine teachers’ levels of use (LoU) of technology (Hall, Dirksen, & George, 2006). This

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Table 1 Sample questions on the Epistemological Belief Questionnaire (EBQ).

<table>
<thead>
<tr>
<th>Beliefs about:</th>
<th>Sample questions from Epistemological Belief Questionnaire (EBQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure of knowledge</td>
<td>“The best thing about science courses is that most problems have only one right answer.”</td>
</tr>
<tr>
<td>Source of knowledge</td>
<td>“Sometimes you just have to accept answers from a teacher even though you don’t understand them.”</td>
</tr>
<tr>
<td>Stability of knowledge</td>
<td>“Today’s facts may be tomorrow’s fiction.”</td>
</tr>
<tr>
<td>Speed of learning</td>
<td>“Successful students understand things quickly.”</td>
</tr>
<tr>
<td>Ability to learn</td>
<td>“Wisdom is not knowing the answers, but knowing how to find the answers.”</td>
</tr>
</tbody>
</table>

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Fig. 1. Sample teacher conception questions.
Interview protocol was constructed based on the Concerns-Based Adoption Model (CBAM), which is frequently applied to assessing teachers' status of technology integration and to providing support for them (Ellsworth, 2000). CBAM has been utilized in a variety of studies and is regarded as "a powerful tool for diagnosing the implementation effort's progress" (Ellsworth, 2000, p. 43). Teachers' responses to the semi-structured interview protocol were analyzed by the research group following the branching chart of LoU (see Fig. 2) and one of the eight levels were determined for each response (see Table 2). The following are some of the questions included in the interview protocol included questions.

- Can you describe your preparation process for a lesson in which you used a technology? (How much time did you spend? Where did you start? How did you pick the technology? Did you talk to your colleagues about your lesson plan?)
- What concerned you the most when you were planning the lesson? (Time you spent for the preparation; students' reactions; technologies failure; etc.)
- Did you feel the class went well? (If so, what aspects were satisfactory? If not, why did you feel it didn't go well? Did you make some changes and try the lesson again?)
- What technologies you think were the most effective? Why?
- Have you felt like you've needed to make changes in your ways of teaching with technologies? How would you like to change the way of using technologies? If so, what kinds of changes have you thought of?

Both the classroom observations and teacher interviews were done by the project team that consisted of four researchers. Before the classroom observations, the team conducted a pilot test by observing a couple of classrooms and scored each item of CLO independently during each classroom observation. After the observations, the team discussed similarities and differences in ratings as well as rationales for each rating in order to synchronize the team's understanding of each item and interpretation as much as possible. For the actual classroom observations, two or three members of the team rated each item independently and then the team debriefed each observation and reviewed scorings as a group to reach a consensus on scores, which were used in the data analysis. Inter-rater reliability was over .70; however, this reliability score is not statistically interpretable due to the small number of observations.

For the teacher interviews, one of the researchers led all the interviews but each interview had two other researchers participating. Each interview was audio-recorded. Two of the researchers participated. Each interview was audio-recorded. Two of the researchers participated.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Levels of use (Hall et al., 2006).</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Nonuse</td>
<td>State in which the user has little or no knowledge of the innovation, no involvement with the innovation, and is doing nothing toward becoming involved.</td>
</tr>
<tr>
<td>1: Orientation</td>
<td>State in which the user has recently acquired or is acquiring information about the innovation and/or has recently explored or is exploring its value orientation and its demands upon user and user system.</td>
</tr>
<tr>
<td>2: Preparation</td>
<td>State in which the user is preparing for the first use of the innovation.</td>
</tr>
<tr>
<td>3: Mechanical use</td>
<td>State in which the user focuses most effort on the short-term, day-to-day use of the innovation with little time for reflection. Changes in use are made more to meet user needs than client needs.</td>
</tr>
<tr>
<td>4A: Routine use</td>
<td>Use of the innovation is stabilized. Few if any changes are being made in ongoing use. Little preparation or thought is being given to improving innovation use or its consequences.</td>
</tr>
<tr>
<td>4B: Refinement</td>
<td>State in which the user varies the use of the innovation to increase the impact on clients within immediate sphere of influence. Variations are based on knowledge of both short- and long-term consequences for clients.</td>
</tr>
<tr>
<td>5: Integration</td>
<td>State in which the user is combining own efforts to use the innovation with related activities of colleagues to achieve a collective impact on clients within their common sphere of influence.</td>
</tr>
<tr>
<td>6: Renewal</td>
<td>State in which the user re-evaluates the quality of use of the innovation, seeks major modifications of or alternatives to present innovation to achieve increased impact on clients, examines new developments in the field, and explores new goals for self and the system.</td>
</tr>
</tbody>
</table>

Fig. 2. Branching chart in (From: Measuring implementation in schools: Levels of Use (Fig. 3.1: Branching Chart, p. 18) by G. E. Hall, D. J. Dirksen, and A. A. George, 2006, Austin: SEDL. Copyright © 2006, SEDL. Reprinted by ChanMin Kim with permission of SEDL.).
team members transcribed the interviews: one of them transcribed the interviews first and the other reviewed the transcripts while listening to the interviews and made changes to ensure the accuracy. The other two members of the team scored transcripts collectively; that is, one of the two scored transcripts first and then the two discussed each scoring line by line to either keep the score or revise it per discussion. We did not record inter-rater reliability.

5. Results

Table 3 shows the descriptive statistics of the data. Pearson correlation coefficients were used to examine the relations among teacher beliefs about the nature of knowledge and learning (epistemology), beliefs about effective ways of teaching (conceptions), technology integration practices (see Table 4).

A summary of significant results is as follows:

(1) Teacher beliefs about the nature of knowledge and learning (epistemology) were significantly correlated with teacher beliefs about effective ways of teaching (conceptions):
   a) Epistemological beliefs about the structure of knowledge was significantly correlated with teacher conceptions on learning process ($r = .444$) and teacher role ($r = .447$).
   b) Epistemological beliefs about the source of knowledge was significantly correlated with teacher conceptions on learning process ($r = .422$).

(2) Teachers’ beliefs about effective ways of teaching (conceptions) was significantly correlated with technology integration practices:
   a) Teacher conceptions on class discussions was significantly correlated with lesson design ($r = .692$) and levels of technology use ($r = .882$).

These results showed that teachers’ beliefs about the nature of knowledge and learning (epistemology), beliefs about effective ways of teaching (conceptions), and technology integration were positively correlated with one another; that is, the more sophisticated epistemology teachers had, their conceptions were closer to the student-centered approach end of the teacher-centered/student-centered continuum (1-a & 1-b) and their status of technology integration showed a more seamless use of technology, meaning that the focus and emphasis remained on the learning rather than on the technology (2-a & 2-b). In addition, there was consistency between what teachers do in their teaching and what they say they do (3-a & 3-b). It is noteworthy that what teachers say they do (levels of technology use) was significantly correlated with both their beliefs about effective ways of teaching (conceptions on class discussions and teacher role) and their actual practices with regard to technology integration (lesson design and lesson implementation). The relations are illustrated in a simplified diagram (see Fig. 3) and example scenarios of Teacher X and Teacher Y illustrating different technology integration practices according to teacher beliefs (see Table 5).

### Table 3
Descriptive statistics.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Variables</th>
<th>Mean (SD)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>3.27 (.25)</td>
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<tr>
<td></td>
<td>Structure of knowledge</td>
<td>3.72 (27)</td>
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<td></td>
<td>Source of knowledge</td>
<td>3.13 (.39)</td>
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<tr>
<td></td>
<td>Stability of knowledge</td>
<td>3.41 (.26)</td>
</tr>
<tr>
<td></td>
<td>Ability to learn</td>
<td>3.65 (34)</td>
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<tr>
<td></td>
<td>Class discussion</td>
<td>3.79 (1.43)</td>
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<tr>
<td></td>
<td>Learning process</td>
<td>2.81 (.70)</td>
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<tr>
<td></td>
<td>Teacher role</td>
<td>2.67 (.55)</td>
</tr>
<tr>
<td></td>
<td>Lesson design</td>
<td>2.69 (.56)</td>
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<td></td>
<td>Lesson implementation</td>
<td>2.62 (.82)</td>
</tr>
<tr>
<td></td>
<td>Level of technology use</td>
<td>3.79 (1.43)</td>
</tr>
</tbody>
</table>

Notes: Possible ranges: 1–5 for a, b, d; 1–6 for c; 0–7 for e. Date sources: d was obtained from observations; e was determined from interview data.

### Table 4
Correlations among variables.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>1.Structure of knowledge</td>
<td></td>
<td>.477*</td>
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<td>2.Source of knowledge</td>
<td></td>
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<td>.486*</td>
<td>.189</td>
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<td>3.Stability of knowledge</td>
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<tr>
<td>4.Speed of learning</td>
<td></td>
<td>.288</td>
<td>.410</td>
<td>.146</td>
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<td></td>
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<tr>
<td>5.Ability to learn</td>
<td></td>
<td>.190</td>
<td>.071</td>
<td>.133</td>
<td>.027</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6.Class discussion</td>
<td></td>
<td>.213</td>
<td>.151</td>
<td>.103</td>
<td>.101</td>
<td>.196</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.Learning process</td>
<td></td>
<td>.444*</td>
<td>.422*</td>
<td>.299</td>
<td>.138</td>
<td>.064</td>
<td>.446*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.Teacher role</td>
<td></td>
<td>.447*</td>
<td>.361</td>
<td>.064</td>
<td>.110</td>
<td>.203</td>
<td>.532*</td>
<td>.556*</td>
<td></td>
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<tr>
<td>9.Lesson design</td>
<td></td>
<td>.233</td>
<td>.327</td>
<td>.047</td>
<td>.143</td>
<td>.077</td>
<td>.692*</td>
<td>.024</td>
<td>.390</td>
<td></td>
</tr>
<tr>
<td>10.Lesson implementation</td>
<td></td>
<td>.235</td>
<td>.157</td>
<td>.154</td>
<td>.233</td>
<td>.065</td>
<td>.549</td>
<td>.016</td>
<td>.372</td>
<td>.782*</td>
</tr>
<tr>
<td>11.Level of technology use</td>
<td></td>
<td>.125</td>
<td>.197</td>
<td>.428</td>
<td>.292</td>
<td>.179</td>
<td>.882*</td>
<td>.479</td>
<td>.673*</td>
<td>.826*</td>
</tr>
</tbody>
</table>

* denotes a correlation that is significant at the .05 level.
6. Discussion

6.1. Summary of findings

As stated previously, our core interest was in relationships between teachers’ beliefs and their technology integration practices. The overall goal of the professional development aspect of the project was to increase the technology capacity and competency of teachers in poorly performing rural schools and the goal was achieved as shown in research on the project (e.g., McKeown, 2008). However, to find ways of improving professional development and to contribute to larger communities of teacher education and technology integration, it was necessary to examine why teachers differently integrated technology into classrooms (e.g., using an interactive whiteboard to show content vs. to interact with students).

As fundamental beliefs, teachers’ beliefs about the nature of knowledge and learning (epistemology) and beliefs about effective ways of teaching (conceptions) were examined. We found that teachers’ beliefs about the nature of knowledge and learning and beliefs about effective ways of teaching were related to their technology integration practices. This finding is consistent with prior research that has shown that teacher beliefs are strongly connected to teaching practices (Kagan, 1992; Nespor, 1987; Pajares, 1992). Although technology integration is about how teaching is practiced, there has been much research on the connections between teachers’ epistemology and conceptions and their technology integration practices.

Our study findings suggest that teacher beliefs should be considered in order to facilitate technology integration. Especially, teacher beliefs about the nature of knowledge and learning that influence their beliefs about effective ways of teaching should be further studied since those fundamental beliefs can be a starting point to overcome the second-order barriers to technology integration. For example, the finding that teachers’ beliefs about the speed of learning and the source of knowledge are most strongly related to their conceptions suggests that personal epistemology determines decision making on how to teach in general as well as how to teach with technology (Chan & Elliott, 2004).

It is worth noting that we only indicate that teacher beliefs are related to technology integration. Correlation does not imply causation. Correlation-coefficients are obtained by standardizing the covariance between variables, which makes it possible to compare the relative strength of covariances. There is an empirical consensus of the magnitude of the value in social sciences (Glass & Hopkins, 2008). Values in this study indicate either strong or very strong relationships since they fell into the range either between .4 and .6 or between .6 (strong) and 1.0 (very strong; see Table 4). We also would like to highlight the practical significance of the correlations in this study. The associations of the beliefs about the nature of knowledge and learning on technology integration seem implicit and mediated by more explicit beliefs such as beliefs about effective ways of teaching. Those findings imply that designing interventions for changes of the beliefs about effective ways of teaching could be more effective and efficient to lead changes of technology integration as well as positively influence the beliefs about knowledge and learning.

It should be further studied what should be done to make positive changes to teachers’ beliefs to enact technology integration that promotes student learning. This is critical in the 21st century when it is expected that “the teacher is a facilitator or coach for learning rather than a purveyor of expert knowledge” (Deakin Crick, 2012, p. 175). To fulfill the expectation, teachers’ beliefs that students can be a source of their own knowledge, for example, can be a gateway belief to facilitate changing how technology is integrated into teaching and learning. The role of teachers as a facilitator is shown to be important in McCombs, Daniels, and Perry’s (2008) study; that is, students’ perceptions of their teachers’ “facilitation of thinking and learning” were positively correlated with their perceptions of their own competence and interest in school (p. 29). The following section describes what can be done to help with positive changes in teachers’ beliefs.

6.2. Suggestions for teacher belief change

Researchers have discussed how and to what extent teacher beliefs can be altered. Pajares (1992) argued that changes in adults’ beliefs are rare and if changes occur, “a gestalt shift” enabled the changes (p. 325). Kagan (1992) acknowledged that teacher beliefs do not change by reading about newer beliefs but change “through conceptual change” that requires them to critically recognize their own beliefs as well as to observe, evaluate, and alternative beliefs (p. 76). Although many agree that beliefs are resistant to change, they also agree that the difficulty changing teacher beliefs comes from experience that teachers bring into their beliefs (Kagan, 1992; Kane et al., 2002; Pajares, 1992). This suggests that we ought to allow experience that can be built up to challenge teachers’ current beliefs but ultimately optimize their beliefs for student learning.

The argument that teacher beliefs ought to be considered to improve teaching practices is consistent among researchers who study teacher beliefs in relation to technology integration. Changes in teacher beliefs are recommended as a critical part for facilitating teacher change in the contexts of technology use (e.g., Ertem & Ottenbreit-Leftwich, 2010). Some attempt to change teacher beliefs as seen in studies like the one we are describing. For example, Perry’s (1970) work with preservice teachers is one approach to changing teacher beliefs.

Table 5

Example scenarios illustrating different technology integration practices according to epistemological beliefs and teaching philosophy.

<table>
<thead>
<tr>
<th>Teacher X</th>
<th>Teacher Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs about the nature of knowledge and learning (epistemology)</td>
<td>Source of knowledge: authority</td>
</tr>
<tr>
<td>Beliefs about effective ways of teaching (conceptions)</td>
<td>Ms. Hill's class discussion (see Fig. 1) was preferred; asking questions that the students could answer quickly based on the reading they had done the day before</td>
</tr>
<tr>
<td>Technology integration practices</td>
<td>Teacher-centered: Highly structured, directed learning</td>
</tr>
<tr>
<td>Teacher's comments: my main concern still today ... when I plan a lesson that involved using technology, the Smartboard or whatever it is, I still make myself a back-up plan in case it doesn't work:</td>
<td>Level of use: 3 (mechanical use)</td>
</tr>
<tr>
<td>“There are so many resources out there so I can use without taking my time.”</td>
<td>Teacher's comments: “They have their own laptops, which could be sometimes a time issue. But it is worthy because they love it and want to and can do much more. For example, there are so many games they can learn from.”</td>
</tr>
<tr>
<td>“Basically I am not here, but the class can go on... just efficient.”</td>
<td>“I would like to know anything new that could interest my students and keep them engaged.”</td>
</tr>
</tbody>
</table>
beliefs by implementing pedagogical interventions such as problem-based learning, modeling laboratory experience, etc. (e.g., Ma, Lai, Williams, & Prejean, 2008; Park & Ertmer, 2008). However, beliefs studied in such contexts tend to be only technology-focused without considering fundamental beliefs (e.g., beliefs about teaching regardless of technology). Moreover, teacher beliefs about the nature of knowledge and learning have rarely studied (Chan & Elliott, 2004), especially in the technology integration contexts (c.f., Maor & Taylor, 1995), despite the notion that “epistemological beliefs play a key role in knowledge interpretation and cognitive monitoring” (Pajares, 1992, p. 325).

Various strategies have been suggested to promote teacher belief change such as observation, practice, reflection, and social cultural support (Ertmer, 2005; Kim & Baylor, 2008; Ma et al., 2008; Shulman, 1987). These strategies can be done through collaboration among teachers that could also change school culture (Chen, 2008). In order to facilitate collaboration, both internal (within the same school) and external (beyond school boundaries) networking is recommended. Both are necessary for the teachers to share information, discuss difficult situations, and guide and encourage the implementation of newer beliefs. For instance, if a cultural environment of teacher collaboration encourages beliefs that not every lesson should be teacher-centered, it is possible for teachers to let students create movie clips to present their understandings of weather changes in a science class. Through the observations of other teachers’ lessons, teachers can reflect on and perhaps alter their roles and responsibilities and change their ways of integrating technology. Besides, a collaborative environment can give teachers more opportunities to see successful outcomes of innovative uses of technology and see different beliefs and technology integration practices in action (Rogers, 1995). A technological environment that allows dialog, debate, and collective sense-making such as Cohere (see De Liddo & Buckingham Shum, 2010) can be used to formulate collective beliefs that a group of teachers are convinced to act on. The process of formulating collective beliefs should include “examining existing beliefs,” “filtering prior beliefs,” and “alignment and conflict of ideas”; these were found to be critical in developing a set of beliefs related to classroom teaching in a study by Mansfield and Volet’s (2010) with Australian preservice teachers (p. 1404).

It is less likely that a one-time effort to change teachers’ belief systems transforms teachers radically. Fundamental changes do not happen quickly or automatically. In order for the sustained growth and positive changes in teaching practice to occur, incremental supports should be provided, and the supports should be ones that satisfy progressive needs for change. First of all, any incremental step or change should be sensitive to the current needs of teachers. For that, both formative and summative evaluations should be conducted (Schiffman, 1995). For example, during the processes of designing, developing and implementing a teacher collaboration program, formative evaluations should be conducted. After implementing a collaboration program, summative evaluation of its impact and effects should be undertaken. Appropriate reflection and support should be followed up only with the understanding of the needs based on the results of the evaluations. In addition, this process of evaluations can contribute to building the leadership that connects policy for professional development to the evidence of what teachers need to know to improve beliefs and improve teaching practice (Timperley & Alton-Lee, 2008).

Allowing school voice and choice in selecting appropriate technologies and teacher leaders was a unique aspect of our project that contributed to its overall success in terms of teacher and principal support. However, we also realized that such a unique effort was not as effective as it could have been in cases where a school lacked strong principal support and advocacy for technology integration. We concluded that a crucial condition for change is the active involvement of leadership, consistent with Ellsworth’s (2000) finding. Not only “the cognitive or rational impact of leadership” but also “the affective influences of leadership” should be emphasized (Ellsworth, 2000, p. 67). The leadership development effort could be made to help principals play the roles of not only an official supervisor but also a consultant to handle teachers’ “fundamental choices, mental models and cultures” (Sparks, 2004, pp.14—15). The leadership of the principal can be empowered to make impact on teachers’ implementation of newer beliefs and provide them with scaffolding for them overcoming their weaknesses and accelerating their strengths (Ellsworth, 2000).

6.3. Limitations and suggestions for future research

There are several limitations in our present study worth mentioning. First, the number of participants is small, which limits the generalizability of the results of this study. The selection of the 22 teachers was based on the goal of examining the second-order barriers (i.e., teacher beliefs) to technology integration of teachers who were actually in classrooms for the three-year project. In addition, the eight schools cannot be considered representative of the population of all schools or even all poorly performing rural K-8 schools in the United States. Also considering that reliability scores for some of the measures were lower in this study than in previous studies, the findings reported earlier should only be considered provisional and suggestive.

Second, the chance of Type I error increased due to the several correlations computed. Bonferroni adjustment could have helped avoiding Type I errors. However, Bonferroni adjustment is also known to cause the inflation of Type II errors reducing statistical power. Researchers question if avoiding Type I errors is more worthy than ignoring the relationship that is possibly real (Nakagawa, 2004; Perneger, 1998). For this reason, the Bonferroni adjustment is often used for corrections as studies of group differences in post hoc or follow-up pairs tests wherein Type I errors are likely to be more considerable. We decided not to use Bonferroni adjustments because making findings insignificant via Bonferroni adjustment would have been a far more problematic than single studies with possible Type I errors.

Third, it was not examined if there were differences in technology integration practices among teachers due to individual differences other than teacher beliefs. There may have been differences in teachers’ beliefs and technology integration practices according to their teaching grades, college majors, prior teaching experiences, age, gender, and so forth. There were not sufficient numbers to investigate such differences in this study. A study with many more participants might well investigate this possibility, which is likely to have implications for teacher training and constructing supports to change teacher beliefs to be more educationally effective with the in-depth knowledge of teachers’ dispositions.

Fourth, some researchers argue that teachers do not always act on their beliefs when it comes to technology integration (Belland, 2009; Chen, 2008; Windishult, 2002). Even when teachers have appropriate beliefs, they may still not integrate technology in effective, efficient, and engaging ways (Spector & Merrill, 2008). There have been attempts to explain beliefs that are not activated in technology integration practices with teachers’ habits (Belland, 2009) and volition (Kim & Keller, 2011). Future studies should take this aspect into considerations to examining of teachers’ actions that are not grounded in beliefs and to understanding the interplay of beliefs with technology integration.
Last, teacher beliefs were examined only once. If there were longitudinal data on beliefs and changes in beliefs over time along with changes in technology integration practices, we might have obtained a better understanding of the dynamics of belief and practice when it comes to technology integration. Future research ought to consider not only multi-time measurements but also the use of a multi-method approach including the examination of lesson planning materials, reflection process, focus-group discussions, and so on to investigate teacher beliefs both quantitatively and qualitatively.

6.4. Conclusion

The process of the adoption and implementation of an innovation requires substantial and sustained teachers’ professional development, which to some extent may provoke teachers’ previous knowledge resulting in “dramatic, fundamental change of their understanding, perception, belief, and attitude” (Merriam & Caffarella, 1999, p. 318). Even though all the participating teachers have received technologies, professional development workshops, and technical and pedagogical assistance, the levels of teachers’ technology integration were not the same. The implication of this fact is aligned with the notion that the adoption of educational innovations is the result of multiple motives and attitudes (Huberman & Miles, 1984), and, in our study, it appears that teacher beliefs, among other factors, influenced their technology integration practices. Teachers’ behaviors do not change without changes in beliefs (Kagan, 1992; Kane et al., 2002; Ng et al., 2010; Pajares, 1992). If proper supports are provided to teachers according to their beliefs, their levels of technology integration could improve. Nonetheless, concerns about the ethical basis of the argument for changes in teacher beliefs still remain, as Raths and McNannich (2003) pointed out that “there is the question of what beliefs to teach and who decides” (p. ix). However, we believe that ethical issues involved in changing teacher beliefs are minimal because the changes proposed herein are to build on a primary belief shared by nearly all teachers — namely to improve student learning. The change in beliefs we propose is to help teachers understand that beliefs other than those they have acted on in the past (e.g., alternative beliefs about the speed of learning and the source of knowledge) might be more effective in achieving something that they already want to achieve.

Despite the several limitations mentioned earlier, our research method and framework connecting teacher beliefs and technology integration can serve to provide future research directions and initial guidelines to promote technology integration practices through systematic efforts to promote positive teacher belief change. This innovative approach to studying the connections between teacher beliefs and practices can provide a point of departure for researchers and practitioners globally. The use of technology for teaching and learning is of interest in many parts of the world and this study provides one model for such studies. Moreover, fundamental beliefs about knowledge and knowledge acquisition exist in every teacher and learner, and these are critically important for understanding effective technology integration. Our ultimate goal is to contribute to teacher education in the area of technology integration to improve pre- and in-service training and professional development programs that take into account the interrelationships between teachers’ beliefs and their technology integration practices.

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References
