Computers & Education 59 (2012) 423–435

Contents lists available at SciVerse ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Teacher beliefs and technology integration practices: A critical relationship

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ARTICLE INFO

Article history:
Received 15 December 2011
Received in revised form
4 February 2012
Accepted 6 February 2012

Keywords:
Inservice teacher
Technology use
Technology integration
Teacher technology use
Teacher professional development

ABSTRACT

Early studies indicated that teachers' enacted beliefs, particularly in terms of classroom technology practices, often did not align with their espoused beliefs. Researchers concluded this was due, at least in part, to a variety of external barriers that prevented teachers from using technology in ways that aligned more closely with their beliefs. However, many of these barriers (access, support, etc.) have since been eliminated in the majority of schools. This multiple case-study research was designed to revisit the question, "How do the pedagogical beliefs and classroom technology practices of teachers, recognized for their technology uses, align?"

Twelve K-12 classroom teachers were purposefully selected based on their award-winning technology practices, supported by evidence from personal and/or classroom websites. Follow-up interviews were conducted to examine the correspondence between teachers' classroom practices and their pedagogical beliefs. Results suggest close alignment; that is student-centered beliefs undergirded student-centered practices (authenticity, student choice, collaboration). Moreover, teachers with student-centered beliefs tended to enact student-centered curricula despite technological, administrative, or assessment barriers. Teachers' own beliefs and attitudes about the relevance of technology to students' learning were perceived as having the biggest impact on their success. Additionally, most teachers indicated that internal factors (e.g., passion for technology, having a problem-solving mentality) and support from others (administrators and personal learning networks) played key roles in shaping their practices. Teachers noted that the strongest barriers preventing other teachers from using technology were their existing attitudes and beliefs toward technology, as well as their current levels of knowledge and skills. Recommendations are made for refocusing our professional development efforts on strategies for facilitating changes in teachers' attitudes and beliefs.

1. Introduction

Technology integration has been a topic of discussion among educators for over thirty years (Lowther, Strahl, Inan, & Ross, 2008). Literally thousands of articles (EBSCO Publishing, 2011) have been published recommending effective strategies to facilitate meaningful integration (i.e., using technology to support a student-centered and student-directed curriculum; Becker & Riel, 1999), with a large portion of these articles proposing strategies for eliminating or circumventing the barriers that schools and teachers encounter during the process.

In 1999, Ertmer distinguished between two types of barriers that impacted teachers' uses of technology in the classroom. First-order barriers were defined as those that were *external* to the teacher and included resources (both hardware and software), training, and support. Second-order barriers comprised those that were *internal* to the teacher and included teachers' confidence, beliefs about how students learned, as well as the perceived value of technology to the teaching/learning process. Although first-order barriers had been documented as posing significant obstacles to achieving technology integration (O'Mahony, 2003; Pelgrum, 2001), underlying second-order barriers were thought to pose the greater challenge (Dexter & Anderson, 2002; Ertmer, 1999; Ertmer, Addison, Lane, Ross, & Woods, 1999; Newhouse, 2001; Zhao, Pugh, Sheldon, & Byers, 2002).

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doi:10.1016/j.compedu.2012.02.001

In 2007, Hew and Brush provided a detailed analysis of the integration barriers that had been documented in the literature over the previous ten years (1995–2006). Six categories of barriers were identified including four that comprised first-order barriers (e.g., resources, institution, subject culture, and assessment) and two that comprised second-order barriers (e.g., teacher attitudes and beliefs; knowledge and skills). Based on the analysis of 48 empirical studies, Hew and Brush delineated the three most frequently cited barriers impacting technology integration: 1) resources, 2) teachers' knowledge and skills, and 3) teachers' attitudes and beliefs, reported in 40%, 23%, and 13% of the studies, respectively.

In the early to mid-2000s, access to technology resources began to increase (National Center for Education Statistics, 2006) effectively reducing, and in some cases even eliminating, this first-order barrier. Given this, researchers and educators began to turn their attention to the relationship between teachers' pedagogical beliefs and meaningful technology use, specifically that which facilitated student-centered learning (Dexter & Anderson, 2002; Ertmer, 2005; Judson, 2006). According to Means and Olson (1997), student-centered learning was defined as using technology to "promote student learning through collaborative involvement in authentic, challenging, multidisciplinary tasks by providing realistic complex environments for student inquiry, furnishing information and tools to support investigation, and linking classrooms for joint investigations" (p. 9). McCain (2005) elaborated: "the use of technology in the classroom is not the critical issue facing education in the 21st century. [Rather], the issue of foremost importance is to develop thinking skills in our students so that they will be able to utilize the power of technological tools to solve problems and do useful work" (p. 84). This, then, translates into the requirement that technology be placed in the hands of students, who are encouraged and enabled to utilize it in the same ways, and for the same purposes, that professionals do – that is, to communicate, collaborate, and solve problems.

Building on earlier work by Hadley and Sheingold (1993) and Becker (1994), researchers investigating the relationship between teachers' beliefs and student-centered learning described a common pattern of results: teachers with constructivist beliefs tended to use technology to support student-centered curricula; those with traditional beliefs used computers to support more teacher-directed curricula (Andrew, 2007; Hermans, Tondeur, van Braak, & Valcke, 2008). Thus, it became clear that simply increasing computer access was not sufficient to change teachers' technology practices especially if this increased access was not accompanied by a corresponding shift in teachers' pedagogical beliefs. However, this led to the false assumption that teachers with student-centered beliefs would readily translate those beliefs into constructivist technology classroom practices (Sandholtz, Ringstaff, & Dwyer, 1997).

Early studies (Berg, Benz, Lasley, & Raisch, 1998; Ertmer, Gopalakrishnan, & Ross, 2001) indicated that teachers' *enacted* beliefs, as represented by classroom technology practices, often did not align with *espoused* beliefs. That is, teachers with constructivist beliefs were observed, at least in some instances, to use technology in fairly traditional ways – asking students to complete drill and practice exercises or to fill in computer-generated worksheets (Ertmer et al., 2001). Reasons for the disparity between practices and beliefs, at least in the Ertmer et al. study, seemed to relate to the external constraints/barriers placed on teachers by pre-determined curricular or assessment practices. Similarly, participants in the Berg et al. study reported *wanting* to incorporate higher-level technology uses, but not being able to do so due to access and time constraints. Ravitz, Becker, and Wong (2000) reached a similar conclusion: teachers' implementations of constructivist beliefs were often limited by difficulties associated with meeting individual student needs within a large classroom, balancing multiple objectives, and responding to external forces and expectations.

In general, teachers' responses to these external forces and constraints have varied. While some have managed to either eliminate or bypass them (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010), many, if not most, have not (Ertmer, 1999, 2005; Judson, 2006). For example, Becker (1994) found that only 45 of the 516 computer-using teachers he surveyed, were able to do so. That is, these 45 teachers reported actually dropping "inconsequential" curricula from their current practices to make room for more student-centered lessons. In the Ertmer et al. study (2001), teachers with constructivist beliefs tended to utilize a "blended" pedagogical approach (using traditional *and* constructivist practices), which allowed them to reconcile differences between their *espoused* student-centered beliefs and their *enacted* teacher-centered practices.

Given that classroom contexts are constantly changing, especially where technology is concerned (Straub, 2009; U.S. DOE, 2010), it is important to revisit this phenomenon. Do external constraints exert the same influence over teachers' technology practices as was true 10 or more years ago? To what extent do external, or first-order, barriers constrain teachers' integration efforts, leading to potential misalignments between beliefs and practices? We consider the current status of key external barriers next.

1.1. Hardware and Internet access

Over the past two decades, substantial funds have been dedicated to increasing technology access in U.S. K-12 classrooms (Culp, Honey, & Mandinach, 2005), with more than $40 billion dollars invested between 1990 and 2000 (Dickard, 2003). As a result, access to Internet-connected computers has increased steadily, with the percentage of public schools connected to the Internet increasing from 35% in 1994 to nearly 100% in 2005 (Wells & Lewis, 2006). Based on the responses of 3159 teachers to a 2009 NCES survey (Gray, Thomas, & Lewis, 2010), 97% of teachers had access to one or more computers in the classroom, with approximately half of these teachers (54%) having the option of bringing in additional computers (e.g., laptops, tablets). Student-computer ratios, based on the number of computers available in the classroom everyday, hovered around 5.3 to 1, yet decreased to 1.7 to 1 if other available computers were considered, a noticeable improvement over the 3.8 to 1 ratio recorded in 2006 (Wells & Lewis, 2006). Furthermore, nearly all (96%) of these available computers are Internet-connected (Gray et al., 2010).

According to an NEA (National Education Association) 2008 survey, the majority (74.1%) of the 1934 responding educators reported that their access to computers, the Internet, and instructional software was "adequate" to do their jobs and almost all (94.6%) reported having additional access to computers and the Internet at home. Furthermore, 81% percent of teachers reported having remote access to student data, and of these teachers, 61% used this remote access sometimes or often (Gray et al., 2010).

1.2. Software and tool access

In addition to hardware and infrastructure, the wide availability of Web 2.0 tools has made access to powerful communication and collaboration tools almost a "non-issue" for any teacher who has Internet access in his/her classroom. Web 2.0 is the term commonly

used to refer to 'second-generation' Internet applications that do something "unique, practical, and/or powerful" while enabling social connections, and thus, greater collaboration among users (Brandon, 2008, para 3). A key characteristic of Web 2.0 is the role played by users in creating, using, and sharing resources. As described by Schrum and Levin (2009): "No longer are we limited to the software someone else has designed, the limited uses of computers that others have pre-determined, or the resources someone else has put on the Web" (p. 47). In its most recent National Educational Technology Plan, the U. S. Department of Education (2010) noted, "Over the past 40 years, we have seen unprecedented advances in computing and communications that have led to powerful technology resources and tools for learning. Today, low-cost Internet access devices, easy-to-use digital authoring tools, and the Web facilitate access to information and multimedia learning content, communication, and collaboration" (p. 52). Given this, teachers no longer need to purchase expensive software or hardware to provide their students with digital content or server-based applications that enable them to communicate and collaborate with others.

Already teachers have begun to adjust their classroom practices to incorporate these tools. As one example, according to the Speak Up 2010 survey (Project Tomorrow, 2011), teachers' classroom uses of podcasts and Internet-based videos increased over 50 percent since 2008. Furthermore, almost all teachers (96 percent) reported using Internet-based communications tools to connect with peers or parents. Based on survey results, educators are regularly using the Internet to find information (almost 90 percent) and to read text-based resources (61 percent) including blogs and wikis (33 percent).

1.3. Training

The most cited reason for lack of implementation of new technology is lack of professional development (Birch cited in Drexler, Baralt, & Dawson, 2008). Fortunately, the results of recent surveys suggest that this, too, is improving. Based on NEA results (2008), the majority of teachers reported feeling adequately trained to operate technology equipment (68.3%), search the Internet for information (71.1%), and use administrative software to take attendance or submit grades (68.3%). Responses to the *Teachers Talk Tech* survey (CDW-G, 2006) verifies teachers' relatively high assessments of their technology skills: 63% rated their skills as "somewhat advanced" to "advanced" while only 2% rated themselves as beginners. NEA results showed that 57% of teachers felt adequately trained to integrate technology into instruction. Furthermore, the majority of teachers who participated in technology-related professional development in the year prior to completing the NCES 2009 survey found training to be relevant, with more than 80% agreeing: "it met my goals and needs," "it supported the goals and standards of my state, district, and school," and "it applied to technology available in my school" (Gray et al., 2010, p. 4).

1.4. Support

There are a number of different types of support needed for effective integration including administrative, technological, professional, and peer. According to the results of the Speak Up 2010 survey (Project Tomorrow, 2011), only 30% of the responding school/district administrators ($n = 3587$) regarded technology support as a top challenge, suggesting that 70% did not. This is supported by data from Education Week (2010), which reported that 83% of responding school districts employed a full or part time staff person in an educational technology leadership role; 68% reported that support for educational technology use was adequate. In addition to the use of technology coordinators, a number of different strategies are being employed by school administrators to provide technology support including the appointment of a technology-planning committee, the development of professional learning communities, and the use of teacher leaders (Schrum & Levin, 2009). Furthermore, teachers are turning to social networking sites to interact with and learn from their peers (Luehmann & Tinelli, 2008).

2. Research purpose and questions

These recent reductions in first-order, or external, barriers to teachers' technology integration practices (U. S. DOE, 2010) provide the opportunity to re-examine the relationship between teachers' beliefs and practices in order to gain a deeper understanding of how teachers translate their beliefs into practice. *If* first-order barriers are no longer operational in teachers' classrooms today, or are operating below a minimal threshold, we may be in a better position to observe how teachers enact their beliefs through purposefully selected practices. This, then, could provide beneficial insights, as well as specific strategies, for other teachers still struggling to achieve higher levels of technology integration. This study was designed to revisit two questions:

1) How do the pedagogical beliefs and classroom technology practices of teachers, recognized for their technology uses, align?
2) To what extent do external, or first-order, barriers constrain teachers' integration efforts, leading to potential misalignment between beliefs and practices?

3. Methods

We used a multiple case-study research design to examine the similarities and differences among the pedagogical beliefs and technology practices of 12 K-12 classroom teachers. Data were collected via in-depth document analyses of teachers' websites, followed by one-on-one interviews. Websites provided evidence of teachers' classroom technology practices while interviews provided insights into the extent to which beliefs supported those practices. Quantitative data (scale ratings of barriers) were analyzed using simple descriptive statistics; interview (narrative) data were analyzed using a constant comparison method to identify patterns among each teacher's espoused beliefs. Finally, websites were analyzed using the criteria of student-centeredness and provided triangulation data to support any observed alignments between espoused beliefs and described practices.

3.1. Role of the researchers

This study was designed and conducted by a team of five researchers including two faculty members and three graduate students, all interested in exploring connections between teachers' beliefs and classroom technology practices. A secure online spreadsheet was created to track information about potential participants during the selection process and to capture team members' rationales and insights while evaluating the different websites. Interviews were conducted by the two faculty researchers and transcribed by the graduate students so that all team members were familiar with the data. The first round of data analysis was completed by the two interviewers then discussed among all team members until consensus was reached regarding overall themes.

3.2. Selection of participants

Participants were selected using a purposeful sampling strategy (Patton, 2002). We began by conducting an online search for the names of technology award winners over the past few years. Specifically, we looked for teachers recognized by the International Society for Technology in Education (ISTE), Apple, Edublog, Eduwiki, Disney, Milken, and PBS, among others, initially identifying 78 potential participants. Using a three-step selection process (described in more detail in the Data Collection section), we identified 20 teachers whose websites presented the most apparent student-centered practices and contacted each, via email, to request participation in a one-on-one interview. Twelve teachers agreed to participate and were subsequently interviewed by one of the researchers.

3.3. Description of participants

Interview participants included seven females and five males who had been teaching an average of 14.8 years; experience ranged from 2 to 31 years. The majority ($n = 9$) of our participants taught at the elementary school level, two taught at the middle school level, and one taught at both the middle and high school level. Eight teachers held a master's degree, with an additional teacher working toward a master's in elementary education. Of the 12 interviewees, all but one was a core subject-area classroom teacher. The remaining participant served as the computer teacher for his school.

Classroom resources varied greatly among the teachers. For example, one teacher taught in the district's "model technology classroom" that included a wide range of resources (laptops, active board, digital still and video cameras, scanners); in contrast another teacher taught in a school that had just secured fiber optic access that month. Teachers in well-equipped classrooms enjoyed one-to-one laptop access, while those in less equipped schools used old computers, brought in their own personal iPhones and iPads, or scheduled computer lab time (see Table 1 for more details about each teacher's available resources, as well as other demographics).

3.4. Data collection and analysis

Data collection was guided by our interest in examining the correspondence between the beliefs and practices of teachers who had been recognized for their technology practices. While some technology awards focused more on the use of specific types of tools (e.g., Edublog),

Table 1
Demographic information for selected participants.

Name	Gender	Years of exp.	Advanced degree	Grade level	Content area	Class size	Resources
Abernethy	F	14	Master's degree (Instructional media)	5th grade	Classroom teacher	26	2 flip videos, smart board, teacher laptop and projector, airliner, karaoke machine, 4–5 desktop computers, iPad, digital camera, u-star, green screen, and 4 computer labs
Barnes	M	19	Master's degree (Teaching and learning)	7th, 8th, 10th, and 12th grades	Language	16–26	2 computer labs, 5 classroom computers, smart board
Buller	F	31		4th grade	All subjects	24	2 classroom computers, a teacher laptop, 1 computer lab, smart board
Cassidy	F	17		1st grade	Classroom teacher	18	2 desktops and 3 laptops in classroom, netbooks, and iPads
Coley	M	15	Master's degree (Curriculum and instruction)	5th grade	Language, Social Studies, Math, Science	30	Student iPods, camera, computers, LCD projector
Crosby	M	30	Master's equivalency	4th, 5th and 6th grades	Classroom teacher	23	Student laptops, 4 digital cameras, sound system, active board, teacher desktop computer, printer
Cross	F	2	Master's degree (Mild/moderate disabilities)	1st grade	Classroom teacher	19	4 computers, and personal equipments (iPhone, iPod touch, and iPod)
DeHaan	M	6	Master's degree (Communication and digital media)	Middle school	Technology	12–22	A computer lab
Garcia	M	10	Master's degree (Science education)	6th, 7th, 8th grades	Science	19–26	One-to-one laptops
Goneau	F	14	Master's degree (Curriculum and instruction)	2nd grade	Classroom teacher	16–18	5 regular computers, iPod, projector, 6 netbooks, 3 iPod touch
Hillman	F	10	Master's degree (Curriculum and instructional technology)	4th grade	Classroom teacher	20–25	3 computer labs, mobile laptop cart, 3 student-computers, teacher computer, interactive whiteboard
Travis	F	9	Working on Master's (Elementary education)	4th grade	Reading, Math, Science	16–22	A computer lab, 3 wireless laptop carts, document cameras, teacher computer, 3 classroom computers, and interwrite (smart board)

Table 2
Categories of classroom practices – teacher-centered to student-centered.

Categories of classroom practice	Teacher-centered (TC)	Student-centered (SC)
	Teacher-directed Primarily didactic	Student-directed Primarily interactive
Teacher role	• Present information • Manage classroom	• Guide discovery • Model active learning • Collaborator (sometimes learner)
Student role	• Store, remember information • Complete tasks individually	• Create knowledge • Collaborator (sometimes expert)
Curricular characteristics	• Breadth – focused on externally mandated curriculum • Focus on standards • Fact retention • Fragmented knowledge and disciplinary separation	• Depth – focused on student interests • Focus on understanding of complex ideas • Application of knowledge to authentic problems • Integrated multidisciplinary themes
Classroom social organization	• Independent learning • Individual responsibility for entire task	• Collaborative learning • Social distribution of thinking
Assessment practices	• Fact retention • Product oriented • Traditional tests • Norm referenced • Teacher-led assessment	• Applied knowledge • Process oriented • Alternative measures • Criterion referenced • Self-assessment and reflection
Technology role	• Drill and practice • Direct instruction • Programming	• Exploration and knowledge construction • Communication (collaboration, information access, expression) • Tool for writing, data analysis, problem-solving
Technology content	• Basic computer literacy • Skills taught in isolation	• Emphasis on thinking skills • Skills taught and learned in context and application

Adapted from Ertmer et al. (2001).

others were designed to recognize teachers who were engaged in "exemplary" (e.g., Tech & Learning), "innovative" (e.g., Apple) or "best" practices (e.g., ISTE) related to technology integration. Given the variety of foci used to recognize technology-using teachers, we applied criteria related to "student-centered" practices (Bellanca & Brandt, 2010) to narrow our pool to those who best matched our research needs.

As noted earlier, data were collected from two primary sources: teacher websites and individual interviews. After identifying our initial pool of 78 teachers, we revisited teachers' websites to determine if there was enough information available to make a fair assessment of teachers' classroom practices related to student-centered technology use. This resulted in 41 of the 78 teachers being dropped from the sample due to either a lack of information or lack of evidence related to student-centered practices.

A preliminary analysis was completed on the websites of the remaining 37 teachers, using the criteria of student-centeredness (See Table 2). Specifically, we looked at 1) the extent to which students, rather than teachers, used the technology, 2) the level of interactivity (with content, teacher, and peers) and collaboration evident, 3) the types of homework assignments students were asked to complete, 4) the resources and web links teachers provided for their students, and 5) the types of assessments used. Based on the results of this preliminary analysis, we identified 25 teachers who "showed promise" and began a more extensive analysis of their websites, rating each, on a scale from 1 to 5 (with 5 being most student-centered; see Fig. 1), in seven categories: Teacher Role, Student Role, Curricular Characteristics, Classroom Organization, Assessment Practices, Technology Role, and Technology Content (Ertmer et al., 2001). From this analysis, we identified 20 teachers for follow-up interviews to provide insights into the extent to which espoused beliefs supported practices evidenced on websites. Of these 20, 12 agreed to participate.

Interviews were conducted over a month's time in Spring 2011, lasted 35–60 min each, were audio-taped, and transcribed. The majority of teachers were interviewed via Skype; four were interviewed by telephone. A semi-structured interview protocol, comprising nine key questions, was used to ensure consistency among interviewers. However, additional questions were added, as needed, to capitalize on specific comments made by the participants. Interviews began by informing teachers that their responses would remain confidential (if they so desired) and asking for their consent to participate. Demographic data, not available on teachers' websites, were gathered, and then participants were asked to describe their journeys to becoming technology-using teachers. Additional questions prompted teachers to share examples of successful lessons or projects in which technology was used, to describe barriers that prevented them from implementing technology according to their beliefs, and to name the factor(s) that had the biggest impact on their abilities to be successful. Questions were structured to be as open-ended as possible to avoid potentially "leading" the interviewees. For example, teachers were asked, "What are your thoughts about how, ideally, technology should be used in the [insert type grade/subject] classroom?" How frequently/often would you say you are able to implement these types of uses of technology into your own classroom? Have there been situations when you were unable

Scale	Teacher – Centered (TC)	Mix – Primarily TC	Mix – Balanced	Mix – Primarily SC	Student – Centered (SC)
Rating	5	4	3	2	1

Fig. 1. Scale used to rate teachers' websites.

(or that were difficult) to implement these types of uses of technology into your classroom? Describe the reasons for these difficulties and how you overcame them. Teachers also were asked to rate, on a scale from 1 to 5 (5 being the most and 1 being the least), the level of impact different barriers had on their practices as well as on the technology practices of their fellow teachers.

Interviews were analyzed using a constant comparison method (Strauss & Corbin, 1998). Analysis efforts began deductively, looking for evidence of student-centered practices or beliefs, using the categories in Table 2. Each interview transcript was read multiple times to identify patterns of beliefs expressed by each participant. Following this, a case record was created for each participant; interview quotes were added to support espoused beliefs and enacted practices. Evidence from teachers' websites also was used to provide support. Teachers' ratings of barriers were analyzed using descriptive statistics to determine those perceived to be the most and least impactful on their classroom practices. Additional interview quotes, when available, were added to support these findings.

3.5. Issues of validity and reliability

Lincoln and Guba (1985) recommended that qualitative results be evaluated using the standard of "trustworthiness," as established by credibility and confirmability. In this study, *credibility* was gained though triangulation of multiple data sources (e.g., interviews, teacher websites). The use of multiple researchers, as well as the use of member checks, led to *confirmability* of the data. In the early stages of the study, regularly scheduled team meetings were held, via Skype, to establish and clarify our research questions, identify our criteria for participant selection, and develop our interview protocol. After data were collected, the two lead researchers examined the data individually and then collaboratively in order to reach consensus regarding the patterns of alignment among beliefs and practices. Subsequently, alignment patterns were presented to the rest of the team for comment and verification. Finally, after tentative results were drafted, member checks were completed with the participants. It is important to note that participants' suggestions all related to errors in demographics; there were no disagreements with our interpretation of their beliefs and practices. Furthermore, all participants gave permission to use their names in the final manuscript.

4. Results

In this study we examined the beliefs and practices of 12 award-winning technology-using teachers to determine the alignment between their beliefs, as expressed in one-on-one interviews, and their practices, as evidenced on their websites and described during their interviews. To examine the extent to which barriers influenced or shaped enacted beliefs, we also explored teachers' perceptions of the impact of internal and external barriers on their technology integration practices.

4.1. Barriers to technology integration

Teachers were asked to rate, on a scale from 1 (not at all) to 5 (very much), the extent to which various barriers impacted their students' uses of technology (see Table 3). Although average ratings suggest that none of these barriers were particularly impactful (all averaging less than 3 on a 5 point scale), it is important to remember who our participants were (i.e., award-winning technology-using teachers). This suggests that although these teachers still experienced barriers, particularly external barriers, they often found ways to work around them, thus reducing the overall impact on their practices (Becker, 1994; Ertmer, 2005). Teachers' ratings suggest that external barriers were more impactful than internal barriers. The most impactful barriers, with a ranking greater than 2.5, were all external and included the following: support ($M = 3.0$), state standards ($M = 2.83$), money ($M = 2.83$), access ($M = 2.67$), time ($M = 2.58$), and assessments ($M = 2.50$). Attitudes and beliefs of *other* teachers were perceived to be the most impactful barrier on students' uses of technology ($M = 3.17$).

In contrast, among the top three *least impactful* barriers, two were internal. That is, teachers' own attitudes and beliefs received an average score of 1, meaning that all 12 teachers believed that their own attitudes and beliefs were *not* a barrier to their students' uses of technology. Garcia indicated that technology was central to his teaching beliefs: "Technology has to be the center piece, or one of the center pieces. That's my big belief." Similarly, as the third lowest-rated barrier, teachers indicated that their own knowledge and skills ($M = 1.42$) was not a barrier to their students' uses of technology. For those few teachers who rated this as a more impactful barrier (i.e., with a rating greater than 1), there was the general belief that their technology skills were, and will always be, incomplete, given how much there is to

Table 3
Perceptions of the impact of different barriers on technology integration.

Barrier to technology integration (from most to least impactful)	Average rating of impact (1 = not at all a barrier; 5 = very much a barrier)
Attitudes and beliefs (other teachers)	3.17
Technology support	3.00
State standards	2.83
Money	2.83
Technology access	2.67
Time	2.58
Assessments (standardized, state)	2.50
Technology problems	2.33
Institution (administration)	2.09
Subject culture	1.91
Knowledge and skills (students)	1.83
Institution (community)	1.42
Knowledge and skills (their own)	1.42
Institution (parents)	1.33
Attitudes and beliefs (their own)	1.00

Note: Internal barriers are highlighted.

learn about technology. As Cross stated: "For me, I would [rate this] as a 2 because I still think there is always so much out there to learn and to discover. And especially with technology, it grows so fast; and not only that, but just figuring out the educational applications of technology. So I think I still have room to grow." Table 3 presents participants' average ratings for these different internal and external barriers. It is also interesting to note that parents were perceived, on average, to be the second least impactful barrier, with the majority of teachers describing them as "very supportive."

When asked to name the *biggest* barrier, overall, to technology integration *in their schools*, three teachers mentioned external barriers, while nine described other teachers' internal barriers. Specifically related to external barriers, two teachers described the lack of administrative or technical support, while one mentioned the strong focus on state assessments. For example, Barnes mentioned that if the administration were more supportive and had an agenda that promoted technology, it would be more widely adopted by teachers. Similarly, DeHaan described problems with network stability and a "lack of responsiveness to issues," as well as limited time for training and implementation. According to Garcia, state assessments operated as the biggest barrier to other teachers, causing them to be slow to adopt new pedagogies as well as new tools: "I think the biggest [barrier] is the state assessments because there is so much fear nowadays regarding that."

The remaining nine teachers, when asked to name the biggest barrier to technology integration, referred to internal qualities or characteristics of other teachers, such as attitudes and beliefs, or knowledge and skills. In her interview, Travis described her perception: "The only [barrier] that is different from mine is – there are some people who don't use technology because they're intimidated by it." In terms of other teachers, Coley also thought the biggest barrier was other teachers' knowledge and skills, as well as time to learn the technology. In his interview, he described it this way: "Know-how and time. They say 'I don't know how to do it and I don't have the time to learn, and if I learn, I don't have time to do it.' Many teachers view this as one more thing to do rather than incorporating it into what they are already doing."

In contrast, we asked teachers to describe the biggest *enablers* to their technology integration practices. Five teachers mentioned internal factors (their own attitudes and beliefs or knowledge and skills) as the strongest contributing factor to their abilities to integrate technology. Four teachers mentioned that professional learning networks (e.g., Twitter, blogs, professional development) played the biggest role in their integration of technology. Finally, three teachers mentioned the support of their administrators, while two mentioned student motivation and engagement as the most influential enablers.

4.2. Alignment among beliefs and practices

For 11 of the 12 teachers in this study, espoused and enacted beliefs appeared to be well aligned. For example, when asked to describe her beliefs about the best ways to use technology in the classroom, Cassidy indicated that technology enables students to collaborate: "*Ideally technology allows the classroom to be open to the world. It's a portal for kids who can show their work and get feedback. It allows for collaboration between classes via Skype, blogs, and Google docs and wikis*." Her practices closely aligned with these beliefs. Students in her first-grade classroom kept individual blogs on which they posted their thoughts and feelings about various classroom activities including "Why we use video" and "My adding strategy," and on which others (parents, peers, outsiders) could comment. When asked to describe a successful technology project, Cassidy described her breakfast project, which used Google Docs, blogs, Twitter, and Wordle to help her students' meet specific social studies' standards:

> *One of the objectives in social studies is that you understand that people in different places eat different things … We decided we wanted to know what other people around the world would have [for breakfast]. And so, I set up a Google doc and each of my kids typed in what they had for breakfast and where they lived. And then I just put a little link to it on my blog and I put a link on Twitter and said, "Can you help some grade one students? Tell us what you have for breakfast."*

When asked why she thought this was a successful project, Cassidy referenced her belief about the importance of using technology for collaboration: "*Kids were learning the value of collaboration, learning from other people. I think, it was successful because the students learned, well, first of all they learned from each other. And then they were able to learn from other people and they were able to learn something that they didn't expect to learn.*"

In another example of close alignment between beliefs and practices, Barnes indicated that one of his most fundamental beliefs was the need to provide students with choices. According to Barnes, teachers should serve as facilitators in the learning process, answering questions along the way and providing just-in-time learning:

> *We really have to create choice for the kids. [I am] trying to create menus of learning outcomes to say, "Here is what we want to learn, this is the end result. … I'd like you to show me how you learned. You can use a blog, podcast, video, slide show program." And they apply and practice, discuss and share and create. And the teacher just goes around and facilitates.*

On his website, Barnes provided a wide range of ideas for potential student projects such as collages, comic strips, newspapers, commercials, posters, and so on. He encouraged students to think "outside the box" and to propose new ideas to him, indicating that he would facilitate their uses of technology with just-in-time instruction. This example, like the previous one, showcases a strong alignment between beliefs and practices. Table 4 provides brief examples of the beliefs and practices of the 11 teachers for whom a strong alignment was observed. [Note: Discussion of the remaining teacher appears later.]

4.3. Role of technology

It is important to note that finding close levels of alignment among the beliefs and practices of 11 teachers doesn't mean they were using technology in identical, or even similar, ways. In fact, teachers' descriptions of the role technology played in their classrooms ran the gamut from a way to reinforce skills ($n = 2$) to a tool to transform their teaching ($n = 3$). This is similar to what Ertmer et al. reported in their 1999 study, in which teachers' technology uses were classified into those that: 1) supplemented the required curriculum, 2) supported the existing curriculum, or 3) facilitated an emerging curriculum. Even though teachers in the current study were using technology to a much

Table 4
Teachers who demonstrated close alignment among beliefs and practices.

Teacher	Beliefs	Practices	Role of technology
Cross	Technology to deliver content; reinforce skills	Math stations; use technology to keep other students busy interacting with the content	Supplement to reinforce skills
Coley	Technology as a motivator; as a leverage for education; as a supplement; reinforces writing and speaking skills	Uses technology to present information learned and to allow students to study for exams (podcasts)	Supplement to reinforce skills
DeHaan	For motivation; appropriate tool for learning specific skills in context (e.g., writing)	Teaching procedural thinking (e.g., programming); digital identity website	Enrich
Goneau	Complements the curriculum; provides student choice; collaborative work; engages students	Mimeo presentation on animals; teacher as facilitator	Enrich
Hillman	Student-centered; authentic applications; peer teaching and student choices	iMovies; digital storytelling	Enrich
Abernethy	Technology as an educational tool; learn skills in context; student choice and excitement	Literature circles; present what they've learned; teach each other; excitement about reading	Enrich
Cassidy	Technology for collaboration; share work with others; higher order thinking; student learning	Breakfast project using Google docs and Wordle; Student blogs; Videos capturing student thinking	Enrich
Travis	For higher order thinking and collaboration (make connections to real world); student excitement and engagement	Teacher-created webquest; created video sharing the importance of math in real world. Student learning and excitement	Enrich
Barnes	Teachers as facilitators; student choice; applied to learning	Results only learning environment (ROLE); students choose their own books; choose ways to demonstrate learning; engaged learning	Transform
Crosby	Tool for learning; as needed to complete certain tasks (transparent); student collaboration; higher order thinking	Energizing energy project – cross-school collaboration; kids teaching each other; higher order thinking (e.g., students anticipating where others might struggle)	Transform
Garcia	Help students become 21st century literate; technology to solve problems; motivates students	Challenge-based learning; claymation movies for learning microbiology; students teach each other; engaged learning	Transform

greater extent than teachers in the 1999 study, uses fell into similar categories. That is, in this study, two teachers described using technology to help students *learn content and skills*, six teachers used technology to *complement or enrich* the current curriculum, and three teachers reported using technology in *transformative* ways (see Table 4). The one teacher, for whom beliefs and practices did not closely align, described using technology in ways that both reinforced skills and enriched the curriculum.

4.3.1. Technology to deliver content and reinforce skills

On their websites, as well as in their interviews, two teachers provided evidence of using technology to help students learn skills. For example, in her interview, Cross described using technology to help her deliver math content and reinforce math skills: "*I think that the main goal has still got to be delivering the content.*" When asked to describe the most successful technology project she had implemented in her classroom, Cross described using technology during her math stations to allow her to work with small groups of students – a task with which she previously had difficulties. Thus, the students who were *not* working with her used technology to reinforce specific skills they were learning: "*I wanted to work with children in* small groups to deliver math instruction, but it was always a struggle for me. Technology has allowed me to fix this because I'll teach one small group and then another small group can be working with the technology, playing games that are reinforcing the exact same skills."

Coley believed that since students already used technology for other purposes outside of school, technology in the classroom should be leveraged for educational purposes: "*Kids have iPods already. You might as well leverage them for educational purposes. Create content that could go on these iPods or on their cell phones…* you can leverage it. If you can publish their work online, you are tapping into far greater motivation than you yourself have." As evidenced on his website, Coley created a series of podcasts to help his students study for exams. In addition, students summarized content they were learning by working in groups to create their own podcasts. Coley commented on the successfulness of these types of uses: "*That's been very successful because it is a great way to review the material; whether before or after the test, it is a great way to [reinforce] what they have learned.*"

4.3.2. Technology to complement or enrich the curriculum

Six teachers fell into the second category of technology use, that is, using technology to complement or enrich the current curriculum. As noted earlier, Cassidy began planning her lessons by considering the standards her students needed to master and then using relevant technology to help students meet those standards: "*I always start with the standard and then think how can I teach this? You know, that changes every year, how I do it. I don't really have a problem meeting standards with technology.*" Additionally, students used technology to demonstrate their learning: making videos during which they read their work or explained their thinking, creating "stories" that they wrote and illustrated, or posting on their blogs.

Students in Abernethy's fifth-grade class created book summaries using a variety of Web 2.0 tools as part of their work for literature circles. Abernethy explained that by offering students more choices, they were more excited to participate in weekly literature circles and seemed more excited about reading. Similarly, Travis asked her fourth grade students to complete a teacher-created webquest to gather information about how math is used in the real world. Students then created their own videos of a job they wanted and how it could involve math. Travis reported that this project was successful because her students were engaged in their learning and were able to make connections to the real world. Goneau allowed her second-grade students to select an animal group to research and then create a Mimio presentation, which they presented to the entire class. Students were encouraged to explore the software on their own while Goneau served as a facilitator: "*You have to be a guide on the side where you're walking around, and helping them as they are learning. They teach me a lot. I am learning different things about the software and they are too. And when another group comes over, they share what they learned. They then try to incorporate that into their projects, too.*"

As a middle school computer teacher, DeHaan emphasized using technology as a tool for learning. For example, instead of teaching Microsoft Word in a step-by-step fashion, he worked with other teachers to apply more contextualized and targeted uses of specific technology. He explained how various writing tools (thesaurus, dictionary, and readability statistics) enabled students to write stronger arguments in clearer ways: "*they use tools like thesaurus and dictionary to make a more compelling argument. …They use readability statistics and ensure that what they are saying is coming from a clear appropriate grade level. I like to back into the use of technology because it changes, like an appropriate tool, after considering what the goals are for an assignment.*"

Hillman, a fourth grade teacher, described her beliefs as student-centered, using technology to support real world, authentic applications: "I try to give [my students] hands-on things, things that have real-life application, and I think that technology just fits in with that." Her most successful technology project involved students creating digital stories, which allowed them to translate their real-life experiences (e.g., with asthma, having a flat tire) into a story that could be shared with others. One student even created a public service announcement about animal abuse and used his digital story to urge listeners/readers to adopt abused animals.

Teachers in this enrich category were observed to use technology in ways that enabled students to go beyond what they were learning in specific subjects and to give students more choices for demonstrating their learning. These teachers also believed that students were more motivated and engaged when they did their school work on the computer. As DeHaan stated, "*Technology is a great hook for catching kids' imagination and their attention.*" Travis elaborated, "*To me, that's what it's about. Because of the technology my kids either become excited about something new or go home and want to do it, even when I'm not there.*"

4.3.3. Technology to transform teaching and learning

The three teachers classified in this category described uses of technology that supported a new kind of pedagogy. For example, Garcia adopted "challenge-based learning" – a method that combined inquiry-based science learning with project-based technology learning (Johnson & Adams, 2011) – as his approach. Barnes coined the term ROLE, *Results only Learning Environment*, modeled after the Results only Work Environment (Pink, 2009), to portray his innovative approach. Similarly, Crosby referred to what was happening in his classroom as "*a new pedagogy, a new way of doing school.*"

For these three teachers, technology was a tool that allowed them to experiment, implement, and refine these new approaches to teaching and learning. According to Garcia, a middle school science teacher, he developed his approach over three years of trial and error and after four years of traditional teaching. He credits his evolution to three factors: 1) professional development in both content and pedagogy, gained through his master's degree program, 2) the support of his administration to think outside the box, and 3) "serendipity" – being in the right place at the right time. Given his belief that "*You cannot use traditional methods to teach the new student, the 21st century student,*" Garcia was committed to enacting an approach that more deeply engaged his students.

Barnes, a middle and high school language arts teacher with 19 years experience, described his conscious efforts, over the last four years, to finding more effective ways to reach his students, and like Garcia, described his approach as "evolving." After doing "a lot of research" to find tools that might engage his students, he experimented with a few small projects involving message boards and gradually "*it [technology] reshaped the way I teach*." This eventually led to the articulation, as well as the implementation, of his ROLE philosophy, which comprises a project-based approach, focused on results, with students assuming the lead role in their own learning. Barnes explained: "*If you walk into my room and you are not sure if I am even there, but the kids are engaged, then I feel like I am being successful because it really has to be student-centered.*"

Crosby, a fifth grade teacher with 30 years experience, has been using technology since his second year of teaching. Given the very diverse, at-risk population with which he works, Crosby stressed the importance of "giving students opportunities to build schema for the world." His goal is for students to "learn a ton" and to "learn deeply." Like Barnes, Crosby uses a project-based approach and explained how "technology leverages that to the max." In his interview he stated, "*I want to give people a taste of what a classroom that does 21st century pedagogy could look like.*" In his TED talk, made at the 2010 ISTE conference, he explained further:

> *That type of environment should not be the exception, the unearned privilege of the children of privileged parents and those lucky enough to attend a school with high test scores. That type of education is the birthright of every child. … We need to build schools that honor kids and make this happen for everyone (from http://www.youtube.com/watch?v=66mrAzz7nLw)*

In addition to illustrating how beliefs and practices closely aligned among these 11 teachers, Table 4 classifies teachers' uses of technology into one of three categories (e.g., reinforce, enrich, or transform). This suggests that simply achieving alignment among beliefs and practices does not necessarily lead to the same types of integration practices, even among award-winning technology-using teachers. At least for these teachers, external barriers/constraints did not seem to limit teachers' abilities to use technology in ways that supported their pedagogical beliefs. What is unclear, however, is if continued use will lead to more transformative beliefs and/or practices. And if so, which aspect, beliefs or practices, should be targeted first?

4.4. Discrepant case: (non) alignment among beliefs and practices

In this study, we observed some discrepancies between the beliefs and practices of one of our 12 teachers (see Table 5), with espoused beliefs appearing more student-centered than enacted beliefs/practices. More specifically, Buller, a fourth grade teacher at a small parochial school, expressed her belief that learning should be hands-on for students: "*[Students] need to be hands-on and they need to be involved.*" Although this belief coincides with the "enrich" category, her beliefs did not consistently translate into these types of practices. Rather, some practices aligned more with using technology to deliver content and skills. For example, students completed web-based programs such as *Study Island* once a week to practice their math and language arts skills. However, in contrast to this skills-based use, Buller described her most successful technology project as the Oreo project in which students stacked Oreo cookies, posted their data, and then compared their results with those from other classes around the world. She rated this project as successful because it was "*hands-on, interest was high, and because of the collaboration aspect*" which Buller noted was "*the best part of it.*" These different uses of technology suggest that Buller may be "in transition," moving from an emphasis on skills to one in which the use of technology enriches the curriculum.

Table 5
Teacher who demonstrated less alignment among teachers' beliefs and practices.

Teacher	Beliefs	Practices	Role of technology
Buller	Technology for instruction and for research; motivation (can make learning hands-on)	OREO project – compare their data to that of many other participating schools; weekly use of study Island – a standards based skills program	Supplement/enrich (technology to bring real time information into the classroom; to provide access to large data sets)

To explain this observed mismatch, we examined the potential barriers that may be impacting, or constraining, Buller's practices. Not surprisingly, Buller worked in a school context with very few resources available. Her school had just recently installed a fiber optic line, thus, severely limiting her access to web resources. In addition, Buller's students had access to only two classroom computers and one computer lab, which students could use "once every couple of weeks." Given these constraints, it is quite possible that her beliefs had not yet been fully enacted simply due to her limited access. This is similar to findings reported by both Berg et al. (1998) and Ertmer et al. (2001). Revisiting this teacher in the future, after greater access is achieved, could inform our growing understanding of this critical relationship.

5. Discussion

5.1. Alignment among beliefs and practices

In this study, we examined the alignment among the beliefs and practices of award-winning technology-using teachers, as well as their perceptions of the barriers impacting their practices. Our findings suggest that, in general, teachers were able to enact technology integration practices that closely aligned with their beliefs. For example, teachers who believed that technology was best used for collaboration purposes, described interesting projects in which students collaborated with local and distant peers. Teachers who believed that technology provided more opportunities for student choice, described examples in which students chose to demonstrate their learning using a variety of technology tools (see Table 4). This finding, however, is in contrast to what others have reported in the past (Ertmer et al., 2001; Fang, 1996). For example, Fang's review of the beliefs and practices of reading teachers indicated that although teachers could articulate their beliefs, practices were influenced by "classroom realities" (p. 53) such as student needs, student–teacher relationships, the school culture, and textbooks. We propose three possible explanations for these differences in findings: change in access, change in students, and change in curricular emphases.

5.1.1. Change in access

As noted by Gray et al. (2010), student-computer ratios are at an all-time low (2:1), with almost all U.S. teachers now having access to the Internet in their classrooms. In addition, the wide availability of Web 2.0 tools (Bull et al., 2009; Schrum & Levin, 2009) has allowed teachers to readily circumvent the "limited resource" barrier previously reported (Hew & Brush, 2007). In this study, all 12 teachers were using Web 2.0 tools to engage students in the curricula. This included teachers working at the elementary level, as well as those working at the middle and high school levels. It also included teachers who had high numbers of available classroom computers, as well as those who had only a limited number. Whereas Internet access, when first introduced, provided students with access to information, the evolution of Web 2.0 tools has enabled a greater level of participation, collaboration, and knowledge construction among students (Brandon, 2008). In essence, this has provided a whole new platform for student learning, and one on which the teachers in this study were quick to capitalize. As predicted by the 2010 Horizon report (Johnson, Levine, Smith, & Stone, 2010), the abundance of resources accessible online and the subsequent changes that will have on the role of the educator will be key to technology adoption over the next five years (i.e., 2010–2015).

5.1.2. Change in students

Another possible reason we saw strong alignment among teachers' beliefs and practices relates to teachers' growing understanding of the "new, 21st century" student (i.e., digital natives) and how they learn. According to Prensky (2010), "more and more young people are now deeply and permanently technologically enhanced, connected to their peers and the world in ways no generation has been before" (p. 2). This growing realization of the differences between today's students and those of even a few years ago has led many teachers to reflect on the way they teach and to begin to try new methods and tools that are more relevant and engaging. As noted by Taylor and Fratto (2012), "Our education systems must reflect our students' world or we will not only miss the opportunity to capture their attention, but also forgo their full potential to learn and grow" (p. 8). In general, the teachers in this study were all committed to finding ways to prepare their students for the future by leveraging the technology, including Web 2.0 tools, students were already using in their personal lives. The journey described by Barnes was similar to those of the other teachers in this study:

> *I made this decision about 4 years ago. I felt like I was maybe spinning my wheels a little bit and I did not feel effective. I think it is important for teachers to look at themselves and do a lot of reflection and say, "what am I doing that is right or wrong?" And so I just had maybe a bad year and I did not feel like the kids were hearing me and really learning and a lot of the stuff was traditional. It was the worksheets, and homework and just they did not like it. So I asked, "what can I do that would engage them and make them want to learn?" And you know I thought about, they talked about being online, you know they were talking about Facebook and getting on MySpace and message boards. I just did some research and I thought, "you know let me get this and take it into school and show it to the kids and see what they'll do with it."*

5.1.3. Change in curricular emphases

It is also possible that the alignment observed in this study relates to the current push to prepare our students for the 21st century (Bellanca & Brandt, 2010). The U.S. Department of Education (2010), national curricular organizations (ISTE, 2008; Windschitl, 2009), and educational researchers have all called for teachers to incorporate 21st century skills within their curricula (Dede, Korte, Nelson, Valdez, & Ward, 2005). Not surprisingly, school corporations are responding by including this goal in their revised strategic plans (Partnership for 21st Century Skills, 2007). As just one example, the Indiana Department of Education (2011) recently reported that 57% of 392 school

corporations ($n = 223$) now formally address 21st century skills in their curricula. As a result, teachers are being encouraged and supported by their administrators to implement classroom strategies aimed at developing students' self-directed learning, collaboration, and problem-solving skills (Overbay, Patterson, Vasu, & Grable, 2010), all of which support a student-centered pedagogy.

Furthermore, as teachers begin to make these changes, they are finding almost unlimited support (via social networks) to try new ideas, and to find people with whom they can collaborate. Two teachers in our study referred specifically to these networked supports as invaluable in their efforts to integrate technology, claiming that access to an online community of educators was key to their implementations of technology.

5.2. Impact of barriers

This is not to suggest that teachers no longer encounter barriers, they do. However, the primary barriers, at least for these teachers, tended to be first-order, or external, rather than second-order, or internal, to the teachers. In this study, every teacher rated their attitudes and beliefs as "not a barrier" – in fact, five teachers indicated that one of the most influential factors enabling them to integrate technology was their own attitudes and beliefs. Not only were their attitudes and beliefs *not* a barrier, they served as a *facilitative* factor, providing the passion and drive needed to devote extra time and effort to enact their strong beliefs about good teaching and learning. This is similar to the results Ertmer, Ottenbreit-Leftwich, and York (2006–2007) reported after surveying 25 award-winning technology-using teachers regarding the differential influence of 19 factors. Teachers rated two internal factors (inner drive and personal beliefs) as the most influential. This suggests that the best way to bring more teachers on-board is *not* by eliminating more first-order barriers, but by increasing knowledge and skills, which in turn, have the potential to change attitudes and beliefs. Previous studies have shown that as teachers develop knowledge about how technology can be used to support student-centered learning, beliefs tend to change (Sandholtz & Ringstaff, 1996). When looking at the relationship between instructional practices, pedagogical beliefs, and teachers' uses of computers, teachers typically viewed computers as assisting in pedagogical change (Dexter, Anderson, & Becker, 1999), as they provide both a platform and a tool for implementation.

In this study, participating teachers viewed their own attitudes and beliefs as the least impactful barrier ($M = 1$), but the attitudes and beliefs of others as the most impactful ($M = 3.17$). That is, while their beliefs did not impede their integration of technology, other teachers' technology attitudes and beliefs were the strongest barrier to the integration of technology within their schools. Similarly, when investigating the relationship between teachers' "degree" of constructivism and their levels of technology use, Overbay et al. (2010) found that "constructivist practices and beliefs were significant predictors of technology use" (p. 103). The results of this study provide more evidentiary support for targeting and changing pedagogical beliefs. However, it is important to remember that when teachers *begin* the process of implementing new pedagogical approaches, first-order barriers may more easily impede the enactment of new, as opposed to more established, beliefs (Kagan, 1992; Pajares, 1992). This seemed particularly true for at least one teacher in this study, whose beliefs appeared to be in transition. According to Bebell and Kay (2010), even in situations in which positive changes in teacher attitudes and practices are reported, it can still take several years to reach full implementation and the first year can require a steep learning curve (Suhr, Hernandez, Grimes, & Warschauer, 2010).

Still, there appears to be what we will call a barrier threshold; if you can't surmount the barrier threshold, practices are limited, despite beliefs. As illustrated by the discrepant case in our study, the teacher working in a school with very limited access to technology had difficulty aligning her beliefs with practice. An alternative explanation, however, is that "different and weightier" beliefs were underlying current practices (Ertmer, 2005; Munby, 1982). Perhaps if core beliefs were more aligned with student-centeredness, first-order barriers would not be able to prevent implementation of student-centered practices. In this study, this was certainly true for Hillman, Cross, and Coley, who all brought in their own equipment to facilitate student use. According to Ertmer (1999) the more significant difference between high- and low-level users related not to the barriers themselves, but to the "relative weight that teachers assigned to first-order barriers" (p. 52). Thus, even if access and resources were low, teachers might assign these barriers little weight due to strong beliefs about the role technology should play in the classroom. This is supported by Travis' comment, noted earlier, "The only [barrier] that is different from mine is – there are some people who don't use technology because they're intimidated by it."

5.3. Limitations and suggestions for future research

Given the relatively small number of participants in this study, results are not readily generalizable. In order to verify these results, a larger sample is needed. In addition, teachers in this study were selected based on their high levels of technology use, thus providing little insight into how beliefs and practices align for teachers at the lower levels of use or for those who are in transition. Our one discrepant case suggests that beliefs change before practice and that practices may be limited by first-order barriers, especially if beliefs are peripheral, or in transition. However additional cases are needed to support this conclusion. Finally, in this study teachers' practices were not directly observed, but rather inferred from their websites and *descriptions* of practice, provided during interviews. Observations would provide a richer understanding of enacted beliefs.

6. Implications and conclusions

The results of this study have implications for practice, specifically related to the professional development of teachers. First, although external barriers have been reduced in many of our U.S. schools, it will be a long time, if ever, before they are completely eliminated (U.S. DOE, 2010). Even among award-winning teachers, barriers such as a lack of resources, lack of administrative support, technology problems, and standardized tests are still considered issues by some. This is similar to what Becker (1994) observed over 15 years ago: even among exemplary users, barriers are known to exist. Yet, 11 of the 12 teachers in this study were able to enact practices that closely aligned with their beliefs, suggesting that second-order, not first-order, barriers are the true gatekeepers. Although efforts are still needed to provide ubiquitous technology access to teachers and their students (U.S. DOE, 2010), little will be gained if second-order barriers (knowledge and skills, attitudes and beliefs) are not addressed. As described by the National Education Association (NEA – AFT, 2008), "We are still woefully short of classroom environments that permit students to engage with technology in a way that prepares them to use technology in the real

world" (p. 12). As one solution, perhaps administrators could assess their teachers' espoused beliefs and work with them to provide specific resources to facilitate the enactment of those beliefs.

The participants in this study viewed their own attitudes and beliefs as *facilitating* technology integration, but the attitudes and beliefs of others as *constraining* integration efforts. Given that our participants were working in schools in which first-order barriers were relatively consistent across classrooms, the primary difference was viewed as being internal to others – their knowledge and skills and attitudes and beliefs. Our participants used words such as "afraid," "fearful," "intimidated," "leery," and "reluctant" to describe their fellow teachers. This suggests that professional development should focus, first, on increasing teachers' knowledge and skills, which can then help increase their confidence and reduce the fear associated with using technology (Ertmer & Ottenbreit-Leftwich, 2010).

One way to reduce fear is to provide teachers with ideas about how their students can assist them with technology. Several of the teachers in this study indicated that their students taught them new ways to use technology and were able to troubleshoot technology problems. Other programs (e.g., Generation YES) have suggested including students in the district's technology plans (Harper, 2008). Not only can students assist with planning (as they have unique digital native viewpoints and skills), but also with the implementation of the technology plan. According to the Generation YES program, over 50,000 teachers have received assistance from students while planning technology-infused lessons. Harper (2008) found that this program was "an effective alternative for schools wishing to integrate technology into their regular curriculum and increase their use of project-based, student-centered learning practices" (p. 3). Implementing this type of program may help address both first-order (i.e., lack of technology support) and second-order barriers (i.e., lack of teacher knowledge and skills; Ertmer & Hruskocy, 1999).

Before teachers will be persuaded to attempt new student-centered practices, however, it will be important to provide evidence that these practices result in meaningful learning outcomes (Ertmer & Ottenbreit-Leftwich, 2010), especially on standardized tests (Geier et al., 2008). In this study, participants recognized they were not exempt from helping their students master state content standards. However, by putting the responsibility for learning on students' shoulders, and employing technology as a motivational tool, students were succeeding beyond expectations. For example, 98% of the students in Garcia's class performed at a Level 4 (the highest level) on the most recent state science test, compared to previous groups of students whose scores averaged around 30%. These are the types of results teachers need to hear more about if they are to be convinced that using technology will enable their students to perform as expected on state assessments (Ertmer & Ottenbreit-Leftwich, 2010). Similarly, work by Geier et al. (2008) could go a long way in assuaging the very real fears teachers today have regarding their students' performances on standardized tests.

Finally, the results of this study suggest we should be utilizing the same technology tools for professional development that teachers are able to use in their classrooms. In a recent report on teacher professional development in the United States, the National Staff Development Council (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009) urged educators to provide professional development in more current and authentic ways: "It is time for our education workforce to engage in learning the way other professionals do—continually, collaboratively, and on the job—to address common problems and crucial challenges where they work" (p. 2). Web 2.0 technologies, such as blogs and wikis, enabled many of the teachers in this study to develop new ideas for their classrooms. Teachers should be introduced to the idea of joining and/or developing their own professional learning networks (PLN; Perkins, 2010). PLNs allow teachers to select one or multiple Web 2.0 technologies (e.g., Twitter, blogs, Google Reader) by which they can "follow" individual teachers or organizations. For example, teachers interested in using Twitter can find a long list of teachers to follow in their particular content areas on the Twitter4Teachers Wiki (http://twitter4teachers.pbworks.com/w/page/22554534/FrontPage). In this way, a science educator could read short posts and gather links to pertinent science lessons on a minute-to-minute basis; teachers are posting new ideas constantly. Perkins (2010) argues that this method of professional development is effective due to the "individualized focus, context-based learning, and empowerment of teachers" (p. 15).

Although many teachers are still struggling to achieve meaningful technology integration in their classrooms (NEA – AFT, 2008), recent changes in access, student characteristics, and curricular emphases may provide some much needed impetus in moving teachers' efforts forward. Our hope is that these changes, together with modifications to professional development and district technology plans, will coalesce into a perfect "technology integration" storm that continues to empower more and more teachers to use technology in ways that prepare our students for the future they will inherit. As noted by Hannafin and Land (1997), "student-centered learning environments represent significant potential for optimizing the capabilities of both technology and learners" (p. 172).

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