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Teachers' Beliefs and Technology Practices: A Mixed-methods Approach

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Abstract

In a sequential mixed methods design, we sought to examine the relationship between teachers' beliefs and their instructional technology practices among technology-using teachers who worked at technology-rich schools to ultimately describe if change in practice toward a student-centered paradigm occurred. The integrated mixed-methods results provide evidence for the following: (a) teachers use technology most frequently for preparation, management, and administrative purposes; (b) teachers' use of technology to support student-centered practice is rare even among those who work at technology-rich schools and hold student-centered beliefs; (c) teachers in technology-rich schools continue to use technology in ways that support their already existing teacher-centered instructional practices. We conclude that future technology professional development efforts need to focus on integration of technology into curriculum via student-centered pedagogy while attending to multiple contextual conditions under which teacher practice takes place. Future technology research must use mixed methods and consider teachers' beliefs if change in practice is the desired outcome. (Keywords: teachers' beliefs, instructional technology practices, mixed methods,student-centered,teacher-centered)

INTRODUCTION

The current educational reform underscores student-centered teaching practices and the use of instructional technologies to support active student learning (ISTE, 2000). Because technology is seen as a major component of school reform, significant amounts of resources have been invested to equip schools with computer hardware and software (Coley, Cradler, & Engel, 1997; Sivin-Kachala & Bialo, 2000). Additional investments have been made into teacher professional development to help them integrate technologies in the classroom and bring about a systematic change toward improving student learning outcomes (Cuban, 2002; Fullan, 2001; Fullan, 2003; Guskey, 2002).

Teachers' beliefs guide the decisions teachers make and actions they take in the classroom (Cuban, 2002; Fullan, 2001; Fullan, 2003; Guskey, 2002; Ringstaff & Kelley, 2002; Sandholtz, Ringstaff, & Dwyer, 1997). Any inquiry into teachers' practices should involve a concurrent investigation into teachers' educational beliefs, as beliefs profoundly influence teacher perceptions and judgments, which in turn influence their classroom behavior (Pajares, 1992).

Many studies have investigated whether schools' technology investments and teachers' increasing ability to use technology have played a major role in the way teachers use technology to improve student learning outcomes.

Some studies tied frequent computer use with teacher change in practice to a student-centered, constructivist pedagogical paradigm (Becker & Ravitz 1999; Becker, 2000; Becker, 2001; Ravitz, Becker, & Wong, 2000; Dexter, Anderson, & Becker, 1999; Matzen & Edmunds, 2007; Sandholtz, Ringstaff, & Dwyer, 1997). These studies concluded that teachers who effectively integrate technology move toward student-centered instructional practices, and this in turn suggests a shift in teachers' beliefs as teachers experience new patterns of teaching and learning. However, other studies reported no significant relationship between frequent computer use and teacher change in practice toward a student-centered paradigm (Cuban, Kirkpatrick, & Peck, 2001; Judson, 2006; Saye,1998; Wang, 2002; Windschitl & Sahl, 2002). The current investigation is another attempt at investigating the relationship between teachers' beliefs and educational technology practices among teachers who work at technology-rich schools and who have been equipped to integrate technology into the classroom through professional development.

Pajares' (1992) referred to beliefs as "messy" in his classic article on the topic. To Pajares, a belief as a construct does not have a single correct definition and is extremely difficult to define because it "does not lend itself to empirical investigations" (p. 308). Pajares argued that a study into beliefs should involve attending to multiple and sometimes conflicting perspectives. Others described teachers' beliefs as situationally determined (Tobin & LaMaster, 1995), context-bound (Orton, 1996; Putnam & Borko, 2000), implicitly defined (Clark, 1988), and ill-structured (Nespor, 1987). Cuban (2002) argued that beliefs by themselves cannot entirely explain how teachers are likely to use technology because teacher practices are inextricably tied to other contextual and organizational factors.

The literature is replete with evidence examining the changes in teacher practice with concurrent investigation into teachers' beliefs. Perhaps due to the messy nature of this construct, however, most previous technology research employed limited, isolated variables in describing teacher technology use (Kay, 2006) and rarely described relationships among factors affecting teacher technology use in the classroom (Zhao & Frank, 2003). Furthermore, previous studies predominantly based their evidence on self-report and quantitative research approach only (Becker & Ravitz, 1999; Franklin, 2007; Hernandez-Ramos, 2005; Niederhauser & Stoddart, 2001; Rakes, Fields, & Cox, 2006; Wang, 2002; Wozney, Venkatesh, & Abrami, 2006). Those choosing to use qualitative research methodology combined classroom observations and interviews to describe selected cases sampled from a single school (Ertmer, Addison, Lane, & Woods, 1999; Levin & Wadmany, 2006; Norton, McRobbie, & Cooper, 2000; Windschitl & Sahl, 2002) or sampled cases from two technology-rich schools using the qualitative methodology only (Cuban, Kirkpatrick, & Peck, 2001). All of these studies used teacher populations from schools with an abundance of technology. Among such studies, two addressed the population issue by sampling teachers exclusively from large technology integration professional development programs such as Apple Classrooms of Tomorrow (ACOT) and The Centers for Quality Teaching and Learning (QTL™) (Matzen & Edmunds, 2007; Sandholtz, Ringstaff, & Dwyer, 1997). Both studies re-

ported a positive relationship between increased use of technology and changes in teachers' pedagogy toward student-centered practice.

This study was prompted by the ongoing contradictions in findings and respects the complexities involved in researching the messy nature of teachers' beliefs. It was intended to bridge the gap in the literature regarding the relationship between teachers' beliefs and their instructional technology practices. A key distinction in this study is the use of a mixed-methods research approach addressing multiple variables (n = 10) and employing two embedded sampling strategies (stratified and maximum-variation) to describe (a) teachers' instructional technology practices in terms of teacher use and student use and (b) how this use related to teachers' beliefs. Ultimately, we wanted to answer this main question: Do teachers who frequently integrate technologies and work at technology-rich schools change their beliefs and consequently their instructional technology practices toward a student-centered paradigm?

METHOD

The study design called for equal integration of both quantitative and qualitative methods, using multiple variables and sampling techniques in selecting technology-using teachers who were trained via multiple models of longitudinal professional development programs. The explanatory mixed methods design (QUAN → QUAL) was followed by collecting quantitative and qualitative data sequentially across two phases (Creswell, 2002; Teddlie & Tashakkori, 2006). This mixed methods design was employed based on the empirical evidence in previous research on the relationship between teachers' educational beliefs and their instructional technology practices: Teacher's beliefs as a messy, ill-structured construct neither easily lends itself to empirical investigation nor entirely explains by itself how teachers are likely to use technology. This combination of mixed methods, sampling strategies, and multiple variables was chosen to minimize errors that may arise from a single technique, and maximize the meaning from results of data interpretation (Patton, 2002; Tashakkori & Teddlie, 2003).

Our study was designed to answer the following two research questions in the QUAN phase:

1. How do teachers' beliefs relate to their instructional technology practices?
2. How do factors other than beliefs relate to teachers' instructional technology practices?

Guided by these answers, we ultimately wanted to answer this question, which integrated the results of both methods, in the QUAL phase: Do teachers who work in technology schools and who are equipped to integrate technologies change their beliefs and consequently technology practices toward a student-centered paradigm?

Sampling

The population of interest consisted solely of technology-using teachers in technology-rich schools. Therefore, the sampling criteria considered only those

schools and teacher types to ensure barriers to technology were minimal in terms of availability, support, and teacher comfort and confidence with using technology. The question of school type was addressed by selecting participants only from the 28 Benedum Collaborative Professional Development Schools in the northern part of West Virginia, were the schools sampled for the study. Teachers were sampled only from the Benedum Collaborative Professional Development Schools (PDS), as these schools had committed to school reform, professional development, and integrating instructional technologies and had adequate technical infrastructure and equipment.

The sample for the QUAN strand was determined using probability sampling from within a randomly selected strata of those teachers in the 28 professional development schools that had completed one of the three reform-oriented teacher professional development programs. The subsequent QUAL strand used the maximum variation sampling strategy (Patton, 2002; Teddlie & Yu, 2007) to purposely select two pairs of cases with extreme or maximal differences in teachers' beliefs. This resulted in the selection of two teacher pairs from opposite ends of the sample population distribution as representative of teachers with diverse educational beliefs.

Participants

Only those PK–12 teachers that met the selection criteria described above were included in the sample, regardless of the number of years of teaching experience, subject-matter expertise, or other demographic variables (gender, age, and ethnic background). Of the 138 teachers who received the surveys, a total of 113 responded with usable returns. The population of participating teachers included nine males and 104 females, with teaching experience ranging between 2 and 39 years, with a mean of 22.13 years. Sixty percent of the participants were teaching grades PK–6, and 40% were teaching grades 7–12. The number of years that teachers reported to have been using computers in the classroom for instruction ranged from 2 to 20 years, with an average of 9.48 years.

Data Sources

Quantitative phase. We collected quantitative data for the study using two surveys. We used the Inventory of Philosophies of Education (Sadker & Sadker, 2003) instrument to measure two of the seven predictors used in the study: teachers' student-centered and teacher-centered beliefs. The Inventory of Philosophies of Education (Sadker & Sadker, 2003) is a self-reporting survey that measures a continuum of five educational philosophies: essentialism, perennialism, progressivism, social reconstructionism, and existentialism. This survey is composed of 28 statements using a 5-point Likert scale with response options ranging from "disagree strongly" to "agree strongly." The survey has content validity for preservice teachers (Sadker, 2004).

We employed the Perceptions of Computers and Technology (Hogarty, Lang, & Kromrey, 2003) instrument to determine teachers' self-reported use of technology in the classroom. The names of variables and number of items are as follows: attitudes toward technology use (20 items); teacher confidence and

comfort (9 items); technical support (5 items); general school support (7 items); ratio of computers to students (1 item); teacher software use (14 items); student software use (14 items); and instructional strategies (12 items). Hogarty, Lang, and Kromrey (2003) reported that the Cronbach alpha internal-consistency reliabilities ranged between .79 and .91.

Qualitative phase. Multiple case study design called for hermeneutic inquiry (Patton, 2002) to conduct, analyze, and interpret the meaning related to teachers' instructional technology practices within the contextual conditions under which this practice takes place. The case-study research design integrated the findings from the QUAN phase both in the selection of the cases and in the interpretation of data. We used the maximum variation sampling strategy to purposefully select two pairs of cases with extreme or maximal differences in teachers' beliefs based on teacher self-report to the Inventory of Philosophies of Education. Upon identifying the cases, teachers were contacted in person to invite them to participate in the study and to further request the following sources of data: (a) a classroom observation, (b) an interview, (c) a lesson plan, and (d) their written reflections to four open-ended questions about their educational beliefs and practices. All four voluntarily agreed to participate in the study without incentives. We scheduled the classroom observations on the same day as the interview. We also asked the subjects to provide the researcher with their written responses to the reflection questions and a lesson plan with their typical use of technology on the same day as the interview. Each interview lasted 60–90 minutes and took place in the teachers' classrooms. We designed the interview questions to capture teacher beliefs, experiences, opinions, and values about education and technology use in the classroom. We used the teachers' reflections and lesson plans during the interview to prompt teachers to provide further explanations of their beliefs and evidence of their practice. The collection of multiple sources of qualitative data provided substantial description of why teachers do what they do in the classroom in terms of technology integration within contexts where both internal and external barriers were minimal.

Data Analysis

The quantitative phase used analyses of multiple regressions and correlations. To answer the two research questions posed in the QUAN phase, we used a total of seven predictor and three criterion variables. The seven predictors used for the analysis were (a) student-centered beliefs, (b) teacher-centered beliefs, (c) attitudes about technology, (d) teacher confidence and comfort with technology, (e) technical support, (f) general school support, and (g) ratio of computers to students in the classroom. The first three of these predictors referred to teachers' beliefs and were used in research question 1. The remaining four referred to factors other than teachers' beliefs and were used in research question 2. We used the same three criterion variables to describe teachers' technology practices for both of the research questions. These are (a) teacher software use, (b) student software use, and (c) instructional strategies.

The qualitative-phase analysis focused on finding out if those teachers who were expected to be frequent technology users as a result of their technology

training and technology availability at their schools changed their beliefs and consequently their instructional technology practices toward a student-centered paradigm. To be able to answer this question, we sequentially integrated both methods and triangulated all data sources around the variables that were used in the QUAN phase. We excluded the variable of ratio of computers to students and used the remaining nine from the quantitative phase as units of analysis to analyze the qualitative data. These nine units captured the recurring themes throughout and across all qualitative sources of data (Maykut & Morehouse, 1994; Merriam, 1998).

We analyzed the interview transcripts by reading, color coding, and merging lines from transcriptions according to the data units revealed in each case. The units were constantly compared through and across interview transcripts and other sources of qualitative data (teacher reflections, classroom observation notes, and a lesson plan) as well as against the self-report data. We then collapsed these nine units into the following six categories: (a) teacher beliefs about education, (b) teacher beliefs about curriculum, (c) teacher and student technology use, (d) teacher attitudes toward technology, (e) support for technology integration, and (f) impact of technology integration on their practice. We described each of the four cases using these six categories to better portray similarities and differences between and among teachers with student and teacher-centered beliefs.

QUANTITATIVE RESULTS

This section will report the findings of the quantitative design by answering how beliefs and nonbelief factors are related to teachers' instructional technology practices.

Question 1: How Do Teachers' Beliefs Relate to Their Instructional Technology Practices?

We conducted multiple regression and correlational analyses to investigate the extent to which beliefs predicted teacher and student technology use and the instructional strategies teachers used when integrating technology. Multiple regression analyses were conducted by regressing the three beliefs predictors (student-centered beliefs, teacher-centered beliefs, and attitudes) on each of the three criterion variables (teacher software use, student software use, and instructional strategies). Second, we conducted a separate correlation analysis to describe how teachers' beliefs were related to the specific items of the three criteria. Though nonsignificant t-test values were obtained for student-centered beliefs and teacher-centered beliefs on the regression analyses, significant t values were revealed in the regression analysis of attitudes on all three criterion variables: Teacher software use ($t = 4.96$, $p < .01$), student software use ($t = 2.96$, $p < .01$), and the selection of instructional strategies ($t = 3.61$, $p < .01$). The model accounted for 21% of the variance in teacher software use ($R^2 = .21$), 14% of the variance in student software use ($R^2 = .14$), and 12% of the variance in instructional strategies ($R^2 = .119$). Itemized correlational analysis findings

point to teacher attitudes toward technology as the most important belief factor for their instructional technology decisions in the classroom.

Question 2: How Do Factors Other than Beliefs Relate to Teachers' Instructional Technology Practices?

We conducted multiple regression and correlational analyses to describe how factors other than beliefs related to teachers' instructional technology decisions for teacher and student technology use and instructional strategies teachers used when integrating technology. We conducted multiple regression analyses by regressing the four predictors (teacher confidence and comfort, technical support, general school support, and ratio of computers to students) on each of the three criterion variables (teacher software use, student software use, and instructional strategies). We obtained nonsignificant *t*-test values for three of the four predictors in the analysis (technical support, general school support, and ratio of computers to students). The *t* value for comfort and confidence was $t = 2.25$, $p < .05$, significant for only teacher software use. The model accounted for 12% of the variance in teacher software use ($R^2 = .12$), 10% of the variance in student software use ($R^2 = .10$) and 21% of the variance of instructional strategies ($R^2 = .205$). Itemized correlational analyses indicate that technical and general school support increased the likelihood of certain types of software use such as Web publishing by teachers. On the other hand, teachers' decisions for student software use and teacher selection of instructional strategies were directly correlated with the ratio of computers to students in the classroom to a greater extent than the general school and technical support.

Tables 1, 2, and 3 display the correlations between the three criterion variables and the seven predictor variables: teacher software use (Table 1, page 424), student software use (Table 2, page 426), and instructional technology use (Table 3, page 428). Each table provides a separate display of how items on a criterion variable related to each of the seven predictors.

QUALITATIVE RESULTS

Case study analysis documents how the two pairs of teachers with similar and contrasting beliefs used technology in the classroom to portray the relationship between teachers' beliefs and their instructional technology practices. Here we describe each case individually first before making comparisons and contrasts among them and between the pairs. Table 4 (page 430) provides a summary of the characteristics of the four cases.

Case 1: Kate

Kate was an experienced teacher with 39 years of teaching experience. She was teaching grade 1 at a midsized rural elementary school. A student teacher was helping Kate when the researcher walked in to observe her class. She was sitting at her desk checking student work while the student teacher conducted a whole-class activity on writing. Students were copying sentences from their books onto their worksheets. Once students finished their work, they walked to

Table 1: Teacher Software Use Items and Their Relationships to Belief and Nonbelief Factors

Teacher Software Use	Correlations with Predictor Variables						
	Student-Centered Beliefs	Teacher-Centered Beliefs	Attitudes	Confidence and Comfort	Technical Support	General School Support	Ratio of Computers
Word Processor	.09	.21*	.31**	.13	.12	.21*	.14
Spreadsheets	.20*	.13	.32**	.17	-.09	-.10	.21*
Databases	.08	.14	.33**	.15	.03	-.05	.22*
Desktop Publishing	.13	.20*	.23*	.14	.10	.09	.07
Presentation Software	-.09	.19	.43**	.47**	.19	.05	.19
Web Publishing	-.03	.04	.40**	.35**	.22*	.25*	.24*
Graphics Programs	.12	.01	.25*	.24*	.02	.06	.06
Drill and Practice	-.06	.-07	.00	.03	.05	-.04	.02
Games	.06	-.05	.11	.04	.03	.10	-.06
Simulations	.07	.05	.11	.19	.01	-.12	.08
Tutorials	-.02	.05	.15	.16	.09	.02	.06
ILS	-.08	-.19	.20*	.20*	.21	.22*	.02
Web Browsers	.01	.13	.38**	.23*	-.03	.02	.16
Programming/ Authoring Tools	.09	-.07	.20*	.07	-.11	.13	.13

* *Correlation is significant at the 0.05 level (2-tailed).*

** *Correlation is significant at the 0.01 level (2-tailed).*

Kate's desk to have her approve their worksheets. She sent three students who finished early over to the computer stations. During the rest of the hour, students continued to practice writing independently while a few students worked on the computer stations independently.

Beliefs and technology practices. Kate's self-report philosophy scores identified her as having teacher-centered beliefs. Kate described herself as a "leader, facilitator, guide" and defined curriculum as a set of essential skills children needed to master to be successful. Kate explained that the essential skills were outlined in the content-specific objectives by the state, and she followed this curriculum guideline teaching for mastery. To Kate, tests were the means for determining student mastery.

Kate's self-report indicated that she used computers for individual instruction, independent leaning, and student-centered instruction and as a reward. Contrary to the variety of different types of computer use in the self-report, Kate provided examples for only two types of use in the interview: drill-and-practice and as a reward. Kate had her students use an integrated learning system (ILS) called Compass because this system complied with the state standards and helped her teach and reteach basic skills as dictated in the content standards. The ILS was a "fun reinforcement" for children because they enjoyed its game-like activities and was an "extra pair of hands" for her because she could have some students work independently while she was doing something else with the rest of the class. In summary, Kate had students use the ILS technology exclusively because it "did not disturb" the regular classroom activities and reinforced skills for mastery through independent, student-centered instruction.

Kate was extremely comfortable with technology. She had rated herself having the highest level for comfort and confidence with technology. Kate's attitudes toward technology were also highly positive. She was the chair of the technology committee and responsible for anything to do with technology at this school. She trained other teachers how to use new educational software as well as how to search and evaluate educational Web sites. She provided technical support such as setting up e-mail accounts, installing software on machines, and helping teachers manage electronic resources.

Support and barriers. Kate made references to her progressive principal, the support from the county, and in-house professional development sessions where she taught technology to other teachers at this school. Access to technology at school was abundant. The computer lab was equipped with 30 new machines, and she had four computers, a color printer, and a scanner in her room. The technology committee had a budget of $7,000 and voted to spend the money on renewing licenses and buying new software. She said they never fell behind; they had four digital cameras, a big-screen TV, and several LCD projectors. All equipment was available to check out from the library. All teachers were expected to use technology because technology had become a content standard and a criterion for teacher evaluation at the school.

Impact of technology. Kate expressed that technology had an impact on her instruction, collegial relationships, and on professional status. Referring to the only technology she had her students use (the ILS), she believed technology created independent learners and allowed her to individualize instruction.

Table 2: Student Software Use Items and Their Relationships to Belief and Nonbelief Factors

Student Software Use	Correlations with Predictor Variables						
	Student-Centered Beliefs	Teacher-Centered Beliefs	Attitudes	Confidence and Comfort	Technical Support	General School Support	Ratio of Computers
Word Processor	.15	.19*	.33**	.19	.05	.15	.29**
Spreadsheets	.22*	.18	.28**	.16	.01	-.08	.25*
Databases	.11	.24*	.17	-.05	-.02	-.13	.19*
Desktop Publishing	.16	.23*	.25**	.14	.04	.02	.09
Presentation Software	.06	.24*	.29**	.30**	.28**	.18	.24*
Web Publishing	.14	.20*	.29**	.21*	.06	.07	.21*
Graphics Programs	.15	.15	.24*	.13	-.03	.06	.20*
Drill and Practice	-.01	.02	.01	.02	.01	.03	.03
Games	.05	-.06	-.01	-.00	.10	.14	-.09
Simulations	.14	.14	.01	.23*	.20	.06	-.00
Tutorials	.14	.13	.18	.19*	.01	.04	-.00
ILS	.02	-.08	.01	.16	.30**	.24*	-.12
Web Browsers	.06	.15	.28**	.25*	-.02	.11	.22*
Programming/Authoring Tools	.14	.13	.18	.13	.07	.15	.14

* *Correlation is significant at the 0.05 level (2-tailed).*

** *Correlation is significant at the 0.01 level (2-tailed).*

When she was prompted to comment on whether she observed any changes in her instructional approaches, she pondered a few seconds. She first said "What changed? I will have to see...," then continued, "As a matter of fact, somebody is doing something different than someone else has made me be more flexible." Kate also noted that her assessment had changed because she now collected data not only via paper-and-pencil-based tests, but also via technology, the ILS.

Technology had an impact on her status and relationship among teachers at this school. Technology helped create a learning community. Before, they were locked in their classrooms, but now they collaborated with each other while working together in the technology-related professional development sessions.

Summary. Kate self-reported being a teacher with teacher-centered beliefs and used technology for drill-and-practice and mastery of subject matter. Despite her positive attitudes, high comfort and confidence, and availability of computer hardware and software, she had limited her students' technology use to one type of technology (ILS) because this technology supported her existing ways of teaching. As a technology leader at her site, she trained and supported other teachers in their use of computers and used a variety of computer technologies for professional productivity. However, frequency and availability of computer technologies, coupled with her high comfort and positive attitudes, did not transform her teaching. She made her technology decisions in line with her beliefs for students and selected only one type to support mastery of skills.

Case 2: Anne

Anne was a grade 8 teacher for the gifted in a large town's middle school near a university. Anne had 9 years of teaching experience. On the day she was observed, six students walked into the classroom and sat next to each other around the round tables. Anne sat beside the students. She began the lesson by passing out a one-page double-sided handout. Today's lesson was on language arts. The lesson modeled how poets and students could give special emphasis to the certain parts of a poem by arranging lines and altering spacing. She had an example poem on one side of the handout illustrating the effect of emphasis. On the other side, she had instructions for practice. She had a student read a couple of lines from the poem, raised a few questions on the topic, and clarified ideas after student discussions. After an approximately 20-minute discussion, Anne invited students to go to the library to use the computer stations there. Each student practiced line arrangement by using a word processor program. Anne walked around the computer stations and helped students with their work until the end of the class hour.

Beliefs and technology practices. Anne's self-report identified her with student-centered beliefs. She described her role "as a facilitator." Anne wanted her students to learn "how to learn" and see "how things work and reasons behind that." She gave students choices to have them make some decisions either right or wrong because she believed that was how they learned. She described herself more of an organizer than the leader of the class. She was not an expert in the class either. She was teaching gifted students and said, "We have kids who have expertise beyond us in some subjects."

Table 3: Instructional Strategy Items and Their Relationships to Belief and Nonbelief Factors

Instructional Strategy	Correlations with Predictor Variables						
	Student-Centered Beliefs	Teacher-Centered Beliefs	Attitudes	Confidence and Comfort	Technical Support	General School Support	Ratio of Computers
Small Group Instruction	.04	-.00	.24*	.11	-.05	.07	.17
Individual Instruction	.08	-.05	.22*	.07	.20	.14	.26**
Cooperative Groups	.18	.04	.20*	.12	-.02	.08	.10
As a Reward	.14	.15	-.03	-.00	.08	.15	-.12
Independent Learning	-.04	-.07	.18	.21*	.20	.21*	.12
To Tutor	-.02	.06	.11	.13	.12	.22*	.11
Student-Centered	-.02	-.01	.27**	.30**	.10	.19*	.24**
Research Tool	.07	.10	.23*	.14	-.04	.06	.25**
Problem Solving Tool	.20*	.14	.34**	.16	-.12	-.02	.44**
Productivity Tool	.04	.05	.12	.21*	-.00	-.05	.20*
Presentation Tool	.01	.08	.44**	.43**	.00	.07	.35**
Communication Tool	.09	.05	.20*	.17	.21*	.09	.27**

* *Correlation is significant at the 0.05 level (2-tailed).*

** *Correlation is significant at the 0.01 level (2-tailed).*

Anne defined the gifted curriculum as individualized and student centered. She used phrases such as "process," "thinking skills," "having choices," and "multiple ways for looking at things" to describe the curriculum. She believed the role of the curriculum was to help students become lifelong learners, and her role in the curriculum was to teach "process" as opposed to focusing on the product or the content. Anne mainly used project-based learning as her teaching strategy and used student journals for assessing student performance. When prompted if she gave any tests, she said, "Just because you do not give a test, it does not mean you do not evaluate performance." She assessed student performance every day through student products such as journals.

Anne's decisions to use technology depended on her curricular goals. "I do not always use technology, but when I use it, I use it as a book. You use a particular book because it is the best way." In the survey, Anne had marked that she has used a variety of instructional strategies except two: using computers as a reward and to tutor. She expressed that technology was a regular part of curriculum and was incorporated in her day-to-day practice. Anne had her students use a variety of technologies but not integrated learning systems. She talked most enthusiastically about a Web-based courseware, Edline, as an example of her technology use in the classroom. Edline was used for storage, retrieval, and communication. Anne used this system to communicate with students and parents as well as to store and retrieve class materials.

Anne self-reported having high confidence and comfort with technology and positive attitudes toward technology. Anne had been a serious home computer user for some time. She bought her first computer in 1986 and learned how to work on it. She had built three computers: one with her sons and two with her students for classroom use. She, like other teachers at this school, used technology because she believed it would be unfair to not provide this service to the students in the 21st century.

Support and barriers. Time was a limitation for learning and using new technologies. Hardware in Anne's room was scarce. She had three very old computers and a scanner in her room. Anne contested that lack of hardware in her room was not a barrier because she was able to use the computers at the school library and in the computer lab. The school's technology leader, Jan, would arrange what they would call "Jan Tech" days. These tech days had begun as Jan showing them computer tricks but had become sessions for collaboration and information exchange.

Impact of technology. Technology had an impact on the way her students learned. She said, "My students are probably more independent because I construct my units more so they work more independently." She explained that project-based learning supported by technology enabled her to create independent learners who could "take care of their own learning." Technology also had an impact on her preparation and management. She said, "I remember doing a lot less than I do now," but she continued, "I cannot do the job I do now without computers." Technology had an impact on the expectations of how teachers at Anne's school were supposed to teach. All teachers were expected to use technology at this school.

Table 4: Summary of Characteristics of the Four Cases

Variable	Kate	Anne	Sandy	Tina
Beliefs about Education	Mastery of skills for student success	Lifelong learning Learning how to learn	Preparing students for life after school	Creating a safe environment to grow, learn, and cooperate
Beliefs about Curriculum	Basic skills for mastery	Process skills Thinking skills Giving choices and decision making	Teach basic life skills that would be helpful for life after school	Process skills Cooperative learning Critical thinking skills
The Role of a Teacher	A leader Teacher of essential skills	A facilitator An organizer Not an expert	Educator A model for appropriate behavior	Nurturing Raising the self-esteem
Beliefs about Technology	A second teacher Fun reinforcement	A learning tool used when appropriate	Privilege	A learning tool to help students with their disabilities
Instructional Strategies	Drill and practice Reward Independent learning	Multiple approaches except using computer as a reward	Drill and practice Reward	Cooperative learning
Attitudes	Beyond average	Beyond average	Below average	Average
Student Software Use	Integrated Learning System	Web-based communication tools and other applications	Integrated Learning System	Developmental software and games
Impact of Technology	Independent learners Professional status	Self-directed learners	None	Independent learners

Summary. Anne self-reported being a teacher with student-centered beliefs who used technology as a learning tool to support her project-based instruction. Despite the lack of computer hardware in her classroom, she was able to transform her face-to-face teaching into Web-based, interactive, student-centered instruction. Anne had her students use a variety of technologies based on her curricular goals, and she had often used technology for planning, communication, collaboration, storage, and retrieval. Anne made her technology decisions in support of her educational beliefs, which culminated in highly flexible, active student learning environments.

Case 3: Sandy

Sandy was a young teacher with five years of teaching experience. She had been teaching special education for grades 9 through 12 for three years in a large high school. The lesson was on language arts on the day the researcher observed her class. She had about 10 students in her room. When the students came into the class, she advised them to pick up textbooks from a book shelf. As soon as the students were seated with their textbooks, she directed them to read examples of parts of speech written on the blackboard. She then instructed students to open to a specific page in their books and to complete an exercise. The book gave two choices for each sentence, and the students were to choose the correct form for a given sentence and write the entire sentence with the correct form onto a blank sheet of paper. As students worked independently, Sandy walked around the student desks and sat down beside students from time to time to help them with the exercise. She collected students' answers to this exercise at the end of the class meeting.

Beliefs and technology practices. Sandy had self-reported having teacher-centered beliefs. She stated that she believed that "all children need to be educated, but we need to educate them in areas that will be helpful and beneficial to them." Her main goals in the curriculum were "to prepare the students for life after high school...to make them help themselves." She wanted each of her students to complete high school, get a job, maintain a job, and be able to support themselves. She viewed curriculum as a "sore spot" because she saw a conflict between what the curriculum dictated her to teach and what she believed was important. She wished the curriculum included "life skills" such as how to budget, balance a check book, write a check with correct spelling and numbers, résumé writing, and interviewing skills. Instead, the special education curriculum required students to take advanced courses. She did not think her students with special needs were able to use these advanced courses in life, nor did she think the current curriculum gave her the flexibility to teach what she believed to be important. Although she believed tests were the best means to measure student understanding, she did not think standardized tests were appropriate for her student population. Referring to the worksheets as student products, Sandy believed measuring student performance through these types of student products was more appropriate for her student population.

Sandy mainly used Plato, an ILS for reinforcement and mastery. Sandy called Plato "a great program" because it was multifunctional, applicable to multiple

subjects, and reinforced what she had taught. The other technologies she had her students use were video DVDs and audio CDs. Students watched videos on the TV in the classroom after reading stories and played audio CDs on a stereo in the classroom after reading the book. When asked if students checked out the CDs or DVDs to listen or watch them on their own, she said, "No, each kid gets the book. I am the only one who has the CDs, so we have to do it in class" as a whole-class activity.

Although Sandy had marked using computers in cooperative groups and to promote student-centered learning in the survey, these types of uses were not evident in the interview or in the class when she was observed. Instead, she gave examples of how she used computers for independent learning and individual instruction. In rare occasions, when she had students use the Internet in class, she highly supervised them because "I do not want them to go and do anything [on the computer] they should not be doing.... I am always in the room and watching computers."

Sandy had expressed high comfort with technologies both in the survey and in the interview. She explained that computers were around when she was growing up, so she used them as a child and as a student. Sandy's husband worked in the computer field. He often helped her with learning and using computer technologies. At school, she was the delegated technology support teacher on her floor. Sandy's attitudes score toward computer use for instruction was low compared to the population average in the survey. In the interview, she said, "Technology is a wonderful aide to education that I use to supplement what I have already done," but she was cautious about using computers in the classroom. She viewed giving students the opportunity to work on computers as a "privilege" and said that "[computers] should only be used as an aide to reinforce what is taught."

Support and barriers. Although Sandy had only one computer in her room, she had explained that the school had abundant hardware and software, technical help, and technology funds for teachers. The school had a mini-lab on her floor and three other labs on other floors. Several dozens of wireless laptop computers were available to teachers for classroom use. One full-time and one half-time technical support personnel were available at the school. Funds were allocated to individual teachers, and it was up to the teachers how he or she wished to spend it. The past year she had received $5,000 and had spent most of this money on purchasing audio CDs, video DVDs, and a DVD/VCD player. The administration was helpful and supported teacher use of technology. Technology was in the content standards and in yearly teacher evaluations. Every teacher was using it in some capacity. Finding time to use new technologies and the limited number of licenses were the only two barriers.

Impact of technology. In Sandy's words, technology had no impact on her practice: "I use technology mainly to reinforce what I have already done. They all like the computer. I kind of use it as a sort of a reward. So I do not use it as a teaching tool as much as I do for reinforcement...and I do not want to overdo it because it just becomes the same rote task, memory, and drill-and-practice thing that they have been doing." Sandy believed student computer use was "a privilege," so she limited student use of computers as a reward.

Summary. Sandy self-reported to have teacher-centered beliefs. Despite her high comfort and confidence with technology, abundant availability of hardware and software, and technical and general support for technology use in her school, she rarely used computers in the classroom. On those rare occasions, she used computers mainly as a reward and for drill-and-practice for skill mastery. She believed her limited use of technology motivated and sustained her students' interest in the lesson. In conclusion, Sandy's teacher-centered educational beliefs influenced her attitudes toward how computers should be used in the classroom, and these beliefs in return manifested themselves in how she taught and how she used technology to support her highly teacher-controlled learning environments.

Case 4: Tina

Tina was a recent graduate with three years of teaching experience. She was a special education teacher for kindergarten through grade 5 at a large elementary school. Tina was working on a student desk with what appeared to be a grade 2 student one on one when the researcher walked into her class to observe. Tina had two teaching aids for the 12 students in the class. Two medium-sized boards displayed the group activities for the day. Students were working in their small reading and writing groups. Two students were working independently on the computers, and a few were working on their own, copying sentences from the board onto their papers. Moving from working with one student to the other, Tina raised her head and asked one student to take a bag of letters and to practice writing the sentences written on the board using the letters in the bag. Tina asked another student who finished her work early to help the student with the bag of letters. Throughout the class time, Tina was extremely occupied with changing students, changing activities, and changing strategies. Students were observed to be on task and working with a peer, with an aide, alone, or in their small groups.

Beliefs and technology practices. Tina had self-identified herself as a teacher with student-centered beliefs. Tina's mission in teaching was "to create a warm and nurturing environment that will allow my students to grow and learn...to help raise the self-esteem and confidence of my children, and challenge them into exploring the unknown for the challenges of life." She believed her students could meet the challenges of life if she helped them improve their critical thinking skills and provided opportunities for cooperative learning in which they learn to make compromises as they work with their peers. The purpose of schooling was to "prepare all students to succeed in life, to prepare students to become productive members of society, and to help students achieve their fullest potential."

Tina mainly had her students work in what she called "cooperative learning" because this strategy gave her children an opportunity "to learn, grow, and feel safe." She believed classroom interactions were very important to student learning and growth. Tina found it troubling that a lot of her children did not know how to work together or play together. She felt strongly about helping students build social skills and learn to cooperate with one another.

Tina had moderately rated herself having an average level comfort and confidence using technology for instruction. She was a recent graduate, and technology had been part of her personal and academic life as long as she could remember. Tina's attitudes toward using technology in the classroom were highly positive. However, her positive attitudes came with this caution: "Technology should not be used in place of direct teacher and student interactions." Because she believed learning should occur in highly interactive cooperative groups, Tina was neither interested in using the computer to tutor nor for drill-and-practice.

Tina used a variety of technologies for planning and management. At the time, she was working on a class Web site to post homework for her "children." She used e-mail to communicate with parents and the Internet to retrieve information to be used in class. Tina viewed her main goal in teaching as increasing the self-esteem of her children with learning disabilities. She used technology to support her students with their learning disabilities. For example, the Microsoft Word spellchecker helped her students with writing stories.

Technology gave her students opportunities to learn and explore concepts on their own at their own pace, and it reinforced concepts in a bright, colorful, and exciting way. She frequently used what she called developmental software such as Curious George, Jump Start, and Reader Rabbit. When asked if she had used an ILS for reinforcement of concepts, she said she was more interested in children's development as opposed to attaining mastery. Tina found mastery as being very difficult to determine with her student population. Instead, she chose technology that would support her children's development in a flexible way.

Support and barriers. Tina described her school as a great place to work with a very supportive administration and saw no barriers to the integration of technology. There was a technology teacher at the school who was very helpful. The administration would generally provide her with what she needed. Tina did not think limited hardware in her room was a barrier. The school had a computer lab, and it was available if she wanted to use it. She was aware of the technology budget, but she chose not to use any money from that budget for her classroom use. Hardware such as digital cameras and scanners were available at the school on a check-out basis.

Impact of technology. Technology had the most impact on creating "independent learners" because students could work at their own pace and succeed. Technology had an impact on her practice because she could not imagine doing her job without technology. The teachers were expected to use technology at the school, and as far as she knew, everybody was using it and talked about different ways they used it.

Summary. Tina self-reported being a teacher with student-centered beliefs who selected technologies to support the development and self-concept of her "children." She believed classroom interactions were very important to student learning and growth, so she set up highly interactive cooperative groups. Tina's teaching focused on student growth as opposed to mastery of skills. She did not have her students use skill-based, self-contained, drill-and-practice types of

computer technologies and did not use open-ended technologies such as the Internet. In conclusion, Tina believed in direct teacher and student interactions and had her students use technology as needed because she lacked models of technology integration to support cooperative learning.

Cross-case Comparisons

Kate and Sandy, two cases with teacher-centered beliefs, perceived that a learner's one-on-one interaction with computers constituted student-centered, independent learning. They had their students use one exclusive technology in the classroom, an integrated learning system, in the same way they taught: repetition and reinforcement until students mastered the skills. They both liked this linear, mastery-based technology because it reinforced what they had already taught without disturbing their classrooms while students worked one-on-one independently in this highly teacher- controlled, technology-supported learning environment.

Anne and Tina, teachers with student-centered beliefs, similarly reported having used technology for independent learning to support student-centered instruction. However, their perception contrasted dramatically from the viewpoint of Kate and Sandy. Anne believed a Web-supported project-based approach to teaching created independent learners who could take care of their own learning at their own time. Tina acknowledged that technology enabled her students to explore concepts on their own at their own pace and supported them with their learning disabilities. Neither Anne nor Tina believed in mastery of skills nor used the computer to tutor or for drill-and-practice. They both emphasized process skills such as critical thinking and cooperative learning (as opposed to mastery) and viewed curriculum and technology integration more flexibly.

Across all four cases, technology had an impact on the expectations of how teachers were supposed to teach and how students were expected to learn. All four cases were evaluated on their use of technology in the classroom and acknowledged technology's role in the lives of their students in the future. Technology had an impact on how they spent their time for learning to use it and using it to plan, manage, and post student grades. Technology increased professional dialogue among teachers. Due to increasing expectations, all four cases used technology frequently for planning, management, and communication. However, technology itself did not mediate the changes in the way they taught in the classroom. The way they taught, and especially ways they had students use technology, were primarily influenced by the teachers' educational beliefs and of what they believed to be good teaching.

DISCUSSION

The main purpose of this study was to investigate whether teachers who frequently integrate technologies and work at technology-rich schools change their beliefs and practices toward a student-centered paradigm. Results from the quantitative phase indicate that shift in teacher practice did not occur despite

the fact that the teacher population in this study (a) had technology availability at their schools, (b) had positive attitudes toward technology, (c) had adequate technical and general support, and (d) were comfortable with technology. The quantitative phase revealed that neither student-centered nor teacher-centered beliefs are powerful predictors of teachers' practices, and that teachers' attitudes toward technology are the most significant predictor for teacher and student technology use and teacher use of a variety of instructional strategies.

The qualitative analysis, which integrated the results of the both methods, found that teachers' positive attitudes toward technology do not necessarily have the same influence on student technology use and instructional strategies that are compatible with the student-centered paradigm such as cooperative and project-based learning. These mixed methods results were contrary to those of the QUAN phase alone, where teachers' attitudes toward technology were found most significant for predicting student and teacher use of technology with a variety of instructional strategies. Although our survey items captured student use, teacher use, and instructional strategy use with technology, it was only through teachers' testimonies that we were able to describe how teachers had students use technology in the classroom. Additionally, teachers' self-report data failed to capture teachers' views of what constituted student-centered compatible instructional strategies. All four cases self-reported to have used a variety of instructional strategies. However, in reality those with teacher-centered beliefs employed highly teacher-controlled strategies where students worked in self-contained technology-supported learning environments, and teachers used technology as a reward, for drill-and-practice, and independent learning.

Our study also provides evidence to support concerns about measuring teachers' beliefs with self-report data alone. We agree with the argument in the literature that dichotomous distinction of teachers' beliefs is complicated to gauge with self-report data alone (Levin & Wadmany, 2006). Similar to many others (Clark, 1988; Nespor, 1987; Orton, 1996; Pajares, 1992; Putnam & Borko, 2000; Tobin & LaMaster, 1995), we argue that teachers' beliefs are extremely difficult to strictly categorize as student-centered or teacher-centered with self-report data alone.

On the issue of the relationship between teachers' beliefs and their instructional technology practices, our findings corroborate results from prior research that indicate teacher technology use in schools with abundant technology did not transform teaching into more student-centered practice (Cuban, 2002; Cuban, Kirkpatrick, & Peck, 2001; Judson, 2006; Windschitl & Sahl, 2002). As with these earlier studies, we find that teachers in technology-rich schools continue to use technology in ways that support their already existing teaching approach.

In addition, our study corroborates Cuban's argument (2002) in that teacher use of technology is most frequent for preparation, administration, and management purposes, but rare when it comes to facilitating student-centered pedagogy even among those teachers who work in technology-rich schools and are comfortable with technology. Teachers use technology most frequently to communicate with parents; to record, assign, and post grades; and to prepare

classroom instructional material, regardless of their beliefs. Using technology to support student collaboration, project-based learning, and problem solving is rare even among teachers who hold student-centered beliefs. This can be explained by two reasons: (a) Teachers may be unable to integrate technology to support student-centered practices because they lack models of technology to facilitate this type of learning, or (b) teachers' beliefs and practices are context-bound and tied to other contextual factors such as class size and student ability.

In our study, only one teacher demonstrated having integrated technology frequently to support her student-centered practice. This teacher was equipped with both pedagogical content knowledge and technical ability, and she had additional privileged contextual conditions. Anne's teacher training background was for the gifted; she was a longstanding, serious computer user who extensively used computers both for personal and professional productivity; she worked under favorable contextual conditions. She taught a small number (n = 6) of gifted students in a high-achieving school. In summary, Anne's reform-oriented teaching practice was a result of her teaching philosophy, teacher and technology training, and favorable contextual conditions under which she operated her practice. The combination of these factors provides further evidence that teaching practice is complex and requires attending to multiple variables and perspectives that are both internal and contextual.

We conclude that, unless the focus of technology integration is explicitly on student-centered pedagogy, technology integration may continue to support teacher-centered practice with inadequate, highly controlled student use in the classroom. Professional development with a focus on the integration of technology for student-centered practices appears to have a positive effect on shifting beliefs and practices (Matzen & Edmunds, 2007; Sandholtz, Ringstaff, & Dwyer, 1997). Focus on teacher training should move away from isolated technology training and toward integration of technology into curriculum to help teachers use technology to support student-centered pedagogy. In addition, technology-related professional development should help teachers work around the limitations of their contextual conditions, as opposed to being built around a "one model that fits it all" perspective. Future professional development efforts may need to consider the findings of this study in creating and modeling a theory of change toward a student-centered paradigm while being sensitive to context-specific factors. Future research on teacher use of technology should employ a mixed-methods design if the investigation involves teachers' beliefs.

Contributors

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