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Teacher Beliefs and Student Achievement in Technology-Rich Classroom Environments

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This research examined a two year project that created technology-intensive classrooms, a learning community of educators, and an intense set of training programs focused on pedagogy first and technology second, including ongoing support for teachers in schools identified as high poverty in one US state. The research sought to understand how participants in this project incorporate the technology and the professional development into their classrooms, and also examined student achievement over the two years through randomly matched classrooms without the technology program. It further sought to examine the ways in which pedagogical beliefs and practices evolved from participation, if at all. Results indicate a change in the pedagogical stance of the educators involved and a small positive impact on student achievement.

Keywords: technology-rich environment; professional development; teacher beliefs, student achievement

INTRODUCTION

Over the last 40 years, the business community, educational researchers, and policymakers have argued about the value of information and communications technologies (ICT) in education. All the while, educational institutions have invested time, money, and energy to improve learning for all students. Technology has often been seen as an addition to traditional learning environments that actually may change the learning outcomes; this hope has been consistently promoted although even with extensive expenditures, evidence of extensive changes is not abundant (Cuban, 2001; Hernandez-Ramos, 2005; Norris, Sullivan, Poirot, & Soloway, 2003).

The extant literature offers little support for the popular rhetoric about technology revolutionizing teaching and learning or teachers fundamentally reworking lesson plans

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and pedagogy (Becker, 2000; Cuban, 1993, 2001, 2006; Tearle, 2003; Williams & Kingham, 2003). As Norris et al., have suggested, "Clearly K-12 schools in the United States have not enjoyed the expected positive impact of technology" (2003, p. 16).

One reason for the failure of technology to change pedagogy on a large scale may be the inconsistent, 'just-in-case' model of professional development, and the lack of access to a consistent and broad array of technology in classrooms (Ertmer, 1999; Lawless & Pellegrino, 2007). Even though a recent study found that 100 percent of institutions with teacher education programs for initial licensure reported teaching the use of Internet resources and communication tools for instruction in all or some teacher education programs and over 90% provide specific training on curricular integration, specific software, or digital content (Kleiner, Thomas, & Lewis, 2007), that introduction does not appear to have transferred to practice when these teachers begin teaching.

STATEMENT OF THE PROBLEM

In 2000, the United States National Center for Educational Statistics (NCES) reported that 74% of teachers received training in educational technology, but only spent one to eight hours of training specifically directed at educational technology for their specific grade or subject taught. Currently, these minimal training hours are predominantly organized as short-term, one-shot workshops focused on learning software with neither specific content-based examples of their use (Ertmer, 2005; McKenzie, 2001) nor pedagogical and curricular connections (Ertmer, 2005; Fishman, 2006; Zhao & Frank, 2003). Past research with educational technology inservice training has consistently shown that the traditional "workshop" model for delivering professional development does not often result in changes in actual practice (Ertmer, Gopalakrishnan & Ross, 2001; Fishman, 2006; National Staff Development Council, 1995). The existing literature on educational technology integration indicates that successful professional development should be tied to content and grade level taught (Dwyer, Ringstaff & Sandholtz, 1991; Ertmer, 2005; Fishman, 2006; Wilson & Berne, 1998) and include practice and follow-up support (Ertmer, 2005; Fishman, 2006; Snoeyink & Ertmer, 2001/2002).

"Despite the power of professional development to improve teaching, the typical school district allocates less than one percent of the budget for such activities" (Sparks & Hirsh, 2000, p. 42). Moreover, there have been recurring questions about the quality of the professional development that is typically offered to practicing teachers.

This study was developed to examine one large scale program (dubbed MINTY for the purposes of this manuscript) that was designed to provide continuous technology support and training. The MINTY program includes 200 hours of training in a collegial "cohort" plan over a two-year period along with classroom visits by program specialists; teachers and students are supplied with electronic materials, such as LCD projectors, computers, Interwrite™ boards, Smartboards™, digital cameras, and scanners. Teachers learn how to incorporate inquiry based lessons and learning activities based on a constructivist learning model and using technology into their curricula. The mission of MINTY was to support educators as they integrate technology into inquiry-based, student-centered, interdisciplinary, collaborative teaching practices that result in higher levels of student performance. The goals of the research were to document the journey through the eyes of the teachers and their beliefs about technology, and to also investigate if the program had any measurable impact on student achievement.

REVIEW OF THE LITERATURE

Research has identified a long list (Zhao & Frank, 2003) of intrinsic and extrinsic barriers to the integration of technology that includes lack of time for professional development (McKenney, 2005), lack of teacher training in pre-service education programs, general resistance by teachers to utilize technology (Staples, Pugach, & Himes, 2005), and lack of technical support (Butler & Sellbom, 2002). But, now teachers are expected and required to use educational technology in one form or another in their classrooms (Collier, Weinburgh, & Rivera, 2004; Hernandez-Ramos, 2005). Overall, current preservice and in-service programs targeted toward classroom technology integration have not been successful. Studies have focused on technology integration in preservice education while other studies have addressed the fact that many current teachers still feel uncomfortable using technology in their teaching (Bauer, 2005).

While research has demonstrated that ongoing support and continuous professional development are required to change practice (Ertmer, 2005; Wang, Ertmer, & Newby, 2004), interdisciplinary, collaborative teaching practices that result in higher levels of student performance have not been demonstrated by the research. Increasingly, researchers have indicated that technology should be integrated into professional development experiences (Fishman, 2006; Hasselbring, Smith, Glaser, Barron, Risko, Snyder, et al., 2000) to ensure the effective subsequent integration of technology into teaching and learning (Fishman, 2006; Reed & McNergney, 2000). Since teachers report a desire for grade-specific content and curriculum integration ideas (Ertmer, 2005; Fishman, 2006; Snoeyink & Ertmer, 2001/2002), providing such content connections may be more successful due to their implicit or explicit reference to teachers' subject matter knowledge and the content they teach. Approaches that emphasize content would target teachers' subject matter knowledge and pedagogical content knowledge in contrast to when technology is learned as a separate, unrelated skill.

The research on professional development as it relates to technology integration indicates that professional development for technology use needs to contain essential components that the research in this context has found to be important. These components include a connection to student learning, hands-on technology use, variety of learning experiences, curriculum-specific applications, new roles and functions for teachers, collegial learning, active participation of teachers, ongoing process, sufficient time, technical assistance and support, administrative support, adequate resources, continuous funding, and built-in evaluation (Ertmer, 2005; Fatemi, 1999; Mathiasen, 2006; National Staff Development Council, 1995; Renzagilia, Hutchins, & Lee, 1997; Speck, 1996). Research has also indicated that teachers must see a direct link between the technology and the curriculum for which they are responsible (Byrom, 1998; Ertmer, 2005). To effectively interpret the impact of professional development, one must consider the outcome of teachers' technology integration efforts and technology-supported pedagogy.

According to the literature, the variation in technology-supported pedagogy may be captured through three categories; that is, technology may function as replacement (Ertmer, 2005; Snoeyink & Ertmer, 2001/2002; Zhao & Cziko, 2001), amplification (McKenzie, 2001), or transformation (Ertmer, 2005). Technology as replacement involves technology replacing (but not *changing*) established instructional practices, student learning processes, or content goals. The technology serves as a different means to the same instructional end and is generally didactic in nature (Wenglinsky, 2005). Technology as amplification capitalizes on technology's ability to accomplish tasks more efficiently and effectively (most of the time), yet the tasks remain the same (McNabb & McCombs, 2001; Wenglinsky, 2005). Technology as transformation may change students' learning routines (e.g., teacher centered vs. student centered) including content (e.g., paper and single source vs. multimedia and multisource), cognitive processes (e.g., memorization vs. problem based learning), and problem solving (e.g., recitation vs. inquiry) (White & Frederiksen, 1998) or teachers' instructional practices and roles in the classroom (e.g., sage on the stage vs. guide on the side) (Wenglinsky, 2005).

Technology in education has the potential to innovate by providing multiple sources, points of view, access to primary sources not available before and support levels of inquiry not previously available, as indicated in transformative uses, but also can maintain the status quo by being used as drill and practice, as indicated in replacement or amplification uses. The fundamental difference between the latter and the former is a constructivist orientation towards learning versus a didactic orientation (Wenglinsky, 2005).

While a constructivist perspective is the foundation of the vision of many of technology's pioneers, it is not necessarily adopted by those who are providing professional development or who are using technology in their classrooms (Schrum, 1999; Zhao & Frank, 2003). Professional development models are largely based on a behaviorist perspective wherein participants are taken through a sequential mapping of the software or technological innovation's features, in which little or no time is spent modeling the ways the innovation might be implemented in the classroom, with little or no thought given to the changes that must occur in classroom routines (McKenney, 2005).

Successful integration does not require teachers to be proficient in a large variety of technology applications. Instead, teachers need to feel comfortable and confident in instructional methods of ICT integration (Germann & Sasse, 1997). This suggests a need for more focus on instructional methods of integrating technology (Bransford & Schwartz, 1999), because effective technology integration in the classroom is grounded in a new pedagogical model, one that is learner centered (Ertmer, 2005; Wenglinsky, 2005). Also, hands-on experiences and opportunities that support constructivist models of teaching and experiences with technology-rich classrooms are necessary for preservice teachers (Schrum, Skeele, & Grant, 2002-2003).

It is also important to consider the context under which much of teacher professional development for technology integration occurs. No matter how much training teachers do receive, unless those teachers also have the leadership of their site based administrator, they may be unable to successfully use that technology (Dawson & Rakes, 2003). As Fullan (2007) presented it, without that leadership, innovations have little chance of success, regardless of a high level of commitment from practitioners.

The process of teacher acceptance and adoption of technology into their teaching practices is grounded in their beliefs about teaching (Cuban, 1993; Schrum, Shelley, & Miller, 2008). Belief systems are dynamic and permeable mental structures, susceptible to change in light of experience (Borko & Putnam, 1996). The relationship between beliefs and practice is also not a simple one-way relationship from belief to practice (Fullan, 2001), but a dynamic two-way relationship in which beliefs are influenced by the four sources of self-efficacy (Bandura, 1986).

Teachers' understanding of teaching is enacted in and through the learning activities they provide their students and "beliefs serve as filters through which new ideas are perceived and interpreted" (Borko, Davinroy, Bliem, & Cumbo, 2000, p. 274). This notion of understanding is embodied and embedded in intersubjective practice. As Cuban (1993) suggested, "The knowledge, beliefs, and attitudes that teachers have shape what they choose to do in their classrooms and explain the core of instructional practices that have endured over time" (p. 256). Unfortunately, this fundamental situation has not changed in the intervening years, since Cuban wrote that (Wang, Ertmer, & Newby, 2004; Glassett, 2007).

This study was designed to first, examine the interacting factors of teachers' beliefs about teaching and learning, how these beliefs are shaped and, in turn, shape/influence technology-integration practices in the context of actual classroom activities. Second, this study sought to examine the outcomes, in terms of student achievement, from this implementation, through a comparative analysis of high stakes test scores of demographically matched non-MINTY students in the same schools and districts.

THEORETICAL FRAMEWORK

We designed this study and examined the results through the theoretical lens of Fullan (2001), which guided our conception about the challenges to changing educational practice. His notion of a complex, non-linear, and difficult process included three stages: initiation or adoption, implementation, and continuation or institutionalization. Initiation refers to the activity involved in preparing for implementation of new practices. Implementation occurs when changes in practice begin, and continuation refers to the point at which new practices become routine and wide spread. This framework provides a language for describing the many simultaneous interactions that take place in schools at the micro and macro levels.

Within the framework , Fullan (2001) described five core competencies or values and practices of leadership required at all levels of the organization that support the stages of adoption: attending to a broader moral purpose, keeping on top of the change process, cultivating relationships, sharing knowledge, and setting a vision and context for creating coherence. These five components "represent independent but mutual reinforcing forces for positive change." (p. 3) Using a variety of examples he offered suggestions for how school districts found ways to weave professional development into the workday so it took on meaningful, real-world contexts. This is similar to the ways in which MINTY professional development appears to have taken place. It is through this lens, of the larger implications from this project rather than the individual teacher, that these data are examined.

Thus, the questions with which we began this investigation were:

1. What do participating educators describe about their experiences with MINTY?
2. What do these educators explain regarding the impact of the technology on their pedagogical beliefs with regard to students' experiences in their classrooms?
3. In what ways does participation in this program impact students' learning outcomes?
4. Are there any differences in the CRT scores between MINTY and non-MINTY students?

METHODS

DESIGN

This study was undertaken to understand the experiences of educators who participated in the MINTY project and to determine the influence of the entire project on student learning. Given the different types of research goals, mixed methods were essential, to be able to gather the types of information that this research sought. Researchers recommend that combining qualitative and quantitative tools presents a viable method for inquiry and exploration in educational research (Onwuegbuzie & Leech, 2004; Reichardt & Cook, 1979). The data collected for this study includes two years of qualitative data and one year of Criterion Reference Test (CRT) data. For each site, there is a nested experimental group (N = 344) and a matched control group (N = 344). Rather than focusing on fidelity to a regimented model, this study explored authentic implementation.

QUALITATIVE METHODS

In order to investigate the MINTY educators' perspective, qualitative measures, such as focus groups, open-ended question interviews, and classroom observations were conducted. The researchers coded the data through the use of descriptive codes and provided a description of criteria for each category (Miles & Huberman, 1994). Reliability of the coding of the focus group notes and interview responses was established through a check-coding process where the two researchers and a graduate assistant separately coded the same data, then came together to compare codes thereby increasing reliability; inter-coder reliability of 80% was met after several coding renditions. Data were analyzed using the constant comparative method (Charmaz, 2006; Corbin & Strauss, 1990), a systematic technique that employs various levels of coding to develop a 'grounded' theory of the phenomenon being studied. The constant comparative method is a research design for multi-data sources in which the formal analysis begins early in a study and is nearly completed by the end of data collection (Bogdan & Biklen, 2003). From these qualitative measures emerged a picture of the educators' pedagogical beliefs and uses of technology.

QUANTITATIVE METHODS

A two group posttest equivalent group design (Cook & Campbell, 1979; Trochim, 2006) of student scores on State mandated criterion referenced tests were compared within and between the nested cluster of students and teachers in classrooms ranging in age from 9-12, in grades four, five, and six (given in the spring, 2007). This approach allowed us to examine teachers' classroom practices as they related to technology integration, the professional development the teacher received in support of technology practices, and characteristics of the teacher external to the classroom (Wenglinsky, 2002). Student data included basic demographic information, such as free and reduced lunch, gender, first language learner status, and CRT performance data from the State assessment. Criterion referenced tests (CRT) are standardized assessments in language arts, mathematics, and science that students take in grades 4-10. Students take the test that corresponds to the grade in which they are enrolled. In the US these grades correspond in age range of approximately 9 years of age (4^{th} grade) to 15 years of age (10th grade). These assessments provide for translating test scores into a statement about the behavior to be expected of a person with that score or their relationship to a specified subject matter. To measure any program effects on student outcomes, demographic matching and analysis of the means were conducted using independent t tests between MINTY and non-MINTY classrooms. Cohen's d effect size calculations (Cohen, 1988) were calculated from those results.

PARTICIPANTS

The participants for this study were members of the MINTY project in both urban and rural school districts throughout a large western state. Schools applied to become part of this project and a minimum number of educators volunteered to participate. This MINTY program equipped each of the participating classrooms with a high-lumen projector, a teacher workstation, printers, digital cameras, and enough student computers (2-to-1 ratio) to facilitate a high levels of student access to Internet-connected computers. In addition, throughout the two years of the program, educators were obliged to participate in 200 hours of after school professional development to provide pedagogical knowledge, enhance their use of higher order thinking skills and problem-based learning, and to learn effective ways to use and integrate the technology into their practice.

The MINTY program (2005-2007) served 24 schools in five of the state's school districts and followed a successful implementation during the 2003-2005 funding cycle. This program included 32 classrooms and for purposes of finding matched classrooms for comparison, 12 sets of matched classrooms were selected for a total of 24 elementary classrooms.

Table. Demographic of Matched Students Ages 9-12, Grades 4, 5, and 6

	n Students	Percent Ethnic Minority	Percent Low Income	Percent LEP	Percent Special Ed
MINTYS	344	40%	60%	20%	12%
non-MINTYS	344	40%	60%	20%	12%
Total	688				

DATA ANALYSIS AND RESULTS

QUALITATIVE ANALYSIS AND RESULTS

A concluding focus group was conducted in May 2007, in an effort to understand the process of MINTY implementation and progress from the perspectives of the teachers who were completing their two years of professional development activities. Additionally, the research team issued an invitation to all MINTY teachers throughout the state who could not attend that meeting to complete an online survey with the same questions as used in the focus group. Ultimately an additional 21 teachers did complete that survey. The data from this iteration of the data collection were added to information gathered in the spring of 2006.

The findings revealed significant evolution of teachers' perceptions of their roles and responsibilities for integrating technology, influence of technology on student success, and type of professional development activities conducted. Teachers in every stage of their professional lives (from first year to 20th year) self-selected to become part of this project.

The coding resulted in five emergent themes that teachers identified regarded as having benefited them as teachers, their classrooms, and their students:

First, they noticed that students' exhibited a tendency towards higher order thinking and learning as a result of cooperative and constructivist learning strategies. One teacher indicated: "It is a new tool and a new way to apply higher level questioning and thinking." Another teacher said, "Technology is a tool that can change the nature of learning." It is essential to note that all teachers made a clear distinction between learning strategies (cooperative learning, higher order questioning, etc...) taught in the program and the technology itself. One teacher explained: "It's the strategies, not just the technology. Everything is covered in MINTY training that is covered in regular professional development by the district, but it is done better!" The same teacher went on to say: "MINTY covered constructivism in a way that made it understandable." Additionally, the teachers explained that because of the professional development and support they received, they felt much more confident and comfortable in designing these cooperative lessons that created an environment for this increase in student participation in challenging tasks.

Second, teachers commented on the substantially better behavior from students due to the motivating forces of technology and constructivist practices. Each teacher indicated that his or her students seemed to care more, were more often engaged, and were less likely to cause disciplinary issues as a direct result of MINTY methodologies. They also said that the students reported and they observed more of a true learning community, in which they each participated in assisting one another, building on each others' work, and working as a team. One participant explained: "It all comes down to who is doing the work—higher order thinking—questioning—the kids are now doing the work and not me." Another participant indicated: "I see the way they help each other. Ownership is higher when they do a report. They value what they have done. Interesting to see what files they keep. How they look at things, they figure it out with a computer, the kids; they have a schema for the gadgets." Interestingly, what cut across all districts and classrooms was the idea that students who were not in MINTY classrooms but in the same school wanted to be in MINTY classrooms. One teacher explained: "The students talk to one another and they see what goes on in my room as opposed to what their teacher does and they want to be in my class." Another teacher said, "The other students in the school want to be in MINTY classrooms; they love this stuff."

Next, the teachers described their experiences during the two years of the project. They consistently felt well supported, mentored, and involved in a learning community. One teacher said: "We were very lucky because of the level of support and professional development. They gave us lots of mentoring."

Most of the respondents loved the opportunity to observe in other MINTY teachers' classrooms, since that is a rare occurrence in most schools. "One of the most powerful ways of becoming a better teacher is being able to observe others and the program allowed us to observe each other as we tried to do this new stuff." They also stated that they had learned far more in this supportive environment than they had ever expected to learn. One teacher indicated: "At first it was about the technology and just getting the stuff, but in the end I can say my teaching has changed." The teachers were asked to describe more specifically the training sessions and support; they offered complements for trainers and support personnel in answering questions or resolving concerns. But they also said that during the second year they became more confident in their own ability to resolve problems, support each other, and move forward with their goals. They would overwhelmingly recommend the program to their colleagues and friends.

Fourth, all teachers spoke in depth about the progress they believe they have made as teachers as a result of exposure to MINTY pedagogy. For example, one stated, "The sessions we had on teaching and pedagogy made me a better teacher." Another added, "I am much more willing to try new things and to plan collaborative projects for the students, because of how confident I am." They frequently compared their work in the program with other professional development sessions they've attended through their school or district, saying in each case that MINTY made strategies and methods they had previously been unsuccessful implementing intelligible and useful for the first time.

When asked about their motivation for participating in the project, a third grade teacher said that she was "eager to learn about improving her teaching, gain knowledge about technology and collaboration, and to try something new." It is worth noting that a small subset of the teachers did describe their primary goal "was to gain access to significant amounts of technology that I did not anticipate getting in other ways." They also commented that the most important and valuable knowledge they took away from the two years of the program had to do with the changes in their teaching, which they felt will last far longer than the technology alone. One first grade teacher said, "This program has had a lasting impact on my teaching and how I approach instruction."

Finally, to varying degrees, each teacher mentioned technological skills they have garnered as an inspiring benefit of the program. Two in particular started with little or no knowledge of modern technology; both are now proficient users of several pieces of hardware and software in and out of the classroom. "When I started this program I knew very little about using technology in the classroom and was actually afraid to use it. Now I don't know what I would do without it." Others reported having known something about using the technology for their own professional activities, but not being comfortable in using the technology with the students on a regular basis, for fear of "not knowing something" in front of the students. Now they report having confidence in using the tools, but also more comfort in allowing the students to teach them about some aspects of using them. One teacher indicated, "The students know this stuff and how to use it. They teach me as much as I teach them."

Another goal of the research was to understand the teachers' perspective on using the technology for their students' instruction in general. The analysis revealed three primary themes that appear to be essential to understanding the use and integration of technology in classrooms and the influence of technology on student success. Those primary themes include: (1) barriers to technology integration; (2) importance of technology training; and (3) support within the learning environment.

All of the school districts provided resource rich contexts that gave the teachers access to hardware and software, but also the professional training to use technology effectively. Professional development was ongoing and focused on student learning. The importance of ongoing professional development is supported by research conducted by Becker (2000), in which he found that a lack of ample professional development opportunities created barriers to successful technology integration. In focus groups and surveys these teachers indicated that they had ample resources, effective training, and support from their administrators and districts with regard to technology.

The teachers indicated that a supportive environment/culture positively influenced how these teachers effectively integrated technology. From these data there seems to be ample agreement that a supportive learning environment is important in effective technology integration. This support takes various forms: technical and administrative support, access to technology, ample professional development opportunities, and a learning environment that encourages sharing (collegiality) of knowledge and expertise.

QUANTITATIVE ANALYSIS AND RESULTS

The between group differences indicated that the MINTY students' mean difference (n=344) (M = 15.92, SD = 6.83) was statistically significantly greater (t [136] = 4.87, p = .0001) than the non-MINTY groups (n=344) (M = 10.68, SD = 5.81). Calculation of the means indicates a medium effect size of 0.62 (Cohen, 1988) overall.

In examining the data for Language Arts, Mathematics, and Science it became clear that the MINTY project had an influence on student learning. The data are reported as percentile rankings on state mandated CRT tests. As seen in Figures 1, 2, and 3, overall the MINTY students performed better than the non-MINTY students.

Figure 1. Language Arts CRT Scores Grades 4, 5, and 6

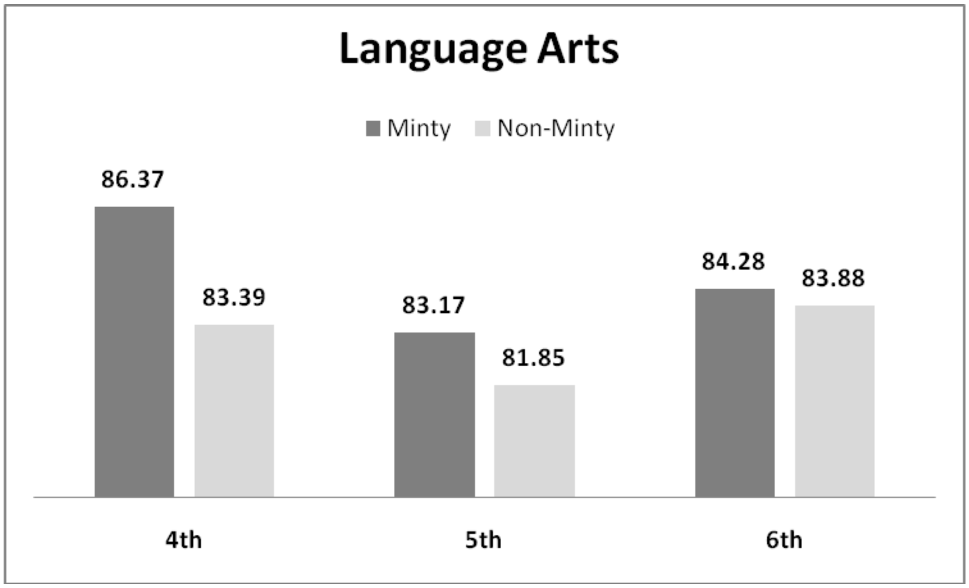
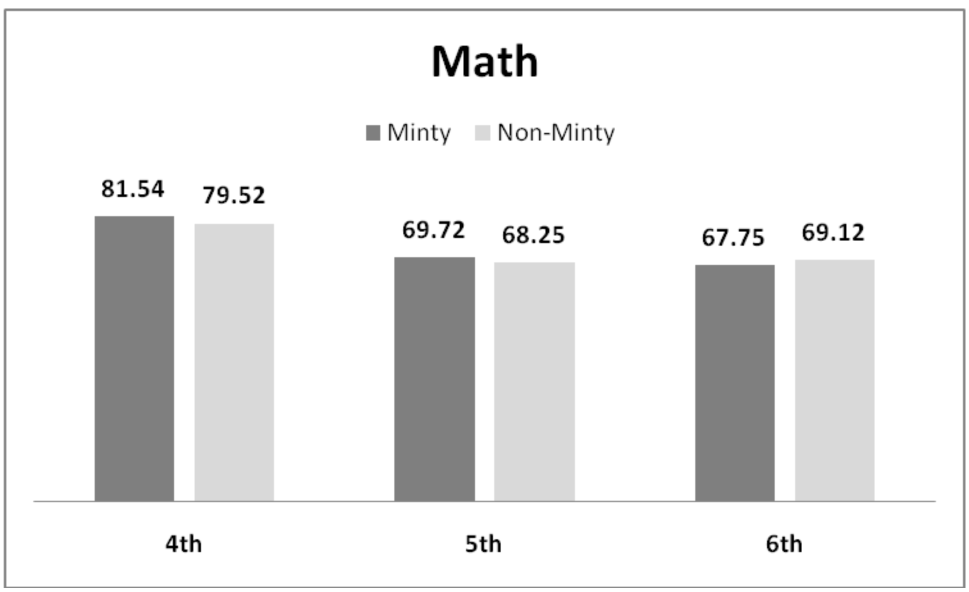
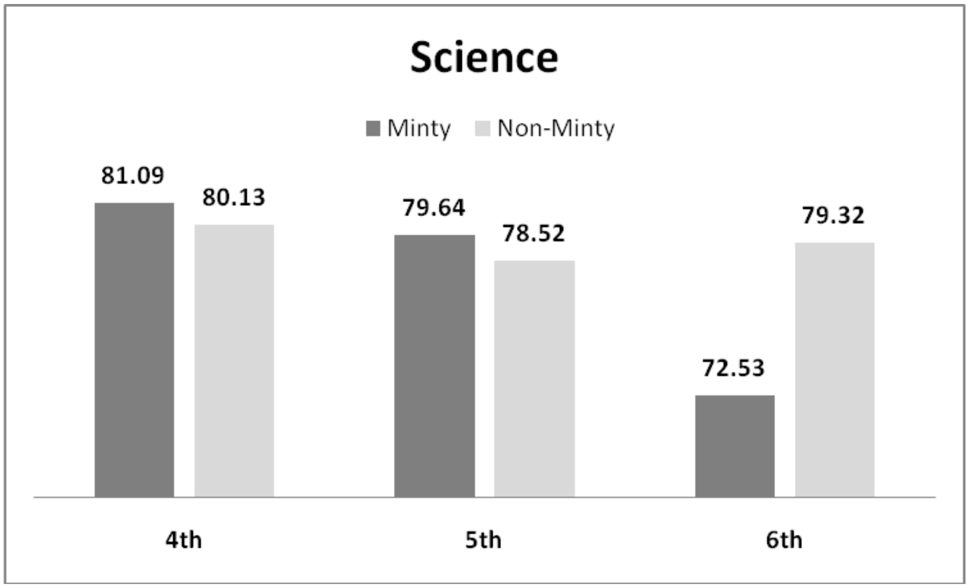


Figure 2. Math CRT Scores Grades 4, 5, and 6



Even with the confounding factors in analyzing these data, and the post-test only design, it seems clear that the students who were in the MINTY program showed higher scores in the fourth and fifth grades; the sixth grade students were either equal to, or lower than, the non-MINTY students. This may indicate that starting earlier in creating a learning community and integration technology with higher order thinking skills would have more of an effect, but that is only a tenuous conclusion.

Figure 3. Science CRT Scores Grades 4, 5, and 6



DISCUSSION

The results of this study have several implications for practice. As noted, a variety of confounding factors make conclusive analyses of data gathered on the success of the MINTY program challenging. As mentioned above, these factors include, but are not limited to differences in implementation of the MINTY methodology between schools and teachers, lack of congruence in relevant descriptors between sampled populations' CRT scores and demographic characteristics, and high levels of noise within data sets with small sample sizes, especially in certain grade levels. Because of their statistical nature, these factors have the largest effect on analyses that focus on small subsets of the population. In light of the large amounts of data collected and effort invested in evaluating the MINTY program, these factors do account for the enormous variation in scores of MINTY and non-MINTY students at nearly all individual grade levels and/or within individual subjects. However, the fact that students in the sample that participated in MINTY classrooms had higher scores on their CRT tests is particularly noteworthy. It is plausible that the MINTY teachers and the technology helped these students achieve higher scores.

The positive influence of technology integration in this instance included improved attitudes towards teaching and learning, increased student achievement and conceptual understanding. However, these positive effects of technology and training teaching and learning are mediated by the fidelity of implementation. Even if schools and teachers are provided with enough access to appropriate instructional technology, and teachers receive proper professional development in the use and integration of educational technology and technology is integrated in curricula, course objectives, and assessment, the outcomes are fundamentally grounded in self-reflective processes in human adaptation and change. This research points to the clear conviction that we need more research that will provide a greater understanding of how and why teachers' pedagogical beliefs are formed and sustained as well as how their beliefs about pedagogy relate to their beliefs about technology. We also need more information about how students with factors that may lead to an expectation of lower achievement (low SES, English language learners, and others) can overcome those factors and succeed in academic performance. This study pointed toward early integration and strong support of teachers for assisting these students, and for creating an educational environment that encourages all learners to excel.

CONCLUSION

This study provided detailed information on the results of a project designed to fundamentally change the ways teachers create instruction by using constructivist approaches and intense technology implementation strategies. In general we can say that teachers' beliefs about instruction have changed dramatically and that the CRT scores appear to be comparable between MINTY and non-MINTY students.

In assessing the overall project design, it is helpful to keep in mind that the MINTY project was not a controlled experiment, but an examination of real program implementation, in real schools. The contrast between an experiment, in which researchers have effective control over treatments, group characteristics, selection of outcomes, etc., and an evaluation project in which researchers must work within the constraints of an existing program, is important to consider when judging the adequacy of the design choices made by the research team. The activities of the MINTY research are a response to decisions and requests made by the MINTY program. One district in this state was the driving force behind the MINTY project and the further districts were geographically from that driving force, the further they were from the original intent of the program implementation.

When considering the data, we have concluded that:

1. The teachers themselves are key to any meaningful changes (Bai & Ertmer, 2008);
2. A study such as this cannot control for years of teaching/experience & skill, and yet these things may have the most profound influence on students' ultimate scores on standardized tests;
3. Implementation does not appear to be uniform across districts, schools, or among individual educators. This is a severe limitation in assigning effects of a program such as this.

This research was interested in the large scale programmatic effects of the MINTY project in one state in the mountain west region of the United States. MINTY students' CRT scores are encouraging; their scores are higher than those of their counterparts—who may be expected to have similar or higher scores. When assessment measures are averaged across sampled MINTY and non- MINTY students, MINTY students' performance is revealed to be clearly better than non- MINTY. We are confident that the effects of MINTY program on a large population are positive and encouraging, but not necessarily statistically significant. It is important to note that non-score related effects were not measured (self confidence, interest in school, attendance, etc.). Hopefully, future research will include all effects. More importantly, it may be time to stop trying to demonstrate that technology alone has an influence on student outcomes and proceed more holistically in examining all teaching and learning for ways to improve students' lives.

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