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Changing teachers, changing students? The impact of a teacher-focused intervention on students' computer usage, attitudes, and anxiety

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ABSTRACT

An important purpose of integrating computer use into everyday classroom instruction is to help students approach technology as a learning tool. Effective classroom integration is dependent not only on access to computers but also teachers' implementation of computing into learning. Successful implementation, in turn, depends largely on teachers' beliefs about classroom computing. The purpose of this study is to examine the effects of a teacher-focused technology intervention on students' attitudes toward and use of computers as learning tools. Teachers' attitudes, anxiety, and classroom computer use are explored as mediators of this relationship. Data were collected during a technology intervention in fourth and fifth grade classrooms in an urban public school district. Results suggest that the technology intervention itself had a positive effect on students' attitudes toward and use of computers for educational purposes. There was no evidence, however, that teachers' use or attitudes had any mediating effect on this relationship. These results suggest that it is possible to increase students' attitudes toward computer use through intense interventions aimed at their teachers. Future research should further investigate the mechanisms through which this relationship exits.

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1. Introduction

The inherent assumption underlying increased computer integration in the classroom is the belief that increased access will effectively enhance students' learning outcomes; however, research on the impact student use of technology has on educational outcomes is inconclusive. On one hand, numerous researchers have pointed to the positive impact classroom computer use has on educational outcomes, including increases in literacy, problem solving skills, student motivation, critical thinking and creativity (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Lowther, Ross, & Morrison, 2003; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010; Suhr, Hernandez, Grimes, & Warschauer, 2010; Weston & Bain, 2010). Further, researchers have noted that increased access to computers in the classroom helps to shift students' views of computer technology from viewing technology as a tool for gaming to viewing computer technology as an effective learning tool (Lowther et al., 2003; Warschauer, 2008).

Many computer integration studies have utilized one-to-one computer access models to test the effects of computer integration on student outcomes. For example, Suhr et al. (2010) utilized a quasi-experimental design to compare changes in English Language Arts (ELA) test scores among 2 groups of elementary students, one group of 54 students with individual laptop access and one group of 54 students without such access. The results of this analysis showed that, after two years of intense computer integration, students in the individual laptop group outperformed non-laptop students in ELA test scores, with significantly higher performance in reading comprehension. Moreover, students with individual access believed they were more involved with their classwork, reported writing longer papers and being better able to revise

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their work using a laptop. Approximately 84% of students said they preferred learning with a laptop and 80% reported that school became more interesting with the integration of computers into their classwork. Other studies have shown similar positive outcomes. In a controlled experimental design in which students were given individual laptop access, Lowther et al. (2003) found that students given access to laptop computers reported very positive attitudes toward the use of computers in the educational setting. Specifically, students reported that access to such computers facilitated a greater understanding of higher level work, better teacher–student communication, cooperative learning, and access to educational resources. In contrast, the students who were not given individual access to computers were less likely to see computers as an essential educational tool and had less confidence in their ability to utilize basic software programs.

Although advancing technology has long been hailed as a benefit to the American education system, its potential is counterbalanced by the challenge of effective integration into the learning process (Cuban, 2009; Weston & Bain, 2010). A series of studies conducted by the U.S. Department of Education (2007) investigated the usefulness of algebra, math, and reading tutorial software on increasing test scores in first, fourth, and sixth grade classrooms, utilizing an experimental design where one group was assigned to use the software (treatment group) and one not (control group). In each study, researchers found that the implementation of these computer technologies had no significant effects on overall test scores; scores did not significantly differ between treatment groups and control groups. Researchers reported that poor implementation and integration of computer technologies were, in part, responsible for the lack of significant findings.

These conflicting results point to a need for a better understanding of factors which mediate the relationship between computer technology and academic achievement. While access is an important factor, access alone does not explain differing effects of educational computing. The purpose of this study is to examine the impact of a teacher-focused intervention on students' use of technology for educational purposes. Additionally, this study investigates whether teachers' anxiety and attitudes toward computers mediate the relationship between the intervention and students' attitudes and anxiety toward computers. The current intervention focuses on integrating computing activities into existing educational curriculum, learning *with* computers, as opposed to learning *about or from* computers (Cuban, 2009). The current study examines the impact of the intervention in terms of, both its improvements in students' attitudes toward and usage of computers for learning purposes, and the degree to which those improvements can be attributed to the intervention's impact on teachers. The intervention involved fourth and fifth grade students in a school system located in a predominantly African–American, lower socio-economic status, and urban area.

2. Literature review

2.1. Teachers' role in student engagement with technology

Because of the movement to increase educational access to computer technology, many teachers now have access to computers to use in their classrooms; however, research indicates that access to computers alone is not enough to impact teacher integration of these technologies into their classrooms or to increase student engagement (Warschauer, Cotten, & Ames, 2011; Weston & Bain, 2010). While various factors are related to students' usage of computers and their attitudes toward them, two factors which numerous studies have shown to be important are computer anxiety and teacher attitudes toward computer usage (Azarfam & Jabbari, 2012; Gibbs, Dosen, & Guerrero, 2009; Gomez, 2012; Rohaan, Taconis, & Jochems, 2010; Shah, Hassan, & Embi, 2012).

Computer anxiety is thought to be one factor reducing the integration of computer technologies into the classroom setting and, as such, an appropriate target for intervention (Azarfam & Jabbari, 2012). Computer anxiety is conceptualized as anxiety or fear when using, or considering using, computer technologies (Leso & Peck, 1992). The relationship between computer anxiety and classroom integration is mixed. Previous research has found that computer skills and technology acceptance are inversely related to computer anxiety (Ekizoglu & Ozcinar, 2010; Shah et al., 2012). On the other hand, some researchers predict that computer anxiety may actually increase when technology use increases because teachers become more aware of computer anxiety when they utilized computers more in their classrooms (Beckers & Schmidt, 2001; Cotten, Hale, Moroney, O'Neal, & Borch, 2011). Further, studies have found that some teachers are apprehensive about teaching students how to use technology because they fear that students will become too reliant on technology and thus not be able to solve problems for themselves (Cuban, 2009; Li, 2007).

In addition to computer anxiety, teacher attitudes and beliefs are important in student engagement because these individuals are effectively the key holders to integration of computer technology and student engagement. Though many students report technology as a beneficial tool for increasing educational engagement (Li, 2007; Suhr et al., 2010), it is unclear whether or not this is consistent with the reality of technology use in educational pursuits. In a recent report, Purcell et al. (2012) found that teachers at the middle and high school levels had mixed views on the overall impact of student technology use in the classroom. Teachers noted that motivated students had become more independent information seekers and explored topics in a variety of different media. However, the same teachers also had concerns about students' ability to discern the quality of information during Internet research and expressed fears that students' use of technology can be more of a distraction than a benefit to learning. The perception from educators therefore appears to be that students are able to quickly engage with more information, utilizing computer technology more than ever before, but at the cost of long-term in-depth engagement in a given topic.

Teacher attitudes and beliefs toward the use of technology in their classroom play a major role in the extent to which they will integrate computers into their classrooms and provide their students opportunities to engage with technology for educational purposes (Hermans, Van Braak, & Van Keer, 2008; Inan & Lowther, 2010a,b; Lowther et al., 2003; Sclater, Sicoly, Abrami, & Wade, 2006). In fact, Inan and Lowther (2010a), utilizing path analysis to examine computer integration among 396 K-12 teachers, found that teacher beliefs were the single most important factor when predicting computer integration. More recent research by Celik and Yesilyurt (2012) echoed these results. With a sample of 471 pre-service teachers, they found that teacher attitudes toward technology, perceived computer self-efficacy, and computer anxiety were significant predictors of attitudes toward using computer supported curricula in their classrooms.

In a qualitative investigation examining the attitudes of 7–12 grade students and teachers toward computer and technology use in the classroom, Li (2007) revealed a disconnect between the attitudes of teachers and students concerning technology use in the classroom. Consistent with previous findings (Lowther et al., 2003), 87.3% of students stressed that they were excited about computing and believed that it could strongly enhance their learning. Students reported feeling that technology is an invaluable resource for diverse learning styles and

facilitates better understand of complex concepts. While students in Li's (2007) study reported realizing the importance of computing skills in contemporary society, they also reported not having many opportunities to engage with technology in the educational setting and not utilizing the educational capabilities of these technologies to the fullest extent possible. Interviews with teachers provided insight as to why this might be the case. Where a large majority of students felt that technology was a valuable tool for learning, a greater number of teachers indicated that technology should only be used when absolutely necessary. Moreover, the teachers reported being particularly concerned over the possible negative effects of technology use. Li's (2007) research reiterates previous work (Cuban, 2009) highlighting a disconnect between students attitudes toward technology and teachers who have not yet developed positive attitudes toward technology in the educational setting.

2.2. The role of teacher-focused computer technology interventions

With the important role that teacher attitudes toward computer technologies play in the classroom it becomes increasingly important to identify effective means of improving teacher attitudes and willingness to adopt computer technologies. Researchers have noted that professional development training that specifically targets increasing teachers' familiarity with technology in the classroom has been shown to be one effective way to significantly impact teachers' willingness to utilize computer technology in their classrooms (Ritzhaupt, Dawson, & Cavanaugh, 2012). Recent research emphasizes that teachers' willingness to integrate technology in their classrooms, and their attitudes and beliefs toward the benefit of doing so, can be positively influenced by training specifically designed to provide them with the skills necessary to integrate technology into their current curriculum (Chen, 2010; Daily, Cotten, Gibson, Howell-Moroney, & O'Neal, 2013; Fluck & Dowden, 2013; Inan & Lowther, 2010b).

Furthermore, increasing positive attitudes and confidence among teachers through increased technology training has been shown to directly affect students' attitudes toward the use of technology for educational purposes (Gibbs et al., 2009; Ritzhaupt et al., 2012; Rohaan et al., 2010; Yerrick & Johnson, 2009). For example, Gomez (2012) studied teachers' willingness to integrate technology in the classroom and the impact such integration had on students' learning using a sample of 125 pre-service teachers. Researchers implemented training courses designed to increase teacher use of technology in their classrooms, providing teachers with the skills necessary to develop classroom curriculum while integrating 21st century skills. With increased training, teachers demonstrated an increased willingness to utilize technological resources in their classrooms and an increased confidence in their ability to do so. Furthermore, students' engagement and academic performance significantly improved when teachers integrated technology into their teaching practices. The results of this study also indicate that students' academic performance further improved when teachers participated in increased technology skills training.

3. Context of the study

Given the previous literature on educational technology, there is sufficient reason to believe that there is a beneficial relationship between integrated classroom computing and student outcomes (Drayton et al., 2010; Lowther et al., 2003; Shapley et al., 2010; Suhr et al., 2010; Warschauer, 2008); however, uses of technology that actually improve student learning are impacted by a number of factors. Teachers' usage and integration of technology in the classroom, as well as their own attitudes and anxiety toward classroom computing, have an impact on the way students use and think about technology as it relates to their education (Gibbs et al., 2009; Gomez, 2012; Ritzhaupt et al., 2012; Rohaan et al., 2010; Yerrick & Johnson, 2009). These findings suggest that changes in teachers' usage, attitudes, and anxiety may result in changes in students' usage, attitudes, and anxiety.

The current study, Integrating Computing across the Curriculum (ICAC), was implemented in a large, urban, predominantly minority school district in the Southeastern United States. ICAC was developed in an effort to increase the number of minority students entering into science, technology, engineering, and mathematic (STEM) careers by helping teachers integrate computing into their existing curriculums in order to enhance students' computer usage, attitudes toward computing, and levels of anxiety associated with using computers. This is accomplished through a novel integration model involving school administrators, teachers, students, and parents. The integration model includes assessment and planning meetings with principals, professional development and in-class support for fourth and fifth grade teachers, summer computing camps for both teachers and students, after-school computer clubs for fourth and fifth grade students, and weekend learning sessions for students and their parents. This intervention, which began with two schools in the first year, has been implemented in increments and incorporates more schools each successive year of the project (e.g., 6 in Year 2, 10 in Year 3, and 12 in Year 4). By the fourth year of the project, ICAC had implemented this computer integration intervention into every single public elementary school in the district.

The ICAC intervention is based on a three part integration model. The first part involves teacher participation in week long training sessions during the summer prior to the school year of ICAC participation. During the summer institute, teachers are exposed to ways to integrate technology into their classrooms, provided with lesson plans/curriculum modules designed to facilitate integration, and encouraged to create their own lesson plans that can the used during the school year. Institute attendance is not mandatory but teachers do receive a stipend and professional development credit hours for participating.

The second part of the model is professional development sessions during the school year. At the majority of schools, these sessions are held during the school day. Teachers who attended summer institutes are provided with a review of the programs learned during the summer while others are learning the programs for the first time. All teachers are asked to develop a lesson plan for each computing application to be used during the in-class integration sessions, which is the third part of the integration model. It is during this final step in the model where teachers actively integrate the learned technologies to create technology enriched learning environments.

Because professional development sessions are not mandatory, and schools are complex environments that are constantly changing, all teachers and schools may not have attended or received the same number of professional development or in-class sessions. Natural differences in teacher participation in the ICAC activities constitute differences in intervention intensity, which is defined as the degree of exposure teachers (and as a result, students) had to the ICAC intervention. A measure of intervention intensity is included in the analytical models to account for these differences.

The purpose of the current study is to examine the impact of the ICAC technology intervention in an inner-city school system on students' usage of technology, and attitudes and anxiety toward technology. The ICAC program has been integrated into a high poverty school system which, based on previous literature (Eteokleous, 2008; Valanides & Angeli, 2005), may affect the degree to which technology has been

integrated into the school system previously. Beyond examining the effects of the intervention, this study also contributes to the understanding of the relationship between students' and teachers' usage of, anxiety and attitudes toward classroom computing. The study further examines the effects of teachers' technology usage, attitudes, and anxiety on students' technology outcomes, and how much of the effect of the intervention on students is due to effects on teachers.

With these purposes in mind, two related hypotheses are proposed. First, it is hypothesized that increased teacher participation in the intervention will have a positive effect on students' educational computer usage and attitudes toward classroom computing, and decrease student anxiety toward computing. Second, the relationship between the intervention and student outcomes is expected to be mediated by teachers' usage of, anxiety, and attitudes toward classroom computing. Examining this relationship adds new information to the discussion of technology's role in education.

4. Data and methods

4.1. Data collection and sample

The sample used in the current analysis is derived from the pre- and post-intervention teacher and student surveys from Year 3 of the ICAC project. The intervention took place during the 2011–2012 school year, during which 10 schools participated in the project. A total of 1295 students and 60 teachers was surveyed at four potential time points: prior to teachers attending the summer institute (T1), immediately following the summer institute (T2), at the beginning of the school year (T3), at the end of the school year (T4). Teachers who completed the surveys during the school year were provided with small incentives. For teachers, the pre-intervention data are from T1 for teachers who participated in the institutes, and from T3 for teachers who did not participate in the institutes. Post-intervention data for all teachers comes from T4. Student participants were surveyed at two different time periods – August 2011 (T3), and May 2012 (T4). Participation was voluntary and all students were provided with a small incentive whether they completed the survey or not. Over 95% of the students elected to participate in the surveys. For students, pre-intervention data comes from the T3 survey, and the post-intervention data comes from the T4 survey.

Of the 1295 students who participated in either wave, 881 students participated in both waves. Additionally, students whose teachers had missing data for either wave could not be included in the analysis, as teacher effects are included in the analysis. This further reduced the sample to 764. After adjusting for missing data on key variables, the sample for this analysis included 696 students. Because students' surveys involved self-report, missing student data is not unexpected, but to ensure that case wise deletion did not affect the outcomes of the analysis, each analysis was first performed with all students (including those with missing key variables). Results of analyses of student effects were similar regardless of whether or not students or their teachers had missing data. Thus it was determined that, despite the reduced sample size after correcting for attrition, missing data is not a major issue in this study.

4.2. Dependent variables

To measure computer use for educational purposes, both the pre- and post-intervention surveys included a series of ordinal items derived from the *Birmingham Youth and Technology Study* (Cotten, 2010). The measure asked students to report how often they use computers for various purposes, such as doing research for school, doing homework, listening to music, playing games, and working on math and science (0 = "none", 1 = "a little", 2 = "some", and 3 = "a lot"). A polychoric factor analysis was used to identity items that were indicative of educational use of computers. Four items relating to educational computer use were identified using this method – homework, research, math, and science – with an eigenvalue of 1.17 for the pre-test and 1.43 for the post-test. Pre- and post-intervention scales were constructed using these four items by taking their average, with a minimum of three items necessary for participants to have a score (pre-test $\alpha = 0.68$, post-test $\alpha = 0.67$). Pre-test values were then subtracted from the post-test values to create change scores, which could range from -3 (indicating an absolute decrease in usage) to $+3$ (indicating an absolute increase in usage), with 0 indicating no change in usage.

Student anxiety was measured using a 14 item scale which asked students a series of statements about computers such as "I don't want to use a computer because I might make a mistake I can't fix" and "I am afraid to use a computer in case I look stupid" (1 = "disagree", 2 = "not sure", or 3 = "agree") (Selwyn, 1997). Scale items are listed in Appendix A. The scale was constructed by taking an inter-item average with a minimum of seven items required for a participant's score to be calculated (pre-test $\alpha = 0.66$, post-test $\alpha = 0.65$). Change scores were calculated for the anxiety measure by subtracting pre-test scores from post-test scores, with a possible range of -2 (absolute decrease) to $+2$ (absolute increase), and 0 indicating no change in anxiety.

In order to develop a variable to measure the students' attitudes toward computing in the classroom, a polychoric factor analysis was performed on a battery of seven questions which asked students whether they 1 = "disagree", 2 = "not sure", or 3 = "agreed" with a series of statements about using computers in the classroom (Cotten, 2010). The factor analysis indicated five items (listed in Appendix A) with a loading score above 0.4, indicating good correlation between variables and an underlying factor, related to a latent variable indicating student attitudes toward computing in the classroom. An oblique rotation was used because the potential factors derived from the analysis were expected to be correlated rather than independent (for a simple explanation of differences between rotation methods, see Brown, 2009). The pre-test eigenvalue for these items was 1.88, and the post-test eigenvalue was 1.69. Scales were constructed from these items by taking the inter-item average, with a minimum of four items required for a participant's score to be calculated (pre-test $\alpha = 0.60$, post-test $\alpha = 0.60$). Change scores were once again computed by subtracting pre-test values from post-test values, with a possible range of -2 to $+2$, and 0 indicating no change.

4.3. Independent variables

The primary independent variable is the ICAC intervention, described above, which consists primarily of summer institute and professional development participation. To operationalize the intervention, the total number of professional development sessions each

teacher participated in was calculated and participation in the institute was weighted such that it was equivalent to 10 professional development sessions during the school year. Thus

Intervention Intensity $=$ 10 * Summer Institute Participation $+$ Professional Development hours

Cut points were then created to generate three roughly equivalent intervention intensity groups (1 = "≤7", 2 = "8–15", and 3 = "≥15").

Teacher classroom computer usage was measured using an eight item inventory of questions asking how often they used computer applications introduced by the ICAC intervention in the classroom, along with more commonly used computer applications such as Microsoft Word, Excel, and Power Point (3 = "more often than 2–3 times per week", 2 = "2–3 times per week", 1 = "about once a week", and 0 = "less often than that"). The scale was calculated by taking an inter-item average with a minimum of four item responses necessary to calculate a score ($\alpha = 0.70$). Because teachers had not used the applications in the scale which were introduced by ICAC, it was only possible to calculate post-intervention teacher computer usage in the classroom. Scores had a possible range of 0–3, with 3 indicating the greatest possible usage of computer applications in the classrooms.

Teacher computer anxiety was measured as a scale including items asking about their comfort with using computers for instruction (see Appendix A). Participants indicated their level of agreement with a series of statements regarding their comfort using computers (1 = "strongly disagree", 2 = "disagree", 3 = "neutral", 4 = "agree", and 5 = "strongly agree") (Fogarty, Cretchley, Harman, Ellerton, & Konki, 2001). The scale was constructed by taking the inter-item average of all scale items, with a minimum of five item responses necessary to generate a score (pre-test $\alpha = 0.69$, post-test $\alpha = 0.81$). Change scores were then calculated by subtracting pre-test anxiety scores from post-test anxiety scores. Scores had a possible range of −4 to +4, with 4 indicating the greatest possible decrease in anxiety and +4 indicating the greatest possible increase in anxiety.

Teacher attitudes toward classroom computing were measured using a set of 11 questions which asked about teachers' perceptions of technology use by students (for scale items, see Appendix A). Teachers rated their agreement with statements regarding their attitudes toward students' computer use (1 = "strongly disagree", 2 = "disagree", 3 = "neutral", 4 = "agree", and 5 = "strongly agree"). Pre- and post-test attitude scales were calculated by taking an inter-item average of all scale items, with a minimum of five item responses necessary to generate a score (pre-test $\alpha = 0.74$, post-test $\alpha = 0.78$). Change scores were calculated by subtracting teachers' pre-test scores from their post-test scores. Attitude change had a possible range of −4 to +4, with −4 indicating the greatest possible decrease in teachers' attitudes, and +4 indicating the greatest possible increase in teachers' attitudes.

4.4. Control variables

At the student level, two control variables were used – gender and grade. At the teacher level, gender and teaching experience were the two control variables. Teaching experience was a continuous variable indicating the number of years that an individual had been a teacher. Teacher age was considered as a control variable, but was highly correlated with teacher experience. To reduce the threat of multicollinearity in regression analyses, age was left out of the final analysis.

4.5. Analysis

A series of Ordinary Least Squares Regressions predicting changes in student computer usage, anxiety, and attitudes was conducted. Because the students and teachers were clustered within 10 schools, clustered robust standard errors were used to account for heteroskedasticity and expected non-independence of observations due to within-school factors. Hierarchical Linear Modeling (HLM) was also considered, but none of the intraclass correlation coefficients (derived from analyses of variance) for the relationship between-school clusters and the dependent variables were large enough to suggest that HLM was necessary. The first model for each outcome variable contains only the ordinal intervention intensity variable, which indicates the intervention intensity group each participant was classified into during the data coding process, as well as the student level control variables. The second model for each outcome variables includes the Model 1 variables as well as the teacher level independent and control variables. All analyses were performed using Stata 12.

5. Results

5.1. Descriptive statistics

The student sample ($N = 696$) was 85.3% African–American, 52.3% female, and composed of 46.7% fifth grade students. The teacher sample ($N = 45$) is 84.9% African–American and 84.9% female. The descriptive statistics for outcome variables are included in Table 1.

As is shown in Table 1, on average, there was little change in any of the student outcome measures as evidenced by the fact that only one change is significant at the $p < 0.5$ level. Educational use of computers appears to have increased over the intervention by 0.08 points, but the change is very slight and only significant at the $p < 0.10$ level. The direction of change is expected, as the intervention should result in an

Table 1
Changes in student computer use, anxiety, and attitudes ($N = 696$).

Variable	Pre-test		Post-test		Change	
	Mean	SD	Mean	SD	Mean	SD
Educational Computer Use	1.26	0.81	1.34	0.74	0.08[†]	0.86
Student Computer Anxiety	0.73	0.31	0.64	0.29	−0.09*	0.33
Student Computer Attitudes	2.35	0.49	2.30	0.48	−0.05[†]	0.71

[†]$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

increase in educational computer use. Attitudes toward classroom computer worsened slightly, by −0.05 points, but again, the pre-test/post-test difference was only significant at the $p < 0.10$ level. Student anxiety toward computers, however, improved significantly, by 0.09 points, between the pre-test and the post-test ($p < 0.05$).

In addition to student outcomes, descriptive statistics were calculated on several teacher variables in order to illustrate changes in teacher anxiety and attitudes toward computers during the intervention. Teacher reported usage statistics were also calculated to illustrate the degree to which teachers reported utilizing computers during classroom instruction. These results are presented in Table 2.

Teachers' computer use was measured on a possible scale of 0–3 (3 = "more often than 2–3 times per week"; 2 = "2–3 times per week"; 1 = "about once per week"; 0 = "less often than that"). The average classroom usage rating was 1.27, with a minimum usage rating of 0.25 and a maximum rating of 2.38 (see Table 2). Of the teacher variables, usage was the only one that was not measured as a change from pre-test to post-test. Therefore, inferences cannot be made about the change in teachers' classroom computer use over the course of the intervention.

Of the teacher variables that were measured in terms of change, only changes in teacher attitudes toward classroom computing were significant ($p < 0.05$). As shown in Table 2, teachers actually exhibited a −0.70 point change in their attitudes toward classroom computing, which was not expected. In terms of computer anxiety, there did not seem to be any significant change. Therefore, inferences cannot be made about the degree of change in teacher anxiety toward computers.

5.2. Regression analyses

Intervention intensity was hypothesized to positively affect changes in educational computer usage and attitudes toward classroom computing among students, and decrease student computer anxiety. Further, it was hypothesized that the effects of intervention intensity would be mediated by teacher usage, anxiety, and attitudes. Each of the hypotheses was tested using multiple linear regression analyses with clustered robust standard errors. The results are presented in Table 3.

There is evidence of a significant and positive relationship between intervention intensity and changes in student attitudes toward computing (see Table 3). There is a significant difference between the low and high intervention intensity groups, and this effect is actually more pronounced when controlling for teacher variables ($b = 0.300$, $p < 0.001$). Teacher gender also had a significant effect, such that students with female teachers demonstrated worsening attitudes toward computers relative to students with male teachers ($b = -0.096$, $p < 0.05$). There is also a marginally significant relationship between changes in teachers attitudes and changes in student attitudes, but the relationship is negative, suggesting that improving teacher attitudes toward computing are actually related to worsening student attitudes toward computing ($b = -0.135$, $p < 0.10$). A marginally significant and positive relationship also between teacher experience and changes in student attitudes ($b = 0.006$, $p < 0.10$). These results suggest that the intervention did have a positive influence on students' attitudes toward computers as learning tools, but only when their teachers participated in the intervention at the highest level possible.

The regression results in Table 3 provide no evidence whatsoever that intervention intensity or changes in teacher variables had a significant relationship with changes in student anxiety toward computing. The first regression model, which excludes the teacher variables, was itself not significant, nor were any of its coefficients. In the second regression model, which did include teacher variables, only teacher gender was correlated with changes in student anxiety ($b = -0.109$, $p < 0.05$). However, the intervention itself appears to have no impact on student anxiety, directly or indirectly through effects on teachers, as it is measured by intensity level.

The regression coefficients in Table 3 provide substantial evidence of a relationship between intervention intensity and educational use of computers by students. In the first model, which does not include teacher effects, both medium intensity ($b = 0.229$, $p < 0.01$) and high intensity ($b = 0.224$, $p < 0.01$) groups demonstrated increases in educational use of computers relative to the low intensity group. However, these effects appear to be slightly diminished once the teacher variables are introduced in the second model. The coefficient for medium intensity becomes only marginally significant ($b = 0.178$, $p < 0.10$) and the coefficient for high intensity decreases somewhat as well ($b = 0.211$, $p < 0.05$). These decreases do not appear to be accounted for by any of the teacher variables included in the model, however. None of the teacher variables or control variables had a significant effect on students' educational usage of computers. These results suggest that the intervention had a definite positive impact on students' use of computers for educational purposes, regardless of whether their teacher participated at the medium or high intensity level. However, this impact does not appear to have been mediated by any of the teacher variables included in the analysis.

6. Discussion

Two hypotheses regarding the impact of the ICAC intervention on students' computer anxiety, attitudes, and usage were proposed. First, it was hypothesized that students whose teachers had more participation in the intervention would demonstrate improvements on computer attitudes, anxiety, and usage. Second, it was hypothesized that these effects would be mediated by changes in teachers' computer anxiety, attitudes, and computer usage.

Some support for the first hypothesis was found. Indeed, students in the highest intervention intensity group demonstrated increases in their educational usage as well as improvements in their attitudes toward computers. However, there did not seem to be any substantial changes in students' computer anxiety regardless of intervention intensity. These findings may be explained by the increasing rates at which

Table 2
Teacher computer use, anxiety, and attitudes ($N = 45$).

Variable	Pre-test		Post-test		Change	
	Mean	SD	Mean	SD	Mean	SD
Classroom Computer Use	–	–	1.27	0.50	–	–
Change in Teacher Computer Anxiety	1.94	0.42	1.90	0.51	−0.04	0.49
Change in Teacher Attitudes toward Classroom Computing	2.75	0.55	2.05	0.39	−0.70*	0.56

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

Table 3
Regression coefficients – student outcomes regressed on intervention intensity and teacher variables.

	Student attitudes		Student anxiety		Educational use	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intervention Intensity[a]						
Medium	0.062 (0.062)	−0.012 (0.078)	0.0260 (0.031)	0.047 (0.046)	0.229** (0.066)	0.178[†] (0.087)
High	0.225** (0.059)	0.300*** (0.062)	−0.0461 (0.061)	−0.054 (0.059)	0.224** (0.059)	0.211* (0.072)
Grade[b]	−0.015 (0.056)	−0.030 (0.067)	0.047 (0.033)	0.025 (0.031)	−0.010 (0.069)	−0.075 (0.055)
Gender[c]	0.070 (0.048)	0.069 (0.050)	−0.0060 (0.025)	−0.007 (0.026)	0.004 (0.047)	0.013 (0.040)
Change in Teacher Anxiety		−0.108 (0.071)		0.014 (0.037)		0.010 (0.124)
Change in Teacher Attitudes		−0.135[†] (0.065)		0.000 (0.043)		0.129 (0.085)
Teacher Classroom Computer Use		−0.086 (0.084)		0.008 (0.026)		−0.206 (0.144)
Teacher Gender[c]		−0.096* (0.031)		−0.109* (0.046)		−0.086 (0.145)
Teacher Experience		0.006[†] (0.003)		−0.004 (0.002)		0.003 (0.006)
N	696	696	696	696	696	696
F	1.83*	1.78*	1.61[†]	1.89*	2.56**	2.28**
R^2	0.034	0.045	0.030	0.048	0.046	0.057

Clustered Standard errors in parentheses (Clustered by School).
[†]$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a] Reference Group – Low.
[b] Reference Group – Fourth Grade.
[c] Reference Group – Male.

students are exposed to computer technology in their day to day lives. Having grown up in a culture where technology is heavily embedded in everyday life, students' anxiety toward computing might simply be so low at baseline that substantial decreases may not be possible.

The examination of computer usage for educational purposes, however, suggests that the ICAC intervention is effective at improving students' attitudes toward computing as well as increasing their usage of computing for educational purposes. Student attitudes only seem to be affected by membership in the highest intervention intensity group, suggesting that moderate teacher participation is inadequate to actually impact the way students view technology as a tool for learning. The findings on educational use are the most encouraging, as both the medium and high intervention intensity groups demonstrated greater increases in educational use than the low intervention intensity group. It would thus appear that any teacher participation above the minimum had the desired result of increasing students' use of computers as learning tools.

While the student outcomes suggest that the intervention has an impact, these effects do not seem to be mediated by teacher variables. This is a somewhat confounding finding, as the ICAC intervention is designed to impact students through its impact on teachers. Further, prior research has shown that teacher attitudes and adoption of technology in the classroom is the most important factor in determining the success of classroom computer integration (Inan & Lowther, 2010b). However, this prior research used teachers as participants rather than students. The results therefore reflect the integration of computers into students' education during class time, but not necessarily students' use of computers to enhance their learning on their own time. Data on student computer use came directly from students in the current study; therefore the results reflect students' actual usage of computers for educational pursuits both during and outside of school. While teachers' reported use of computers in the classroom had no effect on students' use of computers for educational purposes, teacher participation in intervention activities did have such an impact.

Numerous factors may explain why the intervention itself is successful in increasing students' educational use of computers, but not through any of the teacher variables measured. In addition to the impact on teachers, ICAC staff may have had an impact on students directly through their presence in schools. ICAC staff members were available to help teachers with in-class sessions and after-school clubs, and thus had opportunities to interact with students. This interaction may have been the driving force behind improvements in students' attitudes toward and usage of technology. If this indeed is the case, then it would be worth investigating the reasons why ICAC staff members were able to have a greater impact on students than their own teachers. It is possible that ICAC staff provided additional positive role models for students, or that being a part of ICAC was a reinforcing experience for students in and of itself.

Another distinct possibility is that the *quality* of classroom computer usage matters more than the *quantity* of classroom computer usage. Teachers who participated in more intervention activities may have integrated computer use into their class time in more innovative, engaging ways, thus having more of an impact on students' attitudes toward computers as well as their use of computers to enhance their own learning. Unfortunately, this data does not include a reliable measure of differences in the *quality* of classroom engagement, so this conclusion is purely speculative for the time being. Regardless, it is likely that there are unmeasured differences between teachers who participated in more intervention activities and those whose participation was low with regards to how they used computers in the classroom.

6.1. Limitations

While this study is informative regarding the magnitude and nature of the impact of the ICAC intervention on students' attitudes toward and usage of technology, it has some notable limits. One issue of particular concern is the unique context in which the current study took place – a high poverty, urban school district in the Deep South. From a sociological perspective it is important to consider the role that socioeconomic status, both at an individual and neighborhood level, plays in the development of students' interest in and usage of technology. Further, due to the lack of a true comparison group for the inner-city school system, it cannot be known if the interventions would work in different settings. Previous research has indicated that while computer access and training can be an effective means for improving educational outcomes, it does not outweigh persistent academic achievement gaps between individuals with low socioeconomic statuses compared to those with higher economic statuses (Warschauer, 2008). Regardless of the intensity of intervention, it is almost certain that

students' environment and resources, both within their home and their community, play a part in their opportunities to utilize computer technology in their daily lives and to do so in such a way to improve educational outcomes. Such a comparison is simply beyond the scope of the current study but this is an avenue of research which the authors are currently pursuing.

A final limitation is the lack of measurement of administrative levels factors. Previous research suggests that school administrators and resources have an impact on the success of programs within a school, but there was not a set of particular measures available to capture these effects (Angeli & Valanides, 2005; Eteokleous, 2008). While these factors were not measured directly, the use of clustered standard errors and incorporating between-school effects into the statistical models controls for administrative differences. This procedure isolates the effects of the intervention from between-school differences such as administrative factors and resource availability, but it does not allow for the investigation of the impact of such factors on the study outcomes.

7. Conclusions

Despite these limitations, this study demonstrates the effectiveness of the ICAC intervention for enhancing computer attitudes and usage among students in the fourth and fifth grades in inner city, predominantly minority schools. This study supports previous findings that teacher training specifically focused on classroom integration of computer technology holds promise to increase student level outcomes (Gibbs et al., 2009; Ritzhaupt et al., 2012; Rohaan et al., 2010; Yerrick & Johnson, 2009). Because this investigation was able to examine actual changes throughout the school year, this study is able to demonstrate that this teacher-focused intervention does, in fact, have positive effects on both students' attitudes toward computers as learning tools and their actual use of computers for educational purposes.

Further research on the impact of technology interventions on student outcomes should investigate the importance of the quality of teacher integration in order to better understand the circumstances under which successful interventions have the intended impacts on students. Qualitative analysis using classroom observations of the ICAC intervention holds some promise toward investigating unmeasured differences between teachers in order to better understand its actual impact on the ways teachers use computing in the classroom. Further, qualitative research may reveal the characteristics of classroom instruction using computers that are most effective at increasing students' engagement with computers as a learning tool. This research might also illuminate the current finding that teachers appeared to have a more negative attitude toward classroom computing after the intervention compared to before the intervention.

Currently, the ICAC team is collecting and analyzing data on the quality of computer integration into classroom instruction using classroom observations to expand on the findings in the current study. Specifically, the research currently being conducted examines whether or not teacher characteristics prior to the study, as well as participation in summer workshops, are correlated with the quality of teachers' integration of computers into their classroom instruction. This relationship is being investigated in terms of two outcomes – preparedness for in-class sessions and execution of lesson plans. Using field observations from ICAC staff members, teachers' performance during in-class sessions is being evaluated using these two criteria. This investigation will help to establish factors that differentiate between teachers who are particularly effective at integrating technology into instruction and those who are not, by comparing evaluations of in-class performance to participation in summer workshops as well as teacher characteristics.

The current study demonstrates that interventions focusing on teachers' use of technology in the classroom can have an impact on student outcomes. The ICAC intervention may serve as a model to be replicated and improved upon for implementation in school systems similar to the one used in the present study. The ICAC intervention is particularly well suited for school systems with restricted resources and that may not be able to fully implement 1:1 computing programs. Further research should build on these findings to better explain the mechanisms by which interventions like ICAC are able to be effective in order to help educators adopt best practices during their efforts to integrate technology into classroom instruction.

Acknowledgment

Appendix A. Scales and scale items

Student Anxiety toward Computers Scale Items
1. I usually need help to use a computer.
2. I could teach myself most of the things I need to know about computers.
3. Computers are hard to use.
4. If I have problems using the computer I can usually solve them one way or the other.
5. Sometimes I don't know what the computer is doing.
6. I'm no good with computers.
7. I don't think I could do advanced computer work.
8. Computers make me uncomfortable.
9. You have to be smart to work with computers.
10. I don't want to use a computer in case I look stupid.
11. If given the chance to use a computer I am afraid that I might damage it in some way.
12. To use computers in a job you have to go to school for a long time.
13. Using a computer does not scare me at all.
14. I don't want to use a computer because I might make a mistake I can't fix.

Student Attitudes toward Computers Scale
1. I pay better attention to the teacher in the classes that use computers than in the classes that do not use computers.

2. I learn more in the classes that use computers than in the classes that do not use computers.
3. I enjoy school more when I am using computers.
4. Using computers helps me to learn.
5. Computers make math and science more fun.

Teacher Anxiety toward Computers Scale Items
  1. I have less trouble learning how to use a computer than I do learning other things.
  2. When I have difficulties using a computer, I know I can handle them.
  3. I am not what I would call a computer person.
  4. I enjoy trying new things on a computer.
  5. It takes me longer to understand computers than the average person.
  6. I have never felt myself able to learn how to use computers.
  7. I find having to use computers frightening.
  8. I find using computers confusing.

Teacher Attitudes toward Classroom Computing Scale Items
  1. Using computers in class has made my students more engaged as learners.
  2. Using computers in class has made my students more interested in computers and technology.
  3. Using computers in class has made my students more interested in math and science.
  4. On balance, computers in the classroom have been more of a NEGATIVE than a positive for my students.
  5. On balance, using computers has enhanced my students' creativity.
  6. On balance, computers have been more of a DISTRACTION than a useful classroom tool.
  7. I find that my students pay better attention to me in the classes where I use computers than in the classes where I don't.
  8. My students work together more frequently in classes that use computers.

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