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Integrating Computing Across the Curriculum: The Impact of Internal Barriers and Training Intensity on Computer Integration in the Elementary School Classroom

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Abstract
This study examines the relationship between internal barriers, professional development, and computer integration outcomes among a sample of fourth- and fifth-grade teachers in an urban, low-income school district in the Southeastern United States. Specifically, we examine the impact of teachers' computer attitudes, computer anxiety, and computer training on the quality of computer integration in their classrooms. Using data from the Integrating Computing Across the Curriculum project, we utilize a mixed-methods approach to explore these relationships. Our results indicate that teacher attitudes and participation in an intensive computer-based training have a positive effect on computer integration practices. Findings from this study support providing teachers with more computer-based training which aims to improve the quality of classroom integration. This may lead to improvements in

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teacher attitudes toward computing and an increase in levels of computer integration in the elementary school classroom.

Keywords
computer integration, urban education, teacher technology attitudes, professional development

Introduction

Classroom integration of technology is a method of enhancing teaching and learning (Wright & Wilson, 2011). Research suggests that the use of technology in the elementary classroom has positive impacts on student learning and motivation and is therefore important for 21st century teaching and learning. For example, computer use has been linked to improvements in students' problem-solving ability, critical thinking and creative thinking skills, increases in literacy and student motivation, more positive attitudes toward computers, and an increase in student use of computers for educational purposes (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010; Gibson et al., 2014; Lowther, Ross, & Morrison, 2003; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010; Suhr, Hernandez, Grimes, & Warschauer, 2010). Students in settings where computers have been successfully integrated report that such technologies in the classroom enabled more cooperative learning, enhanced access to educational resources, promoted better understanding of identified learning objectives, and increased communication between teachers and students (Lowther et al., 2003). Studies have also found a positive relationship between students' computer usage and more objective outcomes such as standardized test scores in Math, Reading, and Science (Cviko, McKenney, & Voogt, 2012; Shapley et al., 2010; Suhr et al., 2010).

Despite research findings that computer usage in the classroom is beneficial for students and for teachers, the task of integrating computing across the curriculum is challenging. Low levels of computer integration have been linked to external barriers, such as lack of training, access to computers and the Internet, as well as internal barriers, such as teacher beliefs, attitudes, skills, and computer self-efficacy and anxiety (Abbitt, 2011; Baylor & Ritchie, 2002; Buabeng-Andoh, 2012; Christensen, 2002; Eteokleous, 2008; Hayes, 2007; Lim & Khine, 2006; Mueller, Wood, Willoughby, Ross, & Specht, 2008; Paraskeva, Bouta, & Papagianni, 2008; Wong & Li, 2008). Exposure to computing technology through training and support has been found to reduce internal barriers to classroom integration. Teachers report positive gains in content knowledge, reductions in anxiety, and more positive attitudes toward integrating computers following professional developments designed to address such barriers (Alayyar, Fisser, & Voogt, 2012; Carter et al., 2014; Koh & Divaharan, 2011; Wells, 2007).

Considering the impact training has been found to have on internal barriers such as teacher attitudes and anxiety, we ask what impact does professional development have on teacher preparation for and implementation of a computing-based curriculum? While other studies have focused on the impact of professional development on teachers' attitudes, skills, and self-reported frequency of computer training and classroom integration (Alayyar et al., 2012; Carter et al., 2014; Mueller et al., 2008), we focus on the quality of observed computer integration, which could influence student learning. The current study contributes to understanding how internal and external barriers, including training intensity, impacts the attitudes, computer anxiety, and computer integration practices of fourth- and fifth-grade teachers in a high-poverty, high-minority, urban school district in the Southeastern United States. Specifically, the aspects of integration we examine are preparedness, how prepared teachers are to integrate a computing-based curriculum module, and execution, the level of independence with which they execute the module. Social cognitive theory provides the theoretical framework that explains the relationship between professional development, anxiety, and the integration process. Both survey and observational data are used to examine the relationship between these internal barriers, the intervention, and noted aspects of computer integration.

Literature Review

Factors Influencing Computer Integration in the K-12 Classroom

Although research on the use of computers in the classroom is well studied (Hayes, 2007; Jackson et al., 2012; Khine, 2006; Li, 2007), prior research has not examined factors that may influence aspects of integration such as preparedness and execution. Many studies have focused on barriers to integrating computers in the classroom. Ertmer (1999) classified barriers into two categories, first order and second order. First-order, or external, barriers are those outside of the teachers' control such as the availability of computer labs, technical and administrative support, computer-related training, and broken equipment. These barriers can lead to high levels of frustration which discourage many teachers from attempting to integrate computers. Still, with the increase in access to computers and the Internet, especially in schools, evidence suggests less impact from external barriers (Mueller et al., 2008). Despite the decline in external barriers, many teachers are still not integrating computing across their curriculum (Hayes, 2007; Hinson, LaPrairie, & Heroman, 2006). This has led to greater emphasis being placed on the relationship between second-order, or internal, barriers and computer integration.

While teachers' ability to integrate computers into the classroom has been directly affected by external barriers, such as the evolving nature of technology itself (Abbitt, 2011) and teacher access to technology and other resources (Eteokleous, 2008; Mueller et al., 2008), the impact of internal barriers has become more evident (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). According to Ertmer (1999), internal barriers may contribute to teachers blaming external barriers for their lack of integration. Internal barriers are those within the teachers' control and are often a part of the teacher's disposition, for example, attitudes toward computing in the classroom or computer anxiety, as well as perceived computer skills. Internal barriers such as teachers' beliefs and attitudes toward computers, their computing skills, and computer anxiety have all been found to impact classroom integration (Baylor & Ritchie, 2002; Christensen, 2002; Eteokleous, 2008; Hayes, 2007; Lim & Khine, 2006; Paraskeva et al., 2008).

Many teachers do not integrate computers due to low levels of skills or perceived skills, negative attitudes toward computing in the classroom, and high levels of anxiety about using computers with and teaching computing to their students (Azarfam & Jabbari, 2012; Celik & Yesilyurt, 2012; Chen, 2008; Cullen & Greene, 2011; Rohaan, Taconis, & Jochems, 2012; Wachira & Keengwe, 2011). Teacher beliefs and attitudes are significant determinants of computer integration (Cullen & Greene, 2011; Cviko et al., 2012; Kim, Kim, Lee, Spector, & DeMeester, 2013; Mueller et al., 2008). Cviko et al. (2012) studied the relationship between teacher attitudes toward computers, technology integration, student engagement, and student learning. Their findings suggest a strong relationship between teacher beliefs and attitudes and how teachers interact with and use technology for teaching and learning. Cullen and Greene (2011) also found support for the relationship between teacher attitudes and classroom integration. They found that positive attitudes toward technology were the strongest predictor of intrinsic and extrinsic motivation to use computers in the classroom. Similar evidence suggests that a teacher's attitude is the most important factor influencing integration. Mueller et al. (2008) found that attitudes toward technology were the most critical factors in distinguishing the teachers who were more and less successful at integrating technology. Moreover, the influence of teachers' nontechnology-specific beliefs has also been found to influence computer integration practices. Kim et al. (2013) found support for this relationship upon examining teachers' beliefs regarding knowledge and learning as well as effective teaching strategies and technology integration practices.

Computer knowledge and computer skills are also predictors of classroom integration (Hew & Brush, 2007; Hughes, 2005; Lim & Khine, 2006) and may impact teacher anxiety toward using computers in the classroom. Hughes (2005) found that teachers who were more knowledgeable about computers were more engaged in technology and more skilled at developing ways to use computers in the classroom. Moreover, Shah, Hassan, and Embi (2012) found that computer knowledge and skill impact computer anxiety. These findings suggest that teachers who rate themselves as low in computer skills and knowledge will express higher levels of anxiety and thus lower self-efficacy as it relates to integrating computers. Considering the influence of teacher attitudes, beliefs, and self-efficacy, reducing these internal barriers to computer integration may lead to improvements in integration practices and an increase in the use of computers and technology in the classroom. Computer-based trainings designed specifically for K-12 teachers have been found to have such an impact.

Interventions Aimed at Increasing Computer Integration in the K-12 Classroom

Computer-based interventions, professional development designed to promote computing integration by creating lessons that utilize computers as the primary tool to facilitate learning, have increased. These interventions are designed to improve teachers' computer attitudes, skills, and anxiety with the goal being to increase computer integration levels among classroom teachers. Successful professional development models are usually learner centered, meaning teachers learn the way they are expected to teach (Orrill, The InterMath Team, 2006). They also involve in-depth training with an emphasis on specific programs or knowledge and various levels of face-to-face and online support (Alayyar et al., 2012; Carter et al., 2014; Gibson et al., 2014; Keengwe & Onchwari, 2009; Khine, 2006; Wells, 2007). Alayyar et al. (2012) examined the impact of design teams (DTs) on pre-service teachers. DTs are created when teachers establish collaborative environments to discuss technology progress and solutions for technology usage in the classroom. Using the Technological Pedagogical Content Knowledge (TPACK) framework, these researchers assigned teachers to one of two conditions, human support (HS) or blended support (BS). Participants in the HS group received face-to-face support from TPACK trainers. Those in the BS group also received face-to-face support as needed but had access to an online environment which provided additional support. Following this intervention, both groups of teachers had gains, but teachers who were in the BS group had higher gains in knowledge and attitudes and seemed to enjoy technology tools more than the HS group. The model utilized by Carter et al. (2014) included in-service teachers and focused on professional development and in-class support. This model reduced teacher anxiety and had a positive impact on teachers' attitudes toward computing in the classroom.

Professional development designed to promote computer integration has been shown to reduce computer anxiety, promote more positive attitudes, and increase enjoyment of technology in the classroom (Alayyar et al., 2012; Carter et al., 2014; Khine, 2006). Thus, such professional development may be the key to reducing internal barriers and increasing the use of computing across the curriculum. In addition, well-managed opportunities for collaboration in teacher-focused interventions may help the development of teaching pedagogies that are well attuned to the inclusion of computing in the classroom (Wang, 2008). Consequently, developing and improving computer-based interventions to address internal barriers is crucial to improving technology integration in the K-12 classroom. Social cognitive theory helps explain why computer-based professional development may help improve classroom integration.

Theoretical Framework

As Bandura (2001) noted, behavior is determined by personal dispositions and environmental determinants. Yet, it is not simply one aspect acting upon another; there is interaction among disposition, the environment, and behavior. This results in a triadic reciprocal causation with each exerting almost equal influence on the other. Thus, the relationship between professional development (environmental determinant), teacher attitudes, and anxiety (personal disposition) and how prepared teachers are to integrate technology as well as how much assistance they need to do so (behavior) is reciprocal.

The influence of professional development as an environmental determinant on attitude and anxiety as disposition and aspects of integration as behavior is best explained by what happens during professional development. As discussed in the previous section, when trainings are learner centered, there is a modeling of expected behavior and disposition from which teachers are expected to learn. This often results in vicarious learning. Vicarious learning allows individuals to learn by observing others and therefore shortens the time required to acquire new skills through enactive learning (Bandura, 2001). According to Bandura (2001), human beings have the capacity to learn extensively when exposed to various models. However, whether individuals decide to perform an observed behavior or develop a particular disposition is influenced by direct, vicarious, and self-produced motivators. If a behavior is seen as contributing to a rewarding outcome, as opposed to one without any rewards or even punishment, then they are more likely to exhibit the behavior or disposition themselves.

The aim of the current study is to investigate the relationship between teacher attitudes and computer anxiety (personal disposition), teacher participation in a computing-based intervention (environmental determinant), and teacher preparation for and implementation of a computing-based curriculum module (behavior). Considering the influence of vicarious experience on behavior, we predict that teacher attitude and anxiety and exposure to modeled computer integration will all have a significant positive effect on how prepared teachers are to integrate computing and whether they do so without assistance. We also predict that the effect of training intensity will be moderated by attitude and anxiety.

Thus, we seek to answer the following research questions:

1. Are teachers' attitudes toward computing correlated with their preparedness and the degree to which they can execute computer-based lessons independently?
2. Are teachers' computer anxiety correlated with their preparedness and the degree to which they can execute computer-based lessons independently?
3. Does training intensity improve teachers' preparedness and the degree to which they can execute computer-based lessons independently?
4. Is training intensity moderated by teachers' attitudes and computer anxiety?

Method

Integrating Computing Across the Curriculum

Integrating Computing Across the Curriculum (ICAC) was a 5-year research project funded by the National Science Foundation and implemented in a large, urban school district in the Southeastern United States. This computing-based intervention was designed to provide fourth- and fifth-grade teachers with the resources necessary to integrate computing into their classrooms using computers as a primary tool. The integration model included professional development, in-class support, and in-class modeling of curriculum modules. Teachers were invited to participate in a weeklong training institute during the summer prior to school involvement. During summer institutes, teachers spent 7 hours a day learning various programs which were used to integrate computing, were provided with lesson plans and guides designed to facilitate integration, and created their own lesson plans to use throughout the school year. Curriculum modules were modeled for teachers by learning facilitators. Teachers were provided the opportunity to practice their integration skills by modeling lessons for one another. They were paid a daily stipend for their participation and attendance. During the school year, teachers participated in embedded professional development sessions which occurred during the regular school day. These sessions served as a review for teachers who had attended a summer institute and provided an introduction for teachers who were learning the programs for the first time. Embedded sessions were designed to provide a brief overview of various programs and teachers were also provided with lesson plans and guides but did not create their own lesson plans. Curriculum modules were sometimes modeled for the teachers, but the teachers did not practice the lessons as they did during the summer institutes. Finally, there was classroom integration, where teachers implemented the different programs into their curriculum with support from ICAC team members. Implementation took place in computer labs or classrooms depending on the resources available at each school. In computer labs, students used desktop computers while in the classrooms they used laptops. Most lessons were created with a group approach to learning to encourage collaboration among students as well to account for any deficiencies in computer resources between schools. Teachers implemented the curriculum module that was covered at the most recent professional development session. Modules usually took 45 to 60 minutes to complete.

Participants

Data for this study are from Year 4 of the ICAC study, which took place during the 2012–2013 school year. Prior to Year 3, no qualitative data were collected, and thus, prior years are not included in this analysis. The participants for this study were fourth- and fifth-grade teachers within the schools participating in Year 4 of the ICAC study. Teachers were surveyed at the beginning of the summer institutes as well as the beginning of the 2012 school year. Therefore, survey responses were collected prior to the intervention for all teachers. Each paper and pencil survey took approximately 20 minutes to complete and teachers received a small incentive for completing the surveys. In addition to survey data, data were also collected via observation of in-class sessions. Team members who were present as participant observers during implementation wrote field notes following each session. These team members were primarily undergraduate and graduate student research assistants whose role during teaching sessions was to provide technical support to teachers in addition to making observations during the sessions. These notes summarized teacher preparation, lesson implementation, student response and interaction and provided an overall description of the session. These notes were later coded to measure teacher preparation and implementation of lesson plans. Of the 66 teachers who participated in Year 4 of the study, in-class observations were collected for 54 teachers. Efforts were made to collect data from three in-class sessions for each teacher, but many teachers only conducted two in-class sessions. After deleting cases with missing data for the dependent and independent variables, there are 127 observations nested within 54 teachers.

Measurements

Dependent variables. The preparation and execution variables are five-level ordinal variables indicating the degree to which teachers were prepared to instruct in-class sessions (preparedness) and the degree to which they were able to implement the lesson independently (execution). The variables were created from field notes written by ICAC staff observers following in-class observations. For each summary, two raters were asked to rate each teacher's preparedness and execution on a scale of 1 to 3, with 1 indicating *the lowest possible preparedness or execution*, and 3 indicating *the greatest possible preparedness or execution*. In order for teachers to receive a 3 on the preparedness scale, they must have come to the session with a plan consisting of clear directions and lesson objectives. If a teacher came to the session without a plan and without objectives, they received a score of 1. Lesson execution was rated from 3 = *Teacher was able to carry out planned lesson with minimal assistance*, 2 = *Teacher was able to carry out planned lesson with a moderate amount of assistance*, to 1 = *Teacher was not able to carry out planned lesson and deferred to the ICAC team member*. Minimal assistance was defined as the teacher almost never asking for assistance and completing the majority of the lesson with little assistance. Moderate assistance was defined as the teacher asking for assistance sometimes and completing the majority of the lesson with some assistance from the team member. Teachers who asked for assistance most of the time and who depended on the team member for most of the lesson received the lowest rating.

For each session, final ratings were developed by summing the ratings from the two raters and subtracting one in order to generate a five-level rating score (1 = *minimum possible rating*; 5 = *maximum possible rating* (Total Rating = $\text{Rating}_{\text{Rater 1}} + \text{Rating}_{\text{Rater 2}} - 1$). A test of interrater reliability yielded kappa values of .74 ($p < .001$), .64 ($p < .001$), and .55 ($p < .001$) for preparation ratings during the first, second, and third in-class sessions, respectively. Kappa values for the execution ratings were .36 ($p < .001$), .40 ($p < .001$), and .64 ($p < .001$) for the first, second, and third in-class sessions, respectively. Our tests of interrater reliability indicate fair to substantial agreement between raters according to Landis and Koch's (1977) guidelines. It should be noted, however, that Kappa values indicate less agreement on execution ratings. One possible explanation is that preparedness ratings may have been more objectively discernible based on the presence of a lesson plan and planned activities appropriate to the length of the in-class sessions, while execution ratings may have been prone to differences of opinion regarding teachers' demeanor and class management styles. Once average ratings were calculated for each session, the data were converted to long-form such that each case in the sample represented one session observation. Each teacher thus had a total of three possible cases in the final dataset, one for each in-class observation rating.

Independent variables. Attitudes toward classroom computing were measured using a 9-item scale which asked teachers to rate their agreement with statements such as "Using computers in class has made my students more engaged as learners" and "On balance, computers have been more of a distraction than a useful classroom tool." Teachers rated their agreement with these statements on a scale of 1 to 5 (1 = *Strongly Disagree*; 5 = *Strongly Agree*). The scale items had a Cronbach's Alpha of .77, indicating excellent interitem reliability. Scores were calculated by taking the sum of the scale items to create an interval variable with a minimum possible score of 9 and a maximum possible score of 45, with higher scores indicating more positive attitudes toward classroom computing.

Computer anxiety was measured using an 11-item scale adapted from Fogarty, Cretchley, Harman, Ellerton, and Konki (2001), which asked teachers to rate their agreement with statements such as "It takes me longer to understand computers than the average person" and "I find having to use computers frightening." Teachers rated their agreement on a scale of 1 to 5 (1 = *Strongly Disagree*; 5 = *Strongly Agree*). The scale items had a Cronbach's Alpha of .90, indicating excellent interitem reliability. Scores were calculated by summing the scale items, creating an interval variable with a minimum possible score of 11, indicating low anxiety toward computer use, and a maximum possible score of 55, indicating the maximum possible anxiety toward computer use. Computer anxiety also acts as a proxy for self-rated skill with using computers for classroom instruction.

Two variables for training intensity were also included to indicate the degree to which teachers participated in ICAC intervention activities, specifically the summer institutes and professional development sessions during the school year. We measured the total hours of participation in professional development sessions to develop a continuous measure of professional development session participation. Summer institute participation was operationalized as a dichotomous variable, as teacher either participating in the institutes for a full week or not at all (0 = *did not participate in summer institute*; 1 = *participated in summer institute*). Participation in summer institutes and professional development sessions, as well as total hours of professional development, were measured using registration records for each of the sessions and the institute.

Control variables. In addition to the independent variables, we included three control variables in our analysis for teacher race, gender, and years of teaching experience. Age was considered as a control variable but was highly correlated with teaching experience and thus not used. Race was measured by asking participants "How would they best describe themselves?" Due to the racially homogenous nature of the sample, race was coded dichotomously, with 0 indicating that the teacher was non-Black, and 1 indicating that the teacher was Black. There were only 12 teachers who reported being any race besides Black, which were included in the category *not Black*. Gender was measured as a dichotomous variable, with 0 indicating that the teacher was male, and 1 indicating that the teacher was female. Teaching experience was measured as the number of years of teaching experience each teacher reported.

Findings

Descriptive Statistics

Before the final analysis, we calculated descriptive statistics for the independent and dependent variables in the study using Stata 13 (StataCorp, 2013). Statistics for the independent and control variables are presented in Table 1.

Table 1. Descriptive Statistics of Independent Variables ($N = 54$ Teachers).

Variable	Mean	*SD*	Frequency	Percent
Race				
Black	–	–	45	78.95
Non-Black	–	–	12	21.05
Gender				
Male	–	–	11	19.30
Female	–	–	46	80.70
Teaching experience (years)	19.13	7.23	–	–
Attitude toward classroom computing	17.21	2.36	–	–
Computer anxiety	22.35	6.82	–	–
Intervention variables				
Summer institute participation	–	–	27	50.88
Professional development hours	25.17	16.63	–	–

As shown in Table 1, 78.95% of the teachers in the study were Black. Of the teachers in the study, 80.70% were female. Teachers had an average of 19.13 years of experience, with a standard deviation of 7.23. The mean score on the attitude scale was 17.21 (out of a possible 20) with a standard deviation of 2.36. The mean score on the anxiety scale was 22.35 (out of a possible 55) with a standard deviation of 6.82. As mentioned earlier, two measures of the intervention were used in this study. Of the teachers in the study, 50.88% attended the summer institutes. Teachers participated in an average of 25.17 hours of professional development, with a standard deviation of 16.63.

Statistics for the dependent variables are shown in Table 2. As shown in Table 2, more than half of participants received the highest possible rating for both preparedness and execution. Of the teachers in the study, 17.32% received the lowest possible rating for preparedness and 12.6% received the lowest possible rating for execution. The frequency distributions for execution and preparedness also suggest that, while a greater percentage of teachers received the highest possible rating for preparedness (64.57%) compared with execution (51.18%), a higher percentage of teachers received the lowest possible rating for preparedness (17.32%) compared with execution (12.60%).

Random-Effects Ordered Logit Regression Results

Because the observations are nested within teachers, we used a hierarchical approach to conduct our analysis. Using the *xtologit* statement in Stata 13, we ran a series of random-effects ordered logit models to estimate the effects

Table 2. Descriptive Statistics of In-Class Session Preparedness and Execution Ratings ($N = 54$ Teachers).

Variable	Frequency	Percent
Preparedness		
1 (*least prepared*)	22	17.32
2	3	2.36
3	11	8.66
4	9	7.09
5 (*most prepared*)	82	64.57
Execution		
1 (*least prepared*)	16	12.60
2	11	8.66
3	18	14.17
4	17	13.39
5 (*most prepared*)	65	51.18

of the independent variables on preparation and execution scores (StataCorp, 2013). The coefficient estimates examine the effect of each independent variable on the logged odds of an in-class session receiving a given rating or higher, compared with the next lowest rating. Random effects are included at the teacher level to account for differences between teachers that are not measured in the study.

Three models were tested for each dependent variable. Model 1 includes the independent variables for teacher attitudes toward classroom computing and teacher computer anxiety. Model 2 tests for a mediating effect of the training intensity variables on the effects of attitudes and anxiety; that is, whether the effect of attitudes and anxiety on in-class integration is partially attributable to their effects on training participation or not. Model 3 tests for a moderating effect for the training intensity variables; that is, whether training participation affects the relationship between attitudes and anxiety and in-class integration. The results for in-class session preparedness are presented in Table 3.

As shown in Table 3, neither attitudes nor anxiety toward computing appears to have any effect on teacher preparedness ratings. In fact, only summer institute participation appears to have any effect trending toward significance on preparedness, as demonstrated by the results for Model 2 ($b = 2.208$, $p < .10$). Participants in the summer institute appear to have a greater likelihood of receiving a higher preparedness rating compared with nonparticipants, holding other variables in the model constant. Model 3 does not suggest any significant interaction effects on teacher in-class session preparedness ratings.

Table 3. Random-Effects Ordered Logit Regression Coefficients, Teacher Preparedness for In-Class Sessions, Integrating Computing Across the Curriculum Summer–Fall 2012 Teacher Surveys.

	Model 1	Model 2	Model 3
Attitudes	0.205 (0.142)	0.222 (0.146)	0.074 (0.590)
Anxiety	0.047 (0.049)	0.051 (0.053)	0.248 (0.162)
Summer institute participation		2.208† (1.305)	0.919 (2.055)
Professional development hours		−0.051 (0.039)	−0.013 (0.060)
Summer × Attitude			0.395 (0.998)
Summer × Anxiety			−0.323 (0.224)
Professional development × Attitude			−0.012 (0.030)
Professional development × Anxiety			0.006 (0.007)
N	127	127	127

Note. Standard errors in parentheses. Controls included for teacher race, gender, and years of experience. †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

The results for in-class session execution are presented in Table 4. As shown in Table 4, Model 1 results suggest that teacher attitudes toward computers do have a significant and positive effect on in-class session execution ratings ($b = 0.203$, $p < .05$). The effect of attitude remains significant and positive in all but Model 3, which included the interaction terms. More positive attitudes toward classroom computing appear to have a positive effect on the likelihood of receiving a higher execution rating relative to those with more negative attitudes, holding other variables in the model constant. Model 2 suggests that summer institute participation also has a positive effect on in-class execution ratings ($b = 1.754$, $p < .05$). It is estimated that summer institute participants had a greater likelihood of receiving a higher execution rating relative to nonparticipants, holding other variables in the model constant. Conversely, professional development appears to have a negative relationship with in-class execution rankings trending toward significance ($b = -0.050$, $p < .10$). This finding is contradictory to the predicted relationship, with no clear discernible explanation. As with the results for preparedness ratings, there is no evidence in Model 3 for interaction effects between the intervention variables and teacher attitudes and anxiety.

Discussion

This study examined the relationship between teachers' attitudes toward computing in the classroom, their levels of computer anxiety, how prepared they were to integrate a computer-based curriculum module, and whether they were

Table 4. Random-Effects Ordered Logit Regression Coefficients, Teacher Execution of In-Class Sessions, Integrating Computing Across the Curriculum Summer–Fall 2012 Teacher Surveys.

	Model 1	Model 2	Model 3
Attitudes	0.187* (0.086)	0.257** (0.098)	−0.022 (0.415)
Anxiety	−0.005 (0.028)	0.011 (0.032)	0.007 (0.103)
Summer institute participation		1.754* (0.849)	0.747 (1.513)
Professional development hours		−0.050† (0.02)	−0.018 (0.045)
Summer × Attitude			0.510 (0.703)
Summer × Anxiety			−0.004 (0.147)
Professional development × Attitude			−0.0135 (0.021)
Professional development × Anxiety			−0.002 (0.005)
N	127	127	127

Note. Standard errors in parentheses. Controls included for teacher race, gender, and years of experience.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

able to integrate the module independently in their classrooms. The study also explored the impact of the ICAC intervention, as measured by whether teachers participated in summer training and the amount of time teachers were engaged in professional development. Thus, our study expands what is known about the relationship between internal and external barriers and the more practical aspects of integration. We tested the following hypotheses:

1. Teachers with more favorable attitudes toward computing will have higher scores in preparedness and execution.
2. Teachers with lower anxiety toward computing will have higher scores in preparedness and execution.
3. Participation in intensive training (weeklong training session) will have a positive effect on preparedness and execution.
4. Effect of intensive training will be moderated by attitudes and anxiety.

We found support for two of the four proposed hypotheses. Accordingly, our research suggests that teachers benefit from computing-based interventions and provides some support for previous findings that internal barriers, such as teacher attitudes and anxiety, impact how teachers integrate computing in their classrooms (Azarfam & Jabbari, 2012; Celik & Yesilyurt, 2012; Chen, 2008; Cullen & Greene, 2011; Rohaan et al., 2012; Wachira & Keengwe, 2011).

Previous research found that teacher attitudes were a strong predictor of teachers' motivation to use technology and how frequently they integrated technology (Cullen & Greene, 2011; Mueller et al., 2008). In the current study, we found that teachers' attitudes toward computing in the classroom had a positive effect on in-class execution ratings but not preparedness ratings. This suggests that how teachers feel about computing in the classroom does not influence how prepared they are for a session but does influence how they implement the lesson. There are two possible explanations for this finding. One is that it might be attributed to differences in experience of teachers in this and previous studies. The previous studies were conducted with pre-service teachers with no classroom experience (Cullen & Greene, 2011) and did not involve any training or support (Mueller et al., 2008). Thus, the training and experience of the teachers in the current study, who had been teaching an average of 19 years, may have made a difference in the strength of impact as it relates to teachers' attitudes toward computing.

We also found that teachers who attended the summer institute were more likely to have higher preparedness and execution ratings. These findings suggest that teachers who receive intensive training, followed by continued training, are more prepared and are more successful at Integrating Computing Across the Curriculum when compared with teachers who do not receive intensive training. This is supported by social cognitive theory. During the summer institutes, teachers are trained to create technology-based lessons and are exposed to extensive modeling of lessons. Thus, this helps explain why teachers who attend the institute would be more prepared and more likely to implement lessons independently. Despite barriers that have been found to influence whether teachers integrate computing across their curriculum, we find that teachers can integrate computers well if provided with the proper training and support.

It is odd that professional development seems to have a negative relationship with execution ratings, even though the relationship did not reach significance at the $p < .05$ level. One possible explanation for this contrary finding is that while intensive summer institutes prior to the school year were helpful, professional development sessions during the school year may have been less useful as teachers had to attend these sessions in addition to their regular teaching duties. In other words, teachers who attended summer institutes may have benefitted from having a head start on material for in-class sessions but been overburdened by professional development during the school day in ways that counter-acted its potential benefit. This is consistent with the finding that teachers who participated in summer institutes did not receive any additional significant benefit from professional development sessions during the school year. Another explanation is that this finding may be a reflection of overreliance on ICAC staff who were present to provide technical support. Still it might have been due to the difference in training intensity between the intensive summer training and less intensive school year training. While the summer training was a total 35 of hours, which included extensive modeling of curriculum modules, development of curriculum modules by participating teachers, and practical application of those modules, the school year training was a total of 2 to 5 hours and only included partial modeling of curriculum modules.

In addition to providing support for our findings, it is necessary to identify study limitations. On the basis of previous research (Carter et al., 2014), we know that teachers report a decrease in anxiety following the ICAC intervention. Yet, in this sample, anxiety was not associated with preparedness and execution scores and was unrelated to training intensity. It may be that this lack of association was related to how anxiety was measured in the current study. Our measure did not differentiate anxiety related to general computer use from anxiety related to using computers in the classroom for instructional purposes. Future researchers should include measures of both types of anxiety, as they may have differential effects on teacher preparedness and other educational outcomes. Having additional observations would also be helpful for further examination of these relationships as the current study included only two or three observations, all from the first semester of the intervention. It might also have proved useful to seek feedback from the teachers following integration. Knowing how they felt about how the lesson was implemented would allow for the comparison of teacher beliefs to observer report. Another limitation is that we do not have additional measures of external barriers, which may have impacted the degree to which teachers were able to prepare and carry out in-class sessions. Finally, the lack of evidence for moderation effects may be due, in part, to the large number of interaction terms relative to observations, which may have reduced the statistical power of the moderation models.

Conclusion

Overall, the current study provides support for the relationship between internal barriers and classroom integration of technology, with training intensity having the most consistent impact. These findings suggest that future interventions should focus on improving teachers' attitudes toward computing in the classroom, on providing teachers with extensive modeling of curriculum modules, as well as opportunities to practice integrating the modules themselves. These factors seem to impact both how prepared teachers are as well as how well they independently integrate computing across their curriculum.

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References

Abbitt, J. T. (2011). An investigation of the relationship between self-efficacy beliefs about technology integration and Technological Pedagogical Content Knowledge (TPACK) among preservice teachers. *Journal of Digital Learning in Teacher Education*, *27*(4), 134–143.

Alayyar, G. M., Fisser, P., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service science teachers: Support from blended learning. *Australasian Journal of Educational Technology*, *28*(8), 1298–1316.

Azarfam, A. Y., & Jabbari, Y. (2012). Dealing with teachers' technophobia in classroom. *Advances in Asian Social Science*, *2*(2), 452–455.

Bandura, A. (2001). Social cognitive theory of mass communication. *Media Psychology*, *3*, 265–299.

Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education*, *39*, 395–414.

Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education and Development Using ICT*, *8*(1), 136–155.

Carter, A., Cotten, S. R., Gibson, P., O'Neal, L. J., Simoni, Z., Stringer, K., & Watkins, L. S. (2014). Integrating Computing Across the Curriculum: Incorporating technology into STEM education. In Z. Yang, H. H. Yange, D. Wu & S. Liu (Eds.), *Transforming K-12 classrooms with digital technology* (pp. 165–192). Hershey, PA: IGI Global.

Celik, V., & Yesilyurt, E. (2012). Attitudes to technology, perceived computer self-efficacy and computer anxiety as predictors of computer supported education. *Computers & Education*, *60*(1), 148–158.

Chen, C. (2008). Why do teachers not practice what they believe regarding technology integration?. *The Journal of Educational Research*, *102*(1), 65–75.

Christensen, R. (2002). Effects of technology integration education on the attitudes of teachers and students. *Journal of Research on Technology in Education*, *34*(4), 411–434.

Cullen, T. A., & Greene, B. A. (2011). Preservice teachers' beliefs, attitudes, and motivation about technology integration. *Journal of Educational Computing Research*, *45*(1), 29–47.

Cviko, A., McKenney, S., & Voogt, J. (2012). Teachers enacting a technology-rich curriculum for emergent literary. *Educational Technology Research and Development*, *60*, 31–54.

Drayton, B., Falk, J. K., Stroud, R., Hobbs, K., & Hammerman, J. (2010). After installation: Ubiquitous computing and high school science in three experienced, high-technology schools. *The Journal of Technology, Learning and Assessment*, *9*(3).

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, *47*(4), 47–61.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*, 423–435.

Eteokleous, N. (2008). Evaluating computer technology integration in a centralized school system. *Computers & Education*, *51*, 669–686. doi:10.1016/j.compedu.2007.07.004

Fogarty, G., Cretchley, P., Harman, C., Ellerton, N., & Konki, N. (2001). Validation of a questionnaire to measure mathematics confidence, computer confidence, and attitudes towards the use of technology for learning mathematics. *Mathematics Education Research Journal*, *13*, 154–160.

Gibson, P. A., Stringer, K., Cotten, S. R., Simoni, Z., O'Neal, L. J., & Howell-Moroney, M. (2014). Changing teachers, changing students? The impact of a teacher-focused intervention on students' computer usage, attitudes, and anxiety. *Computers & Education*, *71*, 165–174.

Hayes, D. N. (2007). ICT and learning: Lessons from Australian classrooms. *Computers & Education*, *49*(2), 385–395.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Education Technology Research and Development*, *55*, 223–252.

Hinson, J., LaPrairie, K., & Heroman, D. (2006). A failed effort to overcome tech barriers in a K-12 setting: What went wrong and why? *International Journal of Technology in Teaching and Learning*, *2*(2), 148–158.

Hughes, J. (2005). The roles of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education*, *13*(2), 277–302.

Jackson, L. A., Witt, E. A., Games, A. I., Fitzgerald, H. E., von Eye, A., & Zhao, Y. (2012). Information technology use and creativity: Findings from the children and technology project. *Computers in Human Behavior*, *28*(2), 370–376.

Keengwe, J., & Onchwari, G. (2009). Technology and early childhood education: A technology integration professional development model for practicing teachers. *Early Childhood Education*, *37*, 209–218.

Khine, M. S. (2006). Strategic use of digital learning resources in designing e-lessons. *International Journal of Instructional Media*, *33*(2), 127.

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education*, *29*, 76–85.

Koh, J. H., & Divaharan, S. (2011). Developing pre-service teachers' technology integration expertise through the TPACK-developing instructional model. *Journal of Educational Computing Research*, *44*(1), 35–58.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174. doi:10.2307/2529310

Li, Q. (2007). Student and teacher views about technology: A tale of two cities? *Journal of Research on Technology in Education*, *39*(4), 377–397.

Lim, C. P., & Khine, M. (2006). Managing teachers' barriers to ICT integration in Singapore schools. *Journal of Technology and Teacher Education*, *14*(1), 97–125.

Lowther, D. L., Ross, S. M., & Morrison, G. M. (2003). When each one has one: The influences on teaching strategies and student achievement of using laptops in the classroom. *Educational Technology Research and Development*, *51*, 23–44.

Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers & Education*, *51*, 1523–1537.

Orrill, C. H., & The InterMath Team. (2006). What learner-centered professional development looks like: The Pilot studies of the Intermath Professional Development Project. *The Mathematics Educator*, *16*(1), 4–13.

Paraskeva, F., Bouta, H., & Papagianni, A. (2008). Individual characteristics and computer self-efficacy in secondary education teachers to integrate technology in educational practice. *Computers & Education*, *50*, 1084–1091.

Rohaan, E. J., Taconis, R., & Jochems, W. M. G. (2012). Analysing teacher knowledge for technology education in primary schools. *International Journal of Technology and Design Education*, *22*, 271–280.

Shah, M. M., Hassan, R., & Embi, R. (2012). Technology acceptance and computer anxiety. *2012 International Conference on Innovation Management and Technology Research (ICIMTR)*, 306–309.

Shapley, K. S., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the implementation fidelity of technology immersion and its relationship with student achievement. *The Journal of Technology, Learning and Assessment*, *9*(4).

StataCorp. (2013). *Stata statistical software: Release 13*. College Station, TX: StataCorp LP.

Suhr, K. A., Hernandez, D. A., Grimes, D., & Warschauer, M. (2010). Laptops and fourth grade literacy: Assisting the jump over the fourth-grade slump. *The Journal of Technology, Learning and Assessment*, *9*(5).

Wachira, P., & Keengwe, J. (2011). Technology integration barriers: Urban school mathematics teachers perspectives. *Journal of Science Education and Technology*, *20*, 17–25.

Wang, Q. (2008). A generic model for guiding the integration of ICT into teaching and learning. *Innovations in Education and Teaching International*, *45*(4), 411–419. doi:10.1080/14703290802377307

Wells, J. (2007). Key design factors in durable instructional technology professional development. *Journal of Technology and Teacher Education*, *15*(1), 101–122.

Wong, E. M. L., & Li, S. C. (2008). Framing ICT implementation in a context of educational change: A multilevel analysis. *School Effectiveness and School Improvement*, *19*(1), 99–120. doi:10.1080/09243450801896809

Wright, V. H., & Wilson, E. K. (2011). Teachers' use of technology: Lessons learned from the teach education program to the classroom. *Southeastern Regional Association of Teacher Educators Journal*, *20*(2), 48–60.

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