Understanding factors associated with teacher-directed student use of technology in elementary classrooms: A structural equation modeling approach

Helena P. Miranda and Michael Russell

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Abstract
Analyses presented here are secondary data analyses of the Use, Support and Effect of Instructional Technology study aimed at identifying predictors of teacher-directed student use of technology (TDS) in elementary classrooms. Using data from a convenience sample of 1040 teachers nested within 81 schools in 21 Massachusetts’ school districts, researchers developed a teacher-level structural equation modeling for TDS depicting relationships between and among factors associated with TDS. Researchers relied on diffusion and adoption theories as well as prior empirical evidence to specify the hypothetical model. Evidence presented here suggests that the strongest predictors of TDS are as follows: (1) teachers’ experience with technology, (2) belief that technology is beneficial to meet instructional goals, (3) perceived importance of technology for teaching and that (4) experiencing obstacles with the integration of technology appears to be one deterrent to teachers using technology in the classroom. The most important finding reported here is that two of the most important factors in increasing TDS are teachers’ beliefs about the benefits of technology and perceived importance of technology for teaching.

Introduction
The technology revolution of the past several decades has been one of the most influential transformations in modern history. Although slower than other facets of society in following this revolutionary trend, the field of education is rapidly following suit. Over the past two decades, the availability of technology in American classrooms has increased dramatically. Internet access is available to all public schools with 97% connected via high-speed connection. The student-to-computer ratio dropped from 4.4 in 2003 to close to 4 in 2008 (Clausen, Britten & Ring, 2008; Wells & Lewis, 2006) and hundreds of schools and districts are experimenting with 1:1 laptop programs (Bebell & Kay, 2010). The billions of dollars invested in technology have not translated into widespread use in the classroom (Bebell & Kay, 2010; Bebell, Russell & O’Dwyer, 2004; Cuban, 2006; Russell, Bebell, O’Dwyer & O’Connor, 2003b; Wells & Lewis, 2006).
Diffusion theories provide insight into factors related to the disappointing adoption rates of instructional technologies (IT) by schoolteachers (Kebritchi, 2010; Miranda, 2007; Miranda & Russell, 2011). Rogers’ (1995) theory of diffusion and Surry and Farquhar’s (1997) application of diffusion theory to IT suggest that the limited use of IT by teachers and their students may stem from the implementation of technology programs that address only a fraction of the many factors of diffusion. Surry and Farquhar (1997) argue that district leaders should consider both micro-level and macro-level factors of diffusion when planning the adoption of IT innovations (Miranda, 2007; Miranda & Russell, 2011).

Surry and Farquhar (1997) explain that micro-level theories of diffusion, which follow an instrumentalist philosophy that argues that the needs of individuals drive social change, focus on adopter-level characteristics and processes (Miranda, 2007; Miranda & Russell, 2011; Surry & Farquhar, 1997). From this stance, educational leaders and IT developers should develop and implement IT innovations guided by teachers’ and students’ characteristics and their instructional needs. The rationale is that if leaders tailor IT innovations to consider instructional needs, then teachers are more apt to adopting those IT innovations than they would be otherwise.

Practioners Notes
What is already known about this topic
• Diffusion theories may explain the poor adoption rates of instructional technology (IT).
• Top-down initiatives that mandate IT use have not succeeded in increasing IT use.
• Macro-level factors are important drivers of IT use but per se they do not lead to widespread use.
• Several teacher-related factors are associated with IT adoption: philosophy of education, beliefs, background characteristics as well as access to experience and confidence with technology.

What this paper adds
• A cohesive investigation of factors that contribute to classroom IT use, which considers classroom-level factors and their interaction to promote IT use.
• The strongest predictors of the teacher-directed student use of technology (TDS) are beliefs about the breadth of technology benefits; teacher’s experience with technology; and perceived importance for computers for teaching.
• There are strong interactions among predictor variables: between teacher’s experience with computers and perceived importance of technology for teaching; between teacher’s experience with computers and with teacher’s confidence using technology; and between teacher confidence with technology and teacher experience and perceived importance of technology for teaching.
• The largest deterrent to TDS was obstacles experienced integrating technology.

Implications for practice and/or policy
• Closer attention is needed to change teachers’ beliefs and values about technology innovations before their implementation in the classroom.
• Schools and districts to focus on decreasing obstacles related to technology integration.
• A cohesive approach to technology implementation is needed, taking into consideration both micro-level factors, such as teachers’ beliefs and values, and macro-level factors, such as technology support.
Conversely, macro-level theories, which follow a deterministic philosophy, posit that developers provide technological innovations and drive social change; they focus on organizational characteristics (Surry & Farquhar, 1997). Top-down adoption policies, which are crafted by educational experts, policymakers and business leaders, and are promulgated by local communities, reflect a deterministic philosophy whereby experts and leaders determine needs, develop solutions and enforce the use of innovations.

Surry and Farquhar (1997) assert that following either a micro-level or a macro-level approach by itself may limit the diffusion of innovations. If districts use a macro-level approach in isolation, teachers are likely to limit or resist adoption altogether. Conversely, if districts use a micro-level approach, IT adoption will be limited to a few innovators or clusters of IT users because of inconsistencies in IT resources, access and support (Miranda, 2007; Miranda & Russell, 2011). There is a need to identify micro- and macro-level factors that influence instructional use of technology because of the importance of micro and macro aspects of diffusion to the adoption of IT innovations.

Teacher-level factors associated with IT adoption

Earlier research on teacher agency and curriculum adoption emphasized that the best policies, plans, standards are only useful to the extent that teachers adopt them in their classrooms (Miranda, 2007; Paris, 1993). Paris (1993) examined the link between teacher agency and the implementation of a word-processing curriculum in elementary classrooms. The teacher agency perspective of curriculum implementation contends that teachers are critical participants in creating, evaluating and implementing curricula (Paris, 1993). Paris (1993) found that teachers had considerable autonomy in that they “created and critiqued word-processing curricula in the absence of a prescribed computer curriculum” (Paris, 1993, p. 148).

Other researchers who investigated teacher characteristics and teacher-level factors associated with IT use reported teacher characteristics such as philosophy of education, beliefs, background characteristics as well as access to, experience and confidence with technology as contributors to IT use. Evidence suggested that teachers who had a more constructivist teaching approach seemed to use IT more frequently than did teachers with less constructivist views (Becker, 2000; Becker, Ravitz & Wong, 1999; Ertmer, Gopalakrishnan & Ross, 2001; Fisher, Dwyer & Yocam, 1996; Miranda, 2007; Miranda & Russell, 2011). O’Dwyer, Russell and Bebell (2004, 2005), reporting on multilevel analyses of Use, Support and Effect of Instructional Technology (USEIT) data, indicated that a teacher’s beliefs about student-centered instruction were associated with several types of teachers’ uses of technology.

Beyond a constructivist philosophy, the literature identifies teachers’ beliefs about technology as a predictor of IT use. Seemingly, teachers who believe technology is valuable and beneficial for teaching and learning are more likely to use technology more frequently than are teachers who do not hold such beliefs (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Russell et al., 2003b). Teachers’ access to technology and experience and comfort level with technology are also mentioned as possible predictors of technology use (Becker et al., 1999; Guha, 2001; Miranda, 2007; Russell, O’Dwyer, Bebell & Tao, 2007).

At the teacher level, evidence indicates that there may be a relationship between and teachers’ background characteristics such as number of years teaching and educational background factors and frequency of IT use. Several authors reported that academic factors (e.g., educational level, selectivity of college attended and number of advanced courses completed) were some of the best predictors of teacher-directed student use of the Internet; technology use for administrative purposes; and for word processing (Becker, 2000; Becker et al., 1999; Becker & Riel, 2000; Guha, 2001; Mathews & Guarino, 2000; Russell et al., 2003b).
More recently, Mueller et al. (2008) reported that experience with technology, attitudes toward technology, and variables related to computer experience appear to discriminate between teachers who fully integrate technology into instruction and those who do not. Mueller et al. (2008) identified variables related to computer experience, such as comfort with technology and higher frequency of use of computers, as key discriminators between integrator and non-integrator teachers (p. 1532). At the elementary level, although Mueller et al. (2008) reported that training was a significant predictor of integration, they found that “task-relevant and classroom-applicable experience” (p. 1532) were more critical to integrations than was “general” training. The strongest predictor in the discriminating function was the incidence of positive outcomes experienced by teachers while integrating computers in the classroom. The authors add that experiencing positive outcomes with integration may increase teachers’ confidence as computer users and reinforce beliefs of the instructional potential of computers.

Despite the evidence pointing to several teacher-level factors as possible predictors of IT use to guide IT policy, IT use is not commonplace in American schools (Bebell & Kay, 2010; Cuban, 2001; Mueller et al., 2008). Perhaps the poor adoption rate stems from the fragmented style in which researchers provide evidence. Research has largely focused on factors in isolation, ignoring interactions among factors and the cumulative effect of interactions that may promote or hinder IT use in the classroom. A more cohesive analysis of classroom factors and their interactions is required to provide a comprehensive picture of what drives IT use in the classroom. To that end, Miranda (2007) developed a multilevel model depicting micro and macro-level factors that interact across classroom, school and district-levels of analyses to predict TDS. However, top-down macro-level approaches that characterized most of IT implementation efforts of the past two decades have yielded inconsistent results; therefore, there is a need to examine teacher-level factors related to IT use to facilitate the development of alternative approaches to increasing technology use in the classroom. Although findings presented herein originated from Miranda’s (2007) multilevel study also discussed in Miranda and Russell (2011), the focus of this paper is to present findings from the teacher-level model developed in the original multilevel analyses, aiming to inform district- and school-level leaders of possible strategies to increase technology use in elementary classrooms.

Using structural equation modeling (SEM) methodology, we developed the predictive model of TDS presented in this article to generate a path diagram depicting teacher-level factors that may contribute to TDS. These analyses aimed to answer the following questions: (1) Which teacher-level factors have the largest effect on a teacher’s instructional use of technology? (2) How do those factors interact to affect a teacher’s instructional use of technology?

The operational definition of IT use follows Bebell et al.’s (2004) teacher technology use framework, which defines IT as the use of digital or computer technologies (eg, computers, compact discs, digital video discs, liquid crystal display projectors, interactive media, Internet) for teaching and learning in the classroom. The outcome variable in this study is the TDS scale developed for the USEIT study, which we describe in detail in the methods section.

Method

Researchers collected data for this study as part of the USEIT study (Russell, Bebell, O’Dwyer & Miranda, 2003a). The USEIT study examined technology programs in three small urban, five rural and 13 suburban districts located in Massachusetts. The teacher sample consisted of 1040 elementary teachers (kindergarten to 6th grade) from 81 schools. Ninety-four percent of the teachers were female and 6% were male; 87% taught all subjects and the remaining 13% reported teaching a particular subject. Ninety-four percent of the teachers only taught one grade while 5% taught multiple grades, and 1% taught a combination of grades. Of the 1040 teachers
that only taught one subject. 14% taught kindergarten; 16% taught first grade; 18% taught second grade; 20% taught third grade; 19% taught fourth grade; and 13% taught fifth grade. At the time of data collection, 84% of the teachers had Internet access in the classroom, and 86% had computers in their classroom; 14% did not have access to computers in their classrooms but had access to computers in labs or libraries.

Data sources
The authors used as their data collection instrument the USEIT teacher survey, which included a large number of items focusing on a variety of issues related to IT. Researchers at Technology Assessment Study Collaborative (inTASC) developed a 330-item survey around 14 factors theorized to affect technology use. These factors were as follows: (1) district vision for technology, (2) school and district culture, (3) leadership, (4) technology resources, (5) technology support, (6) professional development, (7) technology policies and standards, (8) technology beliefs, (9) pedagogical beliefs, (10) equity, (11) community, (12) demographics, (13) physical infrastructure and (14) preparedness. Most items on the survey were Likert-scale items with three to five response options. Once survey data were entered, response options were coded on a scale from 1 to n; n denotes the number of response options for any given scale of items. Teacher-survey data were factor-analyzed using principal components. Twelve categories of scales emerged from those analyses (see Russell et al., 2003a). Analysts created thirty-one scales, nine of which we used in the analyses presented here. These items included among others are as follows: (1) the ways and frequency with which teachers used IT, (2) availability and participation in professional development related to IT, (3) beliefs about teaching, learning and IT, (4) obstacles to technology use, pressure to use IT and (5) resources and support for IT and (and) leadership.

The authors used the USEIT scale TDS in the Classroom, initially developed by Bebell et al. (2004), as the outcome variable in these analyses; it measures the extent to which students use technology in the classroom to complete work assigned by teachers. This scale included the following items: (1) how often do students work individually using computers?; (2) how often do students work in groups using computers?; (3) how often do students use a computer or portable writing device for writing?; (4) how often do students research/use the Internet or read-only memory compact discs?; and (5) how often do students use a computer to solve problems? The researchers used eight other scales from the USEIT teacher survey as possible predictors of TDS. Table 1 presents USEIT scales used and their respective reliabilities.

Analysis
The investigators used SEM to develop a path diagram predicting TDS. We selected SEM as the analytic technique because it offers flexibility in modeling relationships—ie, it allows variables to be outcomes and predictors in separate but interrelated equations (Hox, 2002; Kline, 1998).

<table>
<thead>
<tr>
<th>Type of variable</th>
<th>Use, support and effect of instructional technology scale</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>Teacher-directed student use of technology during class time</td>
<td>.84</td>
</tr>
<tr>
<td>Predictors</td>
<td>Beliefs about the breadth of technology benefits</td>
<td>.95</td>
</tr>
<tr>
<td></td>
<td>Teacher pedagogical beliefs</td>
<td>.63</td>
</tr>
<tr>
<td></td>
<td>Teacher confidence with technology</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td>Pressure to use technology</td>
<td>.78</td>
</tr>
<tr>
<td></td>
<td>Obstacles integrating technology into lesson plans</td>
<td>.62</td>
</tr>
<tr>
<td></td>
<td>Perceived need for professional development for the integration of technology</td>
<td>.73</td>
</tr>
<tr>
<td></td>
<td>Importance of computers for teaching</td>
<td>.79</td>
</tr>
<tr>
<td></td>
<td>Teacher’s experience with technology</td>
<td>.71</td>
</tr>
</tbody>
</table>
Analyses started with correlation analyses to investigate the strength of the relationships between TDS and other USEIT scales, and relationships among other predictor variables. To maximize the possible pool of predictors, a criterion of a minimum $r$ with an absolute value equal to .2 (Fraenkel & Wallen, 2003) with TDS was used to retain variables in analyses. Once we identified possible predictors of TDS in correlation analyses, we specified a hypothetical path model for teacher-level TDS based on findings from correlation analyses and prior research.

To assess model fit, we used overall fit indices such as the chi-square statistic ($\chi^2$) and the $\chi^2$/degrees of freedom ($df$) ratio. Since $\chi^2$ is sensitive to sample size, we also used the $\chi^2$/df ratio because it controls for large sample size bias. We used a criterion of three or fewer $\chi^2$/df to evaluate model fit (Byrne, 2001; Hoyle, 1995). We also used absolute indices to assess the amount of variance and covariance in the sample matrix explained by the specified model in comparison with the dependence model (Hoyle, 1995); they were the goodness of fit index ($GFI$) and the adjusted goodness of fit index ($AGFI$). We used incremental indices of fit, which assess the improvement the hypothesized model represents in comparison with the independence model; they were the normed fit index ($NFI$) and the comparative fit index ($CFI$). The $NFI$ tends to underestimate fit in small samples; therefore, we also used the $CFI$. In addition to the fit indices described above, we used the root mean error of approximation ($RMSEA$). The $RMSEA$ index measures the discrepancy between the hypothesized model and the population covariance matrix specified with optimal parameter values (Byrne, 2001, p. 84). Table 2 presents evaluation criteria for fit indices used to assess model fit.

When fit indices suggested that respecification would achieve improvements in model fit, we used modification indices provided by AMOS to guide model respecification. We repeated this process of modifying the model and examining fit indices until they obtained an adequately fitting teacher-level model for TDS.

### Results

The questions this study aimed to answer were as follows: (1) which teacher-level factors have the largest effect on a teacher’s instructional use of technology? and (2) how do those factors interact to affect a teacher’s instructional use of technology? To answer these questions, we hypothesized a preliminary model and evaluated its fit. Figure 1 presents the preliminary model for TDS.

The Preliminary TDS Model had eight variables, was identified with 36 observations, 29 paths to be estimated and seven $df$. Table 3 presents fit indices for the Preliminary TDS Model.

Fit indices for the Preliminary TDS Model indicated that that estimating additional parameters could improve model fit; the following indices did not meet the established criteria for accepting a model: $\chi^2$, $\chi^2$/df and $RMSEA$. We used modification indices provided by AMOS to modify the model; Table 4 presents these indices.
As is displayed in Table 4, modification indices for the Preliminary TDS Model indicated that specifying additional correlations between error terms would improve model fit. For example, modification indices indicated that model fit would improve if we specified a correlation between the errors of obstacles integrating technology into lessons (INTEGRATEOBS) and need of professional development for integration (INTEGRATEPD). Similarly, we could obtain a 7-point decrease in the $\chi^2$ by specifying a correlation between the errors of pressure relating to the use of technology (TECHPRESSURE) and teachers’ confidence using computers (TEACONFI). However, we opted to specify paths between the two scales rather than between errors to more

<table>
<thead>
<tr>
<th>Model</th>
<th>Chi-square</th>
<th>Degrees of freedom</th>
<th>P</th>
<th>Chi-square/degrees of freedom</th>
<th>Goodness of fit index</th>
<th>Adjusted goodness of fit index</th>
<th>Normed fit index</th>
<th>Comparative fit index</th>
<th>Root mean error of approximation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary classroom-level TDS model</td>
<td>38.25</td>
<td>9</td>
<td>.005</td>
<td>4.25</td>
<td>.99</td>
<td>.97</td>
<td>.96</td>
<td>.97</td>
<td>.054</td>
</tr>
</tbody>
</table>

TDS, teacher-directed student use of technology.

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accurately reflect the relationships in the data. We respecified the model by adding the two following paths: (1) INTEGRATEOBS to need of INTEGRATEPD and (2) TECHPRESSURE to TEACONFI. Figure 2 presents the Final TDS Model.

The final model consists of eight variables, which we modeled as having direct effects on TDS; they are obstacles integrating technology into lesson plans, teacher’s experience with technology, TECHPRESSURE, pressure relating to the use of technology; TEACONFI, teachers’ confidence using computers; INTEGRATEOBS, obstacles integrating technology into lessons; INTEGRATEPD, professional development for integration; EXPTECH, teacher’s experience with technology.
perceived importance for computers for teaching, perceived pressure to use technology, and beliefs about the breadth of technology benefits. In addition, we modeled two scales—perceived need for INTEGRATEPD and TEACONFI—as indirect effects associated with TDS. The indirect effect of perceived need for INTEGRATEPD occurs through beliefs about the breadth of technology benefits and TEACONFI while the indirect effect of TEACONFI occurs through perceived importance for computers for teaching. We hypothesized direct effects between predictor scales, for example, between perceived pressure to use technology and three other predictor scales—beliefs about the breadth of technology benefits, TEACONFI and teacher’s experience with technology. We also modeled direct effects between beliefs about the breadth of technology benefits and perceived importance for computers for teaching, and between TEACONFI and perceived importance for computers for teaching.

Description of model characteristics for final teacher-level model

The model was a recursive model with 36 estimated observations and 29 estimated paths. The final model was identified and it had seven df. Table 5 presents fit indices and squared multiple correlations ($R^2$) for variables in the model.

Fit indices indicated that the final model was a good fitting model. The $\chi^2$ statistic was relatively small ($\chi^2 = 7$) and non-significant ($p = .47$). The $\chi^2/df$ was only $.95$, leading analysts to conclude that the observed covariance matrix and the implied covariance matrix were statistically identical: the GFI and AGFI were 1.00, both of which are greater than the recommended .9 threshold; the CFI and NFI yielded close to perfect values (.99 and 1.00 respectively); and the RMSEA was 0.

The $R^2$ for the outcome variable TDS was .19, which means that the model explains 19% the variance in TDS. The model also explains 33% of the variance in perceived importance for computers for teaching, 18% of the variance in the confidence variable, and 13% of the variance in beliefs about the breadth of technology benefits. Typically, analysts would want the variance explained by the model to exceed 20% (Fraenkel & Wallen, 2003); the goal of analyses presented here was not to explain variance but develop a model that closely replicated the covariance matrix in the elementary teacher data. Fit indices suggested a close fit between the observed covariance matrix and the implied covariance matrix. One may conclude that the TDS model is a good representation of the data. The model also explains a moderate amount of the variance in the beliefs, confidence and importance variables, all of which are important constructs to drive innovation use (Miranda, 2007; Miranda & Russell, 2011; O’Dwyer et al., 2004, 2005).

Table 6 shows standardized direct, indirect and total effects, which can be interpreted and standardized regression coefficients obtained for the final teacher-level TDS model.

Standardized total effects of the predictor variables on the outcome variable TDS use of technology ranged in absolute value from .11 to .29. Using Kline’s (1998) effect size evaluation criteria, one may classify the total effects of USEIT teacher-level predictor variables on TDS as medium size effects. The variable that had the largest total positive total effect associated with TDS was beliefs about the breadth of technology benefits with a total effect of .25, followed by teacher’s experience with technology ($\beta = .20$), perceived pressure to use technology ($\beta = .20$), obstacles integrating technology into lesson plans ($\beta = -.20$), and perceived importance for computers for teaching ($\beta = .11$). These suggest that a one-point increase in one of the predictor variables is associated with a .11–.25 standard deviation increase in TDS. For example, a one-point increase in the beliefs’ variable may result in a .25 standard deviation increase in TDS. In contrast, the variable that had the largest negative effect on TDS was perceived obstacles integrating technology into lesson plans ($\beta = -.20$), suggesting that a one-point increase in perceived INTEGRATEOBS may result in a .20 standard deviation decrease in TDS.
### Table 5: Fit indices and squared multiple correlations for final teacher-level TDS model

<table>
<thead>
<tr>
<th>Fit Indices</th>
<th>Chi-square</th>
<th>Degrees of freedom</th>
<th>P</th>
<th>Chi-square/degrees of freedom</th>
<th>Goodness of fit index</th>
<th>Adjusted goodness of fit index</th>
<th>Normed fit index</th>
<th>Comparative fit index</th>
<th>Root mean error of approximation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final teacher-level TDS model</td>
<td>6.64</td>
<td>7</td>
<td>.47</td>
<td>.95</td>
<td>.99</td>
<td>.99</td>
<td>.98</td>
<td>1.00</td>
<td>0</td>
</tr>
</tbody>
</table>

**Squared multiple correlations (R²) for variables in the model**

<table>
<thead>
<tr>
<th>Variables</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers’ perceived importance of computers for teaching</td>
<td>.33</td>
</tr>
<tr>
<td>Teacher-directed student use of technology</td>
<td>.19</td>
</tr>
<tr>
<td>Teachers’ confidence using computers</td>
<td>.18</td>
</tr>
<tr>
<td>Beliefs about the breadth of technology’s benefits</td>
<td>.13</td>
</tr>
<tr>
<td>Teacher’s experience with technology</td>
<td>.04</td>
</tr>
<tr>
<td>Perceived need for professional development for integration</td>
<td>.02</td>
</tr>
<tr>
<td>Obstacles integrating technology into lessons</td>
<td>.00</td>
</tr>
<tr>
<td>Pressure relating to the use of technology</td>
<td>.00</td>
</tr>
</tbody>
</table>

TDS, teacher-directed student use of technology.
The most noteworthy relationship found among predictors was the total effect teacher’s experience with computers on perceived importance of technology for teaching ($\beta = .42$). This effect, which one may consider large using Valentine and Cooper’s (2003) criteria, suggests that a one-point increase in teacher’s experience with computers may result in a .42 standard deviation increase in perceived importance of technology for teaching.

Another relevant association of teacher’s experience with computers is that with teacher’s confidence using technology ($\beta = .36$), suggesting that a one-point increase in experience with technology may result in .36 standard deviation increase in teacher confidence. Note that .10 of the total effect of teacher’s experience with technology and perceived importance of computers for teaching ($\beta = .42$) is an indirect effect through teacher confidence with technology. Teacher confidence with technology is a moderator between teacher experience and perceived importance of technology for teaching; that is, teacher confidence interacts with teacher experience to increase or decrease the extent to which teachers perceive technology as important for teaching. This suggests that teachers, who have more experience with technology, may feel more confident of their technology skills and may perceive computers as more important for teaching than do teachers who are less experienced and less confident.

Results also suggest an association between teacher confidence using computers and the extent to which teachers perceive the importance of technology for teaching ($\beta = .34$) and between perceived need for INTEGRATEPD and beliefs ($\beta = .27$). Conversely, perceived INTEGRATEOBS appears to have a negative total effect on other predictors of TDS, namely, teacher confidence ($\beta = -.25$) and teacher beliefs about the benefits of technology ($\beta = -.26$).

**Discussion of findings**

Despite billions of dollars spent on technology over the course of the past two decades, evidence suggests that technology use in the classroom is not as extensive as the exponential increase in

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Results also suggest an association between teacher confidence using computers and the extent to which teachers perceive the importance of technology for teaching ($\beta = .34$) and between perceived need for INTEGRATEPD and beliefs ($\beta = .27$). Conversely, perceived INTEGRATEOBS appears to have a negative total effect on other predictors of TDS, namely, teacher confidence ($\beta = -.25$) and teacher beliefs about the benefits of technology ($\beta = -.26$).

**Table 6: Standardized effects of predictor variables on teacher-directed student use of technology (TDS) for final classroom-level TDS model**

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perceived accountability to use technology</td>
<td>.07</td>
<td>−.19</td>
<td>.07</td>
<td>−.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Experience with technology</td>
<td>−.07</td>
<td></td>
<td>(.02)</td>
<td>−.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Perceived obstacles to integrating technology into lesson plan</td>
<td>.33</td>
<td>−.12</td>
<td>(.03)</td>
<td>−.25</td>
<td>.36</td>
<td>−.25</td>
<td>−.12</td>
</tr>
<tr>
<td>4. Confidence using technology</td>
<td>.01</td>
<td>.15</td>
<td>(.08)</td>
<td>(.08)</td>
<td>.01</td>
<td>−.08</td>
<td>.07</td>
</tr>
<tr>
<td>5. Perceived need for professional development for technology integration</td>
<td>.16</td>
<td>.06</td>
<td>(.04)</td>
<td>−.16</td>
<td>.11</td>
<td>.27</td>
<td>(.04)</td>
</tr>
<tr>
<td>6. Beliefs about the breadth of technology’s benefits</td>
<td>.30</td>
<td>.33</td>
<td>(.12)</td>
<td>−.16</td>
<td>.34</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>7. Perceived importance of technology for teaching</td>
<td>.15</td>
<td>.14</td>
<td>(.05)</td>
<td>−.11</td>
<td>.23</td>
<td>.11</td>
<td></td>
</tr>
</tbody>
</table>

*Direct effects (indirect effects), total effects. Bold numbers are medium and large effects.

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expenditures may imply (Bebell & Kay, 2010; Cuban, 2006). The ubiquitous use of technology in contemporary society and its economic importance dictates that American students become proficient and critical users of technology; we can only achieve this if students use technology in the classroom. The purpose of this study was to identify factors that affect teacher-directed student use of technology (TDS) in elementary classrooms. The investigators developed a SEM model to examine relationships among teacher-level factors to predict TDS.

Similar to findings reported by O’Dwyer et al. (2004, 2005), classroom-level analyses presented here suggest that teachers, who believe technology is beneficial for a broader range of instructional purposes, seem to lead their students to use technology more often than teachers who believe technology is beneficial for a narrower variety of purposes. Additionally, teachers who perceive that technology is important for teaching appear to direct their students to use technology in the classroom more often than do teachers who do not have the same perception. Similarly, teachers who are experienced with technology seem to lead their students to use technology more often than teachers who are not experienced with technology. As reported by O’Dwyer et al. (2004), accountability to use technology appears to be a moderate contributor to TDS. Teachers, who perceive that they are accountable for technology use, appear to direct their students to create products using technology more often than do teachers who do not perceive the pressure.

Results presented here are notable in that they unveiled relationships among predictors of TDS. Among the most noteworthy is the large effect between teacher experience with technology and perceived importance of technology for teaching. The implication of this finding is that, as teachers use technology more often, they begin to value technology more as an instructional tool and as their perceived importance of IT for instruction increases; they are more likely to guide their students to use technology.

The association found between teacher experience with technology and teacher confidence with technology is also relevant. Results suggest that teachers who have more experience with technology tend to be more confident users of technology than are less experienced teachers. More importantly, findings from this study suggest that confidence maybe a moderator between experience and perceived importance of technology for teaching. Teacher confidence appears to interact with teacher experience to enhance the extent to which teachers view technology as a valuable teaching tool. Experienced teachers may be more confident technology users than less experienced teachers; as they research and implement new IT strategies into their lessons, their value for IT increases as they experience and observe IT’s benefits.

Despite the positive effect of most variables studied here on TDS, remarkably obstacles integrating technology into lesson plans appears to have a detrimental effect on technology use. Obstacles integrating technology into lesson plans also appears to have adverse effects on TEACONFI, beliefs about the breadth of technology’s benefits and perceived importance of computers for teaching. This implies that teachers’ beliefs decrease as they experience problems integrating technology into their lessons and that their confidence using technology also decreases; this combined effect may reduce their frequency of use and, in time, their experience with technology.

Similar to findings and commentary provided by Ertmer (2005) and Ertmer & Ottenbreit-Leftwich (2010) one of the important lessons yielded from this study is perhaps the need to increase teachers’ beliefs about the breadth of benefits offered by IT and teachers’ perceptions about the importance of technology for teaching. It may be necessary to provide professional development opportunities to strengthen these two constructs before educational leaders enforce top-down measures. Parallel to what Surry and Farquhar (1997) posit in terms of using both micro-level and macro-level approaches to increasing technology use, these findings imply that closer attention is needed to change teachers’ beliefs and values about technology innovations before their implementation in the classroom.
From policy and technology planning perspective, results presented here also point to the need for schools and districts to focus on decreasing obstacles related to technology integration. It appears that those obstacles are not only detrimental to TDS but also to other noteworthy drivers of use such as beliefs, importance allotted to technology as an instructional tool and teacher confidence using technology. Again, this implies that a cohesive approach technology implementation whereby efforts are made to increase beliefs and the importance of technology and where technology support, perhaps in the form of integration specialists and professional learning communities, assist teachers in designing and implementing technology integrated lesson plans. Aligned with Rogers’ (1995) diffusion model, these models of use could come from other teachers whom other teachers respect as opinion leaders. Models of use may also come from change agents working on behalf of the district (eg, technical support personnel, integration specialists, administrators).

Although the study presented here used sophisticated statistical modeling to develop a predictive model, it has its limitations. Results presented here are not generalizable to the population of elementary teachers as the sample was limited to one state and to, for the most part, suburban school districts. Results may also be limited because of measurement error introduced by self-report measures and by common method variance, resulting when one obtains both the predictor and outcome variables from a single measurement instrument. Other factors not present in the USEIT data could, if included, explicate additional variance in the data. Results presented here focus only on TDS; it is essential to examine factors associated with teachers’ use of technology for other instructional purposes. Additionally, it is necessary to study processes of engagement between students and teachers and factors in that dyadic that contribute or hinder technology use. We recommend that others conduct further research to evaluate other types of teachers’ use of technology using samples that are more representatives of the population; examine factors in teacher-student engagement dyads; and use various instruments and measurement methods to measure outcome and predictor variables.

This study offers a more comprehensive understanding of what drives IT use in the classroom than previous studies. More importantly, this study suggests that increasing the use of IT is not limited to a list of factors that individually contribute to affecting technology use in the classroom. Rather, results presented here point to the necessity of cohesive implementation plans that are crafted with not only macro-level needs in mind—ie, those of IT developers, policymakers and administrators—but also pay close attention to the needs of adopters—the teachers who use IT in the classroom.

Notes
1. Note that we define diffusion factors as constructs that contribute to the diffusion of an innovation.
2. The term effect is used here and throughout this paper to signify a directional relationship from a predictor variable to an outcome variable. The term is used to be consistent with the terminology used in SEM and is, therefore not indented to connote cause and effect.
3. According to Byrne (2001) Modification indices (MI) “reflect the extent to which the hypothesized model is appropriately described” (p. 90) and to what extent analysts may improve the model by specifying additional parameters. AMOS provides a MI for each fixed parameter, which represents the expected $\chi^2$ drop if analysts specify a parameter.

References

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