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# What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms?

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## Abstract

Based on a comprehensive study of 94 classrooms from four states in different geographic regions of the country, this quantitative study investigated the impact of seven factors related to school technology (planning, leadership, curriculum alignment, professional development, technology use, teacher openness to change, and teacher non-school computer use) on five dependent measures in the areas of teacher skill (technology competency and technology integration), teacher morale, and perceived student learning (impact on student content acquisition and higher order thinking skills acquisition). Stepwise regression resulted in models to explain each of the five dependent measures. Teacher technology competency was predicted by teacher openness to change. Technology integration was predicted by teacher openness to change and the percentage of technology use with others. Teacher morale was predicted by professional development and constructivist use of technology. Technology impact on content acquisition was predicted by the strength of leadership, teacher openness to change, and negatively influenced by teacher non-school computer use. Technology impact on higher-order thinking skills was predicted by teacher openness to change, the constructivist use of technology, and negatively influenced by percentage of technology use where students work alone. Implications for the adoption and use of school technologies are discussed.


*Keywords:* Technology integration; Teacher education; Improving classroom teaching; Teacher morale; Technology literacy

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## 1. Introduction

Identifying the value of technology in schools has challenged educational researchers for more than 20 years. Part of the problem is our evolving understanding of how technology accentuates student learning. Rapid changes in the technology itself also hamper research. Finally, the intertwining of complex variables in such a rich environment as a school precludes the pure isolation necessary to determine cause and effect.

Over the past decade, many articles have appeared in popular and educational journals providing anecdotal evidence of changes that educational technology can make in schools. Even though other empirical articles have provided quantitative and qualitative evidence of these changes, most schools rarely base their technology decisions on specific published research findings. Instead, school leaders often start by thinking about the intended *results* that technology should provide within their school environment. Next, these leaders take certain *actions* regarding the attainment, allocation, use, and support of technology. Consequently, this study was framed to consider the question "What actions can school personnel take that most effectively lead to their desired results regarding the integration of technology in schools?"

We considered seven factors (planning, leadership, curriculum alignment, professional development, technology use, teacher openness to change, and teacher non-school computer use) and five outcomes in the areas of teacher skill (level of teacher technology competency and technology integration), teacher morale, and perceived student learning (impact on content acquisition and impact on higher order thinking skills). While there undoubtedly are a large number of possible variables that may affect the complexity of technology integration within the schools, we limited our factors to those that were most supported in the literature while including both teacher-related and school-related factors. Data was collected through structured interviews with teachers and administrators, teacher surveys, and examination of school technology use plans. In the next sections, we discuss the previous research and literature that led us to define the seven factors and five outcomes used in our study. We begin with the seven independent variables.

### *1.1. Technology planning*

Schools that are successful in integrating technology into the curriculum are often guided by a comprehensive technology use plan (TUP). These plans do more than provide a blueprint to the sequence of events the school hopes to achieve. The plans also describe the overall philosophy of technology use and explore how technology will improve teaching and learning.

In this study, technology planning was operationalized from the *teacher's* perspective to include the teacher's role in creating the technology use plan, familiarity with the published vision, and the belief that the plan considers his/her needs. From the *administrator's* perspective, it was operationalized to include three components: strategic, teaching/learning and operational. In terms of the strategic component, this included the extent to which the plan stated a vision and involved stakeholders, which may be the most important action regarding technology planning (Anderson, 1996). The teaching and learning component of the TUP covered instructional innovation. The operational component of the TUP included technology maintenance and support, the presence of an action plan and timeline, and facility infrastructure, configuration, and funding issues. Also included were the extent to which technology decision are based on the official TUP, the extent to which records are kept regarding the type and number of technology activities, and the extent to which purchase and use of technology has closely followed the details as described in the TUP.

### 1.2. Technology leadership

Although grass-roots movements within schools can be successful, more common in technology-enhanced learning environments are leaders who have the leadership ability and vision to direct changes. Modeling technology use, planning and articulating a vision, rewarding teachers as they strive to incorporate technology, and sharing leadership are common characteristics of successful technology leaders. The leadership underlying a school is of critical importance because the school culture begins to reflect new ways of teaching and learning (Maurer & Davidson, 1998). An important component of this change is a school leader who is dedicated to fostering a new culture with shared leadership and technology use.

In this study, technology leadership was operationalized from the *teacher's* perspective to include the presence of positive technology-using role models, such as the principal, and the presence of incentives for teacher use of technology. From the *administrator's* perspective, it was operationalized to include the principal's ability and work with the school community to formulate, articulate, and communicate a school's vision (Dede, 1994; Raizen, Sellwood, Todd, & Vickers, 1995; Rhodes, 1994; Sergiovanni, 1995). The principal's use of technology is also included as part of the leadership component since principals foster credibility and respect by engaging in technology activities such as communicating to the staff via email, demonstrating the use of desktop presentation to the faculty, showing a student how to keep a writer's journal with a word processing program, or describing a technology-enhanced teaching strategy (Maurer & Davidson, 1998). Further, the principal's belief that technology can be integrated into teaching and learning, the participation of the principal in school technology training sessions, and the evaluation of faculty and/or school in reaching stated technology goals are also factors. The extent to which the schools' technology knowledge and leadership is shared by a variety of faculty is also important given that a successful technology leader shares leadership by empowering other school members (Maurer & Davidson, 1998). Also included in the operational definition were the vision of the technology use plan to promote technology for teaching and learning, and the presence of an action plan and timeline within the technology use plan.

### 1.3. Curriculum alignment

Given that a school's curriculum provides instruction that results in student progress towards the stated learning objectives, it would follow that technology activities should be aligned to that curriculum. A variety of researchers conducting meta-analyses (e.g., Kulik, 1994; Liao, 1992; Ryan, 1991) have found that technology can improve scores on national and state tests. But when the technology is aligned to support specific curriculum goals, the increase in student capabilities may not appear in national standardized test results.

In this study, curriculum alignment was operationalized from the *teacher's* perspective to include teacher perception as to whether technology activities are covered through the curriculum documents.

### *1.4. Professional development*

Regardless of the amount of technology or its sophistication, technology will not be used unless faculty members have the skills, knowledge, and attitudes necessary to infuse it into the curriculum. Generally this comes through self-education or professional development. Schools can assist by providing in-service training that meets the needs of the faculty, and by promoting continual growth both within and outside the school boundaries.

Professional development was operationalized from the *teacher's* perspective to include the applicability of the professional development programs, incentive provided to attend programs, access to technical support, and appropriateness of technology equipment. From the *administrator's* perspective, it was operationalized to include the extent to which the school supports faculty to attend workshops or conferences, the listing of professional development activities in the TUP, and the support of school activities to learn to use technology. The latter is important given that teachers require prolonged exposure to new ideas and skills before classroom behaviors change. It has been found that for teachers to feel in command of educational technologies and to know when and how to use them, it can take as long as five to six years (Brunner, 1992; Elmer-Dewitt, 1991). In addition, Rubin (1989) found that the extent to which teachers assist in determining in-service technology training topics relates to how well they embrace the concepts delivered during the workshop. Given that there are varying abilities and knowledge of faculty in a school, seldom will there be agreement on the need for any one in-service topic; consequently, the best strategy would be to identify multiple topics and then involve only people who have needs in the specified content domain (Picciano, 1998). The presence of incentives for incorporating technology was also considered as part of professional development.

### *1.5. Technology use*

Once schools obtain technology, questions arise as to how best to use it. Some schools opt to place computers in labs, whereas others use group techniques in the classroom. Some teachers focus on learning *about* computers while others focus on learning *with* computers. Even when teachers focus on learning with computers, some limit the use of technology to helping students learn basic skills whereas others stress higher order thinking.

There is a basic dichotomy in which the computer is used as the subject matter for study or as an instructional tool to teach other content. About half the time students spend on computers involves learning "computer-specific skills" such as keyboarding, and spreadsheets (Becker, 1991; President's Panel on Educational Technology, 1997). For this study, technology use was delineated according to nine subcomponents, each of which were considered separately in the regression models: (1) how often technology was used for preparing for or during classroom instruction; (2) the percentage of time that subject-matter content was the focus of the technology use; (3) the percentage of time that higher order thinking skills (HOTS) were the focus; (4) the percentage of time technology literacy was the focus; (5) the percentage of time technology was used alone by students, responding to questions, (6) the percentage of time technology was used alone by students, creating; (7) the percentage of time technology was used with others; (8) the percentage of constructivist use of technology; and, (9) the perceived success of technology use by teachers.

### 1.6. Teacher openness to change

Teacher openness to change influences teachers' willingness to integrate technology into the classroom. Although it is generally viewed as an internal prerequisite to success, it is closely tied to external factors such as professional development and a supportive climate. Although an attitude of openness to change facilitates a teacher's acceptance of technology, critical to this acceptance is the need to see relevance in the process.

In terms of the propensity for innovation, Marcinkiewicz (1994) found that self-competence and innovativeness were most closely related to the level of computer use, concluding that more research is necessary to further quantify the role of teacher motivational factors. Pedagogical approach is also related to teacher innovation. Niederhauser and Stoddard (1994) conducted a quantitative investigation of the relationships between constructivist teaching style, the use of constructivist-oriented software, and teacher beliefs about technology. Results split along two lines: teachers who saw computers as a tool to be used in collecting, analyzing and presenting information (correlating with the constructivist approach) and those who saw them as teaching machines (correlating with a behaviorist approach). The former were deemed to be more innovative with technology in the classroom.

Based on this research, in this study teacher openness to change was operationalized from the *teacher's* perspective to include predisposition for trying new instructional innovations, and the belief that they can take risks in teaching. From the *administrator's* perspective, teacher openness to change was operationalized to include whether the technology use plan promotes instructional innovation with technology implementation.

### 1.7. Teacher non-school computer use

The extent to which teachers use technology outside of the classroom may be an indicator of their interest and corresponding skill in using technology. Evan-Adris (1995) identifies three patterns of technology use among teachers. The first is "avoidance", including teachers who assign computer time to the students but do not use the technology for their own purposes. The second pattern she labels "integration" and these teachers spend time experimenting with and learning to use hardware and software and structure learning time to promote effective and increased use of technology by their students. The third pattern is "technical specialization" and includes teachers who have strong computing skills and their use of the computer is more organized and purposeful than average teachers. These classifications, which indicate the effectiveness of teacher technology use, are indirectly supported by the amount of *non-school* computer-use in which the teacher is engaging.

Teacher non-school computer use was operationalized in this study from the *teacher's* perspective to include the number of times technology (e.g. word processing, database, spreadsheet, graphics, multimedia, telecommunications) was used at home for non-school activity.

## 2. Outcome measures

In the previous sections, we examined the factors that may determine the success of technology in a classroom. But what are the areas that schools want to *impact*? The dependent measures are explained in the next sections. Note that several of the factors described previously could be considered interchangeably with the desired outcomes (e.g. it could be argued that high teacher morale should be an independent variable that affects the degree of success in using technology). However, the factors were purposely selected to serve as predictors, and the outcome measures as dependent variables.

### 2.1. Impact on content acquisition

Teachers assess students frequently during the course of a year. Often this assessment is based on the amount of knowledge that a student can demonstrate. This focus on content originates from two areas—most teachers were educated by teachers who focused on content acquisition (and teachers tend to teach the way they learned), and schools are increasingly being held accountable for students' performance on factual recall. In response to this perceived need, the majority of technology-based instruction has focused on the acquisition of factual information rather than on higher-order thinking and problem-solving (Grabe & Grabe, 1998). However, this focus on factual knowledge is not spread evenly across all demographic groups (George, Malcolm, & Jeffers, 1993). Teachers of less able and lower-SES students are more likely to use technology for drill and practice of isolated skills such as math facts, phonics, and grammar rules, or tutorials. In this way technology serves as an effective way to provide remediation when it is assumed that basic skills and knowledge are missing.

Impact on content acquisition was operationalized from the *teacher's* perspective to include the relative impact/importance of technology in terms of the content acquisition, in other words, the extent to which the use of technology added to the class performance in content acquisition. From the *administrator's* perspective, it was operationalized to include the role of the Technology Use Plan's vision in promoting technology for teaching and learning, and the reflection of the plan in describing the use of technology by students to enhance learning based on current knowledge of cognition.

### 2.2. Impact on HOTS

Computer technology may also serve as a cognitive tool by supporting, guiding, and extending the thinking processes of students (e.g. Lajoie & Derry, 1993). When used as a tool to help students analyze, compare, contrast, or evaluate resources, the computer facilitates the student's internal cognitive processes by serving as an extension to their intellectual capacity. This heightened capacity helps students think more critically as they manipulate information. Traditional teaching tends to focus on imparting skills and knowledge that have been found to play an important role in creating an educated society. Today, however, many educators are stating the need to go beyond the basics to prepare our students for a life that will be drastically different from that which the educator experienced. These educators stress the need for students to become creative problem-solvers, able to analyze a wealth of information to draw valid conclusions. These higher-order thinking skills were sometimes alluded to in traditional teaching, but have been more commonly associated with teaching styles developed in the past two decades. Salomon (1986) suggests that computers may be the ideal mechanism for teaching higher order thinking skills, and other researchers are beginning to validate that claim.

Impact on HOTS was operationalized from the *teacher's* perspective to include the relative impact/importance of technology in terms of higher order thinking (i.e. thought processes); specifically, the extent to which the use of technology added to the class performance in higher order thinking. From the *administrator's* perspective, it was operationalized to include the role of the technology use plan's vision in promoting technology for teaching and learning, and the reflection of the technology use plan on current knowledge of cognition in describing the use of technology by students.

### 2.3. Technology integration

The way in which technology is used in a classroom is a critical measure of its success. As stated by the Office of Technology Assessment (1995, p. 57), "...it is becoming increasingly clear that technology, in and of itself, does not directly change teaching or learning. Rather, the critical element is how technology is incorporated into instruction." When students and teachers perceive computers as a separate subject, unassociated with the context of the lesson or classroom, the content or concepts studied are often left fragmented in the learner's mind. But if a technology-enhanced lesson is integrated into the larger curriculum with direct tie-ins, students are more likely to infuse the knowledge into existing cognitive structures. Technology integration requires teachers to alter their teaching processes, no longer being the sole distributor of information. This change in role requires support from many sources in order for the teacher to make the transition.

Given that the integration of technology in education should have the goal of changing the nature of instruction rather than just using technology to perpetuate traditional teaching and learning methods (Hawkins & Collins, 1992), technology integration was operationalized from the *teacher's* perspective to include the extent to which the use of technology fits into the overall unit of instruction, whether there are transitions before and after the activity with the rest of instruction, and the extent to which technology use is not a separate activity from other instructional activities.

### 2.4. Level of teacher morale

Because technology opens new avenues for instruction, and because its use is often linked to professionalism, some schools have intended for technology implementation to improve teacher morale. Hadley and Sheingold (1993) conducted a survey of 608 teachers in 576 schools throughout the country that were known for their efforts to integrating computer technology into their teaching. They found that when teachers were asked to identify incentives for integrating computers in their teaching, two trends emerged: student accomplishment, rather than their own external rewards, was most motivating for the teachers, followed by students' being able to use computers as a tool for their own purposes. As they state, "in the daily professional life of these teachers, it is the psychic payoff of student's learning and engagement that appears to matter most" (p. 281). Teachers also cited increased self-esteem, through recognition, advancement, development, and financial reward, as a motivating factor. When asked to identify barriers, three factors were considered as barriers in the past and persisted as barriers: too few computers and peripheral equipment, not enough time to prepare computer-based lessons, and challenges with scheduling enough computer time for different teachers' classes.

In this study, teacher morale was operationalized from the *teacher's* perspective to include enjoyment of using technology, perception of colleagues' morale regarding technology use, opportunities for collegial sharing of technology ideas and uses, satisfaction with work environment, and extent to which the position provides professional growth and is satisfying. From the *administrator's* perspective, it was operationalized to include the extent to which faculty are rewarded for intent to use technology, the promotion of innovation/creativity within the technology use plan, specific plans for teacher technology maintenance and support, and incentives to participate in professional growth and for incorporating technology as stated in the technology use plan.

### *2.5. Level of teacher technology competency*

Because technology in education is a relatively new phenomenon, most veteran teachers were not technologically proficient when they entered the profession. Yet to effectively broaden the range of instructional opportunities that can be offered to students, teachers must reach and maintain a certain degree of technological competence. Additionally, technology competency allows them to become more efficient in dealing with everyday tasks such as communicating with parents, keeping records, doing research in their subject domain, and preparing presentations. A 1997 report by the Present's Committee of Advisors on Science and Technology (PCAST) found that teachers currently receive little technical, pedagogical, or administrative support and that few colleges of education adequately prepare their graduates to use educational technologies in their classrooms. One of the biggest obstacles to teacher technology proficiency has been the lack of technology training in teacher education program. Teachers commonly report that they have not received adequate preparation to effectively use computers in the classroom (Office of Technology Assessment, 1995).

Teacher technology competency was operationalized to include teacher-perceived confidence in the following areas: using a variety of software programs (e.g. word processing, database/spreadsheet, email, internet), file management, solving general software or hardware problems, use of terms associated with computers, identifying and explaining basic computer components, operating technology equipment, selecting and implementing appropriate technology to support curriculum, incorporating technology (e.g. telecommunications, word processing, spreadsheets, computer based presentations, email, and the Internet) in instruction, and teaching students to use technology (e.g. graphics, internet, word processing, spreadsheets/databases, electronic encyclopedia, and use of appropriate vocabulary).

Considering all of these factors and outcomes together, the primary research question is as follows: Which combination of factors best predicts each of the five desired outcomes?

## 3. Methods

### *3.1. Sampling*

Through purposive sampling we selected schools that were known to be effective users of technology. A set of highly technology-integrative schools was nominated from each of four regions of the country by expert researchers. Specifically, we selected public schools that met the following requirements: (1) the school made a significant effort to implement technology for at least 2 years across many, if not all, of its classes; (2) the key administrator had been in place since the previous year and intended to be there the following year; (3) selected members of the teaching staff were willing to cooperate with data collection activities during the spring and fall; and, (4) the school had implemented a technology use plan.

From this process, 12 schools were selected: five from California, two from Florida, three from Virginia, and two from the state of Washington. In return for their assistance, the schools were provided with a grant for the purchase of instructional materials and a report of the data collected from the school.

Of the 12 schools, five were urban, four were suburban, and three were in rural settings. The percentage range of white to non-white students ranged from 5 to 95% with the mean percentage of non-white students as 32%. Five of the schools were elementary, five were middle schools, and two were high schools. Once the schools were selected, the principal of the school provided the researchers with a list of classrooms meeting the three following requirements: (1) the teacher is the primary provider of instruction (not part of a teaching team); (2) the teacher is using technology in teaching; and, (3) the teacher has been teaching the class since at least the prior school year and is intending to teach at the school through the next year.

From this list of classrooms, we selected at random 10–12 classrooms for each school. Following this, the principal asked each of the randomly selected teachers whether they would be willing to participate. If a teacher declined to participate, a replacement from the pool was randomly selected, until there were at least 10 participating teachers per school.

The resulting sample included a total of 94 teachers and correspondingly 94 classrooms from the 12 schools, with the classroom as the unit of study.

### 3.2. Instrumentation

Given that there were no existing instruments that matched the sources of the data with the independent and dependent variables, we developed four new instruments to collect school, classroom, teacher, and administrator information. The four instruments included the following: administrator structured interview, teacher structured interview, technology use plan evaluation, and teacher survey. Each instrument was created to consist primarily of Likert items on a five-point scale. As appropriate, each instrument was evaluated by a panel of experts for content validity, reliability, and usability, as will be described below. Triangulation was an important component to gather data from multiple sources to gain multiple perspectives. See Table 1 that shows by shading which variables were covered by each instrument.

#### 3.2.1. Administrative interview

A structured interview was conducted and tape recorded with each chief school administrator to gather information regarding the following variables, as shown in Table 1: technology planning, leadership, professional development, and teacher morale. The transcripts of all of the interviews were then analyzed and scored by one researcher. A sample question from the scoring instrument follows: "The principal believes technology has the potential to be transparently infused and integrated into the entire spectrum of teaching and learning. (1—strongly disagree; 2—disagree; 3—neutral; 4—agree; 5—strongly agree)"

Table 1
Instrument coverage, by variable

| *Variable* | Administrator questionnaire (AIQ) | Technology Use Plan (TUP) | Teacher interview (TIA) | Teacher survey questionnaire (TSQ) |
|---|---|---|---|---|
| Technology planning | | | | |
| Leadership | | | | |
| Professional development | | | | |
| Teacher openness to change | | | | |
| Teacher non-school computer use | | | | |
| Curriculum alignment | | | | |
| Technology use | | | | |
| Technology integration | | | | |
| Teacher technology competency | | | | |
| Impact on content acquisition | | | | |
| Impact on higher order thinking skills (HOTS) | | | | |
| Teacher morale | | | | |

### *3.2.2. Teacher interview*

A structured teacher interview was conducted with each of the 94 teachers to identify the teacher's perception of technology in the classroom regarding the following variables, as shown in Table 1: curriculum alignment, technology use, impact on content acquisition, impact on HOTS, and technology integration. Part of the interview required the teacher to list all activities in the prior school year that involved technology. From this list, three activities were randomly selected to focus upon and were scored according to Likert- scaled items. All researchers in the four geographic areas were trained via video together with detailed structured interview questions, all on a Likert 1–5 scale. For example, the interviewer's guidelines for assessing the level of technology integration for an activity follows: "To determine the level of integration of the activity, ask questions such as the following: In a typical day in which this activity was conducted, what would normally be taught right before and right after this activity? How did the activity fit into the unit of instruction? What are transitions like between the different components of the activity with the rest of instruction? Is the activity separate from other instructional activities?'' Following the interview questions, the interviewer would then rate the activity according to the following scale: ''The technology-related aspects of this activity are integrated into classroom instruction. (1—strongly disagree; 2—disagree; 3—neutral; 4—agree; 5—strongly agree).''

#### 3.2.3. Technology use plan

Technology use plans from each of the 12 schools were obtained and evaluated according to how well the plan established a vision for the incorporation and integration of technology by the school's faculty. Analysis of the plan contributed to the following variables, as shown in Table 1: planning, leadership, professional development, teacher openness to change, technology use, integration, content acquisition, HOTS acquisition, and teacher morale. The TUPs were scored by a trained team including one researcher in each of the four geographic areas. Inter-rater reliability was conducted by evaluating sample TUPs until the researchers scores reached a reliability coefficient of 0.9. At that point the researchers each independently evaluated the technology use plans in their geographic areas. A sample rating question regarding instructional innovation follows: ''The plan promotes instructional innovation and/or creativity with technology implementation. (1—strongly disagree; 2—disagree; 3—neutral; 4—agree; 5—strongly agree).''

#### 3.2.4. Teacher survey

A take-home survey was given to each teacher to collect information on the following variables, as shown in Table 1: planning, leadership, professional development, teacher openness to change, teacher non-school computer use, technology use, teacher technology competency, and teacher morale. A sample question regarding teacher morale follows: ''My teaching position is satisfying. (1—strongly disagree; 2—disagree; 3—neutral; 4—agree; 5—strongly agree)''

### 3.3. Procedure

Data was collected according to the following schedule: Administrator interview (Spring, Summer), Technology use plan analysis (Spring, Summer), Teacher survey (Fall), and Teacher interviews (Fall). The instruments were implemented by researchers in each of the four geographic regions. Additionally, there were several classroom observations at each school that were conducted throughout the Fall and following Spring that served to cross-check the data collected through the other instruments.

## 4. Results

Using the four instruments described above (with a combined total of 148 items), data was collected from 94 classrooms, comprising a potential dataset of 13 912 data points, of which 1988 data points (14%) were incomplete or missing. Specifically, there were 735 missing data points on administrator interview; zero missing on technology use plan; four missing on teacher interview;

and, 1249 missing on the teacher survey questionnaire. These data points were left as blank for the data analysis.

A total of 15 independent variables (technology use was broken down into nine subcomponents) were considered as predictors for regression models for each of the five dependent variables. The independent variables were as follows: technology planning, technology leadership, professional development, teacher openness to change, teacher non-school computer use, curriculum alignment, technology use (broken into nine subcomponents: amount technology used, percentage of use focused on content acquisition, percentage of use focused on HOTS, percentage of use focused on technology literacy, percentage of use focused on activities where students worked alone responding to the technology, percentage of use focused on activities were students worked alone creating with technology, percentage of use focused on activities working collaboratively, constructivist use of technology, and success of technology activities). The dependent variables included the following: technology integration, level of teacher technology competency, level of teacher morale, impact on content, and impact on HOTS.

Given that nearly all of the items were on a 1–5 Likert scale, a process of aggregation was used to average the scores and provide one score ranging from 1 to 5 for each classroom, where 1 = low and 5 = high for a given variable. Aggregation was performed by averaging all related item values so that each variable was reduced to one score per variable per class. For example, Mr. Lang's classroom could be rated 1.24 on technology planning, 2.45 on leadership, 4.56 on curriculum alignment, etc. A strength of this method was that multiple sources of information (via the four instruments) contributed to the overall variable scores. Variables that were not on a 1–5 Likert scale (e.g. the technology use subcomponents) were not aggregated, but entered into the model separately as-is. Descriptive statistics are listed in Table 2.

The primary means for analyzing the data was through stepwise regression analyses to identify what combination (if any) of the independent variable(s) predicted the results of the dependent variables. A statistically significant model of independent variable(s) predicted each of the five dependent variables via a forward stepwise regression.

Technology impact on *student content acquisition* was predicted by (1) the strength of technology leadership at a school; (2) openness to change; and (3) (negatively influenced by) teacher non-school computer use. ($R^2 = 0.589$). All independent variables were entered in a forward stepwise regression model. See Table 3.

Technology impact on *higher-order thinking skills* was predicted by (1) the degree of teacher openness to change; (2) (negatively influenced by) the amount of technology use by students working individually in situations where they were "creating"; and (3) the level of constructivist modes of technology use ($R^2 = 0.608$). All independent variables were entered in a forward stepwise regression model. See Table 4.

*Teacher morale* was predicted by professional development and constructivist use of technology. ($R^2 = 0.559$). All independent variables were entered in a forward stepwise regression model. See Table 5.

*Teacher technology competency* was predicted by teacher openness to change. ($R^2 = 0.164$). All independent variables were entered in a forward stepwise regression model. See Table 6.

*Technology integration* was predicted by teacher openness to change and technology use with others. ($R^2 = 0.391$). All independent variables were entered in a forward stepwise regression model. See Table 7.

Table 2
Descriptive statistics

| | *N* | Minimum | Maximum | Mean | S.D. |
|---|---|---|---|---|---|
| **Factors** | | | | | |
| Technology planning | 94 | 1.79 | 4.18 | 2.9531 | 0.6188 |
| Technology leadership | 94 | 1.25 | 4.63 | 3.4467 | 0.5777 |
| Curriculum alignment | 89 | 1.16 | 5.00 | 4.2018 | 1.0026 |
| Professional development | 94 | 2.08 | 4.31 | 3.0261 | 0.4987 |
| Professional development: *number of times* | 59 | 0.00 | 870.00 | 78.6102 | 132.3846 |
| Technology use: *number of times* | 60 | 0.00 | 56.00 | 14.4308 | 10.5259 |
| Technology use: *content%* | 89 | 0.00 | 0.82 | 0.4040 | 0.1793 |
| Technology use: *HOTS%* | 89 | 0.00 | 0.80 | 0.2932 | 0.1495 |
| Technology use: *literacy%* | 89 | 0.00 | 0.78 | 0.3011 | 0.1597 |
| Technology use: *alone responding%* | 89 | 0.00 | 0.95 | 0.1692 | 0.2806 |
| Technology use: *alone-creating%* | 89 | 0.00 | 1.00 | 0.3382 | 0.2854 |
| Technology use: *with others%* | 89 | 0.00 | 1.00 | 0.4782 | 0.3280 |
| Technology use: constructivist | 94 | 1.58 | 4.50 | 3.3895 | 0.6923 |
| Technology use: success | 89 | 2.07 | 5.00 | 4.2742 | 0.6365 |
| Teacher openness to change | 94 | 2.00 | 4.50 | 3.6436 | 0.5917 |
| Teacher non-school computer use (no. times) | 66 | 0.00 | 7.50 | 1.3182 | 1.5634 |
| **Outcome measures** | | | | | |
| Technology impact on content | 94 | 2.00 | 4.75 | 3.8654 | 0.5160 |
| Technology impact on HOTS | 94 | 2.00 | 4.75 | 3.7791 | 0.5649 |
| Teacher morale | 94 | 2.50 | 4.03 | 3.3793 | 0.3423 |
| Technology integration | 94 | 1.02 | 4.74 | 3.5320 | 1.0408 |
| Teacher technology competency | 81 | 2.18 | 5.00 | 3.8399 | 0.6914 |

Table 3
Summary of regression analysis for factors predicting technology impact on student content acquisition

| Variable | Unstandardized coefficients | | Standardized coefficients |
|---|---|---|---|
| | *B* | S.E. | *β* |
| Technology leadership | 0.689 | 0.125 | 0.669*** |
| Teacher openness to change | 0.315 | 0.105 | 0.338** |
| Teacher non-school computer use | −0.110 | 0.043 | −0.304* |

$R^2 = 0.589$.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$

## 5. Discussion

The regression analyses identified that each of the five dependent variables were predicted by a different combination of independent variables (with $R^2$'s ranging from 0.164 to 0.608). Although these predictions do not establish a cause and effect relationship, they do indicate that in the

Table 4
Summary of regression analysis for factors predicting technology impact on student higher-order thinking skills

| Variable | Unstandardized coefficients | | Standardized coefficients |
|---|---|---|---|
| | *B* | S.E. | $\beta$ |
| Teacher openness to change | 0.413 | 0.120 | 0.433** |
| Technology use: alone-creating% | −0.612 | 0.246 | −0.288* |
| Technology use: constructivist | 0.244 | 0.110 | 0.290* |

$R^2 = 0.608$.
* $P < 0.05$.
** $P < 0.01$.

Table 5
Summary of regression analysis for factors predicting technology impact on teacher morale

| Variable | Unstandardized coefficients | | Standardized coefficients |
|---|---|---|---|
| | *B* | S.E. | $\beta$ |
| Professional development | 0.371 | 0.076 | 0.563** |
| technology use: constructivist | 0.183 | 0.057 | 0.375* |

$R^2 = 0.559$.
* $P < 0.01$.
** $P < 0.001$.

Table 6
Summary of regression analysis for factors predicting technology impact on teacher technology competency

| Variable | Unstandardized coefficients | | Standardized coefficients |
|---|---|---|---|
| | *B* | S.E. | $\beta$ |
| Teacher openness to change | 0.455 | 0.174 | 0.405* |

$R^2 = 0.164$.
* $P < 0.05$.

Table 7
Summary of regression analysis for factors predicting technology impact on technology integration

| Variable | Unstandardized coefficients | | Standardized coefficients |
|---|---|---|---|
| | *B* | S.E. | $\beta$ |
| Teacher openness to change | 0.727 | 0.295 | 0.384* |
| Technology use: with others% | 1.026 | 0.486 | 0.330* |

$R^2 = 0.391$.
* $P < 0.05$.

schools and classrooms studied, higher scores on the independent variables were related to higher scores on the dependent variables. The following sections describe the prediction of the five outcomes and the implications for schools, teachers, and students.

### 5.1. The impact of technology on content acquisition

School communities often regard content acquisition as a rationale for earmarking educational technology funds even though previous research has shown that simply placing technology in schools does little to increase student learning. This study found three other variables to be important: (1) the strength of technology leadership at a school; (2) teacher openness to change; and, (3) teacher non-school computer use (negatively influenced by). These three variables had the greatest predictive value for student content acquisition as measured by teacher perceptions.

Strong technology leadership, indicated through both administrative and teacher interviews, may influence student content acquisition through a variety of ways. Administrators may serve as positive role models for both students and faculty. If teachers and students perceive that the administrator values and uses educational technology, it may be more widely incorporated in the classroom and more conscientiously used by students. In addition, strong technology leaders tend to promote technology by providing acknowledgements and incentives. These activities may reinforce the importance of technology, thereby influencing its use by both students and faculty.

Teacher openness to change was also found to positively impact student content acquisition. As teachers progressively integrate computers into their curriculum, they consciously and inextricably delegate some of their duties to the computer and as a result are aware of the changes in their role. The more that the teacher remains sensitive to, is prepared for, and is able to adapt to change, the greater the impact of the technology (Rieber & Welliver, 1989/1990). Further, Marcinkiewicz (1994) found that self-competence and innovativeness were most closely related to the level of computer use in terms of integration.

Unexpectedly, it was found that teacher non-school use of technology negatively affected the impact on content acquisition. Perhaps the more the teacher used technology out of the classroom, the more s/he was a more advanced user and may have focused on the technology itself rather than the *application* of the technology in the classroom.

### 5.2. Technology impact on higher-order thinking skills

The development of HOTS is often stated as an expressed goal of schools, but few studies have examined which variables help reach this goal. We found that the impact of technology on higher-order thinking was predicted by (1) the degree of teacher openness to change, (2) the amount of technology use by students working individually in creative situations (negatively influenced by), and (3) the level of constructivist modes of technology use.

We found a strong positive relationship between teachers who had a higher degree of openness to change and the impact of technology on students' higher-order thinking skills ($R=0.519$, $P<0.001$). This relationship may be because teachers who are innovative and adaptive are better able to implement new teaching strategies that nurture these skills.

The negative influence of activities where the individual is using a computer in isolation suggests the importance of collaborative work on higher order thinking skill development.

It is apparent that not all computer technologies augment higher-order thinking skills. Teachers who desire this development in their students need to extend their use of technology to areas beyond simple drill and practice or tutorial software (which have their strength in accentuating basic skills). To accentuate the development of higher-order thinking skills, the computer needs to be used in activities that incorporate the skills desired to build. Rather, teachers must explore more innoviative uses of technology, which frequently fall under the realm of constructivist activities, where students are required to examine and manipulate resources, then collaboratively construct artifacts of their knowledge. Consequently, the relationship of constructivism as the third predictor would be expected.

### 5.3. The level of teacher morale

We found that the level of teacher morale was predicted by two variables: professional development and constructivist use of technology. Teacher morale influences all aspects of the teaching and learning environment within the school setting. Morale can be made up of many commitment and satisfaction elements, including availability of role models, rewards, recognition, encouragement, professional development, incentives, empowerment in terms of support (e.g. technical) and the ability to demonstrate creativity in the school setting. These elements provide the foundation upon which a teacher can make a positive difference in the learning environment.

It may be that building a strong base of foundational knowledge and skills through well-designed professional development provides teachers with more confidence in their abilities. This confidence is manifested in higher levels of morale. A 1997 report by the President's Committee of Advisors on Science and Technology found that teachers currently receive little technical, pedagogical, or administrative support in the area of technology competency. The committee also found that few colleges of education adequately prepare their graduates to use educational technologies. As school districts increase expectations for technology in the classroom, the gap between current and required skills becomes critical. Without adequate support, teachers may be unsure of best practices, leading to unclear expectations and an inability to cope with change and a corresponding loss of morale. Consequently, proactive school districts are advised to implement professional development programs early and often. Successful technology development programs offer tips, techniques, best practices, and models for classroom implementation. These programs give teachers the opportunity to learn about and observe new teaching methods, share questions and problems with others, and to explore new ideas with experts (Hadley & Sheingold, 1993).

Improved teacher skills in the classroom, in turn, help facilitate improved student performance. Through both personal improvement as well as their students' performance, it stands to reason that teacher morale increases. A critical factor, however, is that the professional development program serve the needs of teachers with relevant examples and instruction. Simply providing off-the-shelf workshops designed by external sources will not have as great an impact as when teachers are surveyed and workshops are tailored to their needs.

We also found that the introduction of technology and constructivist learning philosophies into the classroom environment affects the level of teacher morale (either positively or negatively) as these factors facilitate a fundamental shift in the traditional environment, demanding that teachers alter their styles and expectations. No longer is the teacher the only provider of information or the "sage on the stage". Rather, the teacher becomes a coach, guide, and mentor, providing student with the tools that they need to research, explore, and make meaning. This new role for teachers may positively affect their morale.

### 5.4. Teacher technology competency

It stands to reason that teachers who are more open to change will also be more willing to try new ideas in the classroom as well as in their personal life. When these teachers are provided the opportunity to learn new technology skills and techniques, it appears that they avail themselves of the opportunity with a resulting increase in their competence ($r = 0.329$, $P < 0.01$).

A key element, however, is that the school environment recognizes this initiative and provides positive feedback, training, and technical support. Teachers are strongly attuned to what Marcinkiewicz and Regstad call "the professional milieu" (1996, p. 31) consisting of students, peers and superiors. An innovative teacher who is using technology in the classroom will be sensitive to both positive and negative responses from these sources. Administrators and policymakers seeking to maximize technology use in the classroom are advised to recognize this interrelationship between their leadership, teacher responsiveness, and school results.

### 5.5. Technology integration

We found that technology integration was predicted by two variables: teacher openness to change and the percentage of technology activities with others. Technology integration refers to how transparently the technology was blended into the lesson, and whether it was used to convey content in ways not easily done without technology. In contrast to activities that automate direct instruction (for example, computerized drill and practice used in place of pencil-and-paper tests), integrative lessons often provide students with greater challenge in the form of research, exploration, or expression. These alternative modes of instruction, frequently implemented as collaborative activities, may allow students to construct deeper meanings of the content.

### 5.6. Limitations

One issue that merits attention is the dependent measures of content acquisition and higher order thinking skills. These measures were obtained through focusing on the teacher's technology-related activities and the teacher's assessment of student performance. While we could have had each teacher make a global assessment of student performance based on overall recollection of activities over the year, it would be significantly less precise than going through each activity and mathematically computing the assessment. Consequently, we limited the elaboration of activities to three, which were randomly selected. Importantly, the activities were discussed in an interview format so that the interviewer could probe the teacher to evaluate the task in a way that was appropriate for the analysis.

Along this line, we did not obtain teacher assessment of student *proficiency* given that there is nothing for the teacher to compare the class to (except to previous classes which may not have engaged in the same technology activities). Consequently, we considered improvement of the students from before and after the activity as the best measure. Further, since the unit of study was the classroom without performance measures from students, we could only rely on teacher's perceived impact on content acquisition and HOTS on three randomly chosen activities.

The teacher's assessment of class "performance" per se is questionable, given that there is no external source to compare the assessment. (We would theoretically need a "super" teacher who could normatively rate the class performance relative to all the other classes in the study.) Consequently, there is a subtle but important difference in the data we collected for the impact of technology on content acquisition and HOTS: we obtained data on the *teacher's perceived improvement in performance by the class as a result of the technology-related activity*. According to the interview protocol, the teacher referred to their gradebook to refresh memory about *class* performance on each technology-related activity. Specifically, they assessed the perceived improvement in class performance on the two dimensions of content and HOTS.

Further, given that the selected schools were highly technology-integrative, the generalizability of results regarding factors such as teacher morale may be limited to similar schools that are highly supportive of technology. Future research should include a more diverse sample of schools in terms of technology support in order to address this limitation.

## 6. Conclusion

The degree of teacher openness to change was repeatedly found to be a critical variable as a predictor in our study. Teachers who are open to change, whether this change is imposed by administrators or as a result of self-exploration, appear to easily adopt technologies to help students learn content and increase their higher-level thinking skills. It also appears that as these teachers incorporate these technologies, their own level of technical competence increases, as does their morale. Because this one variable has such an important influence on how well technology and its subsequent influences are embraced in a classroom, administrators and policymakers may wish to encourage further development in this area. Unfortunately, given that it is a personal trait, it is difficult to influence.

Another variable with high predictive influence was the level of technology leadership and support for professional development. It appears that administrators who promote the use of technology, not only in words but also in action, lend credence to a technology culture. Our interview was designed to look beyond administrators who superficially endorse technology, and identify those who actively use, model, and reward teachers who infuse technology into their classroom. The bottom line appears to be that administrators who wish to nurture a technology culture need to figuratively "roll up their sleeves and join in" rather than sitting by the side.

Although we found that administrators contribute to the positive interactions of technology in a school, of greater importance were teacher attributes. Long-range planning for software developers and schools of education should include a vision that nurtures decision-making and development by teachers, rather than implementing systems solely from the level of policymakers. Currently many technology initiatives rely upon policymakers to communicate the value of technology to teachers, instead of involving teachers from the start. By helping teachers find ways to actively infuse technology, investments in time and money will pay off in greater content acquisition and higher-order thinking skills for students and greater teacher competence and morale.

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