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ABSTRACT

What is not fully understood about educational technology is how to transform computer technology into a powerful pedagogical tool. One way to address instructional issues associated with integrating computer technology in classrooms is to analyze educational best practices associated with technology integration in classrooms. Technology standards for teachers were established, and a tool to examine the quality of computer technology integration was developed and validated for a school district undertaking a district-wide technology professional development initiative. The technology standards on which the professional development model was established were formulated by synthesizing national, state, and local technology standards and then identifying educational best practices that supported these standards within the local context. Then a pedagogy was reinforced that enhanced and improved teaching and learning using technology tools and resources through performance assessment and financial incentives. Pattern analysis procedures demonstrated that the measure was appropriate for determining the extent of technology integration and for identifying appropriate technology training themes. (Contains 13 references.) (Author/AEF)

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ANALYZING TEACHER PREPARATION TO INTEGRATE TECHNOLOGY IN CLASSROOM INSTRUCTION

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Abstract

What is not fully understood about educational technology is how to transform computer technology into a powerful pedagogical tool. One way to address instructional issues associated with integrating computer technology in classrooms is to analyze educational best practices associated with technology integration in classrooms. Technology standards for teachers were established and a tool to examine the quality of computer technology integration was developed and validated for a school district undertaking a district-wide technology professional development initiative. Pattern analysis procedures demonstrated that the measure was appropriate for determining the extent of technology integration and for identifying appropriate technology training themes.

Several national organizations are currently involved in the establishment and proliferation of national technology standards for teachers including the International Society for Technology in Education (ISTE) and the National Council for Accreditation of Teacher Education (NCATE). Although many reasonable and appropriate technology standards for teachers exist, these goals are often stated in abstract or general terms. Additionally, since there is a great deal of variability in educational beliefs, technological availability, and state and community expectations, technology integration should be locally defined, using available research models and national standards as a foundation (Pierson, 2001).

We launched a technology professional development initiative in a school district by establishing a set of technology standards and indicators that clearly described educational best practices for teaching and learning with technology that teachers could implement in their classrooms. The technology standards on which the professional development model was established was formulated by synthesizing national, state, and local technology standards and then identifying educational best practices that supported these standards within the local context. We then reinforced a pedagogy that enhanced and improved teaching and learning using technology tools and resources through performance assessment and financial incentives. This study evaluated and validated a comprehensive, standards-based technology professional development model for teachers that can be customized for each local context.

Theoretical Framework

The integration of technology in classrooms and schools is a complex change process that entails supporting curriculum goals through the instructional use of computer technology to enhance student learning (Dockstader, 1999). Educational change models often attempt to assess and explain the change process in terms of dimensions or degrees of change. Consequently, one way to better understand the difficult instructional issues associated with the integration of computer technology in classrooms is to examine how teachers implement computer technology.

Several models or strategies have been employed by educational researchers and practitioners to provide a systematic approach for determining the quality of innovation implementation. The Concerns-Based Adoption Model (CBAM) (Hall, Wallace & Dossett, 1973) emphasizes change as a developmental process experienced by individuals implementing innovations within an organizational context. CBAM has evolved into a comprehensive systemic change model that allows change investigators and facilitators to understand organizational change from the point of view of the persons affected by the change (Surry, 1997).

CBAM is based on the assumption that change is best understood when it is expressed in functional terms—what persons actually do who are involved in the change. Since change involves developmental growth, the focus of facilitation is with individuals, innovations, and the context (Hord, Huling-Austin, & Hall., 1987). CBAM provides for the development of diagnostic tools based on the design of the innovation being evaluated and the operational patterns of those using the innovation.

One such tool that a CBAM investigator may develop and use is the Innovation Configuration Matrix or Map (ICM). The ICM delineates an innovation in the form of a two-dimensional matrix along a scale that renders closer approximations of conceptualized implementation or use along one dimension of the matrix and the various configuration components along the other dimension of the matrix. The ICM has relevance for instructional designers and educational practitioners. Rather than being a static measure, the ICM provides a procedural definition of the specific educational components and features of the innovation within the context in which it is being implemented.

Research questions about educational technology are better formulated when they are concerned with issues of instructional quality and productivity. This study developed and validated an ICM for a school district's technology professional development model based on technology standards and educational best practices associated with these standards. The ICM was used as a tool to analyze the integration of computer technology in classrooms in the school district.

Methods

Instrumentation

An instrument for analysis of technology integration and implementation in classrooms was developed. This instrument, the *Technology Standards Integration Configuration Matrix (TSICM)* was based on a consensus-building process that followed a procedure developed by Heck, Steigelbauer, Hall, and Loucks. (1981) and used previously by the researcher (Mills & Ragan, 2000). Relevant national, state, and local technology standards were reviewed and evaluated by the researcher in conjunction with the district technology committee and technology coordinator. The committee agreed upon 18 technology integration standards that were appropriate for the school district. Technology integration standards were organized into three skill sets or phases: Using and Operating Technology in the Classroom (Standards 1-6), Facilitating and Managing Classroom Technology (Standards 7-12), and Technology Integration (Standards 13-18). Each successive phase was intended to identify a set of instructional strategies that exemplified a more appropriate application of technology or a higher quality of technology integration into classroom instruction and learning.

Each technology standard was established as a component of the TSICM and then variations for each component were identified. Variations for each component consisted of discrete categorizations of technology implementation for the corresponding component. Component variations were designed to represent teacher classroom practices along a continuum from unacceptable use to ideal use. The component variations were refined by the technology committee to reflect the actual practices of teachers using computer technology in classrooms. The components and component variations were organized into matrix comprised of four variations for each of the 18 components with each successive variation indicating a level of use representing a closer approximation of ideal or appropriate educational use. The TSICM was deployed as a paper- and web-based checklist.

Data Collection

The school district used in this study was located in a small town in a Midwestern state. The school district had a total enrollment of almost 2,200 students in grades K-12 with 147 certified teachers. Computer technology was used in all the schools in the district. All schools except the high school had computer labs and all teachers had classroom computers.

The school district had made a substantial investment in computer technology and was beginning a district-wide technology professional development initiative. To collect data regarding computer technology implementation occurring among teachers, all teachers at all grade levels were provided with a paper version of the *TSICM* checklist and the option to complete a web-based version of the *TSICM* checklist on the school district web site. The checklist was designed in a multiple-choice format in which respondents could select more than one response for each *TSICM* component.

Data collection occurred at both the start and end of a school year. A usable TSICM was completed by 70 teachers at the start of the school year and 84 teachers at the end of the school year. 57 teachers completed both the start and end of year administration of the *TSICM*.

Data Analysis

The rubric for recording teacher responses on the checklist was to rate to the highest level of use for each component on the checklist. The responses to the *TSICM* checklist were analyzed by cluster analysis to identify relatively homogenous groups of cases based on the *TSICM* components. Discriminant analysis (DA) was then used to assess the adequacy of the groupings from the cluster analysis by using the *TSICM* implementation components as predictor variables. A step-wise methodology was used to enter variables into the discriminant functions. One-way analysis of variance was used to determine if the component attributes of each group were statistically significant. Comparisons were made between the start and end of year data collections using a paired-samples *t*-test. Descriptive statistics for the data collections are provided in Table 1.

Table 1. Descriptive Statistics for Start and End of Year Administration of TSICM.

TECHNOLOGY STANDARD	Start of Year Administration (N=70)			End of Year Administration (N=84)		
	SUM	MEAN	STD. DEV.	SUM	MEAN	STD. DEV.
1. Operate common technology input devices.	217	3.10	.82	313	3.73	.73
2. Perform basic file management tasks.	206	2.94	1.11	316	3.76	.63
3. Apply trouble-shooting strategies and install software.	226	3.23	.87	318	3.79	.70
4. Use software productivity tools.	182	2.60	1.34	297	3.54	1.01
5. Use technology to communicate and collaborate.	228	3.26	.72	316	3.76	.59
6. Use technology to collect data and perform research.	188	2.69	1.10	286	3.40	.95
7. Model responsible use of technology.	174	2.49	1.42	274	3.26	1.13
8. Facilitate regular student use of computer technology.	208	2.97	1.45	257	3.06	1.43
9. Conduct learning activities using computer technology.	187	2.67	1.43	234	2.79	1.46
10. Select appropriate technology resources for classroom use.	83	1.19	1.33	194	2.31	1.69
11. Evaluate the validity of data collected using technology.	22	.31	.91	93	1.11	1.69

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12. Use technology to present classroom instruction.	154	2.20	1.16	235	2.80	1.23
13. Integrate technology-based learning experiences into classroom instruction.	138	1.97	1.43	207	2.46	1.48
14. Use computer technology for problem-solving and critical thinking.	118	1.69	1.48	199	2.37	1.48
15. Use technology to facilitate individualized/cooperative learning experiences.	94	1.34	1.39	157	1.87	1.40
16. Assess student use of technology using multiple methods of evaluation.	66	.94	1.57	91	1.08	1.53
17. Develop and maintain electronic student portfolios.	23	.33	.88	48	.57	1.01
18. Use computer technology to maintain and analyze student performance.	136	1.94	1.23	224	2.67	1.08

RESULTS

Since the initial cluster centers and the number of dominant patterns were unknown, cluster analysis was performed on the first administration of the TSICM using all 18 components of the TSICM and incrementing the number of clusters until a reasonable model was obtained. The cluster analysis was run for 2, 3, 4, and 5 clusters before a reasonable model was selected. A reasonable model occurred with the number of clusters set at 3. When the number of clusters was set at 3, the number of cases in Group 1 was 21, Group 2 was 33, and Group 3 was 16. In order to make comparisons between the start and end of year data, this same grouping model (3 clusters/groups) was used for analysis of the end of year data collection.

In order to assess the adequacy of the classification of implementation pattern groups by the cluster analysis a Discriminant Analysis (DA) was performed. The 18 TSICM components were used to separate the groups into the discriminant functions. As a result of this procedure 97% of the cases or 68 of 70 cases were correctly classified. The DA reclassified 1 case in Group 2 for Group 3 and 1 case in Group 3 for Group 2.

The TSICM components were entered into the DA using a stepwise model in order to discard variables that were weakly related to group distinctions. Table 2 identifies the unstandardized discriminant coefficients for each TSICM component that best predicted the discriminant functions for the start of the year administration. Based on the discriminant coefficients, Component 13—Integrate Technology-based Learning Experiences into Classroom Instruction made the most important contribution to Function 1 and Component 8—Facilitate Regular Student Use of Computer Technology made the most important contribution to Function 2. Teachers identified with Group 1 (Technology Operators) were characterized by low or inverse relationships to Functions 1 and 2, Group 2 (Technology Facilitators) by high Function 2, and Group 3 (Technology Integrators) by high Function 1.

Table 2. Canonical Discriminant Function Coefficients.

TSICM Component	Function 1	2
8. Facilitate regular student use of computer technology.	.196	.756
9. Conduct learning activities using computer technology.	.471	.072
10. Select appropriate technology resources for classroom use.	.415	-.496
12. Use technology to present classroom instruction.	.177	-.539
13. Integrate technology-based learning experiences into classroom instruction.	.590	.402
16. Assess student use of technology using multiple methods of evaluation.	.408	-.716
18. Use computer technology to maintain and analyze student performance.	.175	.568

A cluster analysis was performed on the end of year data collection with the number of clusters set at 3 to compare with the clusters from the first of year data collection. With the number of clusters set at 3, the number of cases in Group 1 was 35, Group 2 was 18, and Group 3 was 31. The DA was repeated for the end of year data collection of the *TSCIM* to make comparisons with the first of year data collection. As a result of this procedure 92% of the cases or 77 of 84 cases were correctly classified. The DA reclassified 1 case in Group 1 for Group 2 and 6 cases in Group 3 for Group 1. Table 3 identifies the unstandardized discriminant coefficients for each *TSICM* component that best predict the discriminant functions for the start of the year administration of the *TSICM*. Based on the discriminant coefficients, Component 9—Conduct Learning Activities using Computer Technology made the most important contribution to Function 1 while Component 1—Operate Common Technology Input Devices made the most important contribution to Function 2. Teachers identified with Group 1 (Expert Technology Users/Operators) were characterized by high Function 2, Group 2 (Beginning Technology Users/Operators) by low or inverse relationships to Functions 1 and 2, and Group 3 (Technology Facilitators) by high Function 1.

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Table 3. Canonical Discriminant Function Coefficients.

TSICM Component	Function 1	2
1. Operate common technology input devices.	.317	.764
9. Conduct learning activities using computer technology.	.614	.540
10. Select appropriate technology resources for classroom use.	.409	-.146
11. Evaluate the validity of data collected using technology.	.531	-.774
14. Use computer technology for problem-solving and critical thinking.	.602	.287

Paired samples correlations for each of components of the *TSICM* (technology standards) were computed for matched cases on the start and end of year administrations of the *TSICM.* (see Table 4). Almost all components of the *TSICM* indicated significant differences on the *t*-test ($p<.05$) between the start and end of year administrations. Additionally, paired samples correlations were computed when *TSICM* components were grouped by skill set or phase (see Table 5) and significant differences on the *t*-test ($p<.05$) were indicated for all three phases.

Conclusions

An interesting conclusion we deduced from the start of year data collection for this population of teachers was that proficiency in the use and operations of computer technology (Phase 1) was not necessarily a distinguishing attribute of high quality technology integration. Differences among the groups in this study at the beginning of the school year were delineated more by attributes of technology integration than by technology use and operations. This finding had relevance for the provision of technology professional development activities. These results clearly demonstrated that technology training activities for this school district needed to focus more on instructional strategies and methods to integrate technology in the classroom than on training activities to increase skills in the operation of computer hardware and use of software applications.

Table 4. Paired Samples Correlations by Technology Standard for Start and End of Year Administrations of TSICM (N=57).

TSICM Component (Technology Standard)	Correlation	*t*
1. Operate common technology input devices.	.273	-4.375*
2. Perform basic file management tasks.	.190	-4.169*
3. Apply trouble-shooting strategies and install software.	.330	-4.119*
4. Use software productivity tools.	.260	-5.314*
5. Use technology to communicate and collaborate.	.094	-2.950*
6. Use technology to collect data and perform research.	.002	-2.713*
7. Model responsible use of technology.	.419	-4.158*
8. Facilitate regular student use of computer technology.	.659	-.882
9. Conduct learning activities using computer technology.	.696	-1.135
10. Select appropriate technology resources for classroom use.	.374	-4.820*
11. Evaluate the validity of data collected using technology.	.373	-3.853*
12. Use technology to p resent classroom instruction.	.379	-3.340*
13. Integrate technology -based learning experiences in classroom instruction.	.586	-3.040*
14. Use computer technology for problem-solving and critical thinking.	.596	-4.428*
15. Use technology to facilitate individualized/cooperative learning experiences.	.485	-2.573*
16. Assess student use of technology using multiple methods of evaluation.	.474	-.338
17. Develop and maintain electronic student portfolios.	.581	-2.379*
18. Use computer technology to maintain and analyze student performance.	.320	-2.982*
Total Score All Standards	.708	-7.447*

*Significant at .05 level for two-tailed test

Table 5. Paired Samples Correlations by Type or Technology Standard for Start and End of Year Administrations of TSICM (N=57).

Skill Set/Phase of Technology Integration	Correlation	*t*
Using and Operating Technology in the Classroom	.441	-6.777*
Facilitating and Managing Classroom Technology	.746	-6.141*
Integrating Classroom Technology	.638	-4.058*

*Significant at .05 level for two-tailed test

By the end of the school year, the characteristics that delineated differences among the teachers in technology integration was more sharply defined by teachers who were beginning or expert operators of computer technology and those who were facilitators and managers of classroom technology. Thus, there was a clear progression among the teachers from technology operations to technology facilitation. While the technology professional development program at the school did not make

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technology integrators out of all participants, it clearly accommodated reasonable growth and advancement in the technology integration skills of the participants. When we considered only those teachers for whom we had both start and end of year data, a significant pattern of growth across standards and at all skill levels was indicated. This observation suggests that when educational best practices for teaching and learning with technology are clearly defined and established, the professional skills of teachers will begin to exemplify the stated expectations.

We have learned from this study that classroom technology integration was not so much about the quantity of teacher interactions with technology, but rather it was about the quality of teacher interactions with technology. When teacher interactions with technology were accompanied by expert teaching practices and related to curriculum objectives, the quality of technology integration was increased. Over time we have refined our technology integration professional development model to include more powerful technology integration strategies in classrooms beyond that of computer technology use and operations. We have learned that through the establishment of a well-defined set of pedagogical standards and indicators, higher levels of technology integration in classrooms can be identified and achieved. Consequently, when teachers know how to use and then actually use all the tools at their disposal, classroom pedagogy is expanded and improved.

Although many school districts have established benchmarks or standards for the integration of technology in classrooms, no model or methodology exists for substantiating technology standards with actual classroom practices. The *TSICM* represents a flexible and adaptable approach to the evaluation of technology integration in classrooms because the *TSICM* components reflect a set of widely-used standards that can be contextualized.

A methodology to provide comprehensive and continuous analysis of technology implementation is needed to sustain high levels of use and integration of computer technology in classrooms. This study demonstrated that the *TSICM* is an effective tool to determine technology integration in classrooms, to reveal the technology integration characteristics of teachers integrating technology in classrooms, and to distinguish appropriate technology training themes that focus on specific technology standards.

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