Cross-Validating Measures of Technology Integration: A First Step Toward Examining Potential Relationships Between Technology Integration and Student Achievement

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Abstract: The use of proper measurements of diffusion of information technology as an innovation are essential to determining if progress is being made in state, regional, and national level programs. This project provides a national level cross validation study of several instruments commonly used to assess the effectiveness of technology integration in instructional programs.

Keywords [Measures, Assessment, Cross-Validation, Technology Integration, Instrument]

Introduction

There remains in the field of Educational Technology a serious lack of consensus as to what measures of technological innovation on the part of the teacher transfer to academic achievement on the part of the student. Measures of diffusion of information technology as an innovation that are based upon solid theoretical perspectives include instruments such as the Concerns-Based Adoption Model Stages of Concern (CBAM-SoC) (Hall, George, & Rutherford 1974; 1986, 1998), the Concerns-Based Adoption Model Levels of Use (CBAM-LoU) (Hall. Loucks, Rutherford, & Newlove, 1975), the Apple Classrooms of Tomorrow Teacher Stages (ACOT) (Dwyer, 1994), the Levels of Technology Implementation (LoTi) (Moersch, 1995), and the Stages of Adoption of Technology (Christensen, 1997; Knezek & Christensen, 1999), based on Russell (1995). Studies of reliability and construct (factor analytic) validity have been carried out within some of these measurement domains, but no known study has cross-validated these instruments against each other on a national basis. It is possible that this cross validation, when examined with student outcomes in terms of achievement scores on a standardized form such as the Iowa Test of Basic Skills, may yield insight into potential relationships between technology integration and student outcomes. This type of investigation may also inform the design of instruments, in order to improve measurement of integration of information technology as an innovation at the classroom level.

Conceptual Rationale

The long-range purpose of this investigation is to cross-validate measures of technology implementation and correlate those measures with student achievement as a means of establishing the potential of diffusion of innovation indices to impact learning. The project has two long-term goals: first, cross-validate measures of technology implementation to establish valid and reliable instruments for measuring technology adoption at classroom level by the teachers; second, identify the potential impact of the adoption of the technology by correlating technology adoption to student achievement scores on standardized tests. This paper addresses goal number one. The significance of the study rests in the fact that roughly $496 million[1] dollars has been invested in integrating technology at the classroom level in the United States with no consistent means available for researchers to evaluate whether this expenditure is worthwhile. Multiple instruments are currently being used to assess project outcomes with little or no efforts being made to cross validate these measures, or correlate results to student outcomes in a manner helpful to policymakers.

Multiple measures of diffusion of information technology as an innovation as discussed earlier, have been used to evaluate multiple NSF, NASA, and other federal projects as well as statewide initiatives in education. However, there still remain some issues with these measures and no broad-scale study has attempted to cross-validate these instruments and examine their predictive value in terms of student achievement as measured by a nationally recognized achievement test. It is the purpose of the review of literature in the next section to discuss how these tests have been used to assess outcomes of large-scale initiatives, and to provide an overview of the instruments themselves.

Literature Review

Each of the selected instruments was chosen because it has been used for evaluation of NSF, NASA, or other large-scale implementations of educational initiatives. The Concerns-Based Adoption Model Stages of Concern (CBAM-SoC) (Hall,

[1] Enhancing Education Through Technology (EETT) program (Title II part D of NCLB) funding level in FY05.

George, & Rutherford 1974; 1998) a basis for several of the later instruments, was used in Project CATS (Coordinated and Thematic Science), a National Science Foundation program for science in West Virginia, Rock Camp, a geology program with the West Virginia Bureau of Economic Geology; and in Project MERIT, a math initiative of the West Virginia Department of Education. Figure 1 indicates results of a West Virgina study using CBAM-SoC as a means of assessing concerns regarding statewide implementation of an information management system.

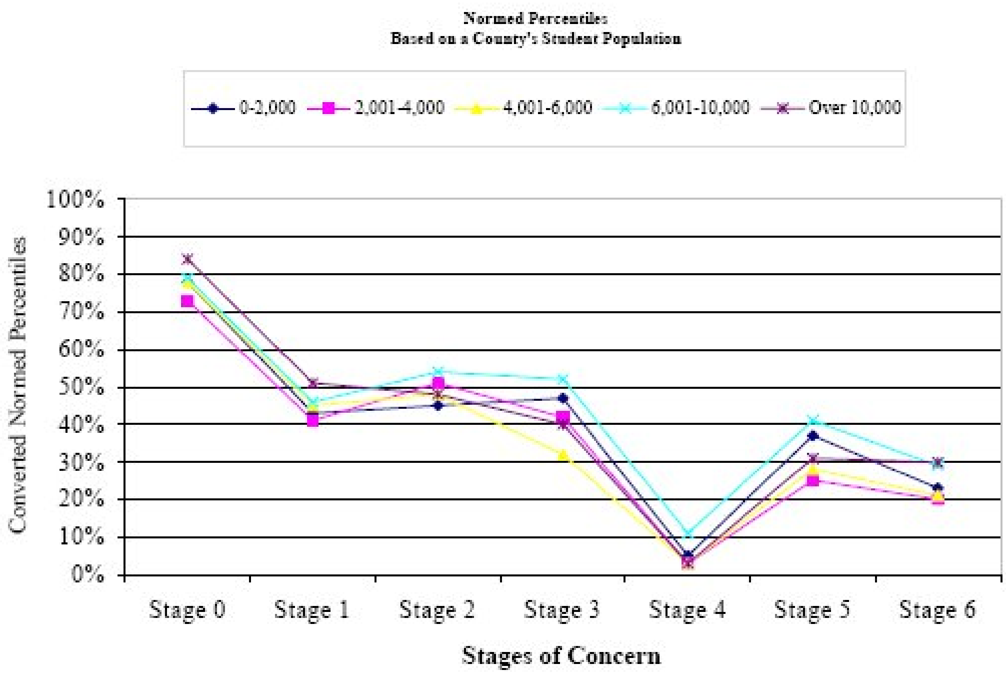

Figure 1. Normed percentiles presented as part of an analysis of a MIS in West Virginia.

CBAM-SoC has also been used in the evaluation of educational programs for the National Aeronautics and Space Administration (NASA)(Dreschel, 1996). Table 1 indicates an alignment of NASA program goals and the CBAM-SoC.

Table 1

Alignment of NASA program goals and the CBAM-SoC.

The Stages of Concern (from Table 1) and The NASA Education Goals and Outcome Indicators (from Figure 1)

Stage of Concern	NEPO Indicators	NEPO Goals
0) Awareness	Teacher awareness and participation in continuing ed. activities.	Dissemination of information (NASA, 1992).
1) Informational	Change in teacher math and science knowledge.	Increased teacher content knowledge (math & science).
2) Personal	Changes in teacher attitudes and practice.	Increased teacher pedagogical knowledge in math and science.
3) Management	Changes in teacher attitudes and practice. (Lesson modification or enhancement)	Increased teacher capability to design/implement stimulating & engaging lessons/ experiences.
4) Consequence	Increasing student interest and achievement in math/science as perceived by the teacher.	Increased student interest and achievement in math/science.
5) Collaboration	"Multiplier" effect on other teachers.	Extend benefits to colleagues. of participants.
6) Refocusing	Changes in teacher attitude and practice (Lesson Plan redesign).	Increased teacher capability to design/implement more stimulating/ engaging lessons/ experiences.

CBAM-SoC is not alone in being used to evaluate large-scale initiatives. CBAM-LoU and Stages of Adoption are often used concurrently to assess project outcomes. For example, Figures 2 and 3 show findings from a Central Nevada Technology Consortium report (Shonkwiler & Velasquez-Bryant, 2004) that employed both instruments.

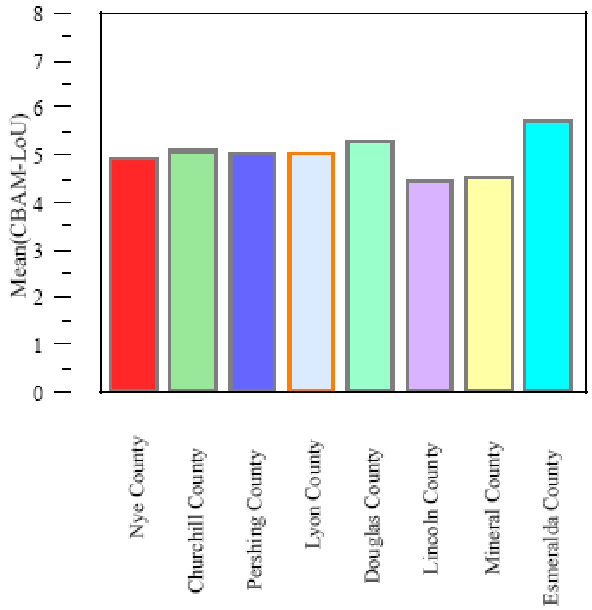

Figure 2. CBAM-LoU results by county for Nevada report.

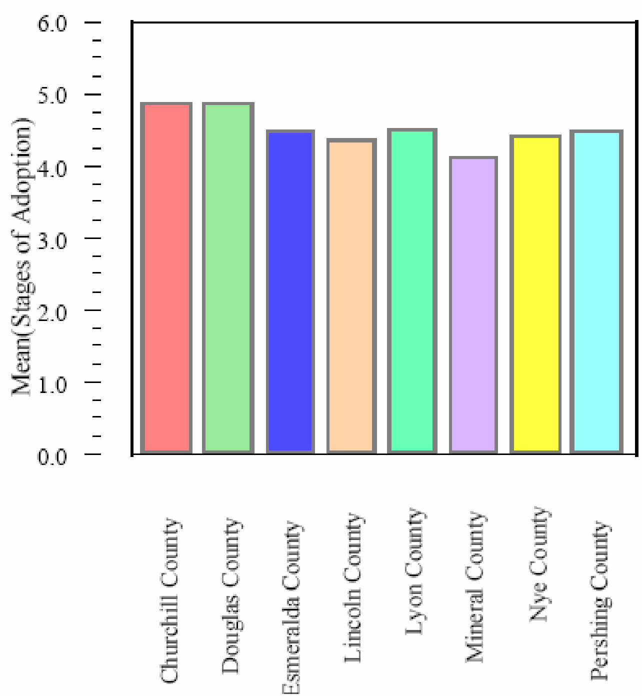

Figure 3. Stages of Adoption results by county for Nevada report.

Shonkwiler and Velasquez-Bryant (2004) also pointed out that the lack of well-publicized information regarding potential validity faults in the instruments makes their use for evaluation purposes more difficult. Interpretation of findings is more straightforward when this information exists. For example, in Figure 1 note the normed percentiles for Stage Four of CBAM-SoC. In the 1974-1976 study, the participants' concerns were estimated after individual interviews. The estimates of their peak stages of concern were compared to their actual peak stages measured by the SoCQ. The correlation of the peak stage estimates by investigators to actual percentile scores shows for all stages, except Stage 4, that validity was supported (Table 2). These validity studies provided increased confidence that the SoCQ measures the hypothesized Stages of Concern in all areas except Stage 4 (Hall, George, & Rutherford, 1986).

Table 2.

Correlation of Peak Stage Estimates and Rank Order of SoC Percentile Scores.

Correlation of Peak Stage Estimates and Rank Order of SoC Percentile Scores

N=65 Critical r =.25

Quantitative Ratings	*Peak SoC Stages 0-6*						
	0	*1*	*2*	*3*	*4*	*5*	*6*
0	.27	.34	-.11	.02	-.22	-.22	-.13
1	.15	.47	.47	-.09	-.11	-.50	-.45
2	.03	.38	.42	-.21	-.10	-.24	-.34
3	-.25	-.08	.00	.30	-.04	.02	.09
4	-.05	-.22	-.26	-.01	.13	.08	.33
5	-.20	-.48	-.20	-.03	.31	.54	.15
6	-.20	-.20	.16	-.15	.24	.17	.31

Reliability and validity issues have not often been addressed and disseminated for recent broad scale studies using these instruments, even as they continue to be used for evaluating interventions. Large scale analyses are important so that researchers and program directors who apply these instruments make policy decisions based upon conclusions that are well-grounded.

History of Instrumentation

The *Concerns-Based Adoption Model* (CBAM) was designed for the study of the adoption of any new educational innovation (Hall & Rutherford, 1974). CBAM Stages of Concern (1974) and Level of Use (Hall, Loucks, Rutherford, & Newlove, 1975) classifications were later constructed to address information technology innovations and have been used by researchers worldwide over the past three decades. CBAM measures concerns toward change. In 1979, Hall reported that at the beginning of an innovation, individuals have high levels of concern at Stages 0-Awareness, Stage 1-Informational, and Stage 2-Personal. First, individuals are concerned about becoming more knowledgeable about the innovation and how it affects them personally. As individuals use the innovation and become more knowledgeable, then Stage 3-Management concerns are more evident. With more experience and skill, the individual's concerns with the innovation move toward Stage 4-Consequence, Stage 5-Collaboration, and Stage 6-Refocusing. Ownership of the innovation and commitment to its use are reflected in the higher stages.

Over time, CBAM as a concept evolved into CBAM-SoCQ, referred to as Stages of Concern. The survey was developed around the theory that individual concerns about an innovation move through stages that can be identified. The stages mentioned previously reflect a level of intensity based upon the respondent's feelings and perceptions about the innovation. Hall, George, and Rutherford (1986) detailed the process of determining the internal reliability of the SoCQ as an instrument. In studies from 1972-1976, the SoCQ was used in cross sectional and longitudinal studies with eleven different innovations. Beginning in 1974, a two-year study of 830 teachers and professors provided data to calculate the coefficients of internal reliability found in Table 3. The alpha coefficients reflect the degree of reliability among items on a scale in terms of overlapping variance (Hall, George, & Rutherford, 1986).

Table 3

Degree of Reliability Among Items on SoCQ in Terms of Overlapping Variance

Coefficients of Internal Reliability for the Stages of Concern Questionnaire

N=830

Stage	0	1	2	3	4	5	6
Alphas	.64	.78	.83	.75	.76	.82	.71

Intercorrelation matrices, judgments of concerns based on interview data, and confirmation of expected group differences and changes over time were components used to investigate the validity of questionnaire scores. The intercorrelation of the stages conducted by Hall and others is shown in Table 4.

Table 4

Intercorrelation of SoCQ Questionnaire Scales

	Intercorrelation of 195-Item Stages of Concern Questionnaire Scales						
		1	2	3	4	5	6
	1	1.00	.68	.47	.21	.21	.19
	2		1.00	.78	.43	.37	.43
Stages	3			1.00	.60	.51	.59
	4				1.00	.82	.80
	5					1.00	.77
	6						1.00

The Concerns-based Adoption Model-Levels of Use (CBAM-LoU) questionnaire (Griffin & Christensen, 1999) is targeted toward describing behaviors of innovation users through various stages-from orienting, to managing, and finally to integrating use of the technology. Designed to be more quickly administered than SoCQ, CBAM-LoU does not focus on attitudinal, motivational, or other affective aspects of the user.

The instrument is based on the eight levels of use defined in the Levels of Use Chart (Loucks, Newlove, & Hall, 1975). The levels of use are: (0) Non-Use, (I) Orientation, (II) Preparation, (III) Mechanical Use, (IVA) Routine, (IVB) Refinement, (V) Integration, and (VI) Renewal. The concept of levels of use also applies to groups and entire institutions. Because the Concerns-Based Adoption Model - Levels of Use is a single item survey, internal consistency reliability measures cannot be calculated for data gathered through it. However, test-retest reliability estimates have been found to generally fall in the range of .84 to .87 for elementary and secondary school teachers (Christensen, Parker, & Knezek, 2005, p. 189).

The Stages of Adoption of Technology instrument is a single-item survey used in both pre-service and in-service education to measure the impact of information technology training as well as trends over time. It was derived from work of Russell (1995) in research assessing adults learning to use electronic mail. Russell's stages included: (1) awareness, (2) learning the process, (3) understanding the application of the process, (4) familiarity and confidence, (5) adaptation to other contexts, and (6) creative applications to new contexts. In the Stages of Adoption of Technology instrument (Christensen, 1997; Christensen & Knezek, 1999) the stage descriptions are generalized to make them appropriate for any information technology.

As with the CBAM-LoU, the Stages of Adoption of Technology instrument is a single item survey, internal consistency reliability measures cannot be calculated for data gathered through it. However, high test-retest reliability estimates (.91 - .96) have been obtained from validation studies on Stages of Adoption (Christensen, Parker, & Knezek, 2005, p. 189).

By the time ACOT research ended in 1998, Apple Classrooms of Tomorrow, had been working with the National Science Foundation for more than eight years on professional development for teachers in different environments. In its entirety, the ACOT project was one of the largest and longest continuing educational studies of its kind.

Drs. Eva Baker, Joan Herman-Cooper, and Maryl Gearhart of the Center for the Study of Evaluation at UCLA designed and implemented a three-year, cross-site study of ACOT. Student demographic and psychometric data were collected annually from participating districts, using subsets of the Iowa Tests of Basic Skills and other measures. The project analysis (Baker, Herman, & Gearhart, 1988) indicated a progression of attitudinal change that the authors believed could be viewed as an evolutionary process similar to other models of educational change (Berman & McLaughlin, 1976; Giacquinta, 1973; Gross & Herriott, 1979) such as CBAM. This served as the basis for what would become labeled stages of instructional evolution in the ACOT classrooms: Entry, Adoption, Adaptation, Appropriation, and Invention (See Figure 4). In this model, text-based curriculum delivered in a lecture-recitation-seatwork mode is first strengthened through the use of technology, and then gradually replaced by far more dynamic learning experiences for the students (Dwyer, Ringstaff, & Sandholtz, 1991).

PHASE	INSTRUCTIONAL TECHNOLOGY	PEDAGOGY	OUTCOME
Entry	Text	Lecture Recitation Seatwork	Social & Cognitive
Adoption	Text	Lecture Recitation Seatwork	Social & Cognitive
	High Computer Access		
Adaptation	Text	Lecture Recitation Seatwork	Social & Cognitive
	High	Play & Experiment	Social & Cognitive

	Computer Access		
Appropriation	Text	Lecture Recitation Seatwork	Social & Cognitive
	High Computer Access	Individualized Cooperative Project-based Simulation Interdiscipline Distance Multimodal Self-paced	Social & Cognitive
Invention	Immediate Computer Access	Interact Do Create	Social & Cognitive

Figure 4. ACOT Stages of Evolution with correlating pedagogy and outcomes.

Here again we see a pattern of a five to eight item scale emerging as a way of gauging progress in educational initiatives, yet there is little information at all in the publicly available (on the ACOT website) reports that deals with reliability or validity of the ACOT stages of instructional evolution. This is also true of any information regarding cross-validation of the ACOT stages with other instruments. The five-stage version of the ACOT used in this study is based upon an adaptation by Tom Clark of Western Illinois University for evaluation of a U.S. Department of Education STAR Schools project (Clark, 2002).

Each year the United States and other countries spend billions of dollars on technology in education. A great many of these programs are using these instruments to evaluate program outcomes, yet the instruments have not received the rigorous attention necessary to render them necessarily fit for evaluatory purposes. It is effort well invested to examine these instruments thoroughly enough to ensure that if they are being used to evaluate technology-assisted programs in education, we are getting accurate answers.

Methods

The study was conceived to proceed in two phases:

1) Phase I: Cross Validation of Instruments to measure technology integration
2) Phase II: Impact of Technology Integration in Learning

The results presented here are the end of the first phase of analysis. Results from the second phase are not yet complete and will be reported in a separate publication.

Phase I: Cross Validation of Instruments to measure technology integration

This study relied upon factor analysis and reliability analysis (Cronbach's Alpha) to cross-validate three instruments:

- The Concerns-Based Adoption Model Levels of Use (CBAM-LoU) (Hall. Loucks, Rutherford, & Newlove, 1975)
- The Apple Classrooms of Tomorrow Teacher Stages (ACOT) (Dwyer, 1983)
- The Stages of Adoption of Technology (Christensen, 1997; Knezek & Christensen, 1999)

Factor analysis is commonly used to assess construct validity because it establishes relationships between latent (unobserved) variables and multiple observable items (Holbert & Stephenson, 2002). Latent variables are the underlying constructs not directly tapped by any one set of measures (2002), but they are hypothesized to influence certain observable items in the model. The latent variables are what a researcher ultimately wishes to capture, but which cannot be assessed directly through any one form of observation (Duncan, 1975).

Reliability analysis is used to assess the consistency of a measurement scale. Cronbach's Alpha is a common index used to determine whether multiple indicators of a construct are internally consistent with each other.

Sample

An online survey was sent out to over 20,000 teachers and administrators across the nation. In order to access these educators, the project has received support from HotChalk, a non-governmental organization that provided free online learning environments to secondary schools, supported by corporate sponsorships and advertisements. The survey was completed by 1114 educators of which 51 respondents were administrators and 1063 were teachers. This response comprised 5.6% of the accessible population. Respondents represented 47 of the 50 US states, plus the District of Columbia. The distribution by state/location is shown in Table 5.

Table 5

Participant Representation by State

State	Frequency	Percent	Valid Percent	Cumulative Percent
Alabama	28	2.6	2.6	2.6
Alaska	2	.2	.2	2.8
Arizona	24	2.2	2.2	5.0
Arkansas	9	.8	.8	5.8
California	70	6.5	6.5	12.3
Colorado	7	.6	.6	13.0
Connecticut	22	2.0	2.0	15.0
Delaware	4	.4	.4	15.4
Florida	67	6.2	6.2	21.6
Georgia	41	3.8	3.8	25.4
Hawaii	8	.7	.7	26.2
Idaho	9	.8	.8	27.0
Illinois	38	3.5	3.5	30.5
Indiana	23	2.1	2.1	32.7
Iowa	3	.3	.3	32.9
Kansas	13	1.2	1.2	34.1
Kentucky	25	2.3	2.3	36.5
Louisiana	24	2.2	2.2	38.7
Maine	3	.3	.3	39.0
Maryland	28	2.6	2.6	41.6
Massachusetts	25	2.3	2.3	43.9
Michigan	40	3.7	3.7	47.6
Minnesota	10	.9	.9	48.5
Mississippi	10	.9	.9	49.4
Missouri	17	1.6	1.6	51.0
Montana&Nebraska	8	.7	.7	51.8
Nevada	6	.6	.6	52.3
New Hampshire	2	.2	.2	52.5
New Jersey	43	4.0	4.0	56.5
New Mexico	11	1.0	1.0	57.5
New York	66	6.1	6.1	63.6
North Carolina	33	3.1	3.1	66.7
North Dakota	3	.3	.3	67.0
Ohio	51	4.7	4.7	71.7
Oklahoma	19	1.8	1.8	73.5
Oregon	9	.8	.8	74.3
Pennsylvania	80	7.4	7.4	81.7
Rhode Island	5	.5	.5	82.2
South Carolina	9	.8	.8	83.0
Tennessee	21	1.9	1.9	85.0
Texas	84	7.8	7.8	92.8
Utah	4	.4	.4	93.1
Virginia	26	2.4	2.4	95.5
Washington	27	2.5	2.5	98.1
Washington DC	6	.6	.6	98.6
West Virginia	4	.4	.4	99.0
Wisconsin	5	.5	.5	99.4
Wyoming	6	.6	.6	100.0
Total	1078	100.0	100.0	

Analysis

A factor analysis (Principal components, varimax rotation) was conducted on the data to assess construct validity of the ACOT, CBAM-LoU, and Stages scales as collective measures of technology integration. Exploratory factor analysis produced a single factor with eigenvalue > 1 for the Stages, CBAM, and ACOT data. As shown in Table 6, the second and third factors that theoretically could be extracted from the data had eigenvalues well below 1.0, and the first factor alone (with eigenvalue 2.27) accounted for 76% of the variance in the data. Because the eigenvalue > 1.0 cutoff is the point at which an extracted factor accounts for more variance than any single variable used alone, it was judged to be a reasonable criterion for a study where the goal was to identify a construct that subsumes several variables as indicators. The underlying construct represented by factor 1 was tentatively named technology integration by the authors.

Table 6

Factor Extraction Summary for ACOT, CBAM-LoU, and Stages of Adoption data

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.270	75.659	75.659	2.270	75.659	75.659
2	.425	14.161	89.820			
3	.305	10.180	100.000			

Extraction Method: Principal Component Analysis.

As shown in Table 7, factor loadings for the component matrix revealed that CBAM-LoU and Stages of Adoption were most strongly aligned with technology integration and CBAM was slightly stronger than Stages. Nevertheless, since the factor loadings represent the correlations of the measures with the construct, these values indicate all three of the measures are well aligned with the construct technology integration.

Table 7

Factor Loadings for ACOT, CBAM-LoU, and Stages of Adoption on Common Construct

Component Matrix (Factor Loadings)

	Component
	1
STAGES	.873
CBAM	.892
ACOT	.844

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Reliability Analysis

A reliability analysis was also carried out on the data to confirm the consistency of a technology integration scale composed of ACOT, CBAM-LoU, and Stages of Adoption indicators. As shown in Table 8, the resulting Cronbach's Alpha for the three-item scale was r = .84. This is in the range of 'very good' according to guidelines for internal consistency reliability provided by DeVellis (1991) in Table 8.

Table 8.

Guidelines for Internal Consistency Measures

Below .60	Unacceptable
Between .60 and .65	Undesirable
Between .65 and .70	Minimally acceptable
Between .70 and .80	Respectable
Between .80 and .90	Very good
Much above .90	Consider shortening the scale
(DeVellis, 1991, p.85).	

Table 8.
Reliability Analysis for Technology Integration Construct Composed of ACOT, CBAM-LoU, and Stages of Adoption Scales

Statistics for	Mean	Variance	Std Dev	N of Variables
SCALE	12.8583	9.2821	3.0467	3

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item Total Correlation	Alpha if Item Deleted
STAGES	7.7545	4.4979	.7096	.7674
CBAM	8.4572	3.9779	.7408	.7379
ACOT	9.5048	4.9009	.6618	.8137

Reliability Coefficients

N of Cases = 829.0 N of Items = 3

Alpha = .8383

Associations Among the Measures

As shown in Table 9, the Pearson Product-Moment correlations among the three measures of technology integration were in the range of .59 to .69, indicating roughly 35-50% of the variance is shared among the pairs of the three variables. Correlations among Stages, CBAM-LoU, and ACOT are about the same as those found in previous studies (Christensen & Knezek, 2001a). For example, in a 1999 North Texas study involving 525 educators, the Pearson product-moment correlation between Stages of Adoption and CBAM-LoU was r = .64 (Christensen & Knezek, 2001a, p. 12). This indicates the 2007 sample gathered on a broad, nationwide basis, yields results comparable to earlier studies utilizing exclusively Texas (Knezek & Christensen, 2000) or Nevada (Shonkwiler & Velasquez-Bryant, 2004) data.

Table 9.
Pearson Correlations among ACOT, CBAM-LoU, and Stages of Adoption

	STAGES	CBAM	ACOT
STAGES	1	.689	.585
CBAM	.689	1	.632
ACOT	.585	.632	1

** Correlation is significant at the 0.01 level (2-tailed).

Discrimination Ability of the Measures

Participants providing data for this study also completed the Teachers Attitudes toward Computers Questionnaire (TAC; Christensen & Knezek, 1996) as an external validation measure. Previous studies have found a relatively smooth progression between Stages of Adoption of Technology and more positive attitudes toward computers (Christensen & Knezek 2001b, 2001c). As shown in Figure 4, this relationship also held true for the nationwide sample of data for this study. There were significant differences by Stage of Adoption of Technology in the level of Interest (TAC Factor 1) exhibited by the participants ($f = 18.4$, 5 x 824 df, $p < .0005$). On a scale 1 (lowest) to 5 (highest), average interest by stage varied from 3.69 for Stage 1 educators, to 4.59 for Stage 6 educators in this study. Trends similar to Figure 5 were also found for CBAM-LoU, ACOT, and the composite measure Technology Integration produced from the factor scores for the Stages, CBAM, and ACOT data. All measures yielded highly significant ($p < .0005$) attitude differentiation across rating categories.

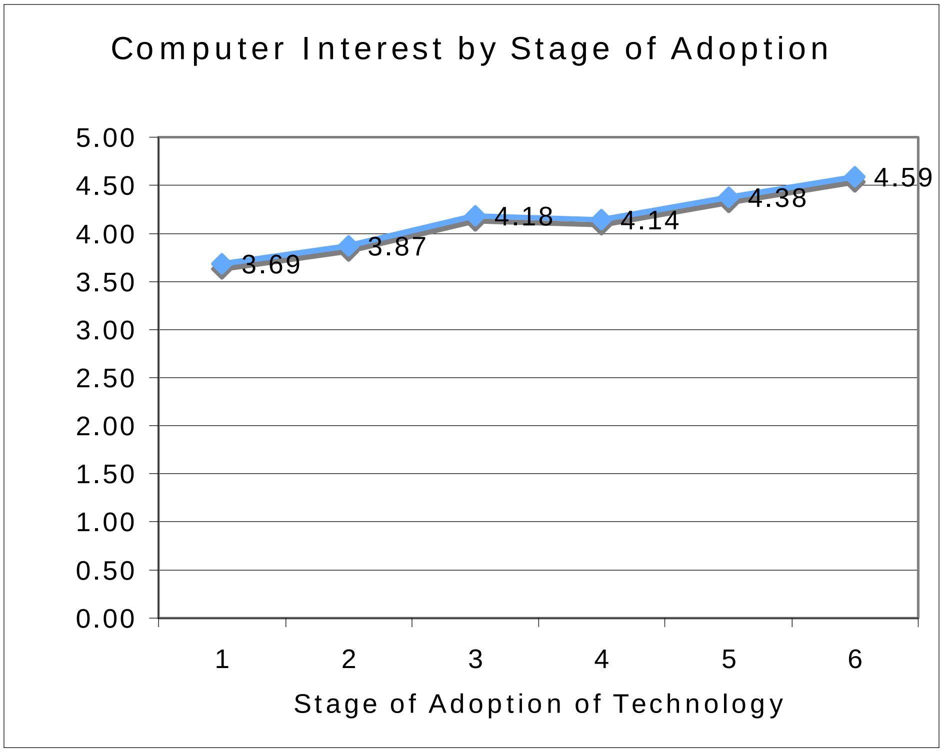

Figure 5. Trend line for Computer Interest by Stage of Adoption of Technology.

As shown in Figure 6, there was a similar trend for the association between higher Stages of Adoption of Technology and computer anxiety. In this case the mean level of anxiety generally declined as the average Stage of Adoption increased. On a scale of 1 = least anxious to 5 = most anxious, Stage 1 educators in this study gave an average self-report rating of 2.79 on computer anxiety, while Stage 6 teachers reported an average rating of just 1.23 on the five-point scale. Trends similar to Figure 6 were also found for CBAM-LoU, ACOT, and the composite measure Technology Integration produced from the factor scores for the Stages, CBAM, and ACOT data. All measures yielded highly significant ($p < .0005$) computer anxiety differentiation across rating categories.

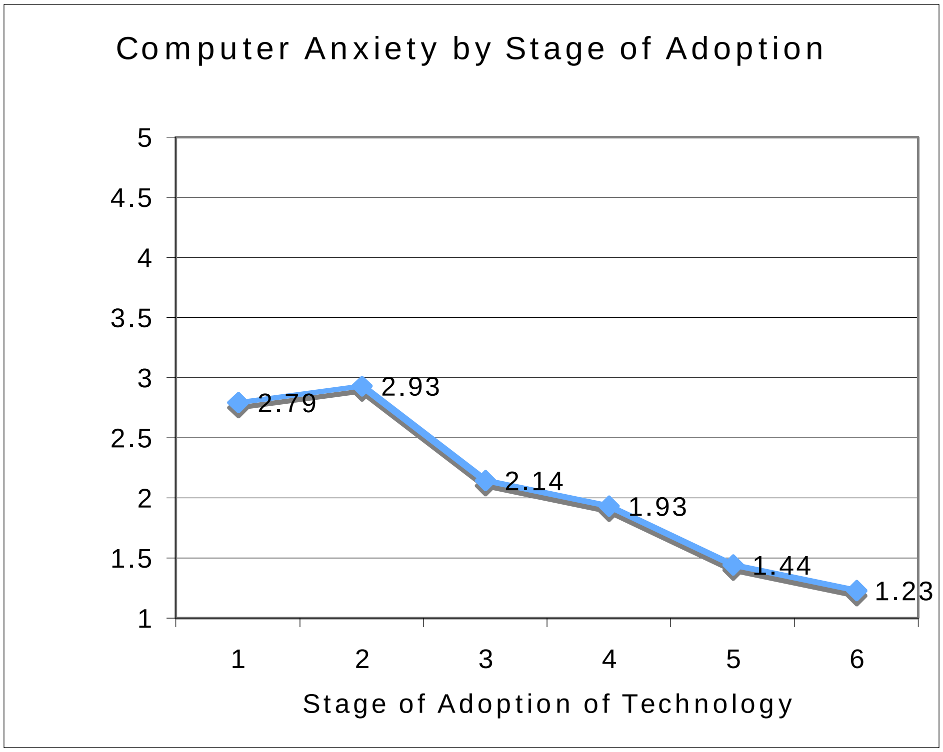

Figure 6. Trend line for Computer Anxiety (Lack of Comfort) by Stage of Adoption of Technology.

Summary of Findings

These findings collectively provide evidence that the three measures featured in this study, when used in combination, form a reliable, valid, measure of the construct Technology Integration that is stable across geographic location and time. Stages of Adoption of Technology, CBAM Level of Use, and ACOT stages of instructional evolution form a consistent self-report measure that has stable construct validity and aligns well with anticipated changes in educator attitudes as level of technology integration progresses.

Discussion

One practical issue related to using the three proposed indicators of Technology Integration is how to combine the three measures into a single scale. Morales (2006) found that transforming two of the three indicators to match the scale of the third increased the precision of the composite measure somewhat. However, he also found that simply averaging the 5-point ACOT, 6-point Stages, and the 8-point CBAM-LoU scale values for each person produced acceptable precision for the Technology Integration construct in his Texas - Mexico cross-cultural study. A simple average (geometric mean) is recommended for future research.

A second practical issue has to do with the time required for administration of multiple technology integration measures. The three measures chosen for this study were selected in part because each instrument typically requires only 2-3 minutes to complete. The combination offers a quick and easy self-appraisal of level of technology integration at the global level. Copies of the instruments are available online at http://iittl.unt.edu.

Not included in this nationwide sample of data were two other measures of technology integration that have been widely used. These are the Concerns-Based Adoption Model Stages of Concern Questionnaire (CBAM-SoC) (Hall, George, & Rutherford 1974; 1998) and the Levels of Technology Implementation Questionnaire (LoTi) (Moersch, 1995). Both were previously described in the literature review section. Further research would be required to determine if these or other measures would align as well as the three used in this study.

Conclusions

The goal of phase 1 of this project was to cross-validate the measures of ACOT, CBAM-LoU and Stages of Adoption against each other. Factor analysis and reliability analysis have confirmed high construct validity and good reliability (.84) for the resulting technology integration scale. The next step is to determine whether this three-legged construct proves to be capable of discriminating among groups known to differ on attributes related to technology and education (ex: online vs. face to face learning). After this is confirmed, the important phase 2 task of using these to predict student achievement can begin.

It is this relationship between integration and achievement that the authors believe may determine the fate of educational technology. It is imperative that the picture we reveal of this relationship be accurate and above reproach. Knowing that we have multiple quick, easy, valid and reliable instruments for assessment is a first step in the right direction.

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