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Measuring Technology Integration Practices of Higher Education Faculty with an Innovation Component Configuration Map (ICCM)

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This paper focuses on the design, development, and standardization of an instrument, Innovation Component Configuration Map (ICCM) (Hall & Hord, 2001), designed to measure technology integration practices of higher education faculty in Schools, Colleges and Departments of Education (SCDEs). The ICCM is grounded in current best practices and technology standards set forth by the International Society for Technology in Education (ISTE). This ICCM was developed using the five standardized steps proposed by Hall and Hord (2001), and Heck, Steigelbauer, Hall, and Loucks (1981). The main purpose of this study was to develop an instrument that provided word picture descriptions of the technology integration practices of faculty in SCDEs. This ICCM was further used to identify and map fidelity levels (high, moderate and low) of technology integration practices of faculty in SCDEs, and then to match the fidelity levels with recommendations for support and interventions.

Keywords: Technology Integration Practices, Standards, and Use

In this era of inevitable change, most educators agree that education needs to reflect technological and social changes in our society (Thornton, 1998; Robyler & Edwards, 2000; Hall & Hord, 2001). This is clearly echoed by the efforts of various national and state organizations in the U.S.A that have invested heavily to enhance the integration of technology into teaching and learning at all levels of education. The International Society for Technology in Education (ISTE) collaborated with the National Council for

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Accreditation of Teacher Education (NCATE) to develop educational technology standards in support of preservice teacher preparation programs. These standards are recognition that technology skills are contemporary expectations in all educational settings. The Preparing Tomorrow's Teachers to Use Technology (PT3) grant program is another example of significant and collaborative efforts to improve technology integration among inservice and preservice teachers. PT3 is an initiative of the U.S. Department of Education, designed to improve teacher preparation programs by focusing on the preparation of preservice educators to more effectively integrate technology into their teaching.

Much of the integration literature describes faculty in higher education who are comfortable using technologies such as word processing, email, and web searching (e.g., Leggett, 1998; McCoy, 1999; Persichitte, Caffarella, & Tharp, 1999; Schmidt, 1996; Vannatta, 2000), but not comfortable integrating technology into their classroom practices for meaningful learning (Glaser & Hardin, 1999; Kozma, 2003; Ropp & Brown, 2000; Vannatta 2000). The issues of best practices in innovative use of technology and integration among higher education faculty are not clearly focused and results of research in this area vary widely indicating the need for additional research (Kozma, 2003; Willis, Thompson, & Sadera, 1999).

The demands on higher education faculty no longer focus solely on content expertise but also on creating active learning environments that integrate technology within content. Faculty can adapt to this role by reflecting, analyzing, observing, implementing, and evaluating successful examples of best practices in technology integration (Ertmer, 1999). Use of an Innovation Component Configuration Map (ICCM) which measures technology integration practices, would also help faculty reflect on their pedagogical practices related to technology integration within their curriculum and allow them to document contemporary exemplary practices in technology integration.

STATEMENT OF THE PROBLEM

Literature in the area of technology integration clearly indicates a distinction between the use of technology for personal and professional purposes and technology integration within instruction for faculty in higher education (e.g., Ertmer, 1999; Jacobsen, 1998). There is consensus in the field that *how* technologies are used in classrooms is more critical to instructional outcomes than *what* technologies are used (Bransford, Brown, & Cocking, 2000). The issue facing Schools, Colleges and Departments of Education (SCDE) administrators is no longer whether faculty and students will use the technology, but how technology can be used to improve teaching and to support learning (Awbrey, 1996; Cummings, 1996; Mills & Tincher, 2003).

There are several large-scale research studies completed in the area of technology integration in the K-12 arena (Barron, Kemker, Harmes & Kalaydjian, 2003; Ertmer, 1999; Mills & Tincher, 2003; OTA, 1995; Shuldman, 2004). However, there is no documented evidence or any current literature that provides vivid descriptions of technological integration practices of higher education faculty in the SCDEs who are responsible for preparing K-12 teachers. Such evidence is necessary when adoption of an innovation by faculty is contingent upon critical factors like availability of technological infrastructure, funding and support from administration, and the need to meet national technology and accreditation standards set by the National Council for Accreditation of Teacher Education (NCATE, 2000; Tharp, 1997).

Stakeholders in higher education are interested in the effectiveness of technology integration. In order to assess effectiveness, it is imperative to know what technology integration practices are in place and the extent to which implementation has occurred.

Most importantly, finding an instrument that measures practices in technology integration and one that captures vivid descriptions of implementation of these practices is difficult (Evans, 2001). This paper focuses on the design, development and validation of a customized, robust instrument (ICCM) to measure technology integration practices of higher education faculty.

THEORETICAL PERSPECTIVES

Technology integration is inherently an innovation adoption decision for faculty. Two theoretical perspectives regarding innovation adoption which are typically cited in innovation research are those of Rogers (1995) and Hall, Wallace, and Dossett (1973). While Roger's theory of diffusion of innovation describes the profile of the innovation adopters (from early adopters to laggards) and the factors critical to innovation adoption, a common criticism is an implied pro-innovation bias. The pro-innovation bias is described as the expectation that an innovation *should* be diffused and adopted by all members of a social system, that it *should* be diffused as quickly as possible, and that the innovation *should* be neither re-invented nor rejected (Rogers, 1995). While other aspects of Rogers' work were foundational to the development of this ICCM to capture the adopter categories, the pro-innovation bias was circumvented by grounding this research in the Concerns-Based Adoption Model (CBAM) (Hall & Hord, 2001; Hall, Wallace, & Dossett, 1973). CBAM is a systemic model used to monitor actual adoption patterns and re-invented uses of the innovation. CBAM includes three diagnostic tools to monitor adoption of an innovation and potentially influence the adoption of an innovation: Stages of Concern Questionnaire (SoCQ), Levels of Use (LoU), and ICCM.

There are several basic premises underlying the CBAM model which apply to technology integration in SCDEs (Hall & Hord, 2001; Heck, Steigelbauer, Hall, and Loucks, 1981; Mills & Ragan, 2000). These include: a) change is a process and not an event, b) understanding the change process in organizations requires an understanding of what happens to individuals as they are involved in change, c) for the individual, change is a highly personal experience, d) for the individual, change entails developmental growth in terms of feelings about and skill in using the innovation, and e) information about the change process collected on an ongoing basis can be used to facilitate the management and implementation of the change process. Facilitating the adoption of any innovation entails *continuous* and *systemic* interventions that may be more easily identified with the use of an appropriate ICCM.

The purpose of the ICCM is to present carefully developed descriptions of different uses of an innovation (see Appendix B). An ICCM is composed of *components* (major features of the innovation), *variations* (different ways in which components may be operationalized), and *configurations* (operational patterns that result from selection and use of different innovation component variations). The concept of innovation configurations and the use of innovation configuration components emphasize concrete and tangible operational forms of the innovation, thereby increasing the possibility of having reliable and valid information about the use of the innovation (Heck et al., 1981).

As per Rogers' (1995) recommendation, the pro-innovation bias was overcome in this study by capturing the adoption process (which in this case is technology integration) while it is ongoing. CBAM instruments, especially the ICCM, allow for measurement of the innovation implemented in different forms thus acknowledging rejection, discontinuance, and re-invention; all frequent occurrences during the diffusion and adoption of an innovation. "Technology integration" may be adopted fully, partially, not at all, or with some apprehension by higher education faculty. The CBAM diagnostic tool, ICCM, captures adoption variations that range from high fidelity to low fidelity.

Hence, Rogers' theory of diffusion of innovations describing the characteristics of innovation users, complemented by the CBAM model's classification of the fidelity levels of an innovation, provided a strong theoretical framework for developing the components and variations of this ICCM.

LITERATURE REVIEW

Two aspects of the research literature were critical to the development of this ICCM: a) the theoretical framework and systematic process related to development and use of ICCMs in previous research studies served as a general guideline for development of the instrument, and b) the component descriptions and variations of the ICCM developed in this study were derived from the current literature in best practices in technology integration and national and state technology standards (ISTE, 2002; NETS, 2000).

Key indicators of best practices in technology integration include access to technology, operability and ease of use, functionality, and direct application in instruction (Ropp & Brown, 2000; Thornton, 1998), collaborations and participation in multiple institutional alliances, diminishing barriers between education sectors, continuity and commitment (Michael, 1998), strong professional development support (Cooper, 1998), organizational leadership (Doebbert, 1998), technical and financial support (Wright, 2000), and stakeholders' involvement (Hall & Hord, 2001). Best practices in technology integration which focus on the learner rather than the technology: include efforts to move the campus to the learner rather than just providing access from a distance; provide multiple opportunities for connection to the student (Doebbert 1998); faculty modeling of technology throughout the curricula; commitment from faculty and administration to support a sustainable technology integration through one-on-one support, grants, collaborative initiatives training and development; emphasis on current research regarding instructional technologies and their application to pedagogy, presence of at least one person who took on the role of change facilitator, use of a variety of educational technologies, use of technology for communication between faculty and students (Persichitte, Caffarella & Tharp, 1999). It is important to emphasize that a pedagogical fit is a critical factor influencing faculty use of technology and students' opportunities to learn with technology. Faculty must find a relationship between their philosophies of teaching and learning and the use of technology applications. Best practices should not be assumed to offer a prescription for ultimate excellence, rather they should be used to help schools evaluate and develop both a vision and road map for successfully overlaying technology across the curricula and pedagogy. These descriptions of technology integration best practices provided concrete and vivid descriptions of effective strategies for integrating technology into classroom instruction for this study.

Several studies have been done that describe the development and use of ICCMs (e.g., Craig & Kacer, 2000; Evans, 2001; Gallagher, 1995; Kacer & Craig, 1999; Kentucky Education Reform Act (KERA), 1990; Mills, 2001; Mills & Ragan, 2000; Tharp, 1997). Most of the ICCM studies have focused on the development of ICCMs and their use as diagnostic tools to find the extent to which the innovation is adopted and is fidel to the developers' intended model of the innovation. The results from these research studies further have been used to identify appropriate interventions to facilitate change and support increased adoption of the innovation.

The purpose of the study done by Gallagher (1995) was to develop and partially assess the technical adequacy of the innovation configuration for problem solving. Gallagher applied the ICCM in an educational setting in which decisions were made about interventions for children. In a similar study conducted by Evans (2001), an ICCM was designed and tested for gifted education in an elementary school, based on the Pre-K to

Grade 12 Gifted Program Standards. Evans operationalized these standards in the form of an ICCM. Data collected with this ICCM allowed change facilitators (e. g., administrators, supervisors, teachers) to identify effective strategies for implementing gifted and talented education in schools and to measure the implementation of best practices in gifted education in the elementary setting.

One of the diagnostic tools used for the evaluation of the programs implemented under the Kentucky Educational Reform Act (KERA, 1990) is the ICCM. The Kentucky Institute for Educational Research (KIER) has created six different ICCMs to measure the implementation of educational reforms in Kentucky (e.g., professional development of the school staff, extended school services, school-based decision making councils, high school restructuring, family resource and youth service centers, educational technology, and the primary education program).

For example, one of the ICCMs was used to investigate the relationship between the level of implementation of educational technology in middle schools and Kentucky's high stakes assessment of academic achievement (Kacer & Craig, 1999). Craig and Kacer (2000) also used an ICCM to assess the relationship between student achievement and the degree of implementation of Extended School Services (ESS) in the middle schools.

The Department of Defense Education Activity (DoDEA) (1994) developed several ICCMs to measure best practices in the teaching of reading, writing, and thematic units using a variety of research based resources to insure successful integration. Each ICCM includes a number of components with variations that describe ways teachers and students interact in the teaching/learning process. The DoDEA designed a similar ICCM for the secondary science program. The descriptions of the ICCM variations were developed around the key components reflected in the National Science Education (NSE) Standards. Each component includes a number of possible variations that describe how teachers teach science and how students learn science. These ICCMs were used for teacher self-analysis and reflection, teacher peer observation and coaching, planning for staff development, and enhancing student involvement.

A study done by Mills and Ragan in 2000 is a robust example of the use of ICCMs. The focus of their study was to develop an ICCM that would track the implementation fidelity of the innovation (an Integrated Learning System). Mills and Ragan attempted to analyze the effectiveness of the implementation of an Integrated Learning System (ILS) called *Successmaker* used in elementary schools. The authors designed and validated an ICCM to measure and analyze the quality of implementation of the ILS instruction by teachers. The Integrated Learning System Configuration Matrix (ILSCM) was specifically used by Mills and Ragan to study to determine if there were differences in the operational patterns of teachers implementing the ILS and to identify which implementation practices of teachers exhibited implementation fidelity.

Mills (2001) developed and validated an ICCM (called *Technology Implementation Standards Configuration Matrix*, TISCM) for examining the quality of implementation of computer technology in classrooms in a school district undertaking a district-wide technology professional development initiative. TISCM was an effective tool for determining technology implementation fidelity, for revealing the technology implementation attributes of teachers integrating technology in classrooms, and for identifying appropriate training themes that targeted specific technology standards.

The primary purpose of the study done by Tharp (1997) was to document critical mass for the use of information technologies within SCDEs. Tharp developed an ICCM for the use of information technologies focusing mainly on e-mail and Internet technologies. Tharp recommended expanding his study longitudinally to document integration and contingency adoption-decision patterns related to the NCATE guidelines as the classroom integration of information technologies continues to evolve. The ICCM development in the current study is a purposeful follow up to Tharp's recommendation for future studies related to technology integration for SCDEs.

PURPOSE OF THE STUDY

It is evident from the ICCM literature (e.g., Evans, 2001; Mills, 2001; Mills & Ragan 2000; Tharp, 1997) that these instruments are a widely used tool for the study of innovations. The purposes of this study were to (a) capture technology integration standards (ISTE and NETS) and technology integration best practices found in the current literature in the form of an ICCM, and (b) follow guidelines and a systematic process of Innovation Component Configuration (ICC) mapping proposed by Hall and Hord (2001), and Heck et al. (1981) to develop, field test, revise and standardize a customized ICCM in preparation for use of the instrument in a full-scale research effort (Javeri, 2003).

METHOD

DEVELOPMENT AND VALIDATION OF THE ICCM

In this study, the innovation is the implementation of best practices in technology integration among higher education faculty in SCDEs. Hall and Hord (2001) emphasize the consensus-building process and debate among ICCM developers as critical to developing a useful and valid ICCM. ICCM development is an interactive and iterative process. One individual is very unlikely to construct a map that is as useful and valid as one that evolves from a team effort. Heck and colleagues (1981) recommend a five-step procedure for developing an ICCM that has been used in several research studies (e.g., Alquist & Hendrickson, 1999; Craig & Kacer, 2000; Evans, 2001; Kacer & Craig, 1999; Kentucky Institute for Educational Research (KIER), 1996a, 1996b, 1996c, 1996d, 1996e, 1996f, 1996g; Mills & Ragan, 2000; Tharp, 1997). The procedure used to develop the ICCM for the study is described here.

STEP 1: IDENTIFY INNOVATION IMPLEMENTATION COMPONENTS

The first step requires the identification of components that are relevant to and major operational features of the implementation of the innovation (Heck et al., 1981). A review of the literature on technology integration practices in K-12 and higher education, best practice literature, and the ISTE National Education Technology Standards (NETS) provided a solid base to start the development of components for an ICCM of best practices in technology integration.

Implementation components describe the operational practices of faculty integrating technology. It is important to reiterate that the ICCM components are behaviorally oriented descriptions of technology integration. The components are designed to capture the essence of the innovation in action terms such that the researcher, faculty, evaluator, or administrator is able to match components and component variations to actual behaviors and activities (Heck et al., 1981). There is widespread agreement that standards reflect shared values by identifying and describing those performances that are important for a teacher (Mills, 2001). Thus, the ICCM implementation components in this study (see Appendix A) were comprised of the technology integration practices and the performance indicators for faculty use of technology as identified by ISTE (2002) and NETS (2000) standards.

STEP 2: IDENTIFY ADDITIONAL COMPONENTS AND VARIATIONS

Heck and colleagues (1981) recommend interviewing or observing a small sample of the users of the innovation to identify any additional components and variations of the implementation for each component. A qualitative study (Javeri, 2002) resulted in a first draft of the ICCM. Seven faculty members from the mid-size western university participated in this initial development effort. These seven faculty members taught preservice student teachers and were also participants in a Preparing Tomorrow's Teachers to Use Technology (PT3) grant project. These faculty members were considered leaders in the area of technology integration within the SCDE. The primary goal of the qualitative study was to explore and identify best practices in technology integration by the teacher education faculty in this particular SCDE. Interviews with these seven faculty, observations in their classrooms, and content analysis of their websites and projects were used to triangulate technology integration practices for these higher education faculty members.

Based on observations and interview feedback from the seven higher education faculty members, variations of each of the 25 technology integration components were identified. Variations for each component consist of discrete categorizations of the technology integration practices for the corresponding component. For each of the 25 components, variations in use were arranged along a continuum; such that technology integration behaviors reflected in each successive level of variation included behaviors from preceding variations (see Appendix B). In the final version of the ICCM, component variations were arranged along an ordinal scale with each successive variation indicating a closer approximation of ideal integration of technology (or fidelity) as recommended by the best practice literature and the ISTE and NETS standards. Such ordinal arrangement of the variations is strongly encouraged by Dr. Gene Hall and other developers of the original CBAM. Higher fidelity variations of a component purposely included preceding lower fidelity variations (Mills & Ragan, 2000).

There are 25 components in the ICCM developed in this study. Each of the technology integration implementation components is comprised of five variations of implementation fidelity (arranged in descending fidelity from left to right) (see Appendix B). The first variation within every component, representing high fidelity implementation, was assigned a value of 5 and subsequent variations assigned values of 4, 3, 2, and 1 with 1 representing the least fidelity along the ICCM continuum. Hence, responses to each component on the ICCM range from a maximum score of 5 (highest fidelity) to a minimum of 1 (lowest fidelity). The ICCM total score ranges from 125 to 25. Numeric coding decisions were made to allow for analysis of integration fidelity in the subsequent full-scale integration study in which this ICCM was implemented.

STEP 3: REFINE THE INNOVATION COMPONENTS

ICCM developers should clarify with the developers of an innovation which components are critical, verify variations, minimize discrepancies between the developer and user viewpoints, and decide upon exact language to use when describing an activity or behavior in the different operational forms. There were three experts in the field of technology integration who contributed to the ICCM development with critical review and feedback. The process was collaborative and highly iterative resulting in new components and variations with each draft. After five revisions, the ICCM was judged ready for review by additional external experts.

To establish content-related validity for this ICCM, two other experts in the area of technology integration and best practices were consulted. Both external experts serve in higher education faculty roles closely affiliated with technology integration and are recognized experts in the field. As recommended by Heck and colleagues (1981), the component labels were removed from the participant version of the ICCM in order to avoid any response bias. The total time period to develop this final version of the ICCM was approximately four months. The ICCM for technology integration was devised as (a) a self-report instrument to be completed by individual faculty members from SCDEs or (b) an observation or interview instrument to be used by a researcher or an evaluator.

STEP 4: TEST THE INNOVATION MAP WITH A FEW USERS AND FINALIZE THE INNOVATION COMPONENTS (FIELD STUDY)

At the beginning of data collection, expansion and/or clean-up of the components may be necessary. It is imperative to field test the ICCM with a small group of innovation users who represent a range of adoption levels for the innovation. ICCMs are typically context specific and should result in robust reliability measures. The ICCM developed in this study was field tested for reliability and content-related validity before implementation in a full-scale research study. The methodology for the field study and completed outputs are described in Figure 1.

The ICCM was field-tested to establish content validity and reliability with faculty members from the SCDE that contributed to the development of the ICCM components. The purposes of the field study were: (a) to assess clarity of the items on the ICCM by interviewing faculty, (b) to test the vocabulary of the ICCM components, (c) to assure the formatting of the ICCM (disseminated as surveys in three formats: online, paper-based and e-mail) was robust, (d) to test the working of the online data capture system, and (e) to identify potential implementation pitfalls prior to implementation in a full-scale study. The phases, procedure, data analyses, and limitations of the field study are described in this section.

Phase 1: Identification of the pilot sample. The sample for the field study included a convenience sample of 85 faculty members from a mid-size western SCDE. Of the 85 faculty members who were mailed the ICCM, 35 faculty provided completed responses for a response rate of 41%. Of the 35 respondents, 10 completed the online version, 25 completed the paper-based version, and none completed the e-mail attachment. Of the respondents, 57.1% were female, 94.3% were Assistant, Associate, and Full Professors with 84.3 % having a doctoral degree, and 94.3% reporting full-time employment status in the SCDE. Teaching experience ranged from 0 to 43 years ($M = 20.9$, $SD = 10.42$).

Phase 2: Mailing the surveys. Each faculty member identified for the field study was mailed an envelope that contained a consent form for the field study, a paper copy of the ICCM with options to complete the ICCM online (URL specified) or via e-mail, and a pre-addressed return envelope which the faculty could return via campus mail.

Phase 3: Orientation of the coding assistant. A graduate assistant at the university was trained to assist in the coding of data for three faculty members who were interviewed as part of the field study. A detailed orientation was provided to the graduate assistant explaining the purpose of the study, the data collection procedures, her role in interpreting the transcribed interviews, and practice in coding the ICCM. The primary purpose of the interviews was to establish content-related validity of the faculty self-report on the ICCM.

Phase 4: Follow up. A week after sending the first e-mail, a follow up e-mail was sent to faculty members who had not responded. A second e-mail of a similar nature was sent two days before the due date as a "last chance" reminder. Each of the two follow up e-mails also had the URL link to the online ICCM.

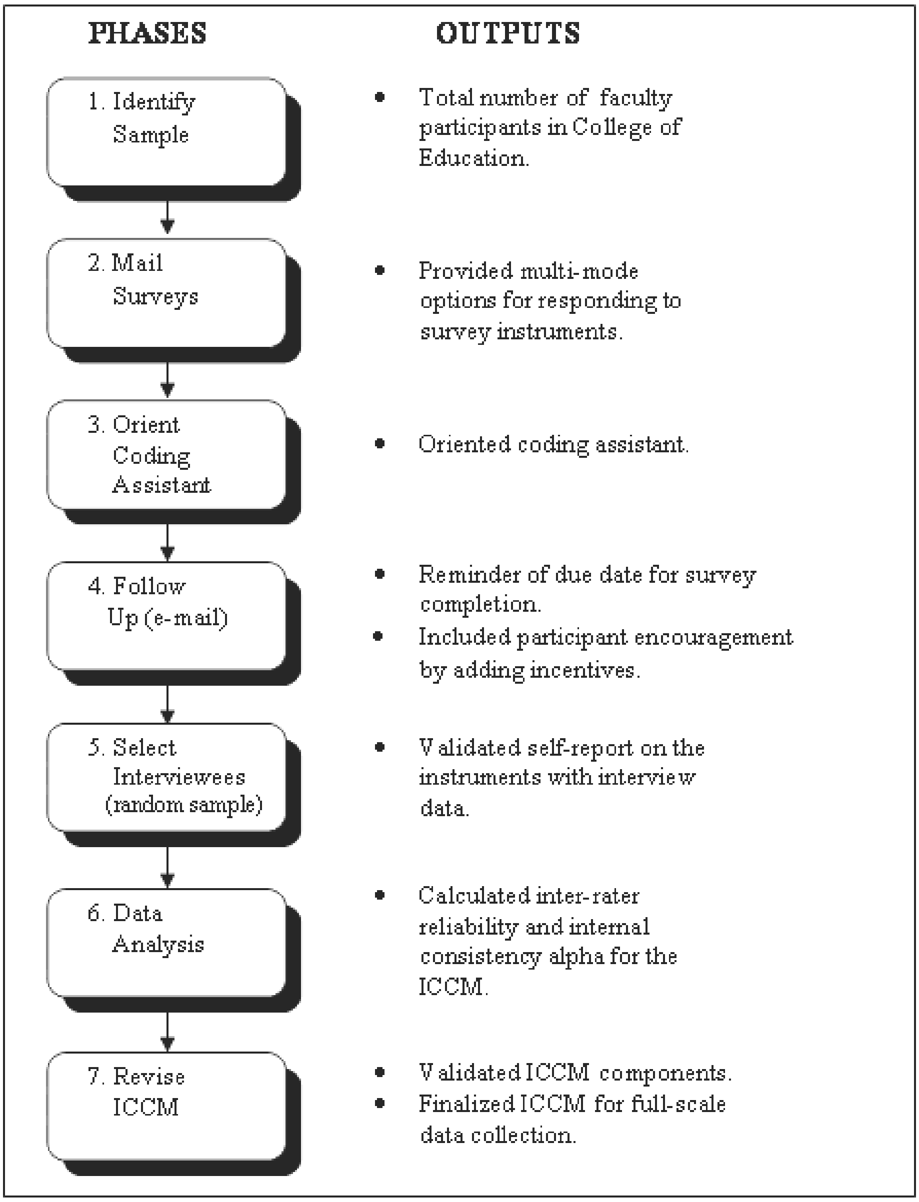

Figure 1. Phases and Outputs for the Field Study

Phase 5: Selection of interviewees. Three faculty members were randomly selected from the respondents using computer generated random numbers. These faculty members participated in a 30 to 45 minute semi-structured interview. The interview protocol was created from the ICCM components. These interviews were tape-recorded and then transcribed for validation with the self-report given on each component of the ICCM. The faculty members for the interview represented a range of disciplines (Special Education, Counseling, and Educational Leadership).

Phase 6: Data analysis for the field study. The field study yielded multiple results. The quantitative data from the ICCM instrument provided information about the reliability of the ICCM components and variations and the qualitative data provided information about the validity of ICCM component descriptions for the self-reporting of technology integration fidelity. Results indicated that the procedures, the instrument, and the design of the study materials were standardized for the full-scale study. Minor adjustments to protocols and timelines were made.

Since a multi-mode method of data collection was used, the online database served as a shell for entering the data from the paper copies and e-mail survey responses. Cumulative data from all the sources (paper, online, and e-mail) were imported into SPSS© 11.0 to perform the various statistical analyses. Of primary interest in the field study was the reliability analyses for the ICCM instrument. The 25-component ICCM had internal consistency (Cronbach Alpha) of .96 for the total scale indicating a very high reliability. The interview data from the three faculty participants were used to establish content-related validity evidence of the ICCM component descriptions. The role of the coding assistant was to thoroughly read and listen to the transcribed interviews of the three faculty members. Based on the interviews, the coding assistant completed the ICCM for each faculty member. The ICCM total score from the interview (completed by the coding assistant) for each faculty member was then compared with the self-report on the ICCM for that faculty member. This process was used to monitor agreement between the self-report by the faculty and the rater (coding assistant) on the ICCM components. The total score ratings on the ICCM for each faculty member and the coding assistant are as indicated in Table 1.

Table 1. ICCM Ratings by Faculty and the Coding Assistant

Faculty	Self-Report on ICCM Score (X)	Coding Assistant Score on ICCM (Y)	Difference between X and Y
Faculty A	107 (High fidelity)	110 (High fidelity)	3
Faculty B	60 (Moderate fidelity)	62 (Moderate fidelity)	2
Faculty C	69 (Moderate fidelity)	65 (Moderate fidelity)	3

Note: High fidelity score (x): $75 \leq x \leq 125$; Moderate fidelity score (y): $50 \leq y < 75$; Low fidelity score (z): $0 \leq z < 50$)

Table 1 compares the total ICCM self-report score with the ICCM rating by the coding assistant for each of the interviewed faculty members. The fidelity categories were established a priori based on the best practices literature and the ISTE and NETS standards. The differences between the self-report by faculty and the coding assistant for each of the three faculty are minimal thus validating the classification of Faculty A in the high fidelity and Faculty B and C in the moderate fidelity group of technology integration practices. Such close agreement between the self-report by faculty and the external coding assistant provided sufficient evidence of the clarity of the vocabulary used in the ICCM component variations as well as evidence of content-related validity. The interviews also contributed to minor revisions in the formatting of the ICCM instrument.

Phase 7: Revising the ICCM. The high reliability statistic and the close agreement between the self-report and the coding assistant on the ICCM did not warrant a major revision or deletion of any items. A few minor adjustments were made to the ICCM before conducting the full-scale study. These revisions included formatting and highlighting key components on the paper-based ICCM, dividing the online ICCM into different screens making it easier to read online, and shortening the URL. The field study and subsequent revisions occurred over a two week period. Limitations of the field study included: convenience sampling, reliability statistical analysis based on a sample size of 35, and interview data from a small random sample.

STEP 5: COLLECT INNOVATION DATA

At this stage, the ICCM was implemented in a full-scale integration research study (Javeri, 2003). ICCMs have been used to collect data in three different ways: 1) completion of the ICCM by the user, 2) as an interview protocol, and 3) as an observation rubric for the innovation in use. Each allows different perspectives on the use of the innovation and each has advantages and disadvantages as a data collection method. The full-scale integration study used this ICCM to collect self-report data from a random sample of 600 faculty members from the 2002 membership of the American Association of Colleges of Teacher Education (AACTE). Data from 208 respondents were then used to 1) establish the factor structure of the ICCM and 2) investigating the complex relationship between the level of technology integration fidelity (high, moderate or low) of SCDE faculty as measured by ICCM and (a) access to adequate support from technological infrastructure, (b) access to adequate support from human infrastructure, and (c) personal attitude toward computer use.

Factor analysis of the ICCM. The goal of factor analysis with the ICCM in this study was to explore patterns of correlations among all the items and to verify that the 25 items could be classified into the six ICCM categories of technology integration practices (see Appendix A). An exploratory factor analysis was used and conducted in two stages: factor extraction and factor rotation. As a part of the first decision to determine the number of extracted factors, a principal component solution (unrotated solution and Eigen value > 1) was obtained on the 25 item ICCM to assess the absolute and relative magnitudes of the eigen values. The scree plot of all the eigen values was used as the criterion to decide on the number of factors that should be used in further analyses. The scree plot (see Figure 2) indicated that the anticipated six factor dimensionality of the ICCM consistent with the six categories of technology integration did not exist. Based on the scree plot, it was concluded that the ICCM had only one interpretable factor accounting for 43.5% of the variance of the 25 variables.

Thus in order to examine the factor loadings on each of the ICCM items, a Maximum Likelihood factor analysis was conducted for a one factor solution. Although the ICCM was designed to measure six distinct aspects of technology integration, the ICCM also gives an overall measure of technology integration fidelity. Hence, it can be understood why the ICCM factor analysis resulted in a one factor structure. Technology integration is a very systemic process, and it involves integration in all aspects of teaching and learning (e.g., integration in design and planning of curriculum, design and planning of learning environments, integration in evaluation and assessment, integration in professional practice). Due to the unidimensional factor structure, total scores on the ICCM were used to categorize technology integration fidelity.

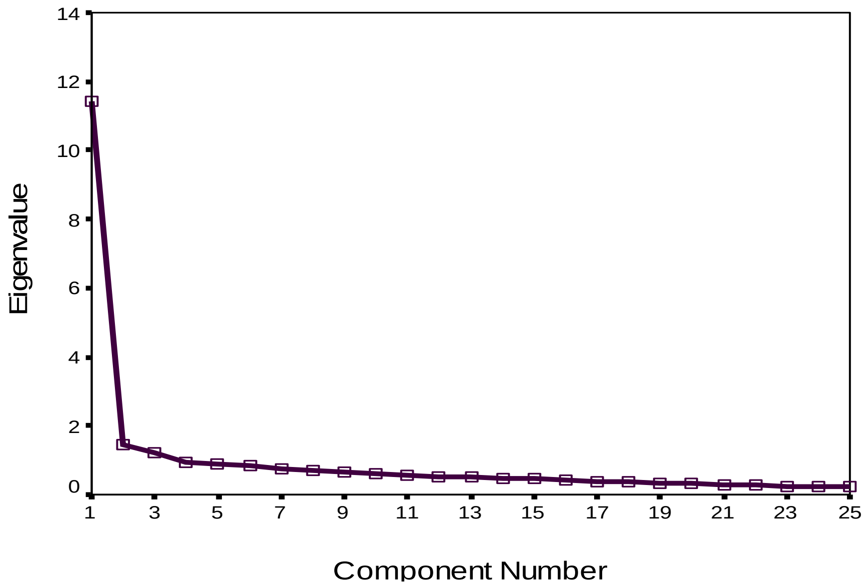

Figure 2. Scree Plot of the Eigen Values.

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Investigating relationship between ICCM fidelity levels, computer attitudes, technological and human support. It was found that (a) on average, 56.7% of the SCDE faculty demonstrated best practices in technology integration (judged significant through t-test), (b) 56.7% of the respondents were classified high fidelity, 38% moderate fidelity and 5.3% low fidelity integrators of technology. The chi-squared goodness of fit test resulted in significant differences in the proportions of the three fidelity groups favoring high fidelity integrators of technology, and (c) multinomial logistic regression analysis showed, “positive reactions to computers” and “comfort with familiar computer-related mechanisms” were the only significant contributors to explaining the difference between high and low fidelity groups. “Comfort with familiar computer-related mechanisms” was the sole significant contributor to differences in the moderate and high fidelity groups. A detailed description of the full-scale study and results are published in the dissertation study by Javeri (2003).

CONCLUSION

The components of the ICCM developed in this study were derived from contemporary literature in best practices in technology integration and national and state technology standards (ISTE, 2002; NETS, 2000). The descriptions of technology integration practices supplemented with examples in this ICCM provide concrete and vivid descriptions of effective strategies for integrating technology into higher education classroom instruction. Faculty members can use the ICCM to self-evaluate their technology integration practices and also to emulate best practices of technology integration within their teaching, subsequently fulfilling the expectations of national and state technology standards. Consequently, the ICCM developed in this study serves a dual purpose: as an evaluation tool as well as an implementation guideline. Further, the characteristics of faculty who report high fidelity, moderate fidelity and low fidelity toward technology integration will be useful to change facilitators who are interested in supporting professional development among their higher education colleagues targeting technology integration.

The process described here resulted in a reliable ICCM instrument with a high degree of content validity for the measurement of a pre-defined innovation. The complete ICCM developed to measure technology integration among higher education faculty in SCDEs is included here for other researchers to use or customize (see Appendix B). These authors recommend both the process and the ICCM instrument for researchers interested in measuring adoption levels and patterns of use of well-defined innovations, and specifically recommend the use of this ICCM to measure the technology integration practices of faculty in SCDEs.

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APPENDIX A

INNOVATION COMPONENT CONFIGURATION MAP (ICCM)
CATEGORIES ICCM Components

1. Faculty demonstrate a sound or in-depth understanding of the technology operations and concepts
    a. Select appropriate technology tools (resources)
    b. Have knowledge and understanding of the various capabilities of technology (e.g., linking learners to information sources, helping learners visualize problems and solutions, tracking learners progress, linking learners to learning tools)
    c. Have knowledge and understanding of file management and archive plans
    d. Have skills related to the use of various productivity and management software
    e. Have skills related to the use of course management tools for Web-based learning
2. Faculty integrate technology in planning and designing learning environments and experiences (Faculty plan, design, and model effective learning environments and multiple experiences supported by technology)
    a. Design developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners
    b. Apply current research on teaching and learning with technology when planning learning environments and experiences
    c. Identify and locate technology resources and evaluate them for accuracy and suitability
    d. Identify and apply instructional design principles associated with the development of technology resources
    e. Collaborate in planning and designing technology based learning environments

3. Faculty integrate technology in the planning of curriculum (Faculty facilitate, model, design, implement and disseminate curriculum plans that include methods and strategies for applying technology to maximize student learning and also address content standards and student-technology standards)
    a. Integrate technology-enhanced experiences that support use of, distance learning environments
    b. Support curriculum that incorporates integration of technology skills to enhance student learning
    c. Integrate technology to address broader and multiple perspectives in the content area
    d. Integrate technology to develop students' higher order skills and creativity
4. Faculty integrate technology in evaluation and assessment
    a. Apply technology to assess student learning of subject matter using a variety of assessment techniques
    b. Apply technology to assess instructional practices and maximize student learning
    c. Apply multiple methods to determine student's appropriate use of technology resources for learning, communication and productivity
5. Faculty integrate technology to enhance their productivity and professional practice (Faculty design, develop, evaluate, model and facilitate application of products created using technology resources to improve and enhance their productivity and professional practice)
    a. Use technology resources to engage in ongoing professional development and life long learning
    b. Continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology
    c. Apply technology to increase productivity
    d. Use technology to communicate and collaborate with peers, students and other peer professionals
6. Faculty understand the social, ethical, legal and human issues surrounding the use of technology and apply that understanding in practice
    a. Model and teach legal and ethical practice related to technology use
    b. Identify and use technology resources that affirm diversity
    c. Promote safe and healthy use of technology resources
    d. Facilitate equitable access to technology resources for all students

APPENDIX B

INNOVATION COMPONENT CONFIGURATION MAP Copyright: Javeri, 2003©

1. Faculty demonstrate a sound or in-depth understanding of the technology operations and concepts					
	5	**4**	**3**	**2**	**1**
a. Select appropriate technology tools (resources)	I always consider current research/evaluations on media (technology tools) before using them in my classroom.	I often look at the current research/evaluations on the media (technology tools) before using them in my classroom.	I consult other teachers about evaluation information for the media (technology tools) before using them in my classroom.	I occasionally refer to research or consult other teachers to find information about the media (technology tools) before using them in my classroom.	I usually do not attempt to review current research nor consult others about media evaluation before using it in my classroom.
b. Have knowledge and understanding of the various capabilities of technology	I consistently use Internet, WWW, e-mail and other technologies to help learners link to information resources, for effective communication, and to help learners visualize problems and solutions.	I often use Internet, WWW, e-mail and other technologies to help learners link to information resources, for effective communication, and to help learners visualize problems and solutions.	I sometimes use Internet, WWW, e-mail and other technologies to help learners link to information resources, for effective communication, or to help learners visualize problems and solutions.	I seldom use Internet, WWW, e-mail or other technologies to help learners link to information resources, for effective communication, or to help learners visualize problems and solutions.	I do not use the Internet, WWW, e-mail or other technologies in the classroom.
c. Have knowledge and understanding of file management and archive plans	I can create, organize and manage files and folders on the computer. I have a system of backing up my computer.	I can create, organize and manage files and folders on the computer.	I try to use the file folder management system to organize files on the computer.	I am aware of a file folder management system on the computer but struggle to use it effectively.	I am not aware of any file folder management system on the computer.
d. Have skills related to the use of various productivity and management Software	I can create my own Web pages, multimedia presentations (e.g., PowerPoint, Hyperstudio), handouts and I use authoring software.	I am able to effectively use and manage my Website and can create my own multimedia presentations.	I can create multimedia presentations like PowerPoint and I am familiar with Web authoring software.	I typically have support to create and manage my Website as well as to create multimedia presentations.	I do not have my own Website nor do I feel comfortable creating any multimedia presentations.
e. Have skills related to the use of course management tools for Web-based learninG	I have used an online course management system (e.g., Blackboard, WebCT) for Web-based learning several times.	I have effectively used an online course management system like (e.g., Blackboard, WebCT) to teach a Web-based class.	I have used an online course management software (e.g., Blackboard, WebCT) in support of a traditional course.	I have seldom used any kind of online course management software for Web-based teaching or to support traditional courses.	I am familiar with online course management software for Web-based learning but have not used any so far.

2. Faculty integrate technology in planning and designing learning environments and experiences (Faculty plan, design, and model effective learning environments and multiple experiences supported by technology)					
	5	**4**	**3**	**2**	**1**
a. Design of developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners	I have created an online database of project-based instructional units modeling appropriate uses of technology to support learning within the context of classroom learning. I also model strategies to support diverse needs of learners including the use of adaptive and assistive technologies.	I have had support to create an online database of project-based instructional units modeling appropriate uses of technology to support learning within the context of classroom learning. I have also had support in the integration of adaptive and assistive technologies in my classroom.	I have used multiple technologies (e.g., computer, video, audio, projectors) to implement different instructional strategies and to support diverse needs of learners.	I always attempt to arrange equitable access to technology resources that enable learners to engage successfully in learning activities across subject/content areas and grade levels.	I am aware of some technology resources and strategies to support the diverse needs of learners but rarely use them in my classroom.
b. Apply current research on teaching and learning with technology when planning learning environments and experiences	I regularly conduct my own research on teaching and learning with technology when planning and implementing learning environments and experiences.	I usually model strategies reflecting current research on teaching and learning with technology when planning learning environments and experiences.	I often engage in ongoing planning of lesson sequences that integrate technology resources.	Sometimes I refer to current research as well as personal experiences with teaching and learning with technology when planning learning environments and experiences.	I try to stay abreast of the current research on teaching and learning with technology when planning learning environments and experiences.
c. Identify and locate technology resources and evaluate them for accuracy and suitability	I have developed, implemented and evaluated technology resources (e.g., computer simulations, tutorials, online databases, research articles) aligned with state and/or national content and technology standards.	I model integration of technology resources reflecting state and/or national content and technology standards.	I assist the learners as they identify and locate technology resources and evaluate them for accuracy and suitability based on state and/or national standards.	I attempt to make appropriate choices about technology systems, resources, and services that are aligned with state and/or national standards.	I typically rely on other sources to help me locate technology resources and evaluate them for accuracy and suitability.
d. Identify and apply instructional design principles associated with the development of technology resources	I consistently integrate and apply instructional design principles when I use technology resources.	I usually integrate and apply instructional design principles when I use technology resources.	I sometimes use instructional design principles when I develop technology resources.	I am aware of the instructional design principles associated with the development of technology resources.	I am not aware of the instructional design principles associated with the development of technology resources.

e. Collaborate in planning and designing technology based learning environments	I regularly participate, collaborate, and share with peer faculty members, other institutions and/or students, when I design and develop technology based learning environments.	I have been involved in multiple institutional alliances with regard to developing and designing technology based learning environments.	I almost always collaborate with peer faculty and/or students when I design or develop technology based learning environments	I often participate in team teaching and sharing technology related materials with peer faculty members.	I seldom participate in team teaching and sharing technology related materials with peer faculty members.
3. Faculty integrate technology in the planning of curriculum (Faculty facilitate, model, design, implement and disseminate curriculum plans that include methods and strategies for applying technology to maximize student learning and also address content standards and student-technology standards)					
	5	**4**	**3**	**2**	**1**
a. Integrate technology-enhanced experiences that support use of, distance learning environments	I consistently design, implement, and evaluate methods and strategies that incorporate a wide range of distance learning systems (e.g., video conferencing, web-based) appropriate for my instruction.	I regularly incorporate some of the available distance learning systems that are appropriate for my instruction.	I sometimes use methods and strategies that support at least one distance learning system in my instruction.	I am aware of some methods and strategies that support the use of distance learning systems (e.g., video conferencing, web-based) in my instruction.	I do not use distance learning systems (e.g., video conferencing, web-based) in my instruction.
b Support curriculum that incorporates integration of technology skills to enhance student learning	I consistently design, implement and evaluate methods and strategies for teaching concepts and skills that support integration of various productivity tools (e.g., Microsoft Word, PowerPoint, spreadsheet), communication tools (e.g., e-mail, listservs), and multimedia tools (e.g., television, audio, graphics, computer animations).	I try to model methods and strategies for teaching concepts and skills that integrate various productivity tools (e.g., Microsoft word, PowerPoint, spreadsheet), communication tools (e.g., e-mail, listservs), and multimedia tools (e.g., television, audio, graphics, computer animations).	I attempt to implement methods and strategies that support integration of some technology tools for teaching concepts and skills.	I am aware of some methods and strategies for teaching concepts and skills that require various productivity tools (e.g., Microsoft word, PowerPoint, spreadsheet), communication tools (e.g., e-mail, listservs), and multimedia tools (e.g., television, audio, graphics, computer animations).	I typically do not use technology tools for teaching concepts and skills.
c. Integrate technology to address broader and multiple perspectives in the content area	I consistently use technology to facilitate interdisciplinary learning and to address global issues.	I often use technology to facilitate interdisciplinary learning and to address global issues.	I sometimes use technology to facilitate interdisciplinary learning and to address global issues.	I rarely use technology to facilitate interdisciplinary learning and to address global issues.	I typically do not use technology to facilitate interdisciplinary learning and to address global issues.

d. Integrate technology to develop students' higher order skills and creativity	I consistently incorporate strategies that require hypermedia development, scripting, and/or computer programming in a problem-solving context.	I often incorporate strategies that require hypermedia development, scripting, and/or computer programming in a problem-solving context.	I occasionally use methods and strategies for teaching problem- solving principles and skills using technology resources.	I am aware of some methods and strategies for teaching problem-solving principles and skills using technology resources.	I seldom use technology resources for teaching problem-solving principles and skills.
4. Faculty integrate technology in evaluation and assessment					
	5	**4**	**3**	**2**	**1**
a. Apply technology to assess student learning of subject matter using a variety of assessment techniques	I consistently develop, implement and assess innovative technology tools/resources (grade books, statistical packages, online rubrics) for assessment and evaluation of student learning.	I typically use technology tools/resources to assess student learning of subject matter using a variety of assessment techniques.	I assist students in their use of technology resources to collect, analyze and interpret results from electronic resources.	I am learning about technology resources/tools that I can use to assess student learning.	I am not familiar with technology tools/resources that support the assessment and evaluation of student learning of subject matter.
b. Apply technology to assess instructional practices and maximize student learning	I consistently use a variety of technology resources to aid in analysis and evaluation of my instructional practices to maximize student learning.	I use technology resources to evaluate and improve instructional practices with a focus on maximizing student learning.	I implement a variety of instructional grouping strategies that include appropriate embedded assessments for meeting the diverse needs of learners.	I occasionally use technology tools to assess my instructional practices.	I am vaguely aware of some technology tools that I might use to assess my instructional practices.
c. Apply multiple methods to determine student's appropriate use of technology resources for learning, communication and productivity	I use multiple methods to assess student's use of technology resources for learning, communication, and productivity.	I employ basic strategies and methods for evaluating my student's use of technology resources for learning, communication, and productivity.	I guide students in applying self and peer assessment strategies to critique student-created technology products.	I assess my student's use of technology resources for one of these: learning, communication, or productivity.	I do not assess my student's use of technology resources for learning, communication, or productivity.

5. Faculty integrate technology to enhance their productivity and professional practice (Faculty design, develop, evaluate, model and facilitate application of products created using technology resources to improve and enhance their productivity and professional practice)					
	5	**4**	**3**	**2**	**1**
a. Use technology resources to engage in ongoing professional development and life long learning	I always use technology resources at professional conferences and to support my continuing professional growth.	I often use technology resources at professional conferences and to support my continuing professional growth.	Sometimes I use technology resources at professional conferences and to support my continuing professional growth.	On occasion, I use technology resources at professional conferences and to support my continuing professional growth.	I rarely use technology resources and seldom participate in professional development activities related to technology.
b. Continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology	I regularly make changes in my use of technology resources based on experiences and reflection in my classroom.	I often make changes in my use of technology resources based on experiences and reflection in my classroom.	I sometimes make changes in my use of technology resources based on experiences and reflection in my classroom.	I rarely make changes in my use of technology resources based on experiences and reflection in my classroom.	I do not reflect on personal experiences in the classroom to make changes in my use of technology resources.
c. Apply technology to increase productivity	I use distance learning delivery systems and electronic communications to support personal/professional development and to conduct and provide professional development opportunities for students and other peer faculty members.	I can create multimedia presentations for classroom use as well as for online delivery, integrated with multiple types of data, using advanced features of presentation tools and model them to audiences both inside and outside of the school using computer projection systems.	I regularly use advanced features of word processing, desktop publishing, graphics programs and other utilities to create professional products.	I sometimes use advanced features of word processing, desktop publishing, graphics programs or other utilities to create professional products	I do not use technology resources to improve my professional productivity.
d. Use technology to communicate and collaborate with peers, students, and other peer professionals	I regularly use e-mail, Web pages, and other telecommunications tools and resources to communicate with peers, students, and other peer professionals.	I sometimes use e-mail, Web pages, and other telecommunications tools and resources to communicate with peers, students, and other peer professionals.	E-mail is the technology resource that I use most often to communicate with peers, students, and other peer professionals.	I rarely use e-mail, Web pages, or other telecommunications tools and resources to communicate with peers, students, and other peer professionals.	I do not rely on technology resources to communicate with peers, students, and other peer professionals.

6. Faculty understand the social, ethical, legal and human issues surrounding the use of technology and apply that understanding in their practice					
	5	4	3	2	1
a. Model and teach legal and ethical practice related to technology use	I advocate and implement rules, policies, and procedures to support the legal and ethical use of technologies inside and outside my classroom.	I encourage students to consider the implications of legal and ethical use of technology use while modeling ethical practices.	I do my best to model ethical practices related to technology use.	I summarize copyright and Fair Use laws related to use of images, music, video, and other digital resources in my coursework.	I am vaguely aware of copyright and Fair Use laws related to use of images, music, video, and other digital resources.
b. Identify and use technology resources that affirm diversity	I conduct research to determine best practices for applying appropriate technology resources to affirm diversity and address cultural and language differences.	I communicate with peers about applying appropriate technology resources to affirm diversity and address cultural and language differences.	I recognize that there are cultural differences in how technology resources are used.	I try to identify capabilities of current and emerging technology resources that support diversity of audience and purpose for my teaching.	I have not yet tried to use technology resources to support the diversity of my students.
c. Promote safe and healthy use of technology resources	I conduct research to understand the safety and healthy use characteristics of all technology resources.	I impose some restrictions on my students to assure safe and healthy use of technology resources.	I recommend technology resources that promote safe and healthy use of technology.	I inform students about the safe and healthy use of technology resources.	I am not aware of the issues related to safe and healthy use of technology resources.
d. Facilitate equitable access to technology resources for all students	For every technology resource I use, I first consider how all students will gain equitable access.	For most technology resources I use, most students have equitable access.	I develop a summary of effective school policies and classroom management strategies for achieving equitable access to technology resources for all student and teachers.	I develop strategies for achieving equitable access to technology resources for all students.	I advocate for equal access to technology for all students and teachers.