Measuring the Use of Information and Communication Technologies (ICTs) in the Classroom

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RUNNING HEAD: Measuring ICT Use

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ABSTRACT. In 2003, the *ICT Curriculum Integration Performance Measurement Instrument* was developed from an extensive review of the contemporary international and Australian research pertaining to the definition and measurement of ICT curriculum integration in classrooms (Proctor, Watson, & Finger, 2003). The 45-item instrument that resulted was based on theories and methodologies identified by the literature review. This paper describes psychometric results from a large-scale evaluation of the instrument subsequently conducted, as recommended by Proctor, Watson and Finger (2003). The resultant 20-item, two-factor instrument, now called *Learning With ICTs: Measuring ICT Use in the Curriculum* is both statistically and theoretically robust. This paper should be read in association with the original paper published in *Computers in the Schools (*Proctor, Watson & Finger, 2003) that described in detail the theoretical framework underpinning the development of the instrument.

Keywords: Information and Communication Technology, ICT, curriculum integration, measurement instrument

INTRODUCTION

While there has been an ongoing push for many years to bring Information and Communication Technologies (ICTs) into classrooms and to integrate them into the curriculum, until recently little attention has been given to how such integration might be measured outside of simply counting the number of machines or calculating student to computer ratios (Proctor et al., 2003).[1] Aligned with the recent well-documented plethora of initiatives to integrate ICTs into the school curriculum in many countries (Department for Education and Skills (DfES), 2002; Finger, 2003; Finger & Trinidad, 2002; Kommers, 2000; Ministerial Council on Education Employment Training and Youth Affairs (MCEETYA), 2002) have arisen parallel requirements to measure the quantity and quality of ICT integration that students experience, based on recent education priorities that emphasize outcomes (Andrich, 2002; Solway, 1999) and accountability (Gordon, 2002; Mulvenon, Murry, & Ritter, 2001). Methodologies to measure the impact of ICT curriculum integration on student learning outcomes have recently appeared in the literature (Ainley, Banks, & Flemming, 2002; British Educational Communications and Technology Agency (Becta), 2003; Cuttance, 2001; Proctor et al., 2003). This global measurement trend reflects the increasing maturity of the use of ICTs in schools that was documented in a recent issue of Computers in the Schools (Maddux, 2003; Proctor et al., 2003; Wentworth & Earle, 2003; Willis, 2003).

However, regardless of this recent research trend, measuring the impact of ICT-based educational innovations remains a significant challenge for schools (Cuttance, 2001). As a consequence, many approaches thus far used by schools and systems either seek to quantify skills (Meredyth, Russell, Blackwood, Thomas, & Wise, 1999), quantify available hardware (Withers & Coupal, 2002), or correlate available hardware with the amount of time students use it (Norris, Soloway, & Sullivan, 2002). Large-scale investigations such as the Second Information Technology in Education Study (International Association for the Evaluation of Educational Achievement (IEA), 2003) and enGauge (North Central Educational Laboratory (NCREL), 2003) have highlighted the need for the development of methodologies that effectively measure student outcomes as a result of ICT integration.

[1] ICTs in this paper refers to computers and computer related devices and processes used for information and communication purposes. Examples of these include computers, peripherals such as digital cameras, computer software, and aspects of the Internet and World Wide Web that utilize digital multimedia and hypermedia technologies.

In the United Kingdom, the British Educational Communications and Technology Agency (Becta) has carried out comprehensive research under commission from the Department for Education and Skills (DfES) as part of their ICT in Schools Research and Evaluation Series (Harrison et al., 2002; Hayward, Alty, Pearson, & Martin, 2003; Somekh et al., 2002). This research has included surveys of the attitudes and experiences of young people aged 5-18 and their parents in relation to the use of ICT at home and at school (Hayward et al., 2003), studies of the impact of ICT on pupil learning and attainment (Harrison et al., 2002), and the use of an innovative concept mapping methodology to determine student understandings of the role of ICTs in today's world (Somekh et al., 2002). In addition, two extensive literature reviews have been undertaken (Cox & Abbott, 2004; Cox & Webb, 2004) to identify aspects of the ways in which ICTs are used and the actions of teachers that can help to ensure that ICTs have an impact on student attainment. Internationally, there is also literature that investigates aspects of the relationship between ICT integration and specific student outcomes (Angrist & Lavy, 2001; Baker, Gearhart, & Herman, 1994; Kulik, 1994; Mann, Shakeshaft, Becker, & Kottkamp, 1999; Sivin-Kachala, 1998; Wenglinsky, 1998). However, there is a fairly limited suite of research that methodically explores the big picture with respect to ICT curriculum integration. Cuttance and Stokes (2000) suggested that this has arisen from the difficulty in defining exactly what ICT curriculum integration comprises, as well as the resultant difficulties of defining a research methodology based on such an ill-defined construct. Hence, theoretical and methodological issues have hampered the study of ICT curriculum integration to date (Proctor et al., 2003).

In Queensland (Australia), an instrument to quantitatively measure the level of ICT curriculum integration was developed in 2003 and reported in an earlier publication (Proctor et al., 2003). This instrument utilized the theoretical constructs described in Good Practice and Leadership in the Use of ICT in Schools (Department of Education Training and Youth Affairs (DETYA), 2000) and The Queensland School Reform Longitudinal Study (Lingard et al., 2001) when defining ICT integration. DETYA identified four dimensions of ICT use in schools that distinguish between ICT as a tool for use across and within the curriculum, and a reform component for curriculum and the reorganization of schooling. Lingard et al., (2001) presented a framework for effective teaching and learning comprising four Productive Pedagogies namely, intellectual quality, connectedness to the learner, classroom environment, and learner differences. Proctor et al's (2003) measurement instrument was underpinned by the two theoretical frameworks of DETYA (2000) and Lingard et al., (2001) and comprised two parts, where the first part (Part A) sought background information on the teacher, and the second (Part B) explored the quality and quantity of ICT curriculum integration with respect to learning, teaching and the curriculum. The background information obtained from classroom teachers included gender, school type, years of teaching experience, confidence with using ICT with their students, and frequency of their students' use of ICT. Part B of the instrument required teachers to react to 45 items, all of which commenced with the sentence stem: In my class *students use* ICTs to …. For example: In my class *students use* ICTs to communicate with others locally and globally. All items were positively worded to align with the sentence stem. Teachers were required to identify the current frequency of student use of ICT for each of the 45 items, as well as indicate their preferred frequency of use on two four-point Likert scales (Never, Sometimes, Often and Very Often). Each item was accompanied by an extensive range of pedagogical examples relevant to three year-level bandings: Preschool to Year 3 (ages 5-8), Years 4-9 (ages 9-14), and Years 10-12 (ages 15-17). The instrument also included an electronic collation tool that generated a results graph for individual teachers, schools and the system at large as required. The development process and initial small-scale testing of this instrument have been reported extensively in Proctor, Watson and Finger (2003); Finger, Proctor and Watson (2003); and Watson, Proctor and Finger (2004).

Since its development in 2003, the instrument has been extensively trialed and evaluated for Education Queensland. This comprehensive evaluation of the instrument comprised three major components: a statistical analysis of the data obtained when the instrument was completed by 929 Queensland state school teachers; a peer review of the instrument involving a 15-member expert Peer Review Team; and interviews with 42 teachers from 6 purposely-selected schools across Queensland who had recently used the instrument. This paper reports only the psychometric evaluation of, and resultant modifications to, the 45-item instrument developed by Proctor et al (2003) using a large sample of teachers in 2004. The other two evaluation components, Peer Review and teacher interviews, which supported and broadened the recommendations obtained from the statistical evaluation, are reported elsewhere (Watson et al., 2004; Finger et al., 2005). The revised instrument is currently used by Education Queensland as part of its ICT census that all schools must complete annually. System-wide data are collected with the instrument on the systemic key ICT driver: Learning, teaching and the curriculum.

METHOD

The state Department of Education in Queensland, Australia supplied data obtained from 929 teachers in 38 state primary and secondary schools who completed the Instrument in late 2003. Of the total of 929 teachers, 133 teachers came from seven schools classified as low socioeconomic by Education Queensland, 268 came from 13 schools in the mid-low socioeconomic band, 372 came from 13 schools in the mid-high socioeconomic band, and 156 came from five schools, classified as high socioeconomic. Of the total number, 75.6% (706) teachers completing the instrument were female, which approximates the ratio of female to male teachers in Queensland state schools. Table 1 displays teacher demographic information obtained from the data with respect to school type, years of teaching experience and perceived confidence in using ICTs with students for teaching and learning. As can be seen from the table, 75% of teachers had more than 5 years teaching experience and 57% considered themselves to be reasonably confident or very confident users of ICTs for teaching and learning.

Table 1

Demographic Information Detailing Teacher Numbers by School Type, Years of Teaching Experience and Confidence in Using ICTs for Teaching and Learning

	Number of teachers	%
School Type:		
Preschool	26	2.8
Primary (Elementary)	513	54.9
Secondary	360	38.5
School of Distance Education	1	0.1
Special Education Unit	29	3.1
Total	929	100
Years of Teaching Experience:		
< 5 Years	239	25.6
6-10 years	154	16.5
11-15 years	154	16.5
16-20 years	123	13.2
21-25 years	114	12.2
26-30 years	79	8.5
> 30 Years	66	7.1
Total	929	100
Confidence to use ICTs for teaching and learning:		
Little confidence	84	9.0
Some confidence	312	33.4
Reasonably confident	406	43.5
Very confident	127	13.6
Total	929	100

<u>The development of the original 45-item instrument</u>

Initially, a suite of 137 items was generated, based on a matrix configured from the four *Productive Pedagogy* dimensions and the *New Basics* curriculum organisers (Lingard et al., 2001). The sentence stem, *"In my class* ***students use*** *ICTs to …."* was used to generate all 137 items. This decision was made in order to ensure that the instrument's structure clearly defined successful professional performance with respect to ICT integration in classrooms specifically in relation to the quantity and quality of *use* of ICTs experienced by *students* rather than teachers (DEST, 2002). Hence, the instrument purposely measured the extent to which *students* used ICTs in productive ways across the curriculum.

All items generated by this process were then examined for redundancy and ambiguity and the resulting reduced set of items was presented for discussion at a consultation workshop comprised of a panel of 20 experts in the area of ICTs for learning. The second iteration of the items took account of feedback from the expert panel regarding face validity, ambiguity, and redundancy; and the items were also examined for apparent goodness of fit with the dimensions of ICT curriculum integration identified in *Good Practice and Leadership in the Use of ICT in Schools* (DETYA, 2000). Each of the remaining 45 items was then located within a matrix comprising the four dimensions of ICT curriculum integration and the four dimensions of *Productive Pedagogies.* Locating the items within this framework added additional robustness to the instrument, as it demonstrated the instrument's relationship to current Australian and international theoretical frameworks. Finally, examples of possible ICT classroom practices illustrating each item were generated to assist classroom teachers when interpreting the items.

Two four-point Likert-style response scales (Never, Sometimes, Often, and Very Often) were used to gauge the *Current* (actual) and *Preferred* frequency-of-use of ICTs by students, as reported by their teachers. The dual frequency-of-use scales were selected in order to enable both performance measurement and professional development (DEST, 2002). It was hypothesised that teachers, schools and the system at large could use the information obtained from both scales to strategically plan the resources necessary to ensure that the current and preferred states align in the near future. The four-point response scale of 'never', 'sometimes', 'often', and 'very often' ensures a recognisable separation for respondents between the frequencies from 'never' to 'very often'. A four-point scale also avoids the selection of a default median frequency as might occur in a 5-point scale. The frequency of 'always' has no meaning in this measurement context as teachers would never indicate that they 'always' use any teaching and learning technology. Hence, 'very often' is a logical compromise. Descriptions for the responses were not included in the Instrument as they become meaningless when the Instrument is to be used across the span of pre-school to year twelve, and all curriculum areas. Allocating a fixed description to each of the response terms was determined to be possibly counter-productive as the normal time definitions used in similar instruments (e.g., <20%, >75% of the time etc.) across such an age and curriculum area range would quite probably give false interpretations. For example, it would be expected that computer studies secondary students might use ICTs for >75% of their class time, hence Very Often, while Preschool students are encouraged to engage in a variety of play-based activities and <20% of their time could be perceived as Very Often in that classroom context. Hence, it was decided that teachers should be free to interpret the responses in light of their own classroom context. Teachers invariably know what is Never, Sometimes, Often and Very Often for their students and curriculum areas.

The 45-items were then trailed with 136 primary and secondary teachers. The analysis of this trial provided the initial factor loadings reported in Proctor et al., (2003). The trial found support for a single factor solution, but recommended a comprehensive evaluation of the instrument to determine any underlying complex factor structure. The full list of 45 items was listed in Proctor et al., (2003) and, therefore, is not restated in this paper.

DATA ANALYSIS AND RESULTS

In this evaluation, responses related to the reported current levels of ICT use in the classroom were analyzed. The item numbers indicate the theoretical dimension of use the item belongs to via the digit before the decimal. Hence, item C2.8 indicates current scale, dimension 2, item 8.

Initial Confirmatory Factor Analyses using the method proposed by Burnett and Dart (1992) and based on the four *Productive Pedagogies* dimensions proved unstable because of high item intercorrelations. Likewise, a series of unitary factor analyses, examining the viability of a single factor solution for each of the four Pedagogies, as proposed following the initial small-scale trial of the instrument (Proctor et al., 2003), reduced the collective number of items loading on each hypothesised factor to less than 17 from the original 45, suggesting the presence of a more complex factor structure. Finally, a series of factor analyses, using

Principal Axis Factoring (PAF) with Oblimin rotation (SPSS 13), were performed on the full set of 45 items. The initial analysis of all 45 items used Eigenvalues to determine the number of factors extracted. This initial set was refined by examining the pattern matrix and selecting items for deletion on the basis of non-significant loadings (<.300), significant (.300) cross-loadings or near-significant (.295+) cross-loadings (Stevens, 1992).

As Table 2 illustrates, this analysis produced a simple and conceptually robust two-factor solution, in which the first two theoretical dimensions of use clustered together as one factor while the second two theoretical dimensions of use clustered together as a second factor. That is, the first factor comprised 16 items that define ICTs as a tool for the development of ICT-related skills and the enhancement of learning outcomes, suggesting the use of ICTs to *improve* teaching and learning. The second factor comprised 6 items that define ICTs as an integral component of reforms that change what students learn and how school is structured and organised, implying a *transformative* ICT function.

Table 2

PAF Analysis with Oblimin Rotated Factor Loadings for 22 Items (N=929)

	Factor	
Item:	**1**	**2**
C1.1	.76	
C1.2	.78	
C2.3	.69	
C2.4	.63	
C2.5	.74	
C2.6	.66	
C2.7	.74	
C2.8	.70	
C2.9	.49	
C2.12	.72	
C2.13	.67	
C2.14	.63	
C2.16	.61	
C2.17	.69	
C2.19	.63	
C2.20	.42	.30
C3.7		.73
C3.9		.73
C3.10		.79
C4.1		.46
C4.3		.52
C4.4		.64

<u>*Confirmatory factor analysis using Structural Equation Modeling (CFA-SEM) and AMOS 5.0*</u>

A decision was taken to investigate the factor structure of the 22-item scale further, using a cross-validation approach and a model testing methodology. The sample of 929 teachers was randomly divided into two sub-samples (sample 1, sample 2). Splitting the sample allowed for the initial model to be refined based on a random sample from the target population (half of the original sample) and then to be tested for stability by comparing its goodness of fit estimates to those obtained by testing this model on another sample from the same population (the other half of the original sample). A model comparison in which the values given to items and scales did not vary significantly across both samples would support the conclusion that the tested model was factor invariant, that is, the resultant theoretical structure was robust.

Both samples were screened for multivariate outliers, for univariate skew, and for univariate and multivariate kurtosis (Mardia's coefficient of multivariate kurtosis). A decision was taken to exclude two outliers from sample 1 and one from sample 2. Another four items in each sample exhibited levels of skew and kurtosis in excess of 1. Since these four items clumped together as part of factor 2 (ICTS as a component of transformation), these four plus the other two items from this six item factor were transformed in both samples, using a square root transformation to diminish positive skew (and kurtosis).

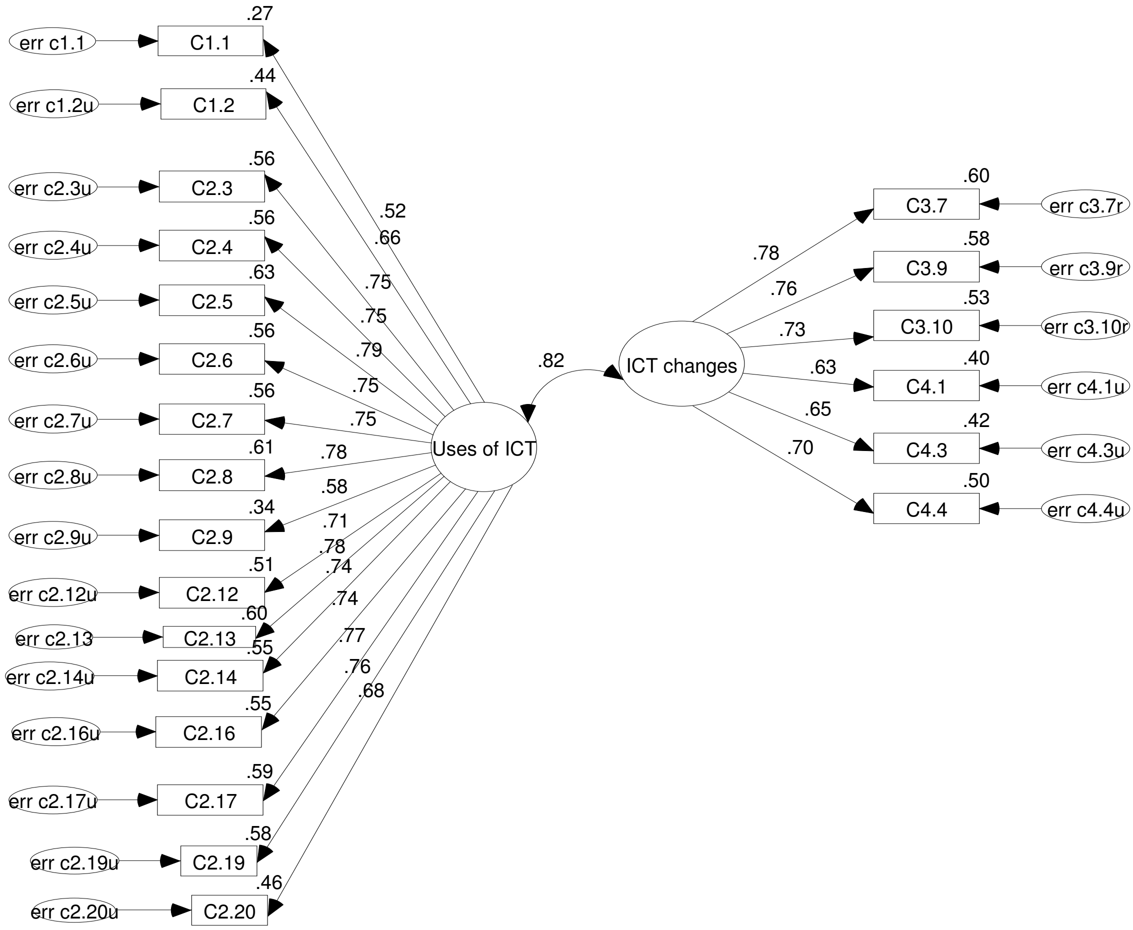

Figure 1: Initial CFA for a two-factor solution with 22 items

The 22-item two-factor solution derived from the initial analysis was examined via a Confirmatory Factor Analysis (CFA), using sample 1 entry data, with a view to identifying a statistically acceptable version of the model. As the two-factor solution illustrated in Figure 1 featured some slightly high correlations between error terms, two additional CFAs were undertaken, each after excluding a further item.

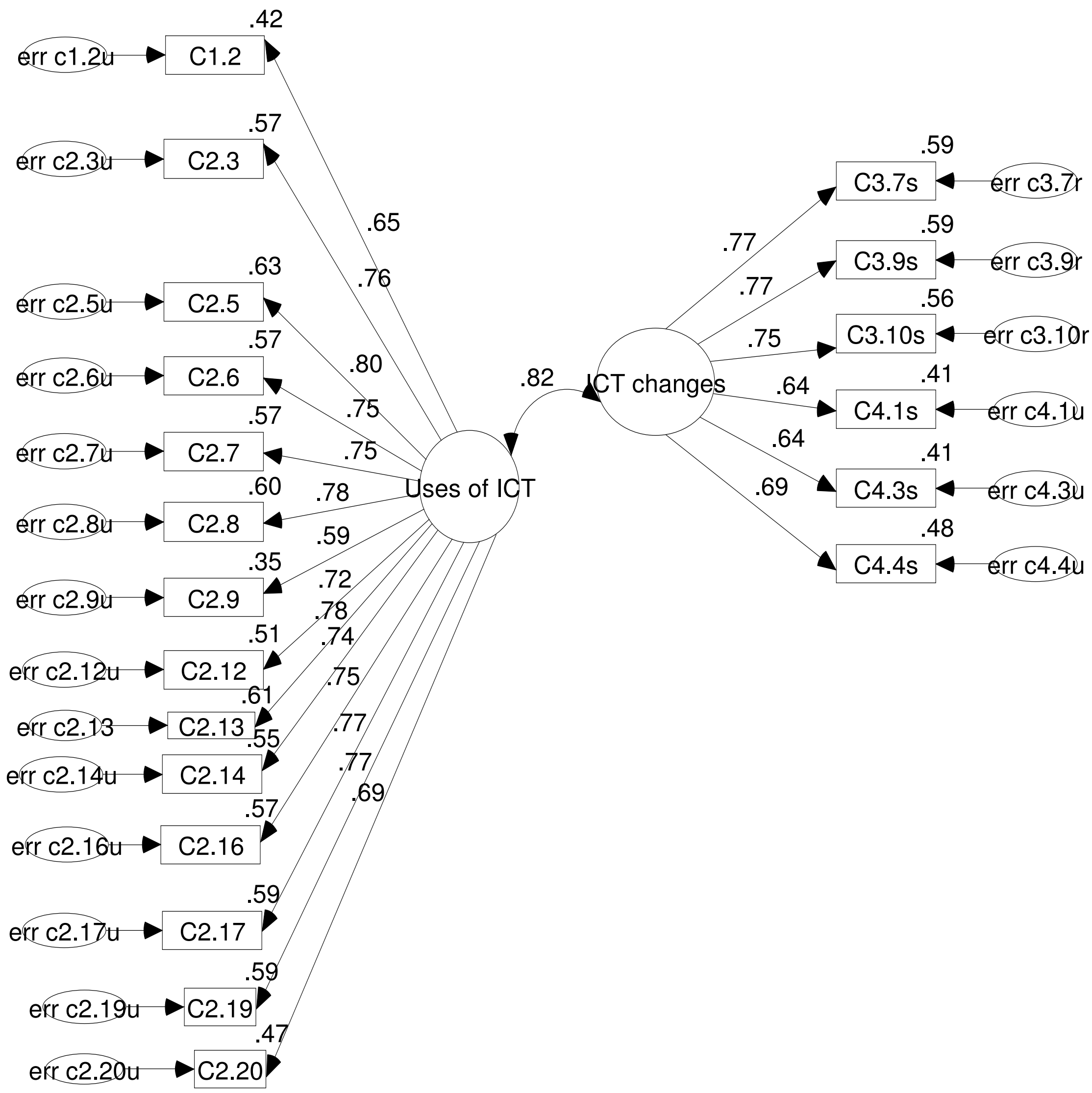

Figure 2: The CFA-SEM for the two-factor ICT instrument with 20 items

This process resulted in the model of best fit illustrated in Figure 2 (Chi square = 414, *df* = 169, *p* < .001). The tested model was compared to a baseline model by four measures that included the Normed Fit Index (NFI), the Relative Fit Index (RFI), the Tucker-Lewis Index (TLI), and the Comparative Fit Index (CFI). In each case, when the examined model fits the sample significantly better than the baseline model, then the fit value tends towards a ceiling of 1, with 0.90 as an acceptable threshold value. Two of these four measures (NFI, RFI) fell below the threshold of acceptability for the 22-item whereas all four exceeded the threshold of acceptability for the 20-item model. That is, the 20-item model compared well with the baseline model.

Two other measures that more generally estimate goodness of fit include the Goodness of Fit Index (GFI) and the Adjusted GFI (AGFI). Here the AGFI takes into account the number of degrees of fit involved. The values for these measures range between 0 and 1, with 1 indicating that the tested model fits the data completely. Again, 0.90 is regarded as an acceptable threshold value. Here, neither measure achieved the 0.90 threshold level for the 22-item model, whereas one of the two (GFI) did achieve the 0.90 level and the other fell marginally below that level (AGFI) for the 20-item model.

Examining the invariance of the factor structure

The final stage in this process was to compare the goodness of fit of the model based on sample 1 with an equivalent test based on sample 2 from the same original population.

Four comparisons were carried out to examine factor invariance, such that in addition to the unconstrained model comparison (model 1), the two models were compared with the measurement weights constrained (model 2), the structural weights constrained (model 3), the structural covariances constrained (model 4), and finally with the measurement residuals constrained (model 5).

Table 3

The Chi Square Fit Statistic for the Five Tested Models

Model	NPAR	CMIN	DF	P	CMIN/DF
Unconstrained	82	767.117	338	.000	2.270
Measurement weights	62	783.844	358	.000	2.190
Structural covariances	61	784.368	359	.000	2.185
Measurement residuals	41	797.966	379	.000	2.105
Saturated model	420	.000	0		
Independence model	40	11364.498	380	.000	29.907

Dividing the chi square value (CMIN) by the degrees of freedom (DF) resulted in a ratio (CMIN/DF) that, as shown in Table 3, fell in the very acceptable range of 0-3 for all five models in question. What this test indicated was that the model in question was acceptably invariant across the two sample groups, regardless of whether or not constraints were imposed.

Table 4

Items with Oblimin Rotated Factor Loadings and reliability coefficients for the Learning with ICTs: Measuring ICT Use in the Curriculum Instrument (N = 929)

	Factor and Items	Factor 1	Factor 2
	In my class, **students use** ICTs to…		
1.2	acquire the knowledge, skills, abilities and attitudes to deal with on-going technological change.	.66	
2.3	develop functional competencies in a specified curriculum area.	.73	
2.5	synthesise their knowledge.	.82	
2.6	actively construct their own knowledge in collaboration with their peers and others.	.76	
2.7	actively construct knowledge that integrates curriculum areas.	.81	
2.8	develop deep understanding about a topic of interest relevant to the curriculum area/s being studied.	.80	
2.9	develop a scientific understanding of the world.	.57	
2.12	provide motivation for curriculum tasks.	.79	
2.13	plan and/or manage curriculum projects.	.74	
2.14	integrate different media to create appropriate products.	.68	
2.16	engage in sustained involvement with curriculum activities.	.68	
2.17	support elements of the learning process.	.74	
2.19	demonstrate what they have learned.	.72	
2.20	undertake formative and/or summative assessment.	.45	
3.7	acquire awareness of the global implications of ICT-based technologies on society.		.78
3.9	gain intercultural understanding.		.75
3.10	critically evaluate their own and society's values.		.82
4.1	communicate with others locally and globally.		.54
4.3	engage in independent learning through access to education at a time, place and pace of their own choosing.		.58
4.4	understand and participate in the changing knowledge economy.		.69
	Alpha Reliability Coefficients	**.94**	**.86**

Table 4 contains the final 20 items with individual factor loadings and scale Alphas. In summary, the 20-item two-factor solution for the *ICT Curriculum Integration Performance*

Measurement Instrument turns out to have more than adequate model fitting qualities and is therefore the statistically and theoretically preferred solution.

DISCUSSION AND CONCLUSION

The *ICT Curriculum Integration Performance Measurement Instrument* was originally designed for Education Queensland to measure the quantity and quality of student learning outcomes as a result of ICT curriculum integration. As Liu and Velasquez-Bryant (2003) stated, “the purpose of technology integration is to achieve learning goals and enhance learning – not to use fancy technology tools” (p. 99). Bull, Bell, and Kajder (2003) identified two philosophical approaches to the use of technology in schools that derive from employing “the technology to deliver the existing content more efficiently” or alternately “to employ the innovation to reconceptualize aspects of the existing curriculum” (p. 64). The instrument’s proposed theoretical 4-factor structure was based on the four dimensions of ICT use described in *Good Practice and Leadership in the Use of ICT in Schools* (Department of Education Training and Youth Affairs (DETYA), 2000) with each factor comprising items indicative of the 4-dimension Productive Pedagogy model described in *The Queensland School Reform Longitudinal Study* (Lingard et al., 2001). It was therefore hypothesized that the instrument would theoretically and statistically contain items that were good indicators of the four dimensions of ICT use (DETYA 2000).

In the original small-scale trial of the instrument (Proctor et al., 2003), a single factor was derived with an Eigenvalue greater than 1. In that trial, the Kaiser-Meyer-Olkin Measure (KMO) and Bartlett’s Test of Sphericity (0.86) indicated a strong relationship among all items and one factor accounted for 29% of the total variance, with 40 out of 45 items loading on that factor at 0.4 or greater. In order to explore the existence of other theoretically viable multiple-factor solutions, Proctor, Watson and Finger (2003) recommended a comprehensive trial of the original instrument be conducted using a confirmatory analysis approach (Burnett & Dart, 1997) in order to determine and refine the factor structure of the instrument.

A comprehensive evaluation of the instrument was conducted and this paper reported the psychometric results of the evaluation obtained when the instrument was used by 929 Queensland teachers in 38 state primary and secondary schools. Results from this large sample of teachers clearly indicate that the instrument contains two strong factors that are theoretically defensible. The first factor is comprised of 14 items that define ICT as a tool for the development of ICT-related skills and the enhancement of curriculum learning outcomes.

The second factor comprises 6 items that define ICT as an integral component of reforms that change what students learn and how school is structured and organized. Thus, the instrument measures both curriculum *enhancement* and *transformational* dimensions in relation to ICT use by students. Items theoretically measuring the first two dimensions from *Good Practice and Leadership in the Use of ICT in Schools* (Department of Education Training and Youth Affairs (DETYA), 2000), namely ICTs as (1) a tool for use across the curriculum or in separate subjects where the emphasis is on the development of ICT-related skills, knowledge, processes and attitudes; and (2) a tool for enhancing students' learning outcomes within the existing curriculum and using existing learning processes, have combined to form one factor. The second factor contains items representative of dimensions 3 and 4, namely: (3) an integral component of broader curricular reforms, which will change not only *how* students lean but *what* they learn; and (4) an integral component of the reforms, which will alter the organization and structure of schooling itself. This resultant two-factor structure is therefore statistically sound and theoretically explainable in terms of the original instrument's theoretical structure.

In conclusion, the *Learning with ICTs: Measuring ICT Use in the Curriculum* instrument, is underpinned by a sound theoretical basis, and is informed by contemporary Australian and international literature relating to recent trends in the definition and measurement of ICT curriculum integration and current theoretical pedagogical and curriculum frameworks. It has undergone an extensive evaluation process that has refined the instrument's statistical and theoretical structure. However, the researchers caution that in view of the rapidly changing scene with respect to ICTs and learning, the instrument will need regular review if it is to continue to measure meaningful student outcomes derived from ICT curriculum integration in relation to its structural dimensions (curriculum enhancement and curriculum transformation). Further, as with all self-report instruments, data collected with this instrument should be complemented with other data collection methodologies to overcome the often-reported difficulties of all self-report instruments.

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