Malaysian Journal of Distance Education 13(1), 21–34 (2011)

Investigating Online Learning Environments Efficiently and Economically

John Clayton
Waikato Institute of Technology, New Zealand
John.Clayton@wintec.ac.nz

Abstract

The use of electronic learning and teaching technologies in formal educational settings, in a variety of formats, is, and has been, a common teaching practice. The advent of the microcomputer in the 1980s, the creation of protocols to network computers and the subsequent explosion of the World Wide Web has influenced all aspects of modern society including learning. Increasingly the perceived benefits of using these networked technologies in learning activities are being exploited within all curricula areas. As web-based and online software applications such as digital-document storage, search engines, communication tools, social-media and multimedia data-bases mature, so does educator's use of this medium for teaching. A key question to be addressed is, "What are the educational impacts of this increased use of online learning on the educational experiences of learners?" The purpose of this paper is to report on the development of a learning environment instrument designed to investigate the online learning experiences of learners in an efficient and economical way.

Keywords: e-learning, learning environment instruments, online learning

Abstrak

Penggunaan teknologi pembelajaran dan pengajaran secara elektronik dalam persekitaran pendidikan formal, dan dalam pelbagai format, sedang dan telah menjadi amalan biasa dalam pengajaran. Kemunculan mikrokomputer pada tahun 1980-an, penciptaan protokol untuk rangkaian komputer dan seterusnya ledakan jaringan sejagat telah mempengaruhi semua aspek masyarakat moden termasuk pembelajaran. Segala manfaat yang diperoleh daripada penggunaan teknologi berangkaian ini dalam aktiviti pembelajaran kian giat dieksploitasikan dalam semua bidang kurikulum. Semakin matang aplikasi yang berasaskan sesawang dan perisian dalam talian seperti simpanan dokumen digital, enjin carian, alatan komunikasi, pangkalan data media sosial dan multimedia, begitulah juga keadaannya dengan penggunaan medium ini oleh pendidik dalam pengajaran. Soalan utama yang dikemukakan ialah: Apakah impak pendidikan ekoran peningkatan penggunaan pembelajaran dalam talian ini terhadap pengalaman pendidikan para pelajar? Tujuan kertas kerja ini ialah untuk melaporkan perkembangan suatu instrumen persekitaran pembelajaran yang direka bentuk bagi menyelidik pengalaman pelajar belajar secara dalam talian dengan cara yang cekap dan berekonomi.

Kata kunci: e-pembelajaran, instrumen persekitaran pembelajaran, pembelajaran dalam talian

Introduction

Evaluation of Learning Environments

In monitoring performance or evaluating the success or failure of time and resources spent in educational settings, a number of quantitative measures such as grades allocated, total number credits earned, participation rates in specified activities, graduation rates, standardised test scores, proficiency in identified subjects and other valued learning outcomes could be used (Clayton, 2009). However, since these quantitative measures are in general focused on educational outputs, they are somewhat limited. They do not adequately measure, monitor or truly evaluate the details of the educational process (Fraser, 1998a). Other measures can be used that are just as effective, for example, student and teacher impressions of the environment in which they operate are vital. Their reactions to, and perceptions of, this environment have a significant impact on individual and group performance (Dorman and Fraser, 2009). Indeed, research indicates student achievement is enhanced in those environments which students feel comfortable within and positive about (Seet and Quek, 2010).

The essence of a learning environment is the interaction that occurs between individuals, groups and the setting within which they operate. The investigation in, and of, learning environments has its roots nourished by the Lewinian formula, B=f(P,E). This formula identifies that behavior (B) is considered to be a function of (f) the person (P) and the environment (E). It recognises that both the environment and its interaction with personal characteristics of the individual are 'potent determinants of human behavior' (Fraser, 1998b). Learning environment instruments and surveys seek the perceptions of the milieu of inhabitants and as such are high inference measures. They ask the respondent to make judgments about the meaning of what is going on around him/her or what she/he feels about the psychosocial environment he/she has worked within (Aldridge, Dorman and Fraser, 2004) The ability to measure, gather and analyse data on activities occurring in educational environments through these instruments can be seen to be a decisive component in the evaluation of teaching practice and for the prediction of educational performance (Dorman, 2002).

Characteristics of e-Learning Environments

In practice e-learning typically involves interactivity, such as student engagement with digital content, online interaction between learners and their instructors and online interaction between learners and their peers. It is facilitated by the use of computers (stand-alone and networked), digital communication tools (such as chat, e-mail, forums, messenger, VoIP) digital content creation tools (such as Wikis, Blogs and Web-folios) and digital content (such as webpages, CD-ROMs and DVDs) (Seok et al., 2010). By focusing on our understanding of the process of learning and the relationships created in this process we can outline five relationships associated with e-learning (Clayton, 2003). These are outlined below:

1. *Learner - Interface Interaction:* What are the features of the interface created that enhance/inhibit learner learning and navigation?
2. *Learner - Learner Relationships:* How, why and when learners communicate with each other and what is the nature of this communication?
3. *Learner - Tutor Relationships:* How, why and when learners communicate with their tutor and what is the nature of this communication?
4. *Learner - Media Interaction:* How is the learner engaged with digitally stored information and how do they relate to the information presented?
5. *Learner Reflection Activities:* How are learners encouraged to reflect on their learning, are they satisfied with the environment and how do they relate to the environment created?

Psychosocial Instrument Development

In the field of learning environment research a general methodology in the development and validation of instruments is followed. The pattern established by these studies involves three core stages (Fraser, 1998a):

1. *Stage 1;* Identification of salient dimensions and items related to the field of study.
2. *Stage 2;* Coverage of social climate dimensions identified by Moos. (Moos, 1979).
3. *Stage 3:* Field testing and analysis.

The above description of the three phases of instrument development is based to a large extent upon what is regarded by instrument developers as an intuitive-rational approach (Walker, 2003). In essence, the intuitive-rational approach involves developers in the identification of salient dimensions, the writing of items, and field testing. To reduce the bias of researcher-generated scales and items, the validation of the scales rests heavily on the subjective opinions of the researcher and other experts in the field (Clayton, 2003). This intuitive-rational approach can be, and often in learning environment research is, complemented by statistical analysis and factor analytic approaches (Clayton, 2009). To ensure internal consistency of instruments (i.e. how well the items in the scale measure the construct identified), the statistical procedure Cronbach Alpha coefficient is generally used (Clayton, 2007). To ascertain discriminant validity (i.e. how well the individual scales measure the construct they are designed to measure and how the scales in the instrument diverge from each other and measure separate constructs), the statistical process of using the mean correlation of a scale with the remaining scales as a convenient index is generally used (Trinidad, Aldridge and Fraser, 2005). Principal Component Analysis (PCA) procedures are used to firstly, potentially reduce the number of variables in the scale and secondly, to detect structure in the relationships between variables. Recent learning environment studies have used the procedures of PCA with varimax rotation (Clayton, 2009). Although applying these mathematical functions is potentially challenging too many researchers, the procedures described can be performed with desktop computers using statistical computer packages now widely available (Aldridge, Dorman and Fraser, 2004).

OLLES: Online Learning Environment Survey

A number of instruments have been developed to explore the use of computers in education and the interactions that occur in computer mediated environments (Newhouse, 2001) and online learning environments (Clayton, 2007). Using these previous studies as a guide, a learning environment instrument, The Online Learning Environment Survey (OLLES), consisting of 7 scales and 35 items has been developed. The matrix in Table 1, provides a descriptive overview of the scales and items used in the instrument.

Table 1 Matrix of dimensions, scales and items of OLLES instrument

Scale	Description	Sample items
Computer Competence	Extent to which the student feels comfortable and enjoys using computers in the online environment.	I have no problems using a range of computer technologies.
Material Environment	Extent to which the computer hardware and software are adequate and user friendly.	The instructions provided to use the tools within the site are clear and precise.
Student Collaboration	Extent to which students work together, know, help, support and are friendly to each other.	I communicate regularly with other students in this course.
Tutor Support	The extent to which the tutor guides students in their learning and provides sensitive, ongoing and encouraging support.	The feedback I received from my tutor helps me identify the things I do not understand.
Active Learning	The extent to which the computer activities support students in their learning and provide ongoing and relevant feedback.	The feedback I received from activities/quizzes are meaningful.
Information Design and Appeal	Extent to which class materials are clear, stimulating and visually pleasing to the student.	The material presented is visually appealing.
Reflective Thinking	Extent to which reflective activities are encouraged and how students enjoyed learning and participating in this environment.	I am satisfied with my experience of using the internet and learning online.

Field Testing

The Sample

The data collected contained 294 rows of responses. However, 10 of the rows contained limited or no response, (i.e. at least 60% of the items were not completed). These could be regarded as unsolicited responses and they were deleted from the final sample. Of the 284 rows of responses remaining, some items had not been completed (216 non-response to the 15,848 identified responses) and the mean of the item was used as a substitution for the non-response. The age range of the sample was reasonably spread from 15 years to over 50 years with no age group being in the majority (see Figure 1).

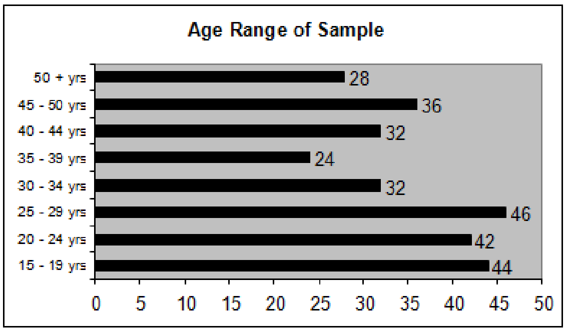

Figure 1 Number and age range of participants

Statistical Procedures

Factor analysis is undertaken to identify and describe the pattern of co-relationships between variables, (i.e. detect structure), and to investigate the reduction of the number of variables and associated data collected (StatSoft, Inc., 2011). Principal Components Analysis (PCA), a technique used to transform the number of correlated variables to a smaller number of uncorrelated variables called principle components, is a common mathematical procedure used in factor analysis (StatSoft, Inc., 2011). To increase the interpretability and usefulness of the factors identified, learning environment researchers often rotate the axes orthogonally or obliquely. Orthogonal analytic rotation methods, in which the factor axes are kept at right angles to each other (coordinates are equal to 90 degrees), could be regarded as the most common rotational method used (Zandvliet and Fraser, 2005). Oblique analytic rotation methods, in which the factor axes are not kept at right angles to each other (coordinates are not equal to 90 degrees), are not as common as orthogonal methods but when used the most popular appears to be Oblimin rotation (Walker, 2003).

As well as selecting the most appropriate factor analytical rotation technique to be used, learning environment researchers also need to clarify the factor loading used in the retention of items and scales. In learning environment research the value of factor loadings used is variable. For example, factor loadings of between 0.30 and 0.35 of items on their a priori scale and no other scale were acceptable in some studies (Chang and Fisher, 2001), while other studies argued factor loadings below 0.50 were unacceptable (Johnson and Stevens, 2001). It appeared a large number of learning environment studies have worked within these two ranges and regarded a factor loading of 0.40 for an item on their a priori scale and no other scale, as acceptable (Dorman, 2003).

In checking if firstly, each item within the same scale is assessing a common construct, internal consistency, and secondly, each scale within a measure is assessing a separate construct, discriminant validity, learning environment researchers follow two common procedures. The Cronbach Alpha reliability coefficient is generally used as an index of scale internal consistency and a convenient discriminant validity index (namely, the mean correlation of a scale with other scales) is used as evidence scale measures a separate dimension distinct from the other scales in this measure (Clayton, 2009).

In the analysis of data for the OLLES instrument firstly, two PCA rotational techniques, orthogonal (varimax) and oblique (oblimin), using an identified factor loading of 0.40, will be employed and secondly, the internal consistency and discriminant validity of the scales will be reported on.

Statistical Analysis and Results

Factor Analysis

Because the OLLES instrument had been developed using a seven scale structure, a seven factor solution was explored. This seven factor solution appeared to be a logical fit to the data investigated. A review of the identical scree plots and eigenvalues, generated by SYSTAT 11 in varimax and oblimin rotation, confirmed this factor solution was acceptable. Factor seven had an eigenvalue of 1.68 and, using Cattell scree test, was visually above the factorial scree or debris (StatSoft, Inc., 2011). See Figure 2.

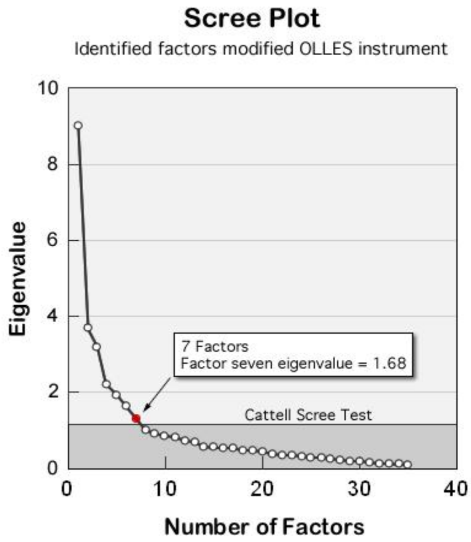

Figure 2 Screen plot identifying factors for analysis in OLLES

Further factor analysis confirmed, in both oblimin and varimax rotations, the refined instrument was structurally sound (see Figure 3).

An unusual discrepancy noted is the apparent 'swap/replacement' of the factors tutor support and material environment in the oblimin and varimax rotations; they have replaced each other in either column 1 or 7.

Ob = Oblimin Rotation **Va**= Varimax Rotation
TS=Tutor Support **CC**=Computer Competence **SC**=Student Collaboration **AL**=Active Learning
RT=Reflective thinking **ID**=Information Design and Appeal **ME**=Material Environment

TS	**M**	**CC**		**SC**		**AL**		**RT**		**ID**		**M**	**TS**	
Ob	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	
				0.75	0.75									*SC1*
				0.70	0.71									*SC2*
				0.83	0.82									*SC3*
				0.68	0.69									*SC4*
				0.85	0.84									*SC5*
		0.83	0.83											*CC1*
		0.82	0.83											*CC2*
		0.78	0.78											*CC3*
		0.72	0.74											*CC4*
		0.73	0.73											*CC5*
						0.78	0.77							*AL1*
						0.89	0.87							*AL2*
						0.84	0.81							*AL3*
						0.68	0.69							*AL4*
						0.85	0.83							*AL5*
0.65													0.67	*TS1*
0.73													0.75	*TS2*
0.50													0.55	*TS3*
0.70													0.70	*TS4*
0.72													0.71	*TS5*
	0.45									0.53	0.54			***ID1***
										0.71	0.71			*ID2*
										0.72	0.72			*ID3*
										0.76	0.75			*ID4*
										0.85	0.84			*ID5*
	0.43											0.37		*M1*
	0.76											0.75		*M2*
	0.49											0.43	**0.41**	***M3***
	0.63											0.62		*M4*
	0.75											0.74		*M5*
								0.60	0.62					*RT1*
								0.73	0.74					*RT2*
								0.64	0.66					*RT3*
								0.82	0.80					*RT4*
								0.79	0.77					*RT5*
Ob	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	*Ob*	**Va**	
TS	**M**	**CC**		**SC**		**AL**		**RT**		**ID**		**M**	**TS**	

Ob = Oblimin Rotation **Va**= Varimax Rotation
TS=Tutor Support **CC**=Computer Competence **SC**=Student Collaboration **AL**=Active Learning
RT=Reflective thinking **ID**=Information Design and Appeal **ME**=Material Environment

Figure 3 Factor loadins for the OLLES instrument

However, this 'swapping/replacement' does not affect the confirmed scale structure of the instrument and was ignored. The table highlights only two items (M3 and ID1) in which the factor loadings show some discrepancies. M3, *I am able to install the appropriate software needed to participate in this course with ease*, in the varimax rotation loads highly (0.41) on another factor other than its a priori factor but in oblimin rotation this loading disappears. Similarly ID1, *The choice of colours and style used in the text assisted my being able to read clearly*, in the varimax rotation loads highly (0.45) on another factor other than its a priori factor but in oblimin rotation this loading disappears. In order to retain consistency of presentation and retain a balanced distribution of items on factors it was decided to retain both these items.

Variance

The factor loadings and percentage of variance for both oblimin and varimax rotations were exactly the same and these are shown in Table 2.

Table 2 Varimax and oblimin rotation eigenvalues and percentage of variance accounted by each factor

% of Variance	26.36	9.55	8.66	5.70	4.93	4.32	3.42
Cumulative %	26.36	35.91	44.57	50.27	55.20	59.53	62.95
Eigenvalue	12.92	4.68	4.24	2.80	2.42	2.12	1.68
Cumulative EV	12.92	17.60	21.84	24.64	27.05	29.17	30.85
Factor	1.00	2.00	3.00	4.00	5.00	6.00	7.00

The cumulative variance of all of the seven scales is 65.75% and, while 34% of the variance is unaccounted for, this cumulative variance total is consistent with the reports of variance of other learning environment research studies (Clayton, 2009).

Internal Consistency and Discriminant Validity

In checking if firstly, each item within the same scale is assessing a common construct, internal consistency, and secondly, each scale within a measure is assessing a separate construct, discriminant validity, learning environment researchers follow two common procedures (Fraser, 1998b).

The Cronbach Alpha reliability coefficient is generally used as an index of scale internal consistency and a convenient discriminant validity index (namely, the mean correlation of a scale with other scales) is used as evidence scale measures a separate dimension distinct from the other scales in this measure. These procedures were used in the analysis of data from the OLLES field test and the results are detailed in Table 3.

Table 3 Internal consistency and discriminant validity for OLLES instrument

Scale	Items	Discriminant validity	Alpha reliability
Computer competence	5	0.16	0.86
Material environment	5	0.31	0.75
Student collaboration	5	0.09	0.83
Tutor support	5	0.37	0.85
Active learning	5	0.33	0.90
Information design and appeal	5	0.32	0.85
Reflective thinking	5	0.33	0.84

The alpha for the scale, Active Learning (at 0.9) can be considered to be excellent. The alpha for the scales Information Design and Appeal, Reflective Thinking, Tutor Support, Student Collaboration, Order and Organisation, and Computer Competence (all above 0.8) could be considered to be good. The remaining scale, Material Environment (alpha above 0.75) can be considered to be acceptable. The discriminant validity results for 2 of the scales, Student Collaboration and Computer Competence (all below 0.16) indicate these scales appear to be measuring distinct aspects of the learning environment. While the discriminant validity results for the 5 remaining scales, ranging from 0.32 to 0.37, indicated the scales appeared to be measuring distinct but overlapping elements of the learning environment and are acceptable.

Limitations

In presenting the validation and reliability results for the OLLES instrument, it must be acknowledged the procedures explained do not exactly match those followed in previous learning environment instrument developments and validations (Walker, 2003). This is caused in part by the initial capture of data where individuals, but not individuals' responses as part of an identified class group, were captured. In essence, the sample was web-based and, since responses were solicited from a potentially unlimited group, the sample was not as well defined as with conventional samples drawn from identified class groups. In previous research, class data has been used to enrich the findings investigating the degrees of similarity and difference between two units of statistical analysis, that of the individual student and that of the class mean. This analysis was not undertaken in this research. It must also be noted the responses were from self-selected participants with a potential affinity towards web-based/ online learning environments. Those students who might not have the same affinity to web-based/online learning may have chosen not to respond. Therefore the results of the study should be treated with particular care.

Summary

This paper has reported on the extensive investigations and data analysis undertaken in confirming the validation and reliability of a perceptual measure, OLLES. Investigations undertaken with 284 respondents confirmed the operational functionality of the instrument. Principal components analysis with firstly oblique, oblimin and secondly orthogonal varimax rotations, confirmed the structure of the 35-item OLLES instrument. The internal consistency, confirmed by Cronbach Alpha coefficients, all above 0.75 are deemed to be acceptable. The discriminate validity scores ranging from 0.09 to 0.37 indicated the scales did overlap but not sufficiently to violate the psychometric structure of the instrument and are small enough to confirm each scale generally measures distinct aspects of the participants' online environment. The cumulative variance of all of the seven scales was 65.75% which is deemed acceptable.

In presenting the validation and reliability results for the OLLES instrument, it must be acknowledged the procedures explained do not exactly match those followed in previous learning environment instrument developments and validations. In previous research, class data has been used to enrich the findings investigating the degrees of similarity and difference between two units of statistical analysis, that of the individual student and that of the class mean. This analysis was not undertaken in this research. Therefore the results of the study should be treated with particular care.

However, the analysis conducted thus far is sufficient to draw tentative conclusions about the reliability and validity of the scales and individual items used in the OLLES instrument and the method of instrument administration and data collection. It would appear from preliminary analysis, the 7-scale 35-item OLLES instrument will allow conclusions to be drawn about student perceptions on the interactions occurring in their online environments in an economical and efficient manner.

References

Aldridge, J., J. Dorman and B. Fraser. 2004. Use of multitrait-multimethod modeling to validate actual and preferred forms of the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI). *Australian Journal of Educational and Developmental Psychology* 4: 110–25.

Chang, V. and D. Fisher. 2001. The validation and application of a new learning environment instrument to evaluate online learning in higher education. Paper presented at the Australian Association for Research in Education, Fremantle.

Clayton, J. 2003. Assessing and researching the online learning environment. In *Technology-rich learning environments: A future perspective,* eds. M. S. Khine and D. Fisher, 127–137. Singapore: World Scientific.

———. 2007. The validation of the online learning environment survey. In *ICT: Providing choices for learners and learning. Proceedings Ascilite Singapore,* 159–167.

———. 2009. *Evaluating online learning environments: The development and validation of an online learning environment instrument*. Köln, Germany: LAP Lambert Academic Publishing.

Dhindsa, H. S. and B. J. Fraser. 2004. Culturally-sensitive factors in teacher trainees' learning environments. *Learning Environments Research: An International Journal* 7(2): 165–181.

Dorman, J. 2001. Associations between classroom environment and academic efficacy. *Learning Environments Research: An International Journal* 4(3): 243–257.

———. 2002. Classroom environment research: Progress and possibilities. *Queensland Journal of Educational Research* 18(2): 112–140.

———. 2003. Cross-national validation of the What is Happening in This Class? (WIHIC) questionnaire using confirmatory factor analysis. *Learning Environments Research: An International Journal* 6(3): 231–245.

Dorman, J. and B. Fraser. 2009. Psychosocial environment and affective outcomes in technology-rich classrooms: Testing a causal model. *Social Psychology of Education: An International Journal* 12(1): 7–99.

Fraser, B. J. 1998a. Classroom environment instruments: Development, validity and applications. *Learning Environments Research: An International Journal* 1(1): 68–93.

———. 1998b. Science learning environments: Assessment, effects and determinants. In *International handbook of science education*, eds. B. Fraser and K. G. Tobin, 527–564. Dordrecht: Kluwer Academic.

Johnson, B. and J. J. Stevens. 2001. Confirmatory factor analysis of the School Level Environment Questionnaire (SLEQ). *Learning Environments Research: An International Journal* 4(3): 325–344.

Lian, C., A. Wong, and V. Der-Thanq. 2006. Validation of the "Chinese language classroom learning environment inventory" for investigating the nature of Chinese language classrooms. *Issues in educational research* 16(2): 139–151.

Moos, R. H. 1979. *Evaluating educational environments*. San Francisco: Jossey-Bass.

Newhouse, P. 2001. Development and use of an instrument for computer-supported learning environments. *Learning Environments Research: An International Journal* 2(2): 115–138.

Nix, R. K., B. Fraser and C. E. Ledbetter. 2005. Evaluating an integrated science learning environment using the Constructivist Learning Environment Survey. *Learning Environments Research: An International Journal* 8(2): 109–133.

Seet, L. Y. B. and C. L. Quek. 2010. Evaluating students' perceptions and attitudes toward computer-mediated project-based learning environment: A case study. *Learning environments research* 13(2): 175–183.

Seok, S., B. DaCosta, C. Kinsell and C. Tung. 2010. Comparison of instructors' and students' perceptions of the effectiveness of online courses. *Quarterly review of distance education* 11(1): 25–36 and 59–60.

StatSoft, Inc. 2011. Principal components and factor analysis. *Electronic statistics textbook*, http://www.statsoft.com/textbook, 2011(accessed 20 March 2011)

Trinidad, S., J. Aldridge and B. Fraser, 2005. Development, validation and use of the online learning environment survey. *Australian Journal of Educational Technology* 21(1): 60–81.

Walker, S. 2003. *Development and validation of an instrument for assessing distance education learning environments in higher education: The Distance Education Learning Environments Survey (DELES).* PhD diss., Curtin University of Technology, Perth.

Zandvliet, D. B. and B. J. Fraser. 2005. Physical and psychosocial environments associated with networked classrooms. *Learning Environments Research: An International Journal* 8(1): 1–17.