Title	The impact of computer-assisted learning on achievement, attitudes and classroom environment
Author(s)	George P. L.Teh and Barry J. Fraser
Source	Annual Conference of Australian Association for Research in Education, 21 – 25 November 1993, Perth, Australia

Copyright © 1993 The Authors

This document may be used for private study or research purpose only. This document or any part of it may not be duplicated and/or distributed without permission of the copyright owner.

The Singapore Copyright Act applies to the use of this document.

Citation: Teh, G. P. L., & Fraser. B. J. (1993, November). *The impact of computer-assisted learning on achievement, attitudes and classroom environment.* Paper presented at the Annual Conference of Australian Association for Research in Education, Perth, Australia.

This document was archived with permission from the copyright holders.

THE IMPACT OF COMPUTER-ASSISTED LEARNING ON ACHIEVEMENT, ATTITUDES AND CLASSROOM ENVIRONMENT

George P.L. Teh
&
Barry J. Fraser

Paper presented at the Annual Conference of
Australian Association for Research in Education,
held in Perth, Australia on 21-25 Nov 1993

The Impact of Computer-Assisted Learning on Achievement, Attitudes and Classroom Environment in Singapore

George P. L. Teh

Nanyang Technological University, Singapore

Barry J. Fraser

Curtin University of Technology, Perth

Abstract

A micro-PROLOG-based innovation in computer-assisted learning (CAL) was evaluated in the unique milieu of Singapore schools in terms of its impact on achievement, attitudes and classroom psychosocial environment. A sample of 671 students from the second year of high school were assigned randomly to either a CAL or control group. In contrast to past research, effect sizes were relatively large and ranged from 1.0 to 3.5 standard deviations. Compared with control students, CAL students had higher achievement and attitude scores and perceived their classes as having greater gender equity, investigation, innovation and resource adequacy.

Background

This evaluation of computer-assisted learning (CAL) courseware is distinctive in several important ways. First, while many studies have examined the efficacy of CAL, the present study's focus specifically on micro-PROLOG-based CAL is quite unusual. Second, in addition to investigation of the impact of CAL on traditional achievement and attitude outcomes, the present evaluation broke new ground in that it also involved the development

Paper presented at annual conference of Australian Association for Research in Educaton, Perth, November 1993.

and use of in instrument which assessed the psychosocial environment in CAL classrooms. Third, the research was conducted in the unique milieu of the Singapore school system.

The Singapore education system is different from that of the many other countries in that it is highly centralized (with almost every school using the same prescribed textbooks), the mode of instruction is essentially expository and achievement-oriented, and schools are graded for excellence based solely on the students' academic performance. Educational applications of computers were introduced fairly extensively into Singaporean schools only in 1980, with the focus initially on computer science and low-level computer literacy courses at the secondary school level. Computer-assisted learning (CAL) was introduced to the schools in 1986, mainly for remediation and enrichment, but no Singaporean schools develop their own CAL courseware.

In Singapore, there is a dearth of research on the effects of CAL. Moreover, the only three research studies that have been conducted (Ong & Lee-Leck, 1986; Low, 1988; Woo-Tan, 1989) involved small and non-random samples, a short duration of the experimental treatment, and a narrow scope of the content selected. Because of the lack of dependable research information, and in view of the potential that research conducted in the unique educational context of Singapore has for our understanding of computer-assisted learning, the present study was conceptualized and conducted.

Purposes

The main purpose of the present study were to evlauate micro-PROLOG-based CAL courseware on the topic of decision-making in geography in terms of its impact upon student achievement, student attitudes and the classroom environment.

The Innovative Teaching Approach

The innovation in computer-assisted learning which formed the focus of this study was distinctive in that it made use of micro-PROLOG, the microcomputer version of PROLOG, a high-level fifth-generation declarative language, which was developed for artificial intelligence research and which has been found to be robust, compact and accessible to students in classroom applications (Chalk, 1987). This CAL courseware covered the topic of decision-making in geography and was designed specifically for a six-week segment in the Singapore school geography syllabus. In order to enhance the validity of conclusions from the evaluative study, a control group, which studied the same topic via the direct expository teaching methods common in Singapore, also was included in the study.

The CAL approach consisted of a sequence of instructions consisting of learning activities for the concept of decision-making, followed by a prescribed set of exercises. During the CAL lessons, students were presented with the necessary information. Students also were guided with instructions on the computer screens, were provided with practice exercises, and had their learning assessed. Feedback was provided contingent upon correct and incorrect responding.

To run the CAL programs, students type *g* for *go* from the menu. This puts the program in play mode. The play screen is divided into three windows: *a text window* that describes the current event or instructions; *a choices window* that offers the user the choices available at each stage in the program – or displays *next* if no choices are available; and *a function key window* which lists the uses of each of the function keys. The student can work through the program by selecting the relevant choices at each stage or using *next* when events are linked together with no choice of path. In addition, the student can select a function key to (1) look up information, (2) start again, (3) go back one step (i.e., looping), (4) go back further (i.e., looping), (5) review the students' notes, (6) trace where the student currently is in the lesson, and (7) immediately stop the running of the lesson. If the lesson is restarted, it will continue from where the student left off.

In other words, the program is user-friendly and easy to run, and the looping and branching options allow students to check, retrace or skip parts of the program. The student also can print a copy of the current screen or the whole lesson. But, whatever the students do, one of the function keys allows the students to look at the progress on various stages of their lessons, or the number of loops or branchings that they have performed. This can be displayed on the screen, or recorded on the diskette or printed out.

Method

Sample

The study involved 12 teachers, each in a different randomly selected school. In order to reduce the 'teacher effect', each teacher taught one experimental and one control class. All schools were coeducational. The total number of students in these 24 classes was 671 (348 in the experimental group and 323 in the control group). Approximately equal numbers of males and females made up the sample. Students were slow learners in their second year of high school in Singapore (referred to as 'Secondary Two Normal' students).

Geography Achievement Test (GAT) and Semantic Differential Inventory (SDI)

The instruments used to measure achievement in and attitude towards geography were developed and validated for the present study. The *Geography Achievement Test (GAT)* is a 30-item multiple-choice test which assesses the concept of decision-making in geography. The *Semantic Differential Inventory (SDI)* is a 20-item semantic differential instrument which measures students' attitudes towards learning geography. The alpha reliability coefficient for the whole sample was found to be 0.95 for the 30-item GAT and 0.94 for the 20-item SDI.

Geography Classroom Environment Inventory (GCEI)

It is now a quarter of a century since the *Learning Environment Inventory* was used as part of the research and evaluation activities of Harvard Project Physics (Welch & Walberg, 1972), and Moos began developing social climate scales for a wide variety of human environments, including the *Classroom Environment Scale* for use in school settings (Moos & Trickett, 1987). Since that time, the field of classroom environment research has flourished (Fraser, 1986, 1993; Fraser & Walberg, 1991). One promising but largely neglected use of student perceptions is as a source of process criteria in evaluating educational innovations (Fraser, 1981). For example, an evaluation of Harvard Project Physics showed that student perceptions of classroom environment differentiated revealingly between curricula, even when various outcome measures showed negligible differences (Welch & Walberg, 1972). The research reported in this paper is distinctive in that it provides one of the first evaluations of CAL which investigated the psychosocial environment of CAL classrooms. Because hitherto there has existed no learning environment instrument which has been tailor-made specifically for use in classrooms using computer-assisted learning, the present study filled a gap by developing and validating such an instrument.

The final version of the new instrument, the *Geography Classroom Environment Inventory (GCEI)*, has four Likert-type scales. The response alternatives for each item are 'almost never', 'seldom', 'sometimes', 'often' and 'very often'. The initial GCEI instrument contained the eight scales of teacher concern, participation, gender equity, investigation, innovation, differentiation, organization and resource adequacy; but four scales (namely, teacher concern, participation, differentiation, and organization) were omitted after item and factor analyses. Each scale was selected because of its relevance to the unique environment of CAL classes (Teh & Fraser, 1993). For example, equity was included because a decade of research in the CAL environment has shown that the use of computers maintained and exaggerated inequities (Sutton, 1991; Kirk, 1992), that equity issues are complex (Schubert, 1986; Sutton, 1991), and that there are gender differences in achievement and attitudes towards computer usage (Hattie & Fitzgerald, 1987; Levin & Gordon, 1989; Siann, Macleod, Glissov & Durndell, 1990; Sutton, 1991). Although a strong tradition in CAL research at all school levels has been to investigate the effectiveness of the usage of CAL in a specific cognate area (Hasselbring, 1984; Bangert-Drowns, Kulik & Kulik, 1985; Roblyer, Castine & King, 1988; Kulik & Kulik, 1991), past CAL research seldom has examined the potential of computer usage in facilitating and promoting student investigation in the classroom. Investigation therefore was another dimension that was incorporated into the GCEI instrument.

Eight items are contained in the final version of each scale. Typical items contained in the GCEI are "The teacher pays more attention to boys' questions than to girls' questions" (gender equity), "Students carry out investigations to answer questions coming from class discussions" (investigation), "New and different ways of teaching are used in this class" (innovation), and "There are enough computer programs available for our lessons" (resource adequacy). The scoring direction is reversed for almost half of the 32 items in the GCEI.

In developing the GCEI, cognisance was taken of Moos's three general dimensions as they apply to all human environments (Moos, 1974). These three general dimensions are relationship dimensions (the nature and intensity of personal relationships within the environment), personal development dimensions (the basic directions along which personal growth and self-enhancement tend to occur) and system maintenance and system change dimensions (the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change). Table 1 shows that the four scales in the final version of the GCEI provide reasonable coverage of the three different basic types of dimensions proposed by Moos.

Table 1. Descriptive information for GCEI scales.

Scale name	Description	Moos's classification
Gender equity	Extent to which boys and girls are treated equally by the teacher	Relationship
Investigation	Extent to which the skills and processes of inquiry are used in problem-solving and investigation	Personal development
Innovation	Extent to which the teacher plans new and varying activities and techniques, and encourages students to think creatively	System maintenance
Resource adequacy	Extent to which the computer hardware and software are adequate	System maintenance

The development of the GCEI also followed the following steps. First, a comprehensive review of the literature on computer-assisted learning was undertaken to identify scales considered important in this unique environment (Plomp & Pelgrum, 1991). Second, extensive interviewing of teachers and students ensured that the GCEI's initial scales and individual items were considred salient by teachers and students. Third, several computer education experts vetted scales and items and agreed that the constructs were relevant. Fourth, following extensive field testing, item and factor analyses were used to refine the original 80-item version with 8 scales to form the final 32-item version with 4 scales (Teh & Fraser, 1993).

Validation Statistics the GCEI

Table 2 shows the statistics obtained with the 348 students in the experimental (computer) group for each of the GCEI scale's internal consistency (alpha reliability) and discriminant validity (correlations between scales). These indices were calculated using the individual as the unit of statistical analysis. Data in Table 2 generally show that, for this sample, GCEI scales displayed adequate internal consistency reliability (with alpha coefficients ranging from 0.52 to 0.68) and discriminant validity (with mean correlations ranging from 0.01 to 0.45). Validation data were fairly similar for the control group.

Table 2. Internal consistency reliability (alpha coefficient), discriminant validity (scale intercorrelations), and ANOVA results (*F* and *Eta*²) for class membership differences for each scale in the modified version of GCEI for the experimental group.

			Scale intercorrelations				ANOVA results	
Scale	Number of items	Alpha reliability	GE	IV	IN	RA	*F*	*Eta*²
Gender equity	8	0.67		0.01	0.22	0.34	17.46**	0.38
Investigation	8	0.65			0.45	0.10	49.30**	0.64
Innovation	8	0.52				0.20	42.12**	0.60
Resource adequacy	8	0.68					31.27**	0.53

** $p<0.01$

Table 2 also provides information about each scale's ability to differentiate between the perceptions of students in different classrooms. These results were obtained by performing for each scale a one-way ANOVA, with class membership as the main effect and using the individual as the unit of analysis. Results of these analyses reported in Table 2 indicate that each of the four scales differentiated significantly ($p<0.01$) between the perceptions of students in different classrooms. The eta^2 statistic, which represents the proportion of variance in environment scores accounted for by class membership, ranged from 0.38 to 0.64 for the various scales. The results for the control group were fairly similar.

Impact of CAL on Achievement, Attitudes and Classroom Environment

A comprehensive synthesis of 134 past meta-analyses of 7,827 individual studies of factors affecting student achievement by Fraser, Walberg, Welch and Hattie (1987) has shown that the average effect size in past studies in education is only 0.4 standard deviations. For computer-based instructional programs, in particular, a review by Roblyer, Castine and King (1988) also revealed an average effect size of 0.4 standard deviations, while Kulik and Kulik's (1991) meta-analysis of computer-based learning effectiveness revealed a value of 0.3 standard deviations.

To investigate differences in students' scores on the achievement, attitude and classroom environment measures between the experimental (computer) and control (non-computer) group, ANCOVA procedures were computed separately for each of the six outcome measures. Three different measures (namely, students' national primary school leaving examination scores, their semestral assessment scores and their pretest scores) were used as covariates. A summary of the results for the significance of differences between the computer and non-computer groups are reported in Table 3. The effect size (i.e., the number of standard deviations of difference between the experimental CAL group and the control group) for each outcome also is reported in Table 3.

Table 3. A comparison of experimental and control groups on achievement, attitude and classroom environment outcomes.

Scale	Number of items	*F*	Effect size
Achievement	30	5824.59**	3.5
Attitude	20	630.13**	1.4
Classroom Environment			
Gender equity	8	219.66**	1.0
Investigation	8	809.14**	1.9
Innovation	8	703.63**	1.7
Resource adequacy	8	504.28**	1.5

** $p<0.01$

Table 3 shows that the present evaluation of the use of PROLOG-based computer-assisted learning revealed statistically significant differences ($p<0.01$) for all six outcome measures. A massive effect size of 3.5 standard deviations (of difference between the experimental CAL group and the control group) emerged for the achievement outcome and an effect size of 1.4 standard deviations was found for the attitude measure. These differences favoured the CAL group.

Also significant differences emerged in the students' perceptions between the computer and non-computer group for all of the four GCEI scales, namely, gender equity, investigation, innovation and resource adequacy. Table 3 reveals that the use of PROLOG-based computer-assisted learning was associated with an effect size of 1.0 standard deviations for gender equity, 1.9 standard deviations for investigation, 1.7 standard deviations for innovation and 1.5 standard deviations for resource adequacy. These differences favoured the CAL group in every case. Relative to control classes, the CAL classes were perceived to have greater gender equity, investigation, innovation and resource adequacy. The present study's findings in the context of computer-assisted learning are consistent with past studies on non-CAL classroom environments (Walberg, 1975; Fraser, 1979, 1981, 1986) in which learning environment measures have proved useful in curriculum evaluation.

Discussion

The present evaluation of computer-assisted learning in school geography education in Singapore is distinctive because, first, the use of micro-PROLOG-based CAL in courseware development has been sparse, second, research on CAL in geography education in Singapore hitherto has been non-existent and, third, the classroom environment formed an important focus in the evaluation. In fact, the present research extended learning environment work in a new direction by developing and using a new instrument for assessing student perceptions of CAL classroom environments.

This study shows that appropriately-designed PROLOG-based CAL can be an effective instructional method in the classroom milieu. It also shows that the educational application of micro-PROLOG as a learning tool in social science classrooms can be efficacious. While a myriad of studies have examined the effects of CAL, the number of studies examining the effect of PROLOG-based CAL is meager at best. Hopefully, this study will serve as a catalyst for further research into the use of PROLOG in the classroom.

No systematic attempts previously have been made to examine the effects of CAL on learning environment characteristics. Little has been studied or is known about the impact of microcomputers on learning climates in education (Ellett, 1986). This study responds to the plea by Ellett (1986) and Lancy (1987) to fill the lacunae represented by the study of computers and their impact on students. This study is significant because, in contrast to previous research, it uses PROLOG-based courseware developed by the researchers in investigating computer learning environments in schools.

One of the study's major contributions is that a new classroom environment instrument has been developed and validated specifically for the unique setting of computer-assisted learning. The scales in this instrument display adequate factorial validity, internal consistency reliability, discriminant validity and predictive validity (in terms of being significantly related to student outcome scores). Also each scale differentiates significantly between the perceptions of students in different classrooms. It is likely that other researchers will find this new instrument useful in future studies of CAL classroom environments.

The major finding was that, in contrast to past research, the use of CAL in this study led to massive impact in terms of achievement (effect size of 3.5 standard deviations), atttitudes (1.4 standard deviations) and classroom environment (ranging from 1.0 to 1.9 standard deviations). The large effect sizes arising from this study could be attributed to the peculiar situation inherent in the Singapore education system. That is, the highly meritocratic, technologically-biased, centrally-controlled and achievement-oriented system might produce students who perform well. The large effect sizes also could be attributable to the PROLOG-based CAL courseware, which took cognisance of the curriculum objectives of the schools, the prerequisites of following the exact curriculum topics, and the integration of the courseware with the syllabus requirements of the schools. The large effect sizes seem to suggest that appropriate computer-based teaching can be effective with low aptitude students (i.e., the Normal students). This finding is consistent with the meta-analysis of CAL effectiveness reviewed by Bangert-Drowns, Kulik and Kulik (1985). But there is a need for replication and further related research because of the uniqueness of the Singapore milieu.

There is considerable scope to make use of the new instrument for computer-assisted learning environments in replicating the present evaluation of innovations in CAL, as well as in investigations of the effects of CAL classroom environments on student outcomes. In addition, it is hoped that researchers will make use of the new questionnaire specifically in CAL settings in pursuing some of the other lines of classroom environment research reviewed by Fraser (1993). These include the use of classroom environment research in school psychology (Burden & Fraser, in press), person-environment fit investigations of whether students achieve better in their preferred classroom environment (Fraser & Fisher, 1983), practical attempts to improve classroom setting (Fraser & Fisher, 1986), studies of links between classroom-level and school-level climate (Fisher & Fraser, in press) and research which combines qualitative and quantitative methods in the study of learning environments (Fraser & Tobin, 1991).

References

Bangert-Drowns, R.L., Kulik, J.A., & Kulik, C.C. (1985) Effectiveness of computer-based education in secondary schools. *Journal of Computer-Based Instruction, 12*(3), 59-68.

Burden, R.L., & Fraser B.J. (in press) Use of classroom environment assessments in school psychology: A British perspective. *Psychology in the Schools.*

Chalk, P. (1987) PROLOG-based computer-aided learning environments. *Programmed Learning and Educational Technology, 24*(2), 102-107.

Ellett, C.D. (1986) Conceptualizing the study of learing environments. In B.J. Fraser (Ed.), *The study of learning environments* (pp. 34-40). Salem, OR: Assessment Research.

Fisher, D.L., & Fraser, B.J. (in press) Interpersonal teacher behavior style and school environment. In Th. Wubbels & J. Levy (Eds.), *Do you know what you look like:*

Interpersonal relationships in education. London: Falmer Press.

Fraser, B.J. (1979) Evaluation of a science-based curriculum. In H.J. Walberg (Ed.), *Educational environments and effects: Evaluation, policy, and productivity* (pp. 218-234). Berkeley, CA: McCutchan.

Fraser, B.J. (1981) *Learning environment in curriculum evaluation: A review*. Evaluation in education: An international review series. Oxford, England: Pergamon Press.

Fraser, B.J. (1986) *Classroom environment*. London: Croom Helm.

Fraser, B.J. (1993) Classroom and school climate. In D. Gabel (Ed.), *Handbood of research on science teaching and learning*. New York: Macmillan. (in press)

Fraser, B.J., & Fisher, D.L. (1983) Student achievement as a function of person-environment fit: A regression surface analysis. *British Journal of Educational Psychology, 53,* 89-99.

Fraser, B.J., & Fisher, D.L. (1986) Using short forms of classroom climate instruments to assess and improve classroom psychosocial environment. *Journal of Research in Science Teaching, 23,* 387-413.

Fraser, B.J., & Tobin, K. (1991) Combining qualitative and quantitative methods in classroom environment research. In B.J. Fraser and H.J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 271-292). Oxford, England: Pergamon Press.

Fraser, B.J., & Walberg, H.J. (1991) (Eds.) *Educational environments: Evaluation, antecedents and consequences*. Oxford, England: Pergamon Press.

Fraser, B.J., Walberg, H.J., Welch, W.W., & Hattie, J.A. (1987) Syntheses of educational productivity research. *International Journal of Educational Research, 11,* 145-252. (whole issue)

Hasselbring, T. (1984) *Research on the effectiveness of computer-assisted instruction: A review* (Technical Report No. 84.1.3). Nashville, TN: George Peabody College for Teachers. (ERIC ED 262 754)

Hattie, J., & Fitzgerald, D. (1987) Sex differences in attitudes, achievement and use of computers. *Australian Journal of Education, 31*(1), 3-26.

Kirk, D. (1992) Gender issues in information technology as found in schools: Authentic, synthetic, fantastic? *Educational Technology, 32*(4), 28-35.

Kulik, C.C., & Kulik, J.A. (1991) Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior, 7*(1-2), 75-94.

Kulik, J.A., & Kulik, C.C. (1987) Review of recent research literature on computer-based instruction. *Contemporary Educational Psychology, 12*, 222-230.

Lancy, D.F. (1987) The message is the medium: Studies of computer learning environments in schools. In B.J. Fraser (Ed.), *The study of learning environments Volume 2* (pp. 64-71). Perth: Curtin University.

Levin, T., & Gordon, C. (1989) Effect of gender and computer experience on attitudes towards computers. *Journal of Educational Computing Research, 5*(1), 69-88.

Low, K.G. (1988) Investigation of various modes of computer-based learning for secondary schools. *Singapore Journal of Education, 9*(2), 27-32.

Moos, R.H. (1974) *The social climate scales: An overview.* Palo Alto, CA: Consulting Psychologists Press.

Moos, R.H., & Trickett, E.J. (1987) *Classroom Environment Scale manual* (2nd ed.). Palo Alto, CA: Consulting Psychologists Press.

Ong, S.T., & Lee-Leck, M.K. (1986) The effects of computer-assisted instruction on attitudes and achievement in mathematics on preservice primary school teachers. *Selected proceedings of Educomp '86: Impact of microcomputers in education – Issues and techniques* (pp. 196-201). Singapore: Ngee Ann Polytechnic.

Plomp, T., & Pelgrum, W.J. (1991) Introduction of computers in education: State of the art in eight countries. *Computers and Education, 17*(3), 249-258.

Roblyer, M.D., Castine, W.H., & King, F.J. (1988) Assessing the impact of computer-based instruction: A review of recent research. *Computers in the Schools, 5*(3/4), 1-149.

Schubert, J.G. (1986) Gender equity in computer learning. *Theory into Practice, 25*, 267-275.

Siann, G., Macleod, H., Glissov, P., & Durndell, A. (1990) The effect of computer use on gender differences in attitudes to computers. *Computers and Education, 14*(2), 183-191.

Sutton, R.E. (1991) Equity and computers in the schools: A decade of research. *Review of*

Educational Research, 61(4), 475-503.

Teh, G.P.L, & Fraser, B.J. (1993) *A study of computer-assisted learning environments in Singapore*. Paper presented at annual meeting of American Educational Research Association, Atlanta, GA.

Walberg, H.J. (1975) Educational process evaluation. In M.W. Apple, M.J. Subkoviak, & H.S. Lufler (Eds.), *Educational evaluation: Analysis and responsibility* (pp. 237-268). Berkeley, CA: McCutchan.

Welch, W.W., & Walberg, H.J. (1972) A national experiment in curriculum evaluation. *American Educational Research Journal, 9,* 373-383.

Woo-Tan, L.B. (1989) *Effects of computer-assisted instruction on the learning of transformation geometry*. Unpublished Master's dissertation, National University of Singapore, Singapore.

BJF-702-DY-7/9/93