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ABSTRACT

There are two main ways in which the practical component of computer science and information systems courses, the computer laboratory class, may be organized. They may be closed laboratories, which are scheduled and staffed in the same way as other classes, or open laboratories where the students come and go as they please. In U.S. universities, the open laboratory is more common, whereas in Australia, it is the closed laboratory that provides the practical experience for students. This study investigates the differences between students' perceptions of some aspects of the learning environment of open and closed computer laboratories, and also investigates differences in student outcomes from courses that adopt these two approaches to organizing computer laboratory classes. In the study, two previously developed instruments, the Computer Laboratory Environment Inventory (CLEI) and the Attitude towards Computing and Computing Courses Questionnaire (ACCC), were used. The CLEI has five scales for measuring students' perceptions of aspects of their laboratory environment. These are student cohesiveness, open-endedness, integration, technology adequacy, and laboratory availability. The ACCC has four scales--anxiety, enjoyment, usefulness of computers, and usefulness of the course. Of the environment variables, differences were found for open-endedness, technology adequacy, and laboratory availability. There was also a difference for anxiety. There was no significant difference in student achievement in the course. (Contains 12 references.) (MES)

A Comparison Between the Learning Environments of Open and Closed Computer Laboratories

By: Michael Newby & Darrell Fisher

A COMPARISON BETWEEN THE LEARNING ENVIRONMENTS OF OPEN AND CLOSED COMPUTER LABORATORIES

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Abstract

In courses such as Computer Science and Information Systems, where the computer is an integral part of the course, there are two main ways in which the practical component of the course, the computer laboratory class, may be organised. They may be closed laboratories which are scheduled and staffed in the same way as other classes, or open laboratories where the students come and go as they please. In universities in the United States, the open laboratory is more common, whereas in Australia, it is the closed laboratory that provides the practical experience for students. This study investigates differences between students' perceptions of some aspects of the learning environment of open and closed computer laboratories, and also investigates differences in student outcomes from courses that adopt these two approaches to organising computer laboratory classes. In the study, two previously developed instruments, the Computer Laboratory Environment Inventory (CLEI) and the Attitude towards Computing and Computing Courses Questionnaire (ACCC) were used. The CLEI has five scales for measuring students' perceptions of aspects of their laboratory environment. These are Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy and Laboratory Availability. The ACCC has four scales, Anxiety, Enjoyment, Usefulness of Computers and Usefulness of the Course. Of the environment variables, differences were found for Open-Endedness, Technology Adequacy and Laboratory Availability. There was also a difference for Anxiety. There was no significant difference in student achievement in the course.

Presented at Annual Meeting of the American Educational Research Association, New Orleans, April 2000

Background

Computers have been used in higher education for over 30 years both as a subject of study in their own right and as a tool to assist in the learning process within other disciplines. They have also been used as a means of delivering educational material and for on-line assessment. More recently, there has been a rapid growth in the use of the Internet in most disciplines and a subsequent demand for suitable courses. In all courses where computers are used, computer laboratory classes play a major role. These classes can take a number of forms, the two most common being the closed or formal laboratory and the open laboratory (Prey, 1996). The formal laboratory is scheduled in the same way as lectures and tutorials with specific exercises being set for students. They are generally staffed by a member of faculty. On the other hand, open laboratories allow students access whenever a computer is available for them. Technical assistance is provided by laboratory demonstrators who are often senior students. Whether open or closed laboratories are used within a course, it is normal for instructors to give students exercises or assignments to complete. With closed laboratories, these exercises are usually more structured and students work on them during the laboratory class getting assistance from the instructor running the class. These students may also use the laboratories outside the scheduled class times. With open laboratories, students are often left to their own devices with some help being provided by teaching assistants, or from the instructor, during scheduled office hours.

The importance of laboratory classes in computer-based courses is generally accepted (Cougar et al., 1995; Knox et al., 1996) and there have been studies into the relationship between the environment of computer laboratory classes and student outcomes (Schuh, 1996; Newby & Fisher, 1997, 1998). Most computing courses in the USA use open laboratories (Denk & Serangarm, 1994), whereas in Australia and the UK closed laboratories are the norm. One factor that undoubtedly affects the provision of closed laboratories in the USA is the way that workloads are measured. This is done on the basis of course credits and in most USA universities, a laboratory class counts as only half a credit. In Australia, laboratory classes carry the same weight as lectures or tutorials.

Despite this difference in the way that computer laboratory classes are organised and the fact the association between learning environment and student outcomes is well established (Fraser, 1991), there seem to be few studies on whether open or closed laboratories provide the more suitable learning experiences.

Methodology

This study involved the use of two previously developed instruments, one called the *Computer Laboratory Environment Inventory* (CLEI) for measuring aspects of a computer laboratory environment and the other, the *Attitude to Computers and Computing Courses Questionnaire* (ACCC) used to measure students' attitudes (Newby & Fisher, 1997). The research focussed on whether there were differences in a student's perception of aspects of their computer laboratory environment or in their course outcomes if they received their computer laboratory experience via open or closed laboratories.

The Computer Laboratory Environment Inventory

The instrument for assessing computer laboratory environment is based on the actual version of the Personal form of the *Science Laboratory Environment Inventory* (SLEI) designed by Fraser, Giddings and McRobbie (1993). It has five scales, Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability. The first three scales are derived directly from the SLEI, and the latter two are new scales designed for this instrument. The scales consist of seven items, with each item being measured on a Likert scale of 1 to 5 with some questions being reversed. Table 1 gives a description of each scale with a sample item.

Table 1
Description of CLEI scales

Scale	Description	Sample Item
Student Cohesiveness	Extent to which students know, help and are supportive of each other	I get on well with students in this laboratory class (+)
Open-endedness	Extent to which the laboratory activities encourage an open-ended, divergent approach to use of computers	There is opportunity for me to pursue my own computing interests in this laboratory class (+)
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	The laboratory work is unrelated to the topics that I am studying in my lecture (-)
Technology Adequacy	Extent to which the hardware and software are adequate for the tasks required	The computers are suitable for running the software I am required to use (+)
Laboratory Availability	Extent to which the laboratory is available for use	I find that the laboratory is crowded when I am using the computer (-)

Items designated (+) are scored 1,2,3,4 and 5, respectively for responses Almost Never, Seldom, Sometimes, Often, Almost Always
Items designated (-) are scored 5,4,3,2 and 1, respectively for responses Almost Never, Seldom, Sometimes, Often, Almost Always

Attitude towards Computers and Computer Courses Questionnaire

The instrument for assessing students' attitudes towards computers and computer courses (ACCC) has been described in earlier studies (Newby & Fisher, 1997). For assessing attitude towards computers, the scales Anxiety, Enjoyment, and Perceived Usefulness of Computers were based upon an instrument devised by Loyd and Loyd (1985). They also included a Confidence scale but differentiating between lack of confidence and anxiety proved difficult so the Confidence scale was omitted. A fourth scale was included to measure the student's perception of the usefulness of the course. As with the CLEI, all the scales have seven items and a description of the scales used in the instrument is given in Table 2 together with a sample item from each scale.

Table 2
Description of ACCC Scales

Scale	Description	Sample Item
Anxiety	Extent to which the student feels comfortable using a computer	Working with a computer makes me very nervous (+)
Enjoyment	Extent to which the student enjoys using a computer	I enjoy learning on a computer (+)
Usefulness of Computers	Extent to which the student believes computers are useful	My future career will require a knowledge of computers (+)
Usefulness of Course	Extent to which the student found the course useful	I do not think I will use what I learned in this class (-)

Items designated (+) are scored 1,2,3,4 and 5, respectively for responses Strongly Disagree, Disagree, Not Sure, Agree, Strongly Agree
Items designated (-) are scored 5,4,3,2 and 1, respectively for responses Strongly Disagree, Disagree, Not Sure, Agree, Strongly Agree

Samples

The instrument was administered to 104 students undertaking courses within the Business School of Curtin University of Technology in Western Australia, and to 109 students within the School of Business and Economics at California State University, Fullerton. All courses involved the use of a computer to solve problems. The Curtin courses provided the laboratory experience by means of formal closed laboratory classes. At Fullerton, laboratory classes were not scheduled and the laboratory experience was provided by open laboratories. Both samples were representative with respect to gender, age, and mode of study (part-time or full-time). In both surveys, the classes included those in which the development of software was the focus of study, such as Information Systems, and others in which the computer was used as a tool. The surveys were carried out in the last third of the semester in which the course was given so that students would have had a sufficient exposure to the laboratories. However, it should be pointed out that the survey in Fullerton and the one in Curtin were conducted at different times of the year. The instructor for all classes, both at Fullerton or at Curtin, was the same, and in this instructor's judgement the students were similar in academic level and background.

Achievement

Achievement was measured as the grade obtained in the course, as a mark out of 100. This grade was contributed to by three components, a final examination, assignments and laboratory exercises. Both the examination and the assignments tested knowledge and skills that should have been gained mainly in the laboratory classes, whose main purpose was to give practical experience of material covered in the lectures. Using means and standard deviations obtained for each course, each grade was converted into a z-score. Of the 104 students from Curtin, 77 provided their student number and of the 109 students from Fullerton, 74 did so. This allowed the grades of these students to be determined.

Results

Table 3 shows the alpha reliabilities and mean correlations with other scales for the scales of the CLEI for both samples. The reliabilities for the Australian sample vary from 0.56 to 0.89, and for the USA sample from 0.61 to 0.80. These are consistent with previous studies and indicate that the reliabilities of the scales are satisfactory.

Table 3
Internal Reliability and Mean Correlations for the Scales of the CLEI

	Australia		United States	
Scale	Alpha	Mean Correlation	Alpha	Mean Correlation
Student Cohesiveness	0.64	0.13	0.72	0.10
Open-Endedness	0.56	0.08	0.61	0.07
Integration	0.89	0.14	0.80	0.13
Technology Adequacy	0.84	0.23	0.78	0.24
Laboratory Availabilty	0.81	0.22	0.71	0.23
Sample Size	104		109	

The mean correlations with other scales varies from 0.08 to 0.23 for the Australian sample and 0.06 to 0.24 for the US sample. These demonstrate that there is little overlap in what the scales are measuring and the results are consistent with previous studies in which factor analysis was used to confirm that there are five distinct scales in the CLEI (Newby, 1998).

Table 4 shows the alpha reliabilities and mean correlations with other scales for the scales of the ACCC. The alpha reliabilities vary from 0.64 to 0.90 for the Australian sample and from 0.72 to 0.89, indicating that the scales have satisfactory internal consistency for these samples. The mean correlations show that the scales measure distinct but overlapping aspects of students' attitudes towards computers and the course. Factor analysis has been used in a previous study to confirm a structure of four factors for the ACCC (Newby, 1998).

Table 4
Internal Reliability and Mean Correlations for the Scales of the ACCC

	Australia		United States	
Scale	Alpha	Mean Correlation	Alpha	Mean Correlation
Anxiety	0.89	0.36	0.88	0.47
Enjoyment	0.90	0.41	0.89	0.47
Usefulness of Computers	0.82	0.36	0.81	0.49
Usefulness of Course	0.64	0.28	0.72	0.36
Sample Size	104		109	

An independent samples t-test was carried out on all environment variables, on all attitudinal variables and on achievement measured by the z-score using country of study as the grouping variable. The results for the environment variables are given in Table 5, and for the attitudinal variables and achievement in Table 6.

Table 5
Comparison of the Means for Environment Variables

Scale	Australia Mean	Australia Std	USA Mean	USA Std	t	*p*
Student Cohesiveness	23.1	3.65	22.2	4.31	0.83	0.411
Open-Endedness	23.5	3.22	22.4	2.65	2.88	0.004
Integration	24.6	5.52	25.8	4.05	-1.83	0.068
Technology Adequacy	22.7	4.65	24.4	4.38	-2.74	0.007
Laboratory Availability	19.7	5.58	22.3	4.96	-3.57	0.000

Of the environment variables, the difference in the mean for Open-Endedness was significant ($p < .01$), with courses having closed laboratories being higher. Both Technology Adequacy ($p < .01$) and Laboratory Availability ($p < .001$) were significantly higher for courses which provided the laboratory experience via open laboratories.

Table 6
Comparison of the Means for Attitudinal Variables and Achievement

Scale	Australia Mean	Australia Std	USA Mean	USA Std	t	*p*
Anxiety	13.7	4.61	15.4	5.39	-2.40	0.007
Enjoyment	29.0	4.96	28.3	4.83	0.97	0.334
Usefulness of Computers	30.8	4.11	30.2	4.14	1.07	0.286
Usefulness of Course	25.2	3.45	25.4	4.06	-0.39	0.695
Achievement	0.35	1.01	0.22	0.89	0.83	0.411

Of the attitudinal variables, only Anxiety showed a significant difference ($p < .01$) in the means with courses using open laboratories being higher. There was no significant different between the means of achievement for the two groups.

Discussion

The results demonstrate that there are some significant differences in students' perceptions of their computer laboratory environment depending whether they receive their laboratory experience via closed laboratories or open laboratories. The only scale in which the mean was significantly higher for courses employing closed laboratories was Open-Endedness. At first sight, this seems somewhat surprising as closed laboratories are designed to be much more structured than open laboratories. However, a possible explanation is that in a closed laboratory setting, students are more confident about experimenting with different ways of solving problems. In an open laboratory, students are more reliant upon laboratory assistants and each other and are likely to be satisfied when they get a solution that works. Of the remaining environment variables, both Technology Adequacy and Laboratory Availability have a significantly greater mean for courses using open laboratories. In many ways, the higher mean for Laboratory Availability is to be expected. With an open laboratory setting, the laboratories are available for use by students all day since there are no classes scheduled in them. The only competition comes from other students. Where closed laboratories are in use, much of the available time is taken by scheduled classes, and students are competing for the time that is unscheduled. The higher mean for Technology Adequacy for courses with open laboratories could have a number of explanations, most of which are not directly related to open and closed laboratories. One such explanation is that the technology at Fullerton is more suitable than that at Curtin for the courses being taught. Certainly, the fact that about half of the students in the Curtin sample used a centralised computer and the rest used a network of PCs, whereas all Fullerton students used a network of PCs could be a contributing factor. Another possibility is that the instructor using closed laboratories set exercises that would more consciously extend the student's knowledge of how to solve problems in such an environment. Being on hand to answer questions immediately as would be the case with closed laboratories makes this more feasible. With open laboratories, the instructor must be more aware that they are setting exercises where the students will, in general, be obtaining limited help. It is interesting to observe that although not significant ($p = 0.068$), the mean for Integration is higher for open laboratories than for closed ones. This could be also be explained by the awareness of the instructor of the limited assistance available to students, and so they make the laboratory work closed related to the material of the lecture.

Of the attitudinal variables, the mean for Anxiety is significantly greater ($p < .01$) for courses with open laboratories than for those with closed ones. This suggests that the presence of a faculty member when they are using unfamiliar software or hardware may reduce their anxiety and increase their confidence in using computers.

Conclusion

The significance of this study is that it is one of the first that has compared the provision of computer laboratory experience by the use of closed laboratories and the use of open laboratories. It has demonstrated that there are some differences in both environment and attitudinal variables for the two groups of students. A previous study (Newby & Fisher, 2000) indicated that laboratory environment affects attitude which in turn affects achievement. Although the present study did not show a significant differences in the means for achievement, it did show a lower mean for anxiety and higher mean for perceived usefulness of the course for those courses with closed computer laboratories. This would indicate that the provision of closed laboratories within courses could improve students' attitudes and eventually their achievement.

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