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ABSTRACT

This study investigated computer laboratories in New Zealand schools. A questionnaire was used to obtain information in four areas: (1) demographic data, including the name of the school, class levels, governing authority, gender composition, roll size, staffing, and socio-economic ranking; (2) qualitative and quantitative data about the school's computer laboratories; (3) similar data about external computer laboratories; and (4) number and types of computers owned by the school. This report discusses results related to the date of establishment of a school's first computer laboratory, computer laboratory layout, reasons for choosing layouts, uses of computer laboratories, and time usage of laboratories. A chart presents student-centered, teacher-centered, and management-centered reasons for selection of the layout. (AEF)

Rows, Isles or Peninsulas?
An Analysis of Computer Laboratory Layouts in Schools

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INTRODUCTION

For some years now the Department of Information Technology at the Central Institute of Technology has been involved in developing a greater understanding of the role Information Technology plays in the primary and secondary education systems. The genesis of this computer laboratory layout research project lies in this ongoing process which includes the two following areas. The first area was the development work associated with CIT's Advanced Diploma of Information Technology in Education programme. The other was the associated research conducted in preparation for the *Tools to Toys* paper (Albertson and Selwood, 1997).

In both these contexts questions emerged about the layout and usage of computer laboratories in schools. Two main concerns were highlighted. One was the extent of capital expenditure on computer laboratories and the other was the way the layout of the room might relate to teaching and learning methodologies and theories. Whilst anecdotal evidence suggested that computer laboratories, in various forms, had been in schools for several years, little evidence could be found that documented how schools designed their computer laboratories. Nor was there much evidence of the rationales schools might have used to reach decisions on the design and layout of their computer laboratories.

Mindful of Cuban's illustrations of the reality of constancy amid change in education, there was a suspicion that traditional classroom layout might be a predominant influence (Cuban, 1993). Specifically that the layout selected would be an overlay of computers on to a conventionally arranged classroom. Such a layout would have its main focus on a *blackboard* area, with the computers located on tables organised in the conventional classroom pattern of rows. This expectation was based largely on two primary assumptions. First, that traditional teaching practice might be a powerful influence on the layout of computer laboratories. Second, that the teaching-learning process typically employed, especially in secondary schools, would tend to be more heavily influenced by objectivist oriented learning theory and a didactic, teacher-centred approach. These assumptions were however tempered by an acknowledgement of the reality of economic factors and building constraints. These latter factors possibly being important determinants of computer laboratory layout that might not necessarily be entirely compatible with the thrust of the first two assumptions.

SURVEY PURPOSE AND DESIGN

In New Zealand, there is little evidence of any investigation of the incidence, size, layout and use of school computer laboratories. Organisations like the Ministry of Education and Telecom have published information about the number of computers and the incidence of telecommunications equipment in schools. Little however appears to have been done to determine much other than quantify equipment.

It was decided therefore to investigate what sort of computer laboratories schools owned. A printed questionnaire was selected as the most efficient way to obtain information from a reasonable number of schools.

The questionnaire consists of four sections. The first section sought demographic information to determine the name of the School, Class Levels taught, Governing Authority, Gender Composition, Roll Size, Staffing and Ministry of Education Socio-Economic Decile Ranking. The second section was designed to obtain a range of qualitative and quantitative data about the schools' computer laboratories. The third section was designed to obtain similar data, but about external computer laboratories. The fourth section asked about the number and types of computers owned by the school altogether.

During the survey development phase it became increasingly apparent that considerable thought needed to be given to the various ways it might be possible to layout a computer laboratory. This was a necessary step to clarify early thinking and also to provide a system of classification for use in any subsequent research. Espinosa describes three basic computer laboratory arrangements (Espinosa, 1990). In the first of these the computers are placed around the perimeter of the room allowing a large open area in the centre of the room. This central space may sometimes contain tables and chairs for group work or instruction. The second arrangement he identifies has the computers placed in rows facing the front or *blackboard* end of the room. The third of Espinosa's arrangements shows the computers placed in clusters in the centre or around the perimeter of the room.

While this classification was useful as a starting point it did not seem sufficiently comprehensive to identify a range of variations, that while similar, might still have important unique identifying characteristics. As a consequence, it was decided to develop a classification system that might cater more adequately for a wider range of the subtle, yet significant, distinctions possible in computer laboratory layouts. After some experimentation with a variety of models a classification system identifying six layouts was finally determined (Appendix A). These models of layout were derived essentially from two primary designs. A layout with the computers placed around the perimeter of the room and another with the computers arranged on tables in rows or clusters. It was acknowledged that the final classification system adopted clearly still did not cover every conceivable layout. The system selected was however, an acceptable compromise between the dual excesses of undue simplicity and extreme complexity.

While the three factors: tradition, teaching approach and economics were identified as likely major determinants of computer laboratory layout, this analysis is not a

straightforward one. For instance, if the layout were influenced by a teacher-centred approach, then the preferred layout would be one similar to a traditional classroom. On the other hand an approach that was more student-centred might favour a model with the computers arranged around the perimeter of the room. Such a layout was considered likely to be more conducive to students working at their own pace while still allowing considerable flexibility for co-operative activities. Cutting across this analysis was the potential of the economic and building considerations to exert an influence. The more traditional model with rows would probably be more expensive to establish, particularly because of the complications of delivering network cabling and power supply to each computer without creating barriers to movement or visual obstructions. By contrast, the alternative layout with the computers arranged around the room's perimeter would be simpler and less expensive to set up, as the cabling, power supply and wiring could be installed relatively easily in wall mounted ducting.

THE SAMPLE

Several factors were considered in determining the schools to be sampled. There did not appear to be much supporting literature in relevant areas and the system for classifying computer laboratories was untested and possibly in need of refinement. There were also, issues of the cost of the survey procedure in both money and time. The survey was eventually confined to Intermediate and Secondary Schools in the North Island south of Levin. These 65 schools represented a cross section of rural, urban, independent, integrated, state, size, single-sex, and co-ed schools. Additionally these schools draw from a variety of communities across the socio-economic spectrum.

The survey forms were sent to these schools and responses were received from 35 (54%) of them. While this response rate may seem low, the schools involved represent 17270 students, or approximately 6% of the comparable national group. The demographic details of the sample and a comparison with New Zealand (Ministry of Education, 1996) as a whole are set out in Tables 1 to 4.

Table 1 - Schools by Year Levels

Year Level	Form	Number of Schools	Sample %	NZ %
Years 9-13	Forms 3-7	17	49%	45%
Years 7-13	Forms 1-7	5	14%	14%
Years 7-8	Forms 1-2	10	29%	25%
Years 1- 13	New Entrants to Form 7	3	9%	16%

Table 2 - Schools by Governing Authority

Type	Sample Number of Schools	Sample % of Schools	Sample Number of Students	Sample % of Students	NZ % of Students
State	23	66%	12715	74%	87%
Integrated	8	23%	3797	22%	9%
Independent	4	11%	758	4%	4%

Table 3 - Schools by Gender Composition

Type	Number	Sample %	NZ %
Co-ed	26	74%	81%
Boys Only	3	9%	8%
Girls Only	6	17%	11%

Table 4 - Schools by Socio-Economic Decile (New Zealand Ministry of Education decile ranking system)

Decile	Number	Sample %
1	0	0%
2	3	9%
3	4	11%
4	1	3%
5	6	17%
6	4	11%
7	3	9%
8	2	6%
9	3	9%
10	6	17%
Not Specified	3	9%

The Year Level range is a very close match with the national distribution for New Zealand. The figures for Governing Authority and Decile Ranking suggest however, that the schools involved in the survey may be somewhat more affluent than would be the case for a truly representative sample. Ministry of Education figures indicate, "especially at the secondary school level - a slight increase in the mean number of computers owned with the rise in decile band". (Owens, 1996). It is therefore likely that there may be a higher number of computers owned by the schools involved in this survey than would be the case for a more representative cross section. Despite this however, the mean student-computer ratio may not be affected as Owens has also observed "the mean student-computer ratios showed little difference across the decile bands".

RESULTS

Date of Establishment of First Computer Laboratory

An analysis of the dates on which each school established its first computer laboratory (Table 5) shows at least two significant matters. Firstly, Secondary Schools have now had computer laboratories for a considerable period of time; in some instances over 15 years. Secondly, Intermediate Schools have followed this trend, but this has occurred only in the last few years. Of the 10 Intermediate Schools in the sample, 8 have set up computer laboratories in the last 4 years. One Intermediate built a laboratory in 1989 and one does not have a laboratory. During the same period no Secondary School established their first laboratory, although several established additional laboratories during this period. This apparent surge in the level of interest in developing laboratories in Intermediate Schools may be a trend that will also flow into Primary Schools.

Table 5 - Date of First Computer Laboratory

Year	Number of First Labs Established	Year	Number of First Labs Established
1997	2 (2 Intermediates)	1988	0
1996	5 (5 Intermediates)	1987	4
1995	0	1986	2
1994	2 (1 Intermediate)	1985	2
1993	0	1984	4
1992	1	1983	2
1991	2	1982	3
1990	1	1981	1
1989	1 (1 Intermediate)	No Response	3

(Only one Intermediate does not have a computer laboratory)

Computer Laboratory Layout

While it was anticipated that there might be some difficulties in classifying all layouts according to the six types used in the survey, this did not appear to create an undue problem. Layout E, with the computers arranged around the perimeter of the room was the most common one adopted by schools (Table 6). Layouts D and B were respectively the next most common. All three of these layouts have the majority of computers arranged around the perimeter of the room with the balance being in either an island or peninsular arrangement. Layouts A, C and F are all more closely modelled on conventional classroom arrangements and the preference for these was lower than their actual incidence.

Table 6 - Computer Laboratory Layouts

Layout	Number of Actual Layouts	Actual % of Labs	Number of Preferred Layouts	% of Preferred Layouts
A	6	8%	0	0%
B	10	14%	6	17%
C	0	0%	0	0%
D	17	23%	9	26%
E	35	48%	17	49%
F	5	7%	1	3%
No Response			2	6%

An initial examination of these results might suggest that, the early hypothesis supporting Layouts A, C and F (those most similar in layout to a conventional classroom) as the most popular, was wrong. Such a conclusion would however, be rather simplistic and premature. Such a line of argument being based on an assumption that teacher-centred and objectivist orientations would necessarily lead to an implementation of Layouts A and F. There are other factors, including ones with financial implications that may influence layout choices. Teachers also often have very pragmatic views about the realities of working in a classroom environment. Additionally, account also needs to be taken of what happens in the rooms and what this reflects of the teaching methods and styles actually adopted in them.

Notwithstanding any tensions these factors may create, the most common reason given for choosing a particular layout (Table 7) was its suitability to the teaching-learning process. This seems to contrast with the work of Sullivan and Patten (1996) who found that 83% of primary teachers and 96% of secondary teachers considered the cost of equipment was a preventing factor in the use of technology. Further reinforcing this apparent anomaly is the finding of the computer laboratory survey that only 5% of responses identified cost as a factor in choosing their laboratory layout. It is also worth noting that class size did not rate as major consideration and that no-one based a decision on research evidence.

Table 7 - Major Reasons for Choosing Actual Layouts

Total	
16%	Building Constraints
4%	Class Sizes
5%	Cost
1%	Environmental Factors
5%	Modelled on another School's laboratory
1%	Other
0%	Parental Views
7%	Power Supply & Cabling Factors
0%	Research Evidence
3%	Safety Factors
1%	Security
0%	Student Views
41%	Suitability for Teaching Learning Process
14%	Teaching Staff Views

As this survey was concerned principally with computer laboratories no attempt was made to seek opinions about the relative merits of having computers in a laboratory setting compared with having them in ordinary classrooms. It is possible therefore, that the typical uses of computer laboratories are more conducive to a didactic style and that it is in the ordinary classrooms that the more student-centred approaches will be found. Of the schools who responded to this survey the vast majority had considerably more computers in laboratories than they had in the administration, staffroom, library and classroom areas combined. It is unlikely therefore that it can be argued that the classroom computers in most of these schools provide a significant learning environment that is student-centred.

Uses of Computer Laboratories

The major uses of computer laboratories (Table 8) focus on *Computer Operations* (learning to use computers) and *Computer Awareness* (learning about computers). The pre-eminence of these two sorts of uses suggests that particular types of classes such as Computer Studies or Word Processing generally dominate computer laboratory use. Alternatively, it may be that there is only limited amount of integration of laboratory activity with other areas of the curriculum. Certainly, *Curriculum Specific Activities* is the next highest ranking use, but more research is needed to determine what these activities cover. For instance Computer Studies and Word Processing may have been included in this category by some schools. In addition, this ranking approach does not quantify the time allocated to each use.

Table 8 - Uses of Computer Laboratories

Laboratory Use	Average Ranking
Computer Awareness	2
Curriculum Specific Activities	3
Online Access including Internet	7
"Drop In" Student-Centred Activities	6
Computer Operations Skill Development	1
Administration	8
CD-ROM, Library Access	5
Other	4

Time Usage of Laboratories

The 35 schools collectively own 1232 computers that are used in laboratories as well as computers that are used and located elsewhere. This represents a very substantial investment, so it was illuminating therefore, to discover the extent to which this resource is used. Each school was asked to indicate the number of hours each laboratory is typically used on school days between 8.30 am and 3.30 pm. These time constraints coincide reasonably closely with a conventional "school day" and provide a maximum of 7 hours per day, or 35 hours per week. In the context of time, two main ways of gauging how laboratories were used. First, is the average number of computer hours per week each student in the school could get on the basis of current usage. Typically this will overestimate the time many students actually have in computer laboratories, as groups such as Computer Studies and Word Processing students often have more time. The second means of assessing time is the percentage of the school week for which the total computer laboratory resource is in use.

If the schools who do not have laboratories are excluded, 7 schools provided less than one hour, 11 schools provided one to two hours, another 11 schools provided two to three hours and 4 schools provided over three mean student computer hours per week. Apart from one very small school with an abnormally high figure of 8.75 student computer hours per week, the next highest was 3.33. The mean figure for the sample was 1.93 hours of computer laboratory time per student each week. This provides an overall picture that students are getting reasonable levels of exposure to computers. This should however be tempered with a consideration of two factors. First, several schools had very low figures like 0.08 and 0.32 student computer hours per week, and nearly a quarter of the schools had average figures of less than one. Second, allowance must also be made for the higher than average level of access given to specific groups of students like Computer Studies and Word Processing classes.

For the sample, the proportion of time laboratory resources is actually used ranged from 14% to 100%, with a mean of 69%. As the investment in this type of resource is substantial it would seem reasonable to expect that computer laboratories would be in use for most of each day. Of the 33 schools with computer laboratories, 12 had usage levels in excess of 75%, 12 had usage levels between 51% and 75%, while 8 had usage levels of 50% or less. Although both these sets of figures have their uses they are probably at their most useful when considered together. The 4 schools indicating a 100% level of use had 1.09, 2.63, 1.48 and 2.01 mean student hours of laboratory time per week. By contrast there are 6 schools who are using less than 60% of the available resource and who give less than about an hour of computer time on average per student each week. Yet another group of schools are able to provide

comparatively high levels of student access with a relatively low proportion of the resource being used. There were for example 6 schools using less than 66% of their computer laboratory capacity who were still able to offer an average of over 2 hours of computer time per student per week. This demonstrates a wide range of effective resource usage and raises the question: "Why don't some schools offer more computer time to their students by increasing the use of the resource?".

MOTIVATION REVEALED

When the reasons given for selecting the actual layouts are compared with those given for a preferred layout based solely on teaching and learning requirements, some interesting insights are yielded.

In Table 9 the reasons provided are classified by the researchers into three groups: *Student-Centred, Teacher-Centred, Management-Centred.* This classification is based on the extent to which the reasons focused on the needs of the teacher or those of the students. This analysis provides a very clear pattern illustrating the motivations for this choice despite the predominance of Layouts B, D and E in both the actual and preferred figures (Table 6). The reasons given have more to do with the teacher-centred issues of control and management rather than the more student-centred ones focusing on the creation of learning environments.

Table 9 - Respondents Reasons for Preferred Layout

Assuming the layout of a new laboratory could be determined solely by teaching and learning requirements the major characteristics influencing the selection of the computer laboratory type would be:

Student-Centred		Teacher-Centred		Management-Centred	
B)	Space available to student "Privacy envelope" for each student View to demonstration	(B or E)	Type E only 3 sides if space allows or type B to increase numbers but with island rather than peninsula. Accessibility and visual access to student screens	(E)	Depends on number of students. 34 in one group is sometimes difficult.
E)	To give students independence/space around each unit. Also easier to run cable out etc	(D)	Most screens are visible from any point in the room. Easy access to each student. (NB Swivel chairs crucial).	(F)	Furniture, power, room
E)	As long as the room is physically large enough to accommodate required number of computers around the edges, I believe this to be the best layout. It leaves the centre of the room available for tables to work at, take notes, listen to instructions/directions etc (not near computers). Keeps room uncluttered and pupils removed from each others backs.	(E)	Ability of teacher to see student screens Movement around the room of students	(B)	A less stereotyped appearance
		(D)	Having computers located around the outside of the wall of the classroom - makes it reasonably easy to move around the room and see what students are doing on computers. We also have desks in the centre of the room which are used by students when they are doing theory work.	(E)	Only old Apple computers available, They are linked to 1 printer. It's an old system and needs urgent updating. the set out is dictated by the fact there are only 3!
		(B)	Room layout etc. Teacher movement Students able to easily face a general display area	(B)	Health and Safety features. Sound ergonomic practices ie avoid radiation emissions etc Students kept safe distances from backs and sides of monitors - therefore layouts A C D & F unsatisfactory. Layout B okay if desks are put in centre of room and workstations around the walls.
(E)	We have central tables in our Type E's which allow the students to come off-computer. and have space to work in groups. It also removes the distraction of the keyboard during discussion or theory lessons	(D) or (E)	Teacher's ability to see all students and monitors and students having direct visual assess to teacher		
		(D)	Most easy to view all students monitors from front of room		
		(E)	This layout allows the teacher to have a clear view of what is happening at each terminal.		
(E)	Space to work off computer in	(B)	Movement of teacher between computers		

centre of the room Space around each computer for group / co-operative work Space for teachers to move around groups Minimal traffic paths All computers visible		cords out of the way, good ventilation and blackout possible
	(D)	Ability to see and get as many computers as possible as quickly as possible. Note that computer terminals are set up sideways to blackboard
	(E)	Being able to see all screens
	(E)	See everyone at once
	(E)	Teacher can see all the screens from a single location at a glance
	(D)	From the centre of the room. Teacher can see ALL students and computers at a glance and have easy access to them.
	(D)	Compact, easy to get to. Room for $^1/_2$ class i.e. 12- 18 students.
	(B)	B & D are best ergonomically. Teacher can see all the screens. Whiteboard at front (instead of workstations) visible to all. (NB Swivel chairs essential.)
	(D)	Being able to see most of the computers from one point of the room. Being able to get around to all students easily. Having enough room at the front of the class to teach students "off the computer".
	(E)	Easy movement of teacher between students to quickly identify students needing assistance

Commonly teachers describe factors such as teacher access to the students, the visibility of monitors from a central point and visual access to the blackboard, demonstration or display area. In a similar vein, are the comments about numbers, power, cabling, health and safety. Layout E, though the most common choice by those teachers expressing a more student-centred reason, is also well represented in each of the other two categories. This suggests that significant factors other than a student orientation influenced the choice. Layouts B and D are seen as advantageous because they include most of the characteristics of Layout E but allow more computers to be incorporated into the room. These models have an additional advantage as they more readily allow one wall of the room to be set aside for a whiteboard or screen, yet still keep computers numbers at a reasonably high level. It is interesting that only a small number of respondents highlighted issues to do with student independence, co-operation and group work.

There is a degree of irony in a situation where teachers seem to have selected a classroom layout that provides considerable opportunities for flexibility as well as chances to operate a much more student-centred environment, yet they appear to have done so for other reasons. The notion of constancy amid change does appear therefore to be a sustainable one.

CONCLUSIONS

As was intimated earlier there is little information available in this area. This survey has scratched the surface, raising more questions than it answers. There still remain some aspects of the data capable of further analysis and of course there are the almost inevitable issues relating to the survey design. Examples for follow-up might include: a fuller analysis of the data, surveying a wider sample, visiting a selection of schools for verification and elaboration, considering that teachers of different subjects may have varying perceptions, looking more closely at why schools use their computing resources to the extent they do and examining more closely the apparent development of computer laboratories in Intermediate and possibly Primary Schools.

There are too, some conclusions that can be drawn about the implications this research might have for the Tertiary Education Sector. Schools do not see Polytechnics or Universities as places to seek advice about computing matters, despite the knowledge and skill available and the potential marketing advantages such a liaison might have for such institutions. Not one school in the sample surveyed acknowledged the use of any *external* computer laboratory. This is despite the proximity of substantial computing resources in Polytechnics, Colleges of Education and Universities to many of these schools.

The layouts and the reasons for their selection may well be worth considering as Tertiary Education institutions upgrade and establish new computer laboratories themselves. The amount of exposure students are now getting to computers at Secondary Schools also has implications for the types and levels of programmes that Polytechnics in particular are likely offer. With the increasing sophistication of the computer laboratory set-ups in schools there will be an accompanying expectation for the Tertiary Sector to provide at least a comparable level of resource. Some very important issues are also raised about the type of teaching-learning environments Tertiary Institutions may wish to create in their computer laboratories and how well this might match with the popular rhetoric associated with the notion of *Open Learning*.

While some aspects of this report may seem critical of schools, this has certainly not been the intention. Schools typically struggle to find the money to acquire resources and have a whole raft of other social and educational pressures to contend with. Given the enormity of the difficulties most of them encounter every day it is remarkable how well so many of them are doing. However there are grounds for at least some schools to consider much more closely what they are doing with their computer laboratories. This scrutiny should focus both on the quality of the learning environment and the quantity of use of the resource.

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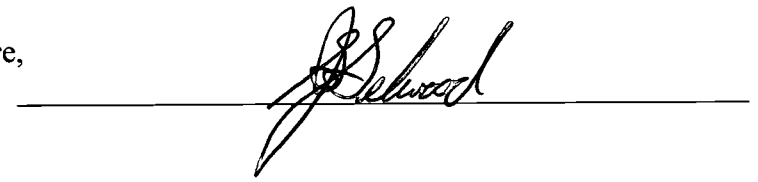
Sign Here, Please 

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