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Development of computing science teaching laboratories

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ABSTRACT

Specialised laboratory facilities are needed to train computing scientists because, by nature, it is both an experimental and an applied science, requiring a large amount of practical work in courses. These laboratories are expensive to build and maintain.

The development of Computing Science teaching laboratories at The University of Wollongong are outlined. Factors effecting laboratory design are examined.

Keywords: Science, Computing, Computer, Informatics, Laboratories, Teaching, Research, Design, Cost, Local area network, System Utilisation.

1. Introduction

Computing Science subjects were first taught at the University of Wollongong in 1976. In 1979 Computing Science separated from the Department of Mathematics to form the second department in the Faculty of Mathematics. The student load has grown rapidly (Table 1) requiring very rapid development and expansion of teaching laboratories.

From the outset the aim was to provide a laboratory environment conducive to learning and experimentation. Students at all levels were to have hands-on interactive computing experience. This required laboratories that could be tailored to the needs of the courses being taught.

Laboratories of this type cost money (table 1) and a new discipline has to compete with older disciplines for a share of the pie [1,2]. This has meant a long fight for money, equipment, staff and space, in a situation where other departments are jealous of one's rising student numbers. In order both to win these battles and to establish the scientific basis of one's discipline every stage had to be carefully justified.

2. Computing Science

Computing Science departments are known by a variety of names [3]: Computer Science, Information Science, Computing Science and Informatics. The name chosen tends to reflect the nature of the department from which it descended and the geographical location of the University. It also reflects the multidisciplinary nature of many of the courses taught by computing science departments; drawing particularly from mathematics and electrical engineering. The discipline has struggled to establish itself as a science and has been defined, by Kristen Nygaard, as follows:-

> Informatics is the science which has as its subject of study the information aspects of processes and phenomena in nature and society:
>
> - their identification and properties.
> - their interaction with other aspects of reality.
> - how they may be understood and described.
> - how they may be designed, implemented and modified.

As taught within universities it is a combination of experimental science and software engineering.

3. Design Considerations

The following factors influenced the final design of the laboratories:

(i) In an experimental science students need to be able to develop and test hypotheses - to explore and experiment.

(ii) A teaching environment that gave the lecturer full control over the facilities was desired. This allows a rigorous approach to teaching fundamental concepts within a flexible course structure. A variety of language processors and software tools is an integral part of such an environment.

(iii) Interactive computing provides an ideal learning environment where the student receives rapid feedback from a user friendly system [4].

(iv) Preparing students for the work force, both now and for a few years to come, requires courses that cover a wide spectrum of computing practice. Also, if possible, the hardware and software needs to be advanced with respect to that of the surrounding user community.

(v) The environment of the laboratories needs to be inviting as the students spend many hours, both in structured laboratory sessions and of their own time, in them.

(vi) Due to rapid obsolescence the equipment has to be upgraded regularly otherwise the department is paying high maintenance costs for low value equipment.

(vii) A new discipline requiring large sums of money is not popular in a contracting financial situation where the proponents of older disciplines hold the purse strings. Thus money has to be spent wisely on effective equipment.

4. Laboratory Design

During 1976 the department used the services of the Computer Centre Univac main-frame. This was found to be inappropriate to the department's needs for the following reasons:

(i) First year programming input was by card decks with a maximum of half an hour turn around. This did not allow many program runs in a three hour laboratory session. Some teletypes were available for more senior students.

(ii) Pascal was not available on the Univac mainframe and the department desired to use it as a teaching language.

(iii) The language processors on the mainframe were not user friendly, particularly when it came to error messages.

(iv) In operating system courses it is often desirable to take the machine down to allow students to experiment. Computer Centres are not particularly keen on this as they have other customers to consider. Besides which it often takes a lot of hard work to get an operating system stable and they didn't like the idea of academics tinkering with it.

(v) As the requirements of a computer centre operation are markedly different from those of an academic computing department the goal of providing a teaching environment where the lecturer has full control over the facilities is not achievable on a central site machine.

The department received some money to purchase a computer in 1976. An Interdata (Perkin-Elmer) 7/32 was bought because it was a thirty-two bit machine, appeared to have good hardware and could be bought (after considerable discount) with the money available. Initially the manufacturers operating system was used. Concurrently a research project rewrote sections of the Unix* operating system and successfully ported [5] it to the Perkin-Elmer equipment. Unix was chosen because it was designed for a programming environment and is extremely user friendly. It made many of the design goals achievable.

Today the department runs two thirty-two bit Perkin-Elmer (a 3220 was bought in 1980) computers supporting forty-four terminals, five printers and a range of computer aided instruction and graphics equipment. The computers are housed in an environmental controlled room (table 2).

4.1. Terminal Laboratories

The terminals and printers are housed in three terminal laboratories. The largest is used for structured laboratory classes. The second is available for use by students doing home work and the third for final year students and staff. Carpeting the laboratories not only improved the aesthetic appeal but considerably reduced both noise and glare. Day light entry into the labs is controlled with venetian blinds, not an ideal solution as it cuts off the view. Each work-station consists of one video display terminal, a moulded chair on castors and a small amount of desk space for print out etc. Finding chairs that are the correct height for typing is not easy.

One decision that has caused considerable controversy was the choice of several 180 cps dot-matrix printers in preference to a single high speed line printer. This choice allows a printer to be placed in each laboratory. As they are a relatively low cost items with a high work load they are cheap to replace when they wear out. The old unit is then used as a set of spares.

4.2. Specialised Laboratories

The department has requirements for several specialised laboratories but space for only two.

(i) Word processing equipment is currently spread through the terminal laboratories. The departmental secretary has her own terminal and types all papers and reports using the word processing facilities. These files are transferred to the appropriate staff members who then correct and finalise their own papers. A daisy wheel printer is used for most output and a Sanders dot-matrix printer is also

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UNIX is a trade mark of Bell Laboratories

Year	Equipment Cost $	Effective Full-Time Student Load (efts)
76	52 000	12
77	15 000	22
78	27 000	33
79	83 000	55
80	161 000	75
81	50 000	89

Table 1. Student load and equipment expenditure over the lifetime of the department.

Laboratory Usage	Floor Space (square metres)
Terminals	71
Terminals	54
Terminals	54
Computer room	36
CAI and Graphics	20
Micro-computers	20
Work shop	11

Table 2. Laboratory Floor Space

User Type	Number of Users	Average terminal usage (hours)	Average number of commands	Average CPU time (minutes)
1st year	90	2.4	129	2.6
2nd year	49	9	559	13.3
3rd year	33	15.4	848	27.8
honours	2	10.6	926	25.1
staff	13	3.5	537	17.8
other	20	3.5	207	8.2

Table 3. Usage of the Perkin-Elmer 3220 for the week 12-18 th October 1981. The thirty two terminals averaged 40.02 hours of usage and 37.5 hours CPU time was used. Lighter than normal first year load (no assignment due that week) is balanced by high third year load.

available for specialised output. This unit is currently being used to handle the output of a photo typesetting package. It is considerably cheaper than a photo typesetter but is slow, has a limited range of fonts and has head reliability problems.

(ii) Computer Aided Instructions and Graphics equipment, housed in a small laboratory, is used for research and graduate courses.

(iii) A micro-computer laboratory is being constructed for use in teaching micro-computer hardware and software, and real-time computing. Several Motorola M6800 micro-computers are connected to working models (for example led displays, robots, slot cars, music cards). Program development is done on the main computer system and then the object code is down line loaded to the micro-computers. This allows students to use all the facilities of Unix, which they know, and concentrate on learning about the micro-computers. The working models are used to provide realistic experiments to teach peripheral interfacing and basic process control principles.

(iv) Due to lack of space the department's research equipment is spread throughout all the other laboratories, the workshop and the staff's offices.

5. System Usage

The number of students a department has is measured in terms of effective full-time student load (efts) where one efts is one student doing a full years work. In 1981 the department offered courses equivalent to 0.25 efts in first and second year, and 0.5 efts in third year.

Regular assignments, of one to two weeks duration, designed to teach specific principles or algorithms, are set in most courses. Assignment size increases in later years where students are expected to be able to combine algorithms and data structures to form complex programs. Third year and graduate students undertake software project courses where they are required to implement a reasonable size piece of software, typical of the jobs they will get on entering the workforce. These projects provide them with an opportunity to acquire essential software engineering skills in the areas of project management, design methodology and idea communication.

Computer usage, for the 3220 only, for a week toward the end of second session is shown in table 3. Progressive increase in assignment complexity is reflected in the load the students place on the system. The average terminal usage was 40.02 hours per terminal with students using 23.5 hours terminal time per efts. Distribution of terminal usage, on the 3220, for that week (figure 1.) shows the continuous utilisation of the laboratories.

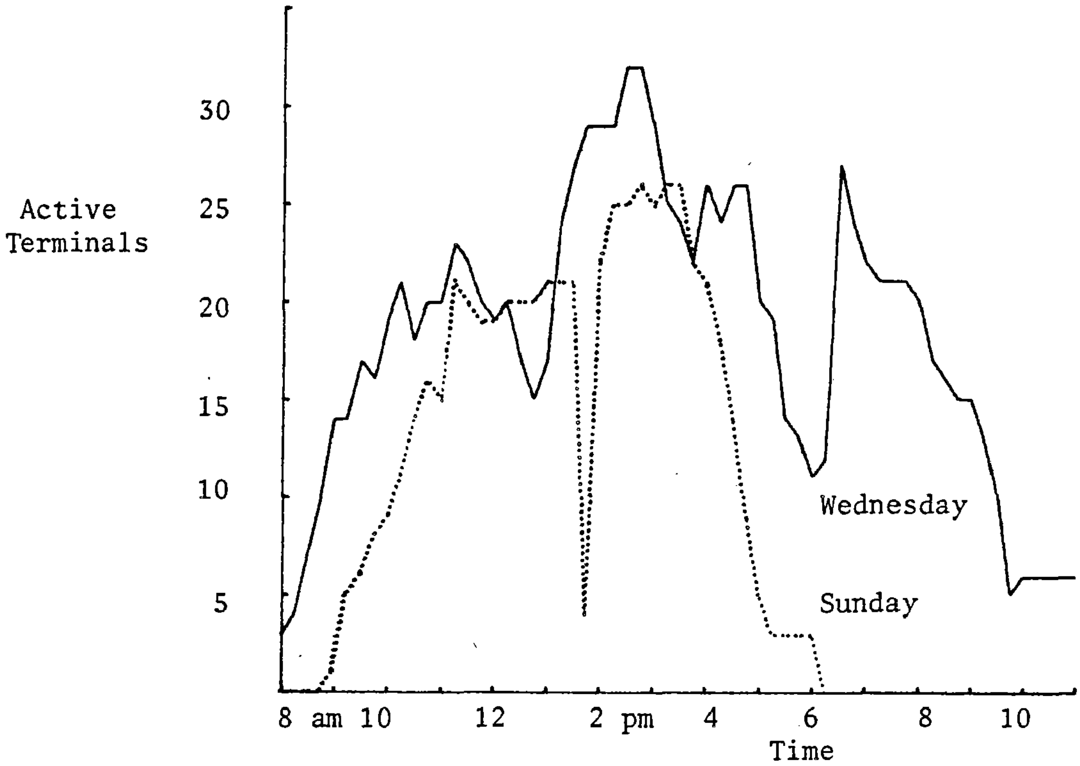

Figure 1. Terminal usage, on the 3220, for two days during the week 12 - 18th of October 1981.

6. Cost

The equipment's purchase cost (table 1), after discount, was $388,000 representing an investment of $4,360 per efts in 1981.

The department had a housekeeping budget of $36,000 in 1981. This included $17,000 for the Perkin-Elmer maintenance contract on the two mini-computers and $12,000 for maintenance work (including spares, freight, software upgrades, magnetic media, printer ribbons etc.) carried out by departmental staff. Laboratory running costs per effective student load is $325 or 7.4% of the investment value. This does not take into account the salaries of the four departmental support staff or the cost of services. All equipment except the two Perkin-Elmer mini-computers are maintained by departmental staff.

7. The Future

Student load is expected to continue to rise due to increased enrolments and the department offering more courses. The department has asked for funds to replace the 7/32 with a second Perkin-Elmer 3220. This will increase the capacity without increasing the maintenance costs. The desire is to have two identical systems in order to make internal maintenance of the mini-computers a viable alternative to manufacturer supplied maintenance. Physical space for additional terminals and laboratories is also a high priority.

Each terminal is wired back to an individual port on the mini-computer costing about $700 per terminal ($350 per port and $350 for cable and installation). A Cambridge ring local area network, which runs at 10 Mega-bit and uses only four wires, will be installed in 1982. Ring stations capable of multiplexing up to sixteen terminals will be available shortly, considerably simplifying the installation of new terminal laboratories and reducing installation costs.

Once the network is operational it should allow a trend away from dumb terminals to personal work-stations connected to the ring considerably reducing the load on the main computers. The day may come when the computing science student buys a personal computer on enrolment just as today's engineering student buys a programmable calculator.

8. Conclusion

Specialised laboratory facilities are needed to train the computing scientist of the future. By nature it is both an experimental and an applied science requiring large quantities of practical work in courses. The equipment needed costs money both to buy and maintain. Distributed processing using local area networks and personal work-stations will take over from the current centralised systems but we are unlikely to see significant cost reductions.

The laboratories discussed are in continual use by students during session. They have met most of the design goals and have certainly provided a very pleasant working environment.

9. Bibliography

1. Bennett J.M., Computer Science Education in the 80's - Some Australian Logistics, Australian Computer Science Communications, Vol 2 No 3, June 1980

2. Lions J., Funding for Computer Science Teaching: Another Experience, Australian Computer Science Communications, Vol 2 No 4, September 1980

3. Sale A.H.J., Bennett J.M., Rohl J.S., What is Computer Science, Australian Computer Science Communications, Vol 1 No 2, June 1979

4. Miller and Thomas, Behavioural Issues in the use of Interactive Systems, Int.J. Man-Machine Studies, 1977, 9, pp 509-536

5. Miller R., UNIX - a portable operating system?, Operating Systems Review, Vol 12 No 3, July 1978, pp 32-37