Proceedings, 18th CAE Computer Conference, Adelaide, 1987

IMPLEMENTING COMPUTER AIDED ENGINEERING IN ENGINEERING COURSES

Abstract

Computer Aided Engineering (CAE), the application of computers in the broadest sense including Computer Aided Design (CAD) and Computer Aided Manufacture (CAM), is expected to affect virtually every aspect of engineering. With the introduction of a new engineering degree in 1984, the Darling Downs Institute of Advanced Education (DDIAE) recognised that the time was opportune and indeed that it was vital that CAE and all its facets be embraced. Computer facilities must include appropriate hardware, integrated software and staff training as essential components to enable institutions to graduate students able to use these new techniques effectively and promote their use in the Australian context.

This paper examines these aspects of CAE and relates details of the computer system eventually purchased by the DDIAE, staff development activities, current and proposed, and the courses and units in which these facilities are currently used.

Mark A. Toleman and David Hall
School of Engineering
Darling Downs Institute of Advanced Education

1. INTRODUCTION

In 1983, the number of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) installations was predicted to be increasing by 40% per year. By 1985 it was predicted that 90% of all mechanical drafting would be done by Computer Aided Drafting (CAD) and that at least 30% of all manufacturers would use some form of CAM [1]. According to [2] CAD/CAM has more potential to radically increase production than any development since electricity. [3] estimated that some applications of computer and advanced tool technology could increase machine utilization by 600%, with resulting reductions in indirect capital and labour costs and improvement in productivity of tenfold. It has also been noted [1] that educational institutions are not providing graduates with the technicial expertise necessary for industrial use of CAD systems.

Sadly, the above world trends, in terms of uptake of these new technologies, have not been repeated in Australia. In 1983, about 80 CAD systems were sold in Australia and there were about 1500 numerically controlled machine tools in Australia distributed among about 400 companies [4]. This compared with 10000 such tools in the United Kingdom and 50000 in Japan, although Australia had one-quarter and one-seventh the population of these countries respectively.

In many cases, Australian companies have waited and are still waiting to embrace CAD/CAM. Meanwhile their competitors in the Far East and South East Asia are going full speed ahead with CAD/CAM. Manufacturing industry in Australia has many handicaps compared with its nearer overseas competitors. The advent of CAD/CAM offered a great opportunity to cancel out some of the disadvantages. Federal Minister for Science and Technology, Barry Jones, has been quoted as saying

"In many respects Australia still has some of the characteristics of an industrial museum - our technology and our approaches to it are characteristic of the 1950s."

[1] has said that in relation to CAD/CAM, Australia's needs are two-fold

- a change of attitude is required
- a substantial investment in higher technologies and human resources to promote and service them is required.

Both can be achieved by sound educational policies within the educational institutions in Australia.

2. CAE AT DDIAE - PRIOR TO 1985

The Darling Downs Institute of Advanced Education is a comprehensive, mulit-level regional college of advanced education. It offers undergraduate courses in Applied Science, Arts, Business Studies, Education and Engineering together with postgraduate courses up to Master degree level in most of these discipline areas. Currently, 7000 students are enrolled from all areas of the state of Queensland and throughout Australia. Of particular importance is the DDIAE's external studies programme which offers a wide range of courses in Australia and international centres including Hong Kong, Kuala Lumpur and Bangkok.

In 1983, a major proposal [5], developed within the School of Engineering of the DDIAE, was presented to the Head of the Computer Services Unit (CSU) of the DDIAE. This proposal gave a detailed account of the following:

- a statement of the computing needs of the School of Engineering
  - central computer requirements
  - specific software requirements
  - stand-alone computing facilities
  - priority
- current facilities at DDIAE
- status of other Engineering Schools in Queensland Colleges of Advanced Education
  - Queensland Institute of Technology
  - Capricornia Institute of Advanced Education
- details of the computing needs of the School of Engineering
  - CAD/CAM
  - Terminal requirements
  - Disc storage requirements
  - Microprocessor support facilities
  - Stand-alone Instrumentation computers
  - Software

Supporting this proposal were a number of other documents [1], [6], [7], [8] and [9], all written about the same time. In all cases the authors emphasised the need for an integrated CAD/CAM system to be implemented at DDIAE so that under-graduates would be exposed continually to this technology. This CAD/CAM system was just part of a pressing need to increase central computing facilities at DDIAE, generally and in the School of Engineering, specifically. In summary, the documents specified that the central computing facility must:

- provide a system with sufficient computational ability and storage facilities to run meaningful Engineering software packages and systems
- upgrade to a system which is widely used throughout industry, business and other tertiary institutions - this ensures an extensive range of available software giving the DDIAE flexibility of choice and ease of software transportability
- ensure that adequate system accessibility and response are provided to all users - the physical location of the computers is not an issue provided they are well serviced, maintained and a network is

provided for inter-computer communication

- provide adequate means of *auto-selection* of the target computer from any terminal - given that more than one computer is available it would be a severe restriction if lines were dedicated to a particular computer

- improve the programmer assistance provided by the CSU - increased facilities increase demand on already over-loaded CSU staff

At the time that [5] was written, the total computing facilities available for teaching support in the School of Engineering included:

- HP3000 mini-computer
- a 24 hour laboratory with 8 terminals
- a restricted access teaching laboratory with 8 terminals
- a general computing area with 4 Decwriters
- two terminals within the School of Engineering
- three desk-top computers for signal processing applications.

Academic computing computing facilities improved substantially over the next two years with purchases including:

- HP3000 Series 68
- Universe supermicro-computer
- MICOM port-selector
- various micro-computers
- many terminals including 8 graphics terminals

None of these aquisitions, however, provided the School of Engineering with solutions to many of its requirements.

3. A PROPOSED NEW SYSTEM

Finally in late 1985, the DDIAE called tenders [10] for new academic computing facilities which needed to include:

- hardware and software, adequate to meet the CAD requirements of the School of Engineering
- hardware and software, adequate to meet the general teaching requirements of the DDIAE

It was envisiaged that the initial configuration would consist of at least two processors - one of which would provide the CAD facility for the School of Engineering and the second of which would provide the facility for general teaching use. Upgrade paths had to be clearly defined for increasing terminal support, disk storage and networking.

The central processing unit, together with its primary memory and appropriate file storage capacity had to be capable of supporting at least four CAD workstations in the case of the CAD system and at least 32 serial terminal ports in the case of the general purpose system. An internal architecture of at least 32 bit with virtual memory capabilities was a minimum requirement. Facilities for backup had to include magnetic tape (9 track 1600/6250 bpi) and a line printer was a must. The facility had to enable high speed communication between the systems and was expected to take the form of an *Ethernet* style link.

The CAD system was expected to be able to form part of a proposed Computer Graphics Centre in the School of Engineering. It was envisiaged that by the end of 1987 the centre would consist of the following:

. a mix of PCs (preferably 16 bit industry standard), terminals and digitizers for a total of 18 work places for 2D drafting and general PC use - ideally the solids modelling software would be addressable by these terminals and PCs.

. four (4) CAD workstations, at least one with high quality colour graphics

. one A1 drumplotter

. one A3 plotter

. one hard copy/screen dump device

All equipment had to be mutually networked, and mutually networked to the central computing facility.

Software requirements were extensive and were considered to be an important and integral part of the tender. The operating system had to include the following:

. a comprehensive and easy to use job control language
. automatic and operator initiated job scheduling
. an output spooling system
. accounting facilities
. the ability for users to assign peripheral devices at run-time
. system-wide backup facilities

A number of compilers and utility packages were regarded as mandatory including:

. FORTRAN 77
. COBOL 80
. a systems programming language
. ISO Standard Pascal
. on-line post-mortem debuggers
. a comprehensive, modern, efficiently implemented relational Data Base Management System

Applications packages, for example cross assemblers, were not mandatory, but information on their potential availability was. This requirement excluded CAD software and requirements here included:

- a solids modelling or 3D representation software package capable of being developed to an integrated computer aided engineering system comparable with industrial systems

- a capacity to carry out normal 2D computer aided drafting with the ability to produce sections and working drawings from solid models

- a capacity to develop a common database accessible to other programs which would be acquired, as the installation was developed, in order to permit:

  - numerical control manufacture
  - finite element analysis, including pre- and post-processing
  - structural analysis - excluding finite element methods
  - quantity survey packages for billing, part lists, etc
  - mapping
  - simulation
  - printed circuit design
  - piping and plant layout
  - dynamic analysis of machines
  - digital terrain modelling
  - design synthesis and optimisation

Training was required for systems programmers, operations staff, and some users and applications programmers. It was expected that training would be provided at further cost and the details would be stated.

The DDIAE's computing systems are required to support a very wide range of programming languages and applications packages to meet the diverse demands of teaching and research in various disciplines. Both the support and documentation of software imposes severe costs on the DDIAE. For each major package, user documentation was needed at various levels, for example, student teaching requires large quantities of a sub-set of full documentation at a low price. To meet these demands the DDIAE required written permission to edit and copy any supplied documentation to produce manuals suited to particular needs.

4. THE ACTUAL PURCHASE

Some 30 tender responses were evaluated in late 1985. Some of these responses addressed only parts of the original tender, while others offered full integrated solutions. After much deliberation, a contract was eventually worked out with the Lionel Singer Group and CEANET who supplied the following to the DDIAE:

- Pyramid 98x - general teaching computer
  - 415Mb disk
  - C ITHO - 600 lpm line printer
  - 1600 bpi tape backup unit
  - OSx 3.0 (UNIX 4.2BSD and UNIX System V combination)
  - UNIX c, f77, pascal, lisp compilers
  - Ace COBOL compiler

- . UNIFY Relational Data Base Management System

. Sun 3/160C - colour graphics workstation to serve as a file server
- . 380Mb disk
- . 5 x Sun 3/75M - monochrome graphics workstations on an ethernet link to the colour machine
- . 10 x Visual 550 - monochrome graphics terminals (2 connected to each Sun 3/75M)
- . HP7580B A1 plotter
- . Datasouth 180+ - graphics dump facility
- . UNIX c, f77, pascal compilers
- . PAFEC DOGS - 2D drafting software
- . PAFEC DOGS - 3D drafting software
- . PAFEC BOXER - solids modelling system software

Currently the DDIAE is trialling a surface modelling package available from CEANET, called SMIGS.

The training requested from the various vendors, particularly that for the CAD software was not adequate. This is no reflection on the quality of training offered, which was of a high standard. Rather, it is now obvious that the tender developed by the DDIAE did not allow sufficient funding to enable an adequate amount of training to be offered by the vendors.

Written permission concerning the copying of manuals and parts therof was obtained successfully.

5. STAFF TRAINING AND DEVELOPMENT

The installation of the system has meant that School of Engineering staff have been very busy becoming familiar with the software packages, particularly DOGS and BOXER. The writing of student and staff manuals has had top priority with respect to this software. The use of this software is now well entrenched in the engineering Associate Diploma and Degree programs and all students in engineering have had at least some exposure to CAD. The CAD software is used extensively in student projects and course work. Some research and development programs are also making use of this software.

Recently one member of staff spent 12 months in the USA and England working in academic institutions and visiting industry on the use of CAD in mechanical and agricultural engineering. The report concerning this development work [11] highlights the many problems of CAE and details various recomendations for the development of a CAE system applicable to both academic institutions and industrial organisations. Previous to this, another member of staff spent 6 months in Adelaide with Simpson using their CAD system [12]. Other staff have been involved in Professional Experience Programs over the years and have investigated CAD systems also.

6. CONCLUSION

Having a good CAD facility is not enough. The School of Engineering is facing the same challenges as industry. Staff have for many years been writing and supervising CAE programs and projects. Many of these were undocumented, some duplicated, few available to industry and few compatible. In general they constituted a hodge podge of uncoordinated individualism with no legacy to the DDIAE, its students or the community. There is no reason to believe that attitudes or habits will change with the era of the engineering computing facility and solids modelling software unless positive policies are developed. The framework for the development of CAE within the School of Engineering can be the same as the framework of development needed in Australian industry. In fact it is desireable.

7. REFERENCES

1 Hall, D., The implementation of Computer Aided Engineering into the Mechanical Engineering Programme, DDIAE Discussion Paper, 1983.

2 Krause, J.K., in Editorial, *Machine Design*, June 1980.

3 Kuhrt, W.A., in Editorial, *Machine Design*, June 1980.

4 Ferme, W., Manufacturing Control Systems, *The Australian*, June 8, 1982.

5 Grehan, P.J., The Computing needs of the School of Engineering, DDIAE Discussion Paper, 1983.

6 Manning, G.E., A Plea for Improved Computing Facilities in 1983 and Beyond, DDIAE Discussion Paper, 1983.

7 Smyth, J., Anticipated Civil Programme's Use of the HP3000, DDIAE Discussion Paper, 1983.

8 Ball, J., Grehan, P.J. and Hancock, N.H., The Electricial Programme's Mainframe Computing Requirements for 1983 Et.Seq., DDIAE Discussion Paper, 1983.

9 Dowling, D., Future Computing Needs of the Surveying Programme, DDIAE Discussion Paper, 1983.

10 Anon, Tender Specification for the Supply of Computing Equipment, BS/508, 1985.

11 Hall, D., Report on Professional Experience Programme in the United States of America and England, 1986.

12 Eastwell, L.J., Report on Professional Experience Programme in Simpsons at Adelaide, 1985.