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Computer-aided drafting/design in technical drawing in W.A. secondary schools

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THE WESTERN AUSTRALIAN COLLEGE OF

ADVANCED EDUCATION

COMPUTER-AIDED DRAFTING/DESIGN IN TECHNICAL DRAWING IN W.A. SECONDARY SCHOOLS

A DISSERTATION SUBMITTED TO

THE SCHOOL OF EDUCATION

IN CANDIDACY FOR THE DEGREE OF

BACHELOR OF EDUCATION WITH HONOURS

BY

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ABSTRACT

This study was conducted with the intention of identifying what effects may have occurred within upper school Technical Drawing in W.A. high schools following the recent introduction of Computer-Aided Drafting/Design (CAD).

With CAD being in its infancy in W.A. high schools it was decided that this study should attempt to answer four specific questions:-

i) Were there any problems experienced by Technical Drawing teachers following the introduction of CAD?

ii) Are there any educational benefits to either students or teachers to be derived from the introduction of CAD?

iii) What methods of teaching and evaluating CAD generated drawings were being used by teachers in this subject area?

iv) Has there been any general effect on student interest in Technical Drawing since the introduction of CAD?

Despite the recommendations by the Secondary Education Authority (SEA) that CAD is appropriate to upper school Technical Drawing there are no specific guidelines or curriculum materials commonly available to assist the efficient and effective implementation of this technology.

Teachers that have initiated the introduction of CAD into upper school Technical Drawing have done so with the support of the Manual Arts Teachers Association (M.A.T.A.) in conjunction with limited in-service training opportunities offered through the Western Australian College of Advanced Education (W.A.C.A.E.) at Nedlands.

Available literature on an industrial and general basis is relatively widespread, but with respect to the use of CAD within the classroom, research particularly dealing with Australia, is extremely limited.

This study was designed to obtain basic research information of an exploratory nature with the intention of identifying some of the interests, benefits and

problems affecting students and teachers involved in CAD in upper school Technical Drawing.

Eleven schools within the Perth metropolitan area were identified as conducting CAD within Year 11 and Year 12 Technical Drawing classes. From these a sample of four schools was subsequently randomly selected for the purpose of this study.

All students and their respective Technical Drawing teachers within the four sample schools were accepted as study subjects and were surveyed using appropriately constructed questionnaires. All questionnaires were duly completed within a twenty day period during the third term of the 1989 educational year (W.A.).

On receipt of all questionnaires the data were subsequently manually tabulated using a tally sheet with frequencies being recorded both as raw scores and as percentages. To ensure accuracy of the tallying procedure the data were also entered into the computer program 'LERTAP' direct from the completed questionnaires. This statistical program enabled the data to be checked using the data validity function, plus the tabber function permitted cross matching of data to determine the presence of significance.

Both the student and teacher questionnaires contained specific items seeking open responses which were duly categorised and tallied. Similarly each student questionnaire included a gender identification item in order that differences/similarities between the sexes may be examined.

The main findings of this study support the general assumption that there has been an 'ad hoc' approach to the introduction of CAD into upper school Technical Drawing courses in W.A. The problems identified by this study which the teachers had experienced related mainly to the limited availability of suitable computers, the lack of sufficient 'hands on' time for students, and the concern for necessary security of equipment.

The study suggests that the major benefits derived by students from using CAD is that they are more able to work at their own pace, plus two of the four study teachers felt they were better able to meet individual student needs.

Similarities with respect to the methods of teaching CAD were found within the four study schools,

whilst the evaluation methods used consisted of a wide range of techniques which reflected traditional drafting evaluation which, it is suggested, are inappropriate when using this form of technology.

It was also found by significant numbers of students that Technical Drawing was regarded as being more challenging and more enjoyable since the introduction of CAD.

DECLARATION

I certify that this thesis does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma in any institution of higher education; and that to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where due reference is made in the text.

ACKNOWLEDGEMENT

I would like to sincerely thank my wife, Glenys, for her constant support and encouragement throughout my studies, without whom the task would have been less enjoyable.

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CHAPTER ONE

INTRODUCTION

BACKGROUND

Schools within Western Australia are increasingly employing computers for teaching. Computer technology has become more readily available providing students with the opportunity to develop computer literacy across a range of subjects.

The Beazley Report 1984, (Recommendation 7) specifically requires all schools and school systems to develop and implement policies of computer usage in schools. The report states that all teachers (where practical) are responsible for all students receiving education within this technological facet of learning.

Schools, students, teachers and parents need to be made aware that the speed of change within the learning environment can readily be addressedthrough the time/labour saving use of computers.

With direct reference to Technical Drawing (Drafting/Design) it is possible that in five years'

time many students will be pushing a digitised stylus or mouse instead of the traditional pencils and T-squares to produce their work.

In order to meet the changing needs of industry, students require experience related to equipment and processes that are commonly enjoyed in the workplace.

Manual Arts teachers, through direction given from the Ministry of Education, and with support from the Manual Arts Teachers Association (M.A.T.A.), have introduced computer use in the form of Computer-Aided Drafting/Design (CAD) into the school Technical Drawing curriculum.

Specific CAD implementation is set out in the Secondary Education Authority (SEA) Syllabus documents for years 11 and 12 Technical Drawing, with the justification that CAD is an activity that would widen students' experience in drafting likely to be found in the post-secondary environment. There is, however, no clear indication as to how CAD should be employed with respect to the time available to students for 'hands-on'

experience. Similarly, there are no clear indications with respect to specific areas of Technical Drawing best suited to CAD technology.

With regard to the introduction and implementation of CAD into schools, there are no specific requirements for this to be initiated. It is reasonable to suggest that this factor will vary considerably from school to school, and community to community.

A highly pertinent aspect which contributes to the existing 'ad hoc' introduction of CAD teaching within W.A. schools is the lack of suitably qualified teachers. Teacher training institutions within W.A. have only offered CAD units to students for approximately four years. Many of the early trained CAD teachers would have received their initial postings in country areas where schools probably do not have the required equipment to teach CAD. These factors are some of the reasons why a concerted and coordinated approach to the implementation of CAD has not yet been achieved.

In view of the present lack of expertise in CAD teaching within W.A. secondary schools, it would be of considerable benefit to both teachers and students alike if a set of guidelines or a model was made available to assist the efficient implementation of such programmes.

Teachers who have CAD programmes well under way, have been 'successful' through trial and error methods (i.e. solving specific problems as and when they arise) and building up a 'network' of likeminded teachers with similar goals.

The benefits and drawbacks of setting up a computer laboratory, methods of teaching, attitudes of students and teachers, and the effects on aspects of teaching CAD in the upper school have not been formally evaluated. Perhaps not even recorded.

The fragmented approach, adopted by West Australian Technical Drawing teachers, of the introduction of CAD, is, educationally undesirable. Common guidelines to assist a more uniform approach by teachers involved in CAD introduction at present do not exist.

Now seems an appropriate time to investigate some of the problems associated with the implementation of CAD within Technical Drawing.

CAD TRIALLING IN W.A. SCHOOLS

Computer-Aided Drafting/Design (CAD) was introduced into W.A. schools' during 1987, on the basis of trialling specific hardware and software with respect to its appropriateness to the Manual Arts Curriculum.

Four schools were chosen to trial a range of equipment, i.e.:

Rossmoyne S.H.S.	Olivetti
Warwick S.H.S.	Microbee
South Fremantle	S.H.S. B.B.C.
Swan View S.H.S.	I.B.M. Compatible

The four schools also trialled the following software:

Beeartistic

Prodesign II

Autocad

Since early 1987 a number of other schools have independently assessed alternative equipment

and its application on an individual basis. The result of this action appears to be an uncoordinated 'ad hoc' approach to the implementation of Recommendation 7 of the Beazley Report, 1984.

PROBLEM STATEMENT

Following the recent introduction of the relatively new technology, Computer-Aided Drafting/Design (CAD) into Technical Drawing courses within upper secondary schools of W.A., it has been suggested, though not substantiated, that teachers and students involved in such courses are experiencing both benefits and problems specific to this area of teaching.

If true, the potential exists for future schools introducing CAD into upper school Technical Drawing courses to replicate a similar situation.

Thus, the purpose of this study is to identify any existing benefits and/or problems in order that schools introducing CAD in the future might be aware of relevant factors that may need to be addressed.

STATEMENT OF HYPOTHESIS

Hypothesis 1: There are no problems experienced by Technical Drawing teachers following the introduction of CAD into upper school Technical Drawing courses in the four study schools.

Hypothesis 2: There are no perceived educational benefits of CAD to students and teachers in the fourstudy schools.

Hypothesis 3: The methods of teaching and evaluation used by Technical Drawing teachers with respect to CAD is the same in all the study schools.

Hypothesis 4: The introduction of CAD into the four study schools has no effect on student interest in Technical Drawing.

The introduction of this document has illustrated the recent development of CAD within W.A. high schools, and identified areas of concern which if investigated may result in a better understanding of the needs of students, teachers and schools, and a more effective implementation of this new technology.

The following chapter intends to review recent literature relating to CAD and CAM published in Australia and internationally in order that direction for this study may be determined.

CHAPTER TWO

LITERATURE REVIEW

The early 1960's heralded significant changes within the field of drafting and design when major industrial companies, such as Boeing and General Motors in the U.S.A. accepted the use of Computer-Aided Drafting and Design (CAD) as the latest technological tool in manufacturing.

CAD has forced its way into the manufacturing industry significantly changing the internationally accepted methods used to produce drawings (Bertoline, 1988), which has had an effect on the drafting and design industry far greater than all the previous changes combined (Fuller, 1988). This change is self-evident by the fact that prior to the introduction of CAD the drafting and design industry worldwide was still employing the same tools and instruments that were used by Euclid (the father of geometry) and Pythagoras.

The improvement of recent CAD technology, coupled with the steady reduction in necessary

capital investment for essential hardware and software, have been two of the main reasons for CAD increasingly becoming more common place throughout industry.

Despite the general economic downturn in Australia, if current trends persist CAD will reach boom proportions during the 1990's (Building Today, 1990).

The major benefit of any CAD system is increased efficiency which translates directly to greater productivity and in turn higher profitability (Cheng, 1985). CAD systems can produce drawings of higher consistency, greater accuracy, neatness, legibility and much faster, (Murphy, 1987). The production of CAD generated drawings can be from 2-10 times faster than manual drafting (Bertoline, 1988).

The increased speed in producing CAD generated drawings is achieved from a range of operating features incorporated within the system. Automatic dimensioning, quick easy lettering selected from an extensive range of styles, the provision of overlay functions, the elimination of repetitive work,

storage and recall of information (full and part drawings), and most importantly, the facility to make 'instant' corrections all contribute to the significant increase in production speed and operator efficiency (Goetsch, 1981; Hall, 1982; Giesecke, 1984).

Industry's acceptance of CAD technology has had a direct effect on related occupations, (e.g. Architecture, Electrical and Mechanical Engineering) bringing about changes in the numbers of workers required and the very nature of the occupations involved. Computer-Aided Manufacture (CAM), an evolutionary extension of CAD, is now extensively being used to help plan, operate and manage complex production systems (the Illinois State University, 1987).

CAM is helping to automate factories in order that their operations may become more productive through the freeing of people from boring repetitive tasks and allowing them more time to be creative and solve problems. It has been estimated (Becker, 1987) that by the turn of the century there will be in excess of 1.2 million jobs created for CAD/CAM within the U.S.A. If this projection proves correct, then

given the same circumstances, the growth in demand for CAD/CAM related occupations (proportionate to population) is likely to occur in Australia. Similarly, with an increase of automation in manufacturing there is a high probability of a corresponding increase for more CAD operators (Bertoline, 1988).

Western Australia is recognised as a leader in the field of CAD (Lingane, 1989), especially within the areas of mining and geology. The West Australian State Energy Commission (SECWA) is the largest user of CAD in Australia (Lingane, 1989). In the light of this evidence there is a strong suggestion that CAD technology, which is gathering ever-increasing acceptance by the drafting and design industry, has a significant potential benefit to the needs of industrialised society.

The significance to society in general has been put into perspective by Fuller (1988, p.1) who states

> A computer-aided drafting system is to drafting what a word-processor is to words and writing.

Industry's requirements for employees trained in the use of CAD systems is quite clear. If the education system can not provide industry with computer literate people then industry will be set back up to two years (Hall, 1982). The establishment of computer-aided drafting and design within secondary schools will not only confirm in the minds of students the relevance of current technology, but will ensure that graduates take with them into industry their CAD background. Both industry and students derive benefit (Becker, 1985; Williams, 1987). Therefore, responsibility falls to the schools to aid industry in meeting its needs (Becker, 1987).

The Beazley Report (1984, p.60) Recommendation 7, clearly identifies the responsibility of schools and school systems to provide computer education to all students. As a policy recommendation it provides a general direction for teachers, but it has been left to the Secondary Education Authority (SEA) to produce upper school curriculum documentation in order that specific subject programming may be facilitated.

One of the aims of upper secondary school Technical Drawing is that students should have experience of a range of drafting activities likely to be found in the post-secondary environment (SEA Technical Drawing Syllabus [Year 11] - D859 p.324 and [Year 12] - E859 p.294). A specific example of this stated requirement is computer-aided drafting and design (CAD).

The above SEA documents clearly illustrate that the education administration of W.A. secondary schools recognise industry's needs in respect of prospective employees being familiar with CAD technology (Hall, 1982). The question that now needs to be addressed is "How should computer-aided drafting and design be taught in schools?"

Virtually every type of drafting is being done with the assistance of CAD (Goetsch, 1981), but it should be stressed that the computer does not draw, the operator does. Therefore, this suggests that the operator needs to be aware of the concepts and meanings of drafting techniques (Pedras and Hoggard, 1985) and have the ability to visualise objects within this context in order to obtain a

basic mastery of Technical Drawing. Consequently, traditional drafting classes will not be replaced by CAD, but will be a necessary pre-requisite (Fesolowich, 1987; Sorensen, 1988). The research suggests that CAD should be related to and incorporated within the existing curriculum, rather than become a separate course of study (Sweet, 1986; Drushler, 1988), and simultaneously students need to be reminded that drafting is a dynamic and changing fi[illegible] (Noderer, 1985) in which CAD has become a valuable aid.

Students need to be given a general understanding of the basic concepts and principles of CAD followed by 'hands-on' experience, because they tend to forget the instruction over a period of time if not practised (Becker, 1987). CAD should not be seen as a video game to be learned by trial and error. Instruction needs to be structured, whilst providing a measure of freedom for student self-expression (Chowenhill, 1987). Although CAD does de-emphasise the use of traditional drafting instruments (Pedras and Hoggard, 1985) Technical Drawing remains a skill oriented subject, rather than pretty picture development (Sweet, 1986).

Methods of CAD instruction would vary in relationship to the ratio of students to computers. Becker (1987 p.24) suggests that there are four viable (if not ideal) methods of CAD instruction with limited facilities, i.e:

Class lecture with supplement hand-out

Step by step self tutorial

Rotation of students

Student aides

Some of the more traditional aspects of Technical Drawing (e.g. lettering, construction techniques, dimensioning) are performed automatically when using a CAD system to produce drawings. This being the case, it permits a greater emphasis to be placed on creativity and problem solving (Sweet, 1986; Fesolowich, 1987; Bertoline, 1988; Sorensen, 1988).

The increasing acceptance of computer-aided drafting represents a serious challenge to drafting instructors and Technical Drawing teachers with respect to the need to update their educational skills (Goetsch, 1981). It may be suggested that traditional

methods of assessment and evaluation may no longer be relevant and demand re-definition.

CAD produces drawings plotted to programmed uniformity, eliminating the need for line quality assessment. Sweet (1986) makes the observation that it is difficult to assess student CAD work, but the literature offers no suggestion as to how this problem for teachers might be overcome. Wilkinson (1989) stated that he doesn't mark any of the students work, but only records completion of set exercises.

Following the introduction of CAD into Technical Drawing classes some teachers have observed a significant increase in student motivation and enthusiasm (Kimney, 1985; Sweet, 1986; Becker, 1987; Belliston and Marsing, 1987; Chowenhill, 1987). Noderer (1985) suggests that there is a flow on of enthusiasm to the instructor, which, if correct should contribute to a more positive and beneficial learning environment within Technical Drawing in general.

SUMMARY

The literature reviewed in this document has illustrated clearly the need of industry for CAD trained employees; plus the responsibility of the education

system (within Western Australia) to provide the opportunity for students to gain the appropriate exposure to the latest technology currently used in drafting and design.

Attention has been drawn to the widely held view (Cheng, 1985; Pedras and Hoggard, 1985; Fesolowich, 1987; Sorensen, 1988) that fundamental and traditional concepts, conventions and standards of drafting need to be taught to and understood by students as a pre-requisite to CAD experience.

Opposition to this view is scarce, but Gow (1987) states the basics of drafting can be learned if a CAD system is used from the start.

The literature suggests that because of the nature of CAD, and the limited resources available within schools generally, there would tend to be necessary adaptions required to teaching strategies on the part of Technical Drawing teachers (Zuleger, 1985; Goetsch, 1987).

The question of assessment of student CAD produced drawings is only superficially addressed by the sighted literature. It was found that difficulties

exist in using appropriate methods and assessment procedures. No practical suggestions in respect of assessment were found in the literature and, therefore, this study intends to examine current methodologies used by Technical Drawing teachers in Western Australia.

In this chapter, literature of a wide and diverse nature was sighted and reviewed. A range of issues and concerns have been identified and discussed, and they form the basis of the topics of investigation of this study. The following chapter deals with the necessary methods and procedures to be used in conducting this study.

CHAPTER THREE

METHOD AND PROCEDURES

STUDY POPULATION

For the purpose of this study, the samples of students and corresponding teachers were selected from the State senior high schools within the Perth Metropolitan area, which are currently (1989) conducting computer-aided drafting/design (CAD) within their Year 11 and Year 12 Technical Drawing courses.

Eleven schools fulfilled the given criteria, from which a random sample of four (4) was selected. It was considered that four schools would produce a proportionately large enough sample to establish population external validity.

Students

Data were collected (in the form of questionnaire responses) for 44 students, 37 males and 7 females. These included all students actively participating in Year 11 and Year 12 Technical Drawing courses

currently (1989) employing the use of Computer-Aided Drafting/Design (CAD).

Teachers

Data were collected (in the form of questionnaire responses) from four teachers, all male. All four were the corresponding Technical Drawing teachers of the above students. All of whom had more than four years' Technical Drawing teaching experience.

GENERAL PROCEDURE

The collected data were in the form of questionnaire responses. Specific questionnaires were designed for students and teachers respectively (Appendix 1 and Appendix 2).

STUDENT QUESTIONNAIRE

The student questionnaire was comprised of nineteen items, plus a gender identification item. Each item sought individual opinions from students relating to Hypothesis 1, 2 and 4 of the study. Items 7, 11 and 17 relate to Hypothesis 1; items 4, 9, 10, 13, 14 and 15 relate to Hypothesis 2; items 2, 3, 5, 6, 8, 16, 18 and 19 relate to Hypothesis 4. Items 1 and 12 were not related to any specific

Hypothesis, but instead sought general background information on respondents within the study.

The order of items on the student questionnaire was arranged at random with the intention to minimise any possible interference in the relationship between items, real or imagined by the students.

Students were required to select an appropriate response to each item, and indicate their choice by placing a [✓] in the relevant box. There were, however, two exceptions to this format. Item 10 required a short written statement, and Item 13 requested a written qualification to a YES/NO response.

This quick and simplistic method of recording student responses was most appropriate for this study in consideration of the limited time available (during a Technical Drawing class) for students to complete the questionnaire. Consideration of the length of the questionnaire (i.e. four sides of A4 paper) was taken into account when adopting the [✓] format of response, as it was viewed that the completion of such a questionnaire might appear

as an undesirable task to some students. An alternative method to the [✓] format might evoke a less committed effort on the part of some students.

The response format [✓] was regarded by the researcher as an appropriate and effective aid to processing student responses. Initial manual tallies of student responses could be conducted quickly and accurately, plus, the direct entry of data from the student questionnaire into 'LERTAP' 2.6 (Statistical Computer Program) could be facilitated with a minimum of complication.

TEACHER QUESTIONNAIRE

The teacher questionnaire comprised twenty four items, without the need for a gender identification item because of the limited number (4) of respondents within the four study schools.

Items sought individual opinions from teachers relating to all four hypotheses of the study.

Items 3, 4, 5, 6, 7, 8, 9, 10, 14 and 23 relate to Hypothesis 1; Items 16, 17, 18, 20 and 24 relate to Hypothesis 2; Items 11, 12 and 15 relate to Hypothesis 3; and Items 13, 19 and

21 relate to Hypothesis 4. Items 1, 2 and 23 were not related to any specific Hypothesis, but instead sought general background information on respondents within the study.

Teachers were required to select an appropriate response to each item, and indicate their choice by placing a [✓] in the relevant box. There were, however, two exceptions to this format. Item 11 required teachers to indicate how they taught CAD in Technical Drawing from a list of four identified methods. If the methods listed were not applicable then provision was made available on the questionnaire for teachers to state and explain what method they used. Similarly, item 15 required teachers to indicate how they evaluated student CAD work from a list of six identified methods. If the methods listed were not applicable, then provision was made on the questionnaire for teachers to state and explain what method they used.

There were no significant differences in format between the student and teacher questionnaires used in this study. Teachers were required to complete the relevant questionnaire during the same

Technical Drawing period as the corresponding study school students. Therefore, time was limited for completion of the questionnaire. If teachers were asked to complete a questionnaire requiring more complex responses without prior notification of the content, the reliability of the responses may have been impaired through lack of due consideration of each item.

The response format [✓] was regarded by the researcher as an appropriate and effective aid to processing teacher responses. Initial manual tallies of teacher responses could be carried out quickly and accurately, plus the direct entry of data from the teacher questionnaire into 'LERTAP' 2.6 (Statistical Computer Program) could be facilitated with a minimum of complication.

COLLECTION PROCEDURE

Permission to conduct the proposed survey was granted by the Ministry of Education, the Principals of the sample schools, and the relevant Technical Drawing teachers involved in this study.

All data were collected within a 20 day period during the third term of the 1989 education year (W.A.).

Students

Suitable contact times were arranged where involved students were available for efficient administration of the questionnaire. Only one school within the study required the researcher to return to administer the questionnaire because of students being absent on the first occasion.

The researcher was the sole administrator of the survey in each of the four study schools. Any tendency for bias as a result of the researcher being present during the time questionnaires were completed should be regarded as uniform in all instances, and therefore of no significance to this study.

The researcher was introduced to participating students, on a class basis, by each Technical Drawing teacher involved in the study. The researcher identified himself, the Institution (W.A.C.A.E., Nedlands) at which he was studying, and the subject matter of the survey.

Students in all classes were informed in the same manner that there was a questionnaire containing 19 items to be individually completed. They were informed that all questionnaires would remain anonymous and that there were no 'right' or 'wrong' responses. Students were told that if they experienced any problems with particular items, they should raise their hand and the researcher would provide the appropriate guidance. All students completed the questionnaire within ten minutes.

Teachers

Participating teachers were made aware of the nature of the study when permission to conduct the survey was originally sought. Teachers completed their questionnaires in the presence of the researcher, either simultaneously with their students, or in a one-to-one situation with the researcher.

COMPLETED QUESTIONNAIRES

On receipt of the total sample of questionnaires (44 student, 4 teacher) item responses were given a numerical code (item specific) which

would simplify the ordering of tallies. Exceptions to this method of treatment of the data were Items 10 and 13 of the student questionnaire which requested an open response. It was therefore more appropriate to examine the data and record tallies in categories established from the content identified within the given responses.

Questionnaires were edited for completeness, each item double-checked by the researcher and cross-checked by an assistant. Missing responses were noted and accepted as part of the study because anonymity of respondents prevented subsequent contact.

DATA TREATMENT

Student Data

A tally sheet was used to record all student responses item-by-item (with the exception of item 10 which required an open response). Provision was made to record the gender of respondents and for these tallies to be totalled. Any irregularities (e.g. non-response to particular items) were noted at the foot of the tally sheet.

Frequencies were compiled in respect of individual responses, which in turn were converted to percentages. Where applicable the range, mode and mean were calculated and recorded. Provision was made on the student tally sheet to record the frequency of items which gave either no response, or contained any ambiguity.

The computer program 'LERTAP' was employed to ensure that all data were correctly tabulated. Data for both student and teacher sets were entered directly from the study questionnaires. A second entry of all data was performed using the 'LERTAP' data validity function to ensure correct data recording.

The 'LERTAP' 2.6 tabber function for cross-matching data for determining the presence of significance across data was similarly used with selected items. Complete frequency tabulation print-outs were obtained for student and teacher data sets.

Individual Gender Data

Separate tally sheets were constructed for both male and female student responses, following

the identical format of that used for all students. This technique was adopted to provide for possible gender similarities/differences present within the study to be examined.

Open Response Data (i.e. Items 10 and 13)

Responses for Item 10 were randomly examined for content, and it was found that there were five general areas where students felt CAD experience would be of benefit to their future employment. The procedure was repeated in a different random order, with the same five categories being identified and subsequently accepted for the purpose of this study. Separate category tally sheets were compiled for all students, male students and female students.

Item 13 required students to select a Yes or No response. Affirmative responses required qualifying comments which subsequently would be categorised. Responses were randomly examined for identifiable subject areas where students felt skills developed using CAD would be useful, resulting in a list of six being established. The procedure was repeated in a different random order with the same six categories

being confirmed and accepted for the purpose of this study. Separate tally sheets were complied for all students, male students and female students.

In order to ensure an acceptable degree of reliability across category frequencies, within Item 10 of the student questionnaire, the researcher carried out the tallying procedure twice, with a seven day lapse between procedures. The category, 'General Computer Use', recorded a reduced score of two frequencies on the second tallying, the difference being tallied equally under categories, 'Drafting and Design' and 'Non-Specified area'. The difference between frequency scores on the first and second tallies was regarded as having no significance to the study, therefore the tallying for Item 10 of the student questionnaire contained an acceptable degree of reliability.

Item 13 asked students to state specific subject areas where skills experienced through CAD might be helpful, therefore the complexity of establishing categories and their respective frequencies was minimised. Only two categories 'Drawing' and 'Designing', differed in their frequency totals (one score

only), subsequently the degree of reliability was considered as acceptable for the purpose of the study.

In addition, an assistant independently carried out the same frequency distribution procedure for Items 10 and 13. There was no significant difference found between the results of the assistant and those of the researcher. Therefore, confirmation of the reliability of the data was accepted.

Teacher Data

A tally sheet was used to record all teacher data in the form of response frequencies. In consideration of the size of sample (4 teachers) the use of additional ordinal representation was deemed unnecessary.

Items 11 and 15 provided respondents with the opportunity to include additional information which was individually examined.

Chapter three dealt with the methods and procedures used in this study. It identified the study

population, the general survey procedure and instrument of survey, together with the data collection and data treatment methods.

Chapter four reports the data and findings of this study derived from the implementation of the methods and procedures detailed in this section.

CHAPTER FOUR

FINDINGS

PROBLEMS EXPERIENCED BY TEACHERS

Hypothesis 1: There are no problems experienced by Technical Drawing teachers following the introduction of CAD into upper school Technical Drawing courses in the four study schools.

All teachers surveyed stated they use computers in addition to Technical Drawing, but their discussion about Technical Drawing had stayed at the same level of that prior to the introduction of CAD. However, three of the four teachers questioned did feel they looked forward more to Technical Drawing lessons now that CAD was being used.

Security of Technical Drawing equipment was of greater concern to two of the teachers now that it included computers, although all teachers agreed that students took reasonable care with CAD equipment. It was found that 50 percent of students felt they took more care than usual with equipment during CAD lessons. However, only two teachers permitted students

to operate CAD equipment in an unsupervised situation.

The survey showed that in all instances there was limited availability of computer equipment. Only two of the teachers had access to a single computer, and in no instance did teachers have the use of more than three workstations.

All teachers stated that class attendance levels had remained the same following the introduction of CAD, whilst three of the four teachers said that their relationship with their students had improved. Conversely, less than 30 percent of students questioned felt any improvement in their relationship with their teacher, while the remainder of the sample stated that there had been no improvement in their relationship following the introduction of CAD.

There was no significant difference between male and female students in their response to the question about the improvement in their relationship with their teacher as a result of the introduction of CAD.

For the majority of teachers, the level of off-task behaviour and class disruptions had remained unchanged following the introduction of CAD. However, one teacher noted that both off-task behaviour and class disruptions had in fact decreased. It was noted by three of the teachers that students produced less work when using CAD than when they employed traditional drawing instruments.

All teachers declared they would prefer students had more 'hands-on' experience. Similarly over 77 percent of students also indicated more 'hands-on' time was desirable.

Conclusion

The study has identified a range of problems experienced by Technical Drawing teachers following the introduction of CAD into Technical Drawing courses into the four study schools. Therefore, Hypothesis 1 is rejected.

Most problems identified related to the limited availability of computer equipment within the study schools. As a direct consequence of this

situation, students were restricted in their opportunities for 'hands-on' experience, which in itself may be a contributing factor for students using CAD producing less work than students who used traditional equipment.

Security of computer equipment was also a concern to teachers. Each of the four study schools had incorporated their CAD equipment within their traditional Technical Drawing classrooms which did not cater for such a security need.

The major problems identified within this study, experienced by Technical Drawing teachers incorporating CAD into their courses were the insufficient availability of suitable computer equipment and an appropriately secure teaching environment.

EDUCATIONAL BENEFITS

Hypothesis 2: There are no perceived educational benefits of CAD to students and teachers in the four study schools.

Teachers unanimously agreed that skills acquired through the use of CAD would be a significant benefit to students in other subject

areas. It was found that more than 61 percent of all students disagreed with this view. Using the Yates' Correction for discontinuity because of small cell numbers in respect of the teacher population χ^2 (1, N = 44) = 6.545, $p < .02$), df=1. This result illustrated a significant difference between the views of the teachers and students. However, over 72 percent of all students did believe that skills developed using CAD would be of assistance when seeking employment and/or further education. Over 80 percent of this group thought the skills acquired from using CAD related mainly to general computer use and specialised drafting/ design such as architecture. Student responses on a gender basis produced no significant differences from the student population as a whole in this respect.

All teachers agreed that the introduction of CAD into Secondary School Technical Drawing at Year 8 would be of some benefit to students. Two of the teachers felt that students would benefit to a reasonable degree. Similarly, all students indicated that CAD should be introduced into Technical Drawing. The largest number of respondents

favouring Year 10 (38.6 percent) and Year 8 (31.8 percent).

Two of the teachers felt that the use of CAD made it easier for them to meet individual student needs and 81.8 percent of students stated that they were able to work at their own pace. Less than 16 percent of students said they worked at the teacher's pace. In this respect, two of the teachers stated they provided students with the opportunity to 'earn' extra 'hands-on' time within their Technical Drawing courses.

Half the teachers surveyed thought that cooperation between students had improved, with the remaining teachers observing no change in this respect. Confidence was another facet examined with 22.7 percent of students feeling that their confidence in Technical Drawing had increased with the use of CAD. Correspondingly, 36.4 percent of all students indicated they felt increased confidence when asking questions during CAD lessons.

Visits to industry by students to see how CAD is used was viewed by teachers as having a potential to provide a small educational benefit.

Conversely, over 80 percent of students thought that visits to industry would be valuable and/or interesting.

Conclusion

The study identified a wide variety of benefits perceived by students and teachers to be gained from CAD experience, although in some instances student and teacher perceptions were diametrically opposed. Therefore, Hypothesis 2 is rejected.

It was interesting to note that half the teachers surveyed felt they were better able to meet the individual needs of students through the use of CAD, whilst concurrently over 81 percent of students felt they were able to work at their own pace.

If this situation is true for all schools then the use of CAD should be acknowledged as being supportive of the concept for schools to meet the needs of all students. Consequently it may, therefore, be appropriate for CAD to be taught as a separate subject as distinct from Technical Drawing or Computer Studies.

METHODS AND EVALUATION

Hypothesis 3: The methods of teaching and evaluation used by Technical Drawing teachers in respect of CAD is the same in all the study schools.

All teachers within the study used a method of student rotation when running CAD programs, whereby students were rostered to use the limited CAD equipment for either a set time period, or for the completion of a set task or exercise.

One teacher, in addition to the use of the student rotation method of instruction, supplemented his teaching technique with a combination of step-by-step self-tutorials, together with a class lecture supported by appropriate hand-out materials.

The literature identified student teaching aides as an alternative method of instruction, but none of the teachers within the study used such a strategy. Similarly, teachers surveyed had not identified or used instructional methods other than mentioned in the literature.

With respect to evaluating student work the study showed that no two teachers used exactly the same system. However, all teachers surveyed did use a combination of two or more methods.

Three teachers evaluated students finished hardcopy, two teachers incorporated the time spent on specific exercises as part of their evaluation process. Two teachers used direct observation of students incorporating the CAD system, and only one teacher set a formal test or exercise to be evaluated.

Conclusion

The study suggests that the limited availability of computer equipment has led teachers within the study to adopt a system of rotating students as a practical method of CAD instruction. Methods of teaching CAD within the four study schools indicate that they are both teacher and school specific, and suggest that there is no exchange of ideas and information taking place between these teachers.

With reference to the evaluation of student CAD work the study found that there was

no uniform method presently in use, but instead the study teachers used a variety of methods which reflected traditional drafting assessment techniques.

The methods of teaching CAD within the four study schools showed similarities, but the evaluation processes were made up of a diverse range of techniques. Consequently, Hypothesis 3 is rejected.

However, attention should be drawn to the desirable increase in the availability of computer equipment (ideally one workstation per student) whereby the opportunity would be provided for a more effective method of instruction to be used, i.e. class lecture supplemented by individual self-tutorial work sheets. Should this situation eventuate, it is suggested that CAD teaching methods would tend to become more uniform and standardised within W.A. high schools.

Some traditional methods of evaluating Technical Drawing are no longer valid when producing drawings using CAD (e.g. line quality and dimensioning), but the teachers surveyed did not offer any relevant alternatives. This situation may

reflect the level of development of teaching CAD within the four study schools and it is suggested that given time and greater experience on the part of the teachers involved more appropriate evaluation methods should evolve.

STUDENT INTEREST

Hypothesis 4: The introduction of CAD in the four study schools has no effect on student interest in Technical Drawing.

Over half the students surveyed said they used computers other than in Technical Drawing, with 27.3 percent indicating that their level of discussion with friends and/or parents about Technical Drawing had increased since the introduction of CAD. The use of CAD resulted in 52.3 percent of all students stating that their sense of professionalism in Technical Drawing had increased.

Since the introduction of CAD into Technical Drawing more than 95 percent of all students found the subject more enjoyable. Also, 59.1 percent considered the lessons to be more challenging. The study found that almost 30 percent of students looked forward more to Technical

Drawing lessons since the introduction of CAD, whilst 68.2 percent stated there had been no change in their outlook. Similarly, 15.9 percent of students indicated that their level of study of Technical Drawing had increased following the introduction of CAD, whilst 77.3 percent said that there had been no change in their study pattern.

All teachers within the study confirmed that students are freely encouraged to ask questions during CAD lessons.

Conclusion

The study found that almost all students found Technical Drawing which involved the use of CAD more enjoyable, whilst more than half the study population stated that they regarded the use of CAD more challenging. Thirty percent said they looked forward more to Technical Drawing lessons where CAD was used, with almost 16 percent stating their level of study of Technical Drawing had increased following the introduction of CAD. This suggests that there has been a significant effect on student interest in Technical Drawing involving CAD and, therefore, Hypothesis 4 is rejected.

Possible reasons for the increase in student interest in Technical Drawing involving CAD may be attributed to the attitude and enthusiasm of the teacher running such programs, in conjunction with a general increase in computer usage in other subject areas and the home.

This chapter of the document has set out the findings of the study, categorising them under the appropriate headings, problems experienced by teachers; educational benefits; methods and evaluation; and student interests. Each section relates directly to the relevant hypothesis in stated order, providing a concise conclusion of the salient information at the end of each sub-section.

The next chapter discusses the study findings in conjunction with the sighted literature, and proposes suggested conclusions which may be drawn from such discussions.

CHAPTER 5

CONCLUSIONS

PROBLEMS EXPERIENCED BY TEACHERS

The scope of problems experienced by teachers covered by this study were mainly centred around the area of organisation of CAD classes, as opposed to the use of specific hardware and/or software. The findings showed in all cases that there was a limited availability of computers for students to use CAD programs, which in turn created a high ratio of students to workstations. This far from ideal situation would tend to suggest the main reason for the significant desires of both teachers and students for more 'hands-on' opportunities for CAD work.

Becker (1987) stresses the need for frequent and sufficient 'hands-on' experience for students, otherwise they tend to forget the instruction over a period of time if the skills and operations are not practised. Therefore, the restricted access of students to workstations within schools would

suggest that potential benefits to students using CAD may be limited.

Prior to the introduction of CAD, the question of security of Technical Drawing equipment was addressed by ensuring the correct return of instruments at the end of lessons, overnight and at weekends. Equipment was usually locked away in cupboards and stockrooms. From the study findings, it appears that with the introduction of CAD concern among Technical Drawing teachers for the security of equipment is increasing.

This increase in concern is probably because of the high level of capital investment (in proportion to traditional drafting instruments) involved in providing suitable computers. Damage to, or loss of, such equipment in consideration of its limited availability within schools, would render many CAD components of upper school Technical Drawing inoperable.

If computer stations were permanently anchored within a secure work area, it would be reasonable to assume that the concern shown by some teachers for equipment safety could be alleviated.

However, the study cases did not generally afford such a situation, but instead computers were provided with mobility enabling them to be wheeled into lockable stockrooms when not in use. This situation might suggest that the teachers responsible for CAD equipment have employed the best levels of utilisation and security possible given the environment and the temporary nature of the developing subject area, i.e. more computers becoming available as time and funding permits.

Despite all teachers stating they thought their students took reasonable care with CAD equipment, only half the teachers surveyed permitted students to operate the CAD programs without supervision.

In all case situations, access to CAD equipment also provided student access to entire Technical Drawing rooms, equipment and materials. It is understandably acceptable that teachers might regard this potential situation as undesirable, although there is no direct evidence to support this view.

Conversely, where teachers permitted students to operate CAD equipment without direct supervision an increase in opportunities for 'hands-on' experience was created.

The issue of unsupervised use of computer equipment would appear to centre around the degree of trust particular teachers invest in individual students. Unlike most other subjects taught within the field of manual/industrial arts, which employ the use of machinery, CAD poses little risk (if any) to physical injury of students. Therefore, the question of trust would seem more likely to be weighted towards student attitude, rather than classroom behaviour. In this respect the depth of relationship between teacher and student would be of paramount importance. The findings showed that almost 30 percent of students together with three of the four teachers felt that there had been an improvement in their relationship, which could suggest that a potential basis for greater mutual trust exists. This situation in turn may encourage more teachers to provide the opportunity for students to use CAD equipment unsupervised.

The question of unsupervised students using CAD remains a personal decision on behalf of teachers. In view of the limited availability of CAD equipment in all schools, the advantages gained by employing unsupervised CAD use would outweigh the potential disadvantages of under utilisation, misuse or damage to expensive highly important equipment. Teachers should recognise that it would be wise to establish a system whereby computer use by students may be monitored enabling direct responsibility for equipment at any one time to be readily identifiable.

Students who work unsupervised would probably require a specific form of instruction in accordance with Chowenhill's (1987) recommendation that instruction needs to be structured. The step-by-step self-tutorial as identified by Becker (1987), and employed by one teacher within this study, would fulfil this need appropriately, and at the same time provide Technical Drawing teachers with the opportunity to give greater individual attention to other students employing manual drafting instruments within the

traditional classroom setting (i.e. the majority of upper school Technical Drawing students).

Three of the four teachers questioned observed that students produced less work using CAD as opposed to using traditional drafting instruments within an equal time period. This result on face value appears to be contradictory to the available literature, in which Bertoline (1988) states CAD is 2-10 times faster than manual drafting.

This difference is best explained in relationship to the level of development of computer literacy of students within this study. It has been shown in all cases of schools operating CAD programs that there is limited availability of computer hardware, plus a restricted amount of 'hands-on' opportunities for the students involved. The combination of these two aspects would suggest that students are not afforded the desired circumstances in which to maximise the retention of CAD requirements.

Students involved in CAD are required to be exposed to a large amount of information within a short period of time, which supports the view that

instruction needs to be structured in order to enhance student learning. If work output (e.g. printed drawings) is of importance, then much of the CAD program needs to be related specifically to drawing procedures and not organisational procedures such as setting scales, line-types. co-ordinates, etc., all of which may be 'written in' the program and automatically selected. For this option to be available to students, it would require CAD teachers to be highly conversant with the individual capabilities of chosen CAD programs.

Additionally, the fact that students produce less work when using CAD may suggest that the assignments students are required to complete are technically too complicated for their level of CAD comprehension. This is another reason for structuring the drawing requirements to the level of student experience.

All teachers recorded no change in class attendance following the introduction of CAD, which suggests students are not sufficiently threatened by computer use in Technical Drawing to adopt forms of avoidance behaviour as a result of such an

introduction. Further, in consideration that over 50 percent of all students use computers other than in Technical Drawing, it would indicate that computer technology is generally received by students in a beneficial and non-threatening way. Therefore, it may be concluded that the introduction of CAD should not have a significant effect on class attendance, although particular individuals may prove the exception to this rule.

Off-task behaviour and class disruptions, similar to class attendance, generally remained unchanged, although one teacher did note some improvement in this respect. With all variables (excluding the introduction of CAD) remaining unaltered, it may be said that CAD had no significant negative influence on student behaviour. The accommodation of CAD within the traditional drafting classes of Years 11 and 12 appears to have been accomplished without affecting student behaviour and, therefore, it may be assumed that this facet of class organisation should not be cause for teacher concern.

EDUCATIONAL BENEFITS

The results of the study found that there was a significant difference of opinion between teachers and students in the transfer of skills acquired through the use of CAD, to other subject areas. Although the survey did not seek specific examples from the teachers questioned as to which subject areas might gain benefit, students did indicate that, in their opinion, maths, physics, art, drawing, designing and general computer studies would benefit from student exposure to CAD.

Evidence supporting the teachers' viewpoint that skills acquired with CAD would be of benefit to students in other subject areas was not sought. However, it should be acknowledged that teachers advocating the introduction of CAD do have a personal vested interest and would generally be aware of the need for support from staff in other areas when competing for funding for computer equipment. Therefore, it is possible that teachers of CAD might adopt an attitude of 'selling' their subject whenever the opportunity arises, and bias in the data is possible.

Conversely, teachers of CAD should hold a more comprehensive perspective of potential educational benefits offered by this form of technology than do students who generally are precluded from fully appreciating the scope of such benefits because of their level of development.

The majority of students felt CAD experience was a positive benefit to their future employment, with a large proportion of students specifying areas of general computer use and/or drafting as being the most relevant. This common response would suggest student interest to be concentrated particularly toward the more obvious uses of CAD in business. A suggested reason for this viewpoint would be because at present CAD is taught within W.A. high schools as a tool to drafting, with little additional background information in respect of the use of such technology in industry, being made available to students.

A desire for wider understanding of CAD applications within industry is best illustrated by the interest shown by students for visits to

businesses employing CAD. This response may be interpreted as an expression by students to see how the real world uses skills students are taught in the classroom. Teachers, however, were not as enthusiastic as the students towards excursions, and they placed less educational value on the potential benefits to students by such trips. This conservative approach by teachers may be related to the restricted 'hands-on' opportunities available to students not being diminished further. In addition, teachers organising such visits would be required to take on extra work and responsibilities which, at the time the survey was conducted, was an industrial issue.

Notwithstanding the problems involved in organising visits to industry, it could be suggested that activities which allow students to experience 'real world' applications of school learning should be encouraged wherever possible. Benefits to students and teachers may well be derived from such visits. Although excursions of this nature may serve as a stimulus of interest on a superficial

level, they also have the potential to provide a wider understanding of CAD applications and contribute indirectly to student decisions for future employment and education.

The results of the study highlighted that all teachers and students were unanimously in favour of CAD being introduced in Technical Drawing. Over 70 percent of students questioned stated that CAD should be introduced in lower school, which may reflect student interest in computer use generally. Teachers were less convinced of the degree of benefit students in Year 8 may derive from such exposure to CAD. This reservation is supported by the view that traditional drafting classes are a necessary prerequisite of CAD (Fesolowich, 1987; Sorensen, 1988). Students at Year 8 level are not sufficiently familiar with the basic concepts and conventions of Technical Drawing to be able to apply them correctly when using CAD.

The use of demonstrations and displays of CAD work at Year 9 level may serve as a motivational tool for students who would be introduced to 'hands-on' CAD in Year 10, when, it is suggested that students would have a better

grasp of Technical Drawing concepts and conventions. This view should not preclude teachers from introducing students to CAD at any level they might feel is appropriate acknowledging the constraints of computer availability, class numbers, adequate staff levels and any other factors.

The use of computers in education, particularly in Technical Drawing, provides students with the opportunity to work at their own pace, a feeling held by over 80 percent of students questioned. Students working alone or in pairs, employing the use of self-tutorials (Becker, 1987) was the most probable reason for this attitude. The fact that all teachers within the four study schools had limited access to computer equipment requiring them to use a system of student rotation whereby students operated the CAD system alone or in pairs, could suggest support for the students' feelings. Teachers' intervention was of low incidence using this strategy because students faced with problems are able to refer back to previous tutorials for guidance to solutions. Working in this way enables students to revise/relearn aspects of CAD not previously fully mastered.

Two of the teachers felt that CAD enabled them to better provide for individual student needs, an important aspect where a large proportion of students are able to work at their own pace. The utilisation of the self-tutorial permits teachers to closely monitor the progress of individual students. If needed, drawings may be substituted and/or inserted as required to provide the most appropriate course/ learning activities for individual students.

For this teaching strategy to realise the potential benefits (as previously discussed under the section relating to problems experienced by teachers), teachers are required to invest a considerable proportion of time and effort, which is an issue for individual teachers.

The final concerns to be examined under the heading of educational benefits were cooperation between students and student confidence relating to Technical Drawing.

The results suggest that cooperation among students had improved, but this change in behaviour can not be directly attributed to the introduction of CAD. It should be noted that an increase in cooperation among students in upper school may be as a result of the natural process of maturation and social development within a group or as individual adolescents.

A significant number of students felt their confidence in Technical Drawing had improved with the use of CAD, which might suggest the 'fear' of making mistakes when drawing may be less than when using traditional drafting instruments. The ability of CAD to erase mistakes and redraw assignments provides the students with the potential for greater freedom of expression.

The growth in student confidence in Technical Drawing may be attributed to the collective (or combination of) educational benefits identified within this study; in particular, students working at their own pace and the potential for students' needs to be more readily addressed.

METHODS AND EVALUATION

CAD within W.A. high schools is in its infancy, the teaching methods and evaluation procedures used are generally on a trial basis. Therefore, this aspect of the study was examined on a superficial level as indicated by the limited data sought.

No two teachers used exactly the same method(s) for teaching CAD, which suggests that the 'ad hoc' introduction of CAD into W.A. high schools has not produced a single clearly preferred system best suited to prevailing circumstances. However, the study did indicate that the self-tutorial and class lecture/handout methods did have the greatest support.

An appropriate method of teaching CAD directly relates to the facilities available within schools, plus the number of students involved in such courses. This study found, within the schools surveyed, a maximum of three computers available for CAD, which would suggest that the use of self-tutorial would be the most appropriate method of

teaching under these restricted conditions.

However, in the 'ideal' situation (one computer to each student), the class lecture/handout would be more appropriate, although some students may feel that the opportunity to work at their own pace is restricted.

The results from the study indicated that a choice or combination of the self-tutorial and/or class lecture/handout teaching methods will continue as the teacher preferred format within W.A. high schools until the availability of computer work stations is significantly increased.

The results identified a wide range of evaluation methods currently used by W.A. CAD teachers. When assessing student work the literature (Sweet, 1986; Fesolowich, 1987; Bertoline, 1988; Sorensen, 1988) has identified a number of aspects (i.e. lettering, dimensioning, line work) of manual drafting as being performed automatically when using CAD and, therefore, suggests that many traditional assessment methods are no longer appropriate.

A significant number of teachers examined finished plotted hardcopies of student work to

evaluate their skill levels, but the results of this study suggest that this method alone would not sufficiently the overall ability of students.

The results of this study showed that most teachers also employed a complementary assessment technique. The recording of time taken by students in completing assignments (as used by some teachers) may be of significance, but when related to general course work (when students generally desire more 'hands-on' time), this assessment technique may be misleading. To assess work completed in a specified time would, it is suggested, be a more appropriate assessment method, plus it would provide a reasonable framework of assessment for students across the ability continuum.

One teacher used direct observation of students whilst operating CAD programs to aid assessment of individual skill levels. Without the use of an itemised checklist, casual observation may become a highly subjective exercise with the potential of personal bias affecting the assessment. Direct

observation may also affect individual student behaviour (i.e. stimulate inhibition/exhibition), thus distorting the assessment.

Conversely, informal observation and encouragement on behalf of the teacher has the potential to aid understanding of concepts and processes which cause difficulties with individual students. Teacher observation may more appropriately be regarded as a learning opportunity, rather than a point of assessment.

The study found only one teacher used a formal test exercise/assignment as part of his assessment process. This method of assessment permits the teacher to determine the accuracy of a finished product, but fails to address the need for assessment of the processes involved with computer generated drawings.

The literature sighted (Goetsch, 1981; Hall, 1982; Giesecke, 1984; Cheng, 1985; Murphy, 1987; Bertoline, 1988) identifies two of the major benefits of CAD as the speed/efficiency of producing new drawings, and the potential ease of editing/modifying

existing drawings. Teachers questioned in this study made no specific reference to either of these features of CAD in their assessment methods, which suggests little relevant consideration has been given to their importance.

No two students will produce the same drawing using identical command sequences. Therefore, no two students should consume identical amounts of computer memory. An appropriate method of assessing the efficiency of students' work on a comparative basis would be for individual student work disks to be examined for the volume of memory used.

Student skill levels relating to the editing facilities of CAD programs may be better assessed by providing completed drawings that require specified alterations to be made. The plotted hardcopy then produced would provide a means for the teacher to better assess students' comprehension of CAD, as opposed to assessment of the traditional sensori motor skills which CAD obviously renders inappropriate. In additon to this strategy, the

previously described system of examining individual work disk memory consumption should aid overall student assessment and make it more relevant.

This form of assessment might best suit teachers employing a formal test exercise/assignment as a significant part of their CAD course assessment.

STUDENT INTEREST

More than half the students surveyed used computers other than during Technical Drawing, which may indicate a carry over of student interest into Technical Drawing involving CAD. There was a notable increase of discussion about Technical Drawing between students and their friends/parents which supports the view that there has been a significant increase in student interest in Technical Drawing following the introduction of CAD.

The study found that since the introduction of CAD almost 30 percent of students questioned said they now looked forward more to Technical Drawing lessons, with over 15 percent indicating that their level of study of Technical Drawing had also increased.

Therefore, it may be suggested that the introduction of CAD within the four study schools has had a significant effect on student interest in upper school Technical Drawing.

It may be argued that the findings on the benefits to students and teachers derived from the introduction of CAD, suggest possible reasons for the increase of student interest in Technical Drawing.

A significant number of students said they felt more able to work at their own pace when using CAD, plus two of the four study teachers believed they had the opportunity to more readily meet the needs of individual students.

The findings showed that within two of the four study schools, teachers felt cooperation among students had improved; also over 22 percent of students questioned said their confidence had increased (75 percent of students stated no change in their confidence level) within this subject. Therefore, it may be suggested that these responses reflect an outcome of an increase in student

interest in Technical Drawing following the introduction of CAD.

Many of the teachers who have introduced CAD into their Technical Drawing courses have been personally interested and enthusiastic towards the wider acceptance of this recent drafting technology. It should be acknowledged that this attitude of teachers, when openly displayed (as a role model), may positively contribute to the recognised increase of student interest in Technical Drawing.

Chapter five followed the established format of the previous chapter in presenting discussion on, and suggested conclusions to, the findings of this study. The suggested conclusions of this chapter provide the basis for the recommendations of this study, and are presented in the following chapter.

CHAPTER 6

RECOMMENDATIONS

PROBLEMS EXPERIENCED BY TEACHERS

The most common factor restricting simple and effective introduction of CAD into W.A. high schools is the significant lack of availability of suitable computer hardware.

RECOMMENDATION 1

That CAD teachers should seek to achieve an optimum ratio of one computer to each student, whenever practical.

Security of computer equipment is a real concern to CAD teachers in respect of the essential nature of such equipment to upper school technical drawing courses; the capital investment involved and the general lack of appropriate secure operating/storage facilities.

RECOMMENDATION 2

That where possible, secure computer laboratory facilities provided with a monitored access system should be used for CAD education.

Most CAD teachers have gained their experience mainly as a result of personal interest and self-teaching. Teacher education institutions introduce CAD units of study as an integral component of three or four year courses with the provision for teachers inexperienced with CAD to study a single unit on a non-award basis.

Teachers have spent their own time and money in acquiring these additional skills, particularly when endeavouring to keep pace with developing technology applicable to schools.

RECOMMENDATION 3

That teacher training institutions ought to offer in-service/day release courses, on a current needs basis, for teachers requiring the necessary experience/ qualification to teach CAD in W.A. high schools.

EDUCATIONAL BENEFITS

Students believed that CAD experience was of general benefit to their potential future education/ employment opportunities, but their perspective of its

application remained somewhat narrow. Where possible, students need exposure to the applications of CAD in industry, in order that they might gain broader understanding of this technology.

RECOMMENDATION 4

That the use of videos and/or educational visits to industry to observe a variety of CAD applications would provide students with a wider scope of understanding of this technology.

Technical Drawing students are initially introduced to CAD in Year 11, which means that a significant proportion of students leave school after completing Year 10 never having been exposed to this form of technology.

Students within this study have stated that CAD should be introduced at an earlier stage of their Technical Drawing studies, but it has been shown that reasonable knowledge and understanding of the basic concepts and conventions involved is a necessary prerequisite of CAD. Therefore, given the necessary facilities, students would benefit from the introduction of CAD prior to Year 11.

RECOMMENDATION 5

That where practical, Year 10 Technical Drawing students should be made aware of CAD, and receive some 'hands-on' experience with this form of technology.

METHODS AND EVALUATION

CAD teaching methods are directly related to student/computer workstation ratios. In view of the current restricted availability of computers in W.A. high schools, teachers prefer to use a self-tutorial teaching method in conjunction with student rotation. However, if access to appropriate hardware is made available, tuition may better be addressed by using a class lecture/handout approach.

RECOMMENDATION 6

That the utilisation of a well structured self explanatory, self paced tutorial is recommended when teaching CAD to classes of high student/ computer workstation ratios.

RECOMMENDATION 7

That the utilisation of a class lecture supplemented by a sequenced procedure handout is recommended when teaching CAD to classes with an equal student/computer workstation ratio.

Teachers use a wide range of criteria for CAD assessment, but there is little consistency or continuity of their methods across schools. CAD has made many of the traditional manual drafting assessment criteria redundant and, therefore, alternative and more appropriate methods need to be established.

RECOMMENDATION 8

That the examination by teachers of the used memory space (number of bytes consumed by a single assignment/drawing) on individual student work disks may be used as an appropriate guide to student efficiency/comprehension levels when working with CAD.

RECOMMENDATION 9

That individual student CAD literacy levels may better be assessed when students are required

to edit existing drawings in addition to the construction format of assignment/exercise common to traditional manual drafting.

STUDENT INTEREST

Student interest in Technical Drawing has significantly increased following the recent introduction of CAD. The potential exists for more students to choose Technical Drawing studies if they are adequately informed prior to course selection deadlines. Teachers may more readily argue for greater computer availability if student demand significantly increases.

RECOMMENDATION 10

That Manual/Industrial Arts teachers, where practical, should positively promote student awareness of the application of CAD in Technical Drawing (and industry generally) across all student levels.

This study has dealt with a specific range of effects experienced by teachers and students following the recent introduction of CAD into upper high school Technical Drawing courses within W.A. It has shown a clear indication that the

suggested 'ad hoc' approach to this introduction is in fact present, and therefore many questions as to the worth of CAD in the school situation are left unanswered by this study.

There has been no attempt to identify current hardware being used in this subject area, nor has the software being used been identified or evaluated for its appropriateness within the high school situation.

The study found that the class lecture/ worksheet handout was the favoured method of teaching CAD adopted by teachers, but no opinion was sought with respect to subject content. Further study into these areas may provide the basis for a more effective approach to the introduction of CAD throughout W.A. high schools.

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STUDENT QUESTIONNAIRE

Please Read

Please complete the following questionnaire making sure that each item is fully answered. Most questions only require a tick [✓], but others have space provided for a brief statement.

Do not make any other marks on the questionnaire.

Male [ ] Female [ ]

****

1. How many years have you been studying Technical Drawing? (Tick answer).

1 year	[ ]
2 years	[ ]
3 years	[ ]
4 years	[ ]
5 years	[ ]

2. Do you use a computer other than during Technical Drawing lessons?

YES	[ ]
NO	[ ]

* APPENDICES *

3. Is Technical Drawing more enjoyable when computers are used?

YES	[ ]
SOMETIMES	[ ]
NO	[ ]

4. Has your relationship with your Technical Drawing teacher improved since the introduction of Computer-Aided Drafting/Design?

YES	[ ]
NO	[ ]

5. Do you look forward to Technical Drawing lessons since the introduction of Computer-Aided Drafting/Design?

MORE	[ ]
THE SAME	[ ]
LESS	[ ]

6. Since the introduction of Computer-Aided Drafting/Design, time spent on Technical Drawing study has

   INCREASED [ ]

   STAYED THE SAME [ ]

   LESSENED [ ]

7. How much care do you take with Computer-Aided Drafting/Design equipment?

   MORE THAN USUAL [ ]

   USUAL AMOUNT OF CARE [ ]

   LESS THAN USUAL [ ]

8. How much 'hands-on' time with Computer-Aided Drafting/Design would you prefer?

   MORE [ ]

   ABOUT THE SAME [ ]

   LESS [ ]

9. In your opinion, will your experience with Computer-Aided Drafting/Design be of assistance when seeking employment/further education?

YES [ ]

NO [ ]

10. In what way do you feel that Computer-Aided Drafting/Design is/is not of benefit to your future employment?

_____

_____

11. When in your opinion should Computer-Aided Drafting/Design programs be introduced to secondary students?

YEAR 8 [ ]

YEAR 9 [ ]

YEAR 10 [ ]

YEAR 11 [ ]

YEAR 12 [ ]

NOT AT ALL [ ]

12. How challenging/demanding do you find using Computer-Aided Drafting/Design in comparison to traditional pencil and paper drawing?

MORE [ ]

ABOUT THE SAME [ ]

LESS [ ]

13. Would the skills developed using Computer-Aided Drafting/Design be useful in other subject areas?

YES [ ]

NO [ ]

If YES, how would those skills help in other subject areas?

_____

_____

14. By using Computer-Aided Drafting/Design, has your confidence in Technical Drawing

IMPROVED? [ ]

STAYED THE SAME? [ ]

REDUCED? [ ]

15. When using Computer-Aided Drafting/Design, do you feel you work

AT YOUR OWN PACE? [ ]

AT THE TEACHER'S PACE? [ ]

AT THE CLASS PACE? [ ]

16. When using Computer-Aided Drafting/Design, instead of instruments, does your sense of professionalism

INCREASE? [ ]

STAY THE SAME? [ ]

DIMINISH? [ ]

17. When asking the CAD teacher questions, do you feel

CONFIDENT? [ ]

INHIBITED? [ ]

NEITHER? [ ]

18. Discussion about Technical Drawing with your friends, parents, etc., since the introduction of Computer-Aided Drafting/Design has

INCREASED [ ]

STAYED THE SAME [ ]

DECREASED [ ]

19. Visits by Technical Drawing students to see how Computer-Aided Drafting/Design is used in industry would be

VALUABLE [ ]

INTERESTING [ ]

WASTE OF TIME [ ]

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE.

TEACHER QUESTIONNAIRE

Please Read

Please complete the following questionnaire making sure that each item is fully answered. Most questions only require a tick [✓], but others have space provided for a brief statement.

Do not make any other marks on the questionnaire.

****

1. How many years have you been teaching Technical Drawing?

   1 - 3 YEARS [ ]

   4 - 5 YEARS [ ]

   6 - 10 YEARS [ ]

   10 YEARS OR MORE [ ]

2. Do you use a computer other than in Technical Drawing lessons?

   YES [ ]

   NO [ ]

3. Since the introduction of Computer-Aided Drafting/Design (CAD), how much do you look forward to teaching Technical Drawing?

MORE [ ]

THE SAME [ ]

LESS [ ]

4. Since the introduction of CAD, has the relationship with your students in Technical Drawing improved?

YES [ ]

NO [ ]

5. Time spent off task by students following the introduction of CAD, in your opinion, has

INCREASED [ ]

REMAINED THE SAME [ ]

DECREASED [ ]

6. Behavioural disruptions within the class since the introduction of CAD, in your opinion, have

INCREASED [ ]

REMAINED THE SAME [ ]

DECREASED [ ]

7. Since the introduction of CAD, have class attendances

IMPROVED? [ ]

STAYED THE SAME? [ ]

DECREASED? [ ]

8. Do students take reasonable care with CAD equipment?

YES [ ]

NO [ ]

9. Are students permitted to operate CAD programs/equipment without supervision?

YES [ ]

NO [ ]

10. How many workstations (PCs) are available at any one time for running CAD programs?

1 workstation [ ]

2 - 3 workstations [ ]

4 - 6 workstations [ ]

7 or more [ ]

11. Which teaching format do you usually employ when running CAD programs in Technical Drawing?

CLASS LECTURE/HANDOUT [ ]

SELF-TUTORIAL [ ]

ROTATION OF STUDENTS [ ]

STUDENT AIDES [ ]

OTHER [ ]

If OTHER, please state.

_____

_____

12. With the introduction of CAD, cooperation between students, in your opinion, has

IMPROVED? [ ]

STAYED THE SAME? [ ]

DECREASED? [ ]

13. Do students produce more work (in an equal time period) when using CAD compared to students using instruments?

YES [ ]

NO [ ]

14. The security in respect of CAD equipment (i.e. computers, hardware, software) has created

MORE CONCERN [ ]

THE SAME LEVEL OF CONCERN [ ]

LESS CONCERN [ ]

15. How do you evaluate student work?

a) Finished plotted/printed hardcopy [ ]

b) Time spent on each exercise [ ]

c) Formal test exercise/assignment [ ]

d) Demonstration observation [ ]

e) Print out at set stages [ ]

f) Any combination of the above [ ]

g) Other (please state) _____

_____

_____

16. Would you prefer students had more individual time with 'hands-on' experience of CAD programs?

YES [ ]

NO [ ]

17. In your opinion, would the introduction of CAD in Year 8 benefit students?

GREATLY [ ]

A REASONABLE DEGREE [ ]

LITTLE [ ]

NOT AT ALL [ ]

IT WOULD BE DISTRACTING [ ]

18. In your opinion, would the skills developed using CAD be of any significant benefit to students in other subject areas?

YES [ ]

NO [ ]

19. Are students given the opportunity to 'earn' extra time using CAD programs?

YES [ ]

NO [ ]

20. In your opinion, does the use of CAD make it easier to cater for individual student needs?

YES [ ]

NO [ ]

21. Are students freely encouraged to ask questions during CAD lessons?

YES [ ]

NO [ ]

22. In comparison to pre-CAD Technical Drawing, to what degree do you discuss Technical Drawing now?

MORE [ ]

ABOUT THE SAME [ ]

LESS [ ]

23. Which areas of Technical Drawing do you use CAD. When teaching

ORTHOGONAL? [ ]

OBLIQUE? [ ]

ISOMETRIC? [ ]

PERSPECTIVE? [ ]

GEOMETRY (SOLID AND/OR PLANE)?[ ]

24. How much benefit to students do you feel that visits to see how CAD is used in industry would be?

A GREAT AMOUNT [ ]

A SMALL AMOUNT [ ]

A NOMINAL AMOUNT [ ]

NOT AT ALL [ ]

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE.

E.V. Beagley,

W.A.C.A.E.,

Stirling Highway,

NEDLANDS. 6009.

The Principal,

Dear Sir,

Request to conduct a survey

I am writing to request your permission to conduct a research study within your Manual Arts Department as part of my B.Ed. (Hons.) studies.

The purpose of the study is to determine/ identify interests of, and benefits to, both students and teachers within the upper school Technical Drawing course, following your introduction/implementation of Computer-Aided Drafting/Design (CAD).

The proposed survey is in the form of Student and Teacher questionnaires which would take approximately ten minutes to complete. The information gathered would be guaranteed total anonymity and confidentiality, and would be used for the sole purpose of this study.

It is hoped that the findings of this study may be reproduced in the form of a Resource Leaflet, which might assist future Technical Drawing teachers introducing CAD into their schools.

I would appreciate your confirmation of my request, together with the name and contact number of the relevant Technical Drawing teacher in order that I might seek his/her permission regarding this subject.

Yours faithfully,

E.V. BEAGLEY
RESEARCH STUDENT

J. HEGNEY
RESEARCH SUPERVISOR