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Integrating Computer-Aided Design (CAD) Technology Into Technical and Vocational Education Programs in Zimbabwe

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INTEGRATING COMPUTER-AIDED DESIGN (CAD) TECHNOLOGY INTO TECHNICAL AND VOCATIONAL EDUCATION PROGRAMS IN ZIMBABWE

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Chapter 1

INTRODUCTION

Computer-aided design (CAD) and computer-aided manufacturing (CAM) have become significant inroads into most industrial enterprises. Studies have revealed that the use of CAD increases the output per draftsperson by between 200 and 6000 per cent (Ebel & Ulrich, 1987). Such productivity gains are very necessary to any economy. Zimbabwe, which has the second most developed manufacturing sector in the Sub-Sahara Africa after South Africa needs to harness this technology for dynamic economic growth in its manufacturing and construction industries (ZimWEB, 1996)

Research Problem

The problem of this study was to analyze and identify the most effective means of integrating Computer Aided Design (CAD) practices into Industrial technology programs offered by technical colleges and universities in Zimbabwe.

Statement of Purpose

The purpose of this study was to determine the most effective means of integrating and implementing CAD technology into technical and vocational programs in technical colleges and universities in Zimbabwe.

Statement of Need

The need for this study was based on recommendations from the Zimbabwe Presidential Commission of Enquiry into Education and Training in collaboration with the British Council. One of the most important proposal put forward by this commission of enquiry was the need to enhance the quality of education and training in Zimbabwe by ensuring that schools and tertiary institutes were well equipped and staffed to meet the challenges of the 21st century (Courtney, 1998).

The major weakness in Zimbabwe's education and training system is the lack of a systematic linkage between the educational system and the economic needs of the society (Hubbard, 1997). For instance, most of the drafting and design courses offered in Zimbabwe's technical colleges are still based on the traditional board and tee-square method yet drafting and design practices in most industries have now been computerized (Ministry of Higher Education Drafting and Design Syllabi, 1999). In order to address this anomaly, it is imperative that colleges and universities should seek to integrate computer-based technologies such as CAD into their education programs as has been the case USA and Britain.

Analysis and evaluation of procedures, criterion, models and considerations employed by technical colleges, universities and some manufacturing firms in the State of Iowa, USA and colleges in Great Britain to replace manual drafting techniques could be valuable to Zimbabwe's colleges and universities. Information from CAD equipment suppliers indicate that as high as 30 per cent of CAD/CAM installations fail as a result of mistakes made in investment policies by companies and institutions (Ebel & Ulrich, 1997). This leads us to cost-benefit considerations.

<u>Research Questions</u>

This Research paper is therefore intended to address the following research questions:

1. Is there a need for CAD technology in Zimbabwe?

2. Does the industry in Zimbabwe require CAD technology as a Drafting or Design tool?

3. How can educational institutions integrate CAD technology into technical and vocational programs in Zimbabwe?

Limitations

This study was conducted in view of the following limitations:

1. The study was limited to two educational institutions in USA and colleges in Great Britain.
2. The study was restricted to literature reviews of models developed by educational institutions in USA and Great Britain, and documents on education and Training in Zimbabwe.

Definition of Terms

The following terms as defined here were used throughout the study:

1. Tertiary Institute -- Any institute offering post-secondary education in Zimbabwe. (Mambo, 1998).
2. Technical College -- Any college offering training in technical courses or programs (Munetsi, 1996).
3. CAM -- An acronym meaning computer-aided manufacturing (Johnson, 1992).
4. CNC -- An acronym meaning computer numerical control machines (Bedworth, Henderson and Wolfe, 1991)
5. Traditional method -- The teaching of drafting and design using drafting boards and tee-squares or drafting machines (Kashef, 1993)

Chapter 2

LITERATURE REVIEW

Most African governments are turning to computer technology in their efforts to build stronger economies. Zimbabwe is one of the countries taking a lead in this field (Hawkrige, 1991). CAD and CAM have become important to the economic well being of any nation in these times of great competition in the manufacturing arena (Bedworth, Henderson and Wolfe,1991).

The impact of CAD in industry has challenged educators to train personnel to acquire necessary skills to use these new design tools (Hamblett, 1997). This chapter focuses on the review of literature on five key issues, which may be considered important in the integration of CAD courses into industrial technology programs in Zimbabwe. The five areas researched were: (1) CAD technology, (2) Selection and purchasing of CAD systems and equipment in USA and United Kingdom education institutions, (3) A brief account of the Zimbabwe's economy, and (5) The educational and training system in Zimbabwe.

CAD Technology

CAD packages are now extensively used in all engineering fields (Bedworth, Henderson and Wolfe, 1991). The ability of the computer to manipulate large amounts of information involved in design has brought about many benefits from CAD technology over manual drafting techniques; the outstanding benefit being productivity (Duelem, 1986). Drawings or the databases can now be used as production tools to develop computer numerical control (CNC) machine codes which are ultimately used to produce parts (Stewardson and Mann, 1994).

Pollard (1985) cited the following reasons for switching to CAD: speed, ease of editing, use of stored symbols, accuracy, less tediousness, and less manual skill requirements. Rodestein (1985) complemented Pollard's list by adding the following benefits: easy modifications of designs, provision of more time to experiment with designs, CAD with 3-D enhancement cuts costs and time in model building, and the flexibility of CAD to create and combine drawing views on different layers. Rodenstein also suggested that a person using a CAD system is four to eight times faster and more efficient than a person using a drafting machine.

CAD technology can be split into two broad categories, 2D CAD and 3D CAD. The latter form of CAD is becoming popular with most manufacturing and construction industries. A survey conducted by Dataquest in 1996 revealed that 66% of CAD users in Europe were using 3D CAD as their main design method. The French were the biggest users of 3D CAD with 82%. The Germans ranked last with 47% in the use of 3D CAD, but were in the forefront in the use of 2D CAD (Hars, 1996).

Findings from the Dataquest study also show that the economic stature and type of industry influence the use of 2D or 3D CAD technology in any country. For instance, the Germans have a huge machinery-building industry and hence tend to run more towards 2D CAD (Hars, 1991). In North America CAD investments are usually made on project basis such as building a new plane or automobile and they tend to make use of 3D CAD technology over 2D CAD.

Architectural Design firms are increasingly turning to CAD. In a 1991study conducted in USA involving 150 architectural, engineering and construction firms; statistics showed that 93% of the respondents used some form of CAD on design work.

This study by Computer Graphics World also revealed that 61 percent of the respondents accomplished 75 percent to100 percent of their 2D drafting with a CAD system (Teichoilz, 1991). Twenty three percent of the survey respondents were already using 3D CAD for all of their design work. Most firms were seriously considering installing 3D CAD systems. This shift is attributed to the advanced impact on design and presentation activities available in3D CAD technology (Teichoilz, 1991). They include 3D modeling and numerous rendering techniques.

The use of CAD technology in any country is dependent on many factors. Hars (1991) stated that, "The main difference in users worldwide is not so much relative to geography as it is to the type of product they're creating and the type of industry they're in" (p. 21).

Selection and Purchasing of CAD Systems and Equipment in USA and Great Britain Educational Institutions

The selection and purchasing of CAD technology needs thorough consideration. Educators need to be well informed in order for them to come up with wise decisions and avoid spending limited resources on technology, which may not meet their expectations or become obsolete within a short period of time (Stewardson and Mann, 1994). This research project reviewed two educational institutions in USA, Linn Technical College and Iowa State University, and how they integrated CAD into the design and graphics curricula. A paper on how colleges in Great Britain could incorporate CAD technology in engineering courses was also reviewed. The following section is a summary of the findings of the three institutions:

Linn Technical College

Franken's (1984) study on Linn Technical College, *A Multidisciplinary Research Team Approach to Computer-Aided Drafting (CAD) System Selection*, adopted a three step approach in integrating CAD technology into the Drafting and Design Department. The approach allowed Linn Technical College Drafting staff to: 1) methodically review existing CAD systems, 2) establish criteria for CAD system performance within Linn Technical College, and 3) select the optimum system.

The research team in the Franken study was comprised of faculty from Linn Technical College, experts from industry, and representatives from the Missouri State Department of Elementary and Secondary Education. The first task for this team was to review as much literature on CAD as possible. The team reviewed over seventy books, pamphlets, newsletters and periodicals.

The research team used the literature review findings to design an evaluation instrument. The evaluation instrument checked on one hundred and eight items pertinent to CAD technology. A total of fifty-four CAD systems were evaluated against this criterion. Findings from the evaluations enabled the team to narrow their search to twenty possible CAD systems.

To avoid over dependence on vender published literature and to validate some of the research team's findings, on-site visitations on companies and institutions using CAD technology were arranged. The visits assisted the team to further cut down the number of possible choices from twenty to five.

The research activities yielded data that enabled the team to recommend the Tektronix Plot 2D system with a great degree of confidence. The reasons for this choice were excellent machine function, reputation of the manufacturer, availability of other services, and the amount of program material (software) compatible with the system.

It is interesting to note that the entire research exercise took six months. It should also be noted that the field of CAD technology is constantly in state of change and flux. From this study, three of the companies which were in CAD business when the project started had declared bankruptcy prior to the final selection of the best CAD system for Linn Technical College.

Iowa State University

Iowa State University developed a five-step model, which has been successfully used for the purchase of CAD software and hardware for technology education. According to Smith (1992), this model is ideal to situations where both hardware and software are to be purchased. The model does not work well in cases where computer hardware has already been selected as is typical with most educational institutions. Smith also suggested that, given the choice, the preferred method for system selection is to identify the software needed first and the select the hardware to run it. The five components, which constitute the model, are collection of information, observation of CAD in use, arrangement of on-site demonstrations, selection of CAD software, and choosing the vendor.

Collection of information is primarily based on literature reviews. A guide on what to review is provided. The guide is made up of the following items: identification of objectives, costs, frequency of updates, reviewing of specific software and equipment, documentation, and training required.

Visitations by a research team to vendor demonstrations at technology and engineering conferences and trade shows should be conducted to obtain first hand information on the latest technology. Potential buyers are also urged to visit and observe CAD technology at work in schools, universities and the local industry during trade shows and promotional events. Computer stores selling CAD software and hardware should also be visited. The model also advises potential clients to visit local CAD and engineering consultants for expert advice.

The next step involves the arrangement of on-site demonstrations by the school. Possible packages have to be tried out and evaluated with respect to the existing facilities. Representatives from different vending companies or manufactures should be invited to present demonstrations on-site. The interested party must ask the vendors show the capability of CAD software or a CAD system. Faculty should select simple, but unique designs from their own sources and ask the vendors to prepare drawings as they observe. Faculty is urged to try out the similar drawings under the supervision of the vendors.

Before confirming orders, the team should visit schools, colleges and universities using the software or hardware to check on the strengths and weaknesses of the system. The last step in this model requires the institution to select the vendor. It is logical to choose the vendor with the lowest price, but it is important to check on how the vendor is accessible in view of service backups. There is need to check on the vendor's reputation, experience, stability, and the type of services provided.

Computer-Aided Design for Colleges in Great Britain

The Further Education Unit in Great Britain developed a seven-step approach which, colleges can use to incorporate CAD technology into engineering and technical programs (Ingham, 1988). The seven steps proposed are: The organization of the CAD task group, analysis of departmental needs, selection of possible CAD systems, invitation of bids from vendors, selection of a system, system management, and staff training.

The initial stage is to assemble a CAD task group made up of four to six people. A good mix of the group should include experts in design, manufacturing, information technology, and business studies. A sense of urgency should be engendered in the Task group right from the onset. This is necessary in view of the frequent changes in CAD technology. The task group becomes the center of expertise and its mandate is to gather information about CAD systems, analyze departmental needs, selects the ultimate system to be bought, and organize the purchase and installation of the selected system. A team leader should be appointed, and is expected to convene and run meetings.

It is useful for the task group to visit colleges of similar profile that are already using CAD technology, to see how various systems suit the different academic environments. Visitation and liaison with the local firms using CAD technology may be helpful in creating opportunities for staff training placements and student employment.

In analyzing departmental needs, several relevant factors must be considered. The number of disciplines that are to use the system must be established first. The Task Group should also examine existing facilities such as the central computer system and microcomputers available. Other factors to consider are departmental course profiles, the degree of commitment by the various disciplines to CAD, student throughput, student attendance profile, and college opening hours.

When selecting possible CAD systems it is important to retain the original system specification as a criterion to narrow your choices. It is advisable to consider buying the whole system from one supplier so as to avoid the 'shedding blame' effect in the event of system failure. The Task Group must select a short-list of a minimum of six vendors and then invite tenders.

The short-listed vendors are expected to provide technical proposals and quotations. Proposals should specify the software and hardware proposed, the price, terms of contract, details of warranty, available maintenance for both hardware and software, and manuals for both training courses and installations.

The final choice must made after observing demonstrations by the short-listed vendors on a benchmark of your choice. Colleges are discouraged from basing their decisions from vendors' well-practiced demonstrations. It is also important to verify the technical expertise of the supplier's staff and the commercial viability of the supplier's firm.

Once the purchasing deal is finalized, a system manager should be chosen, preferably from the Task Group. The purpose for this choice is primarily to ensure commitment to the system. It is recommended to select someone with good organizational skills since the manager's major duties will include the design and implementation of running procedures. It is important to note that the organization of even a modest installation takes up a lot of time, particularly in the early days. This makes the selection of the systems manager critical.

The system manager is responsible for the CAD room layout. Considerations for the CAD room layout must include the following factors: workstation positioning, ergonomics, power supply, cable routing, trunking of cables, use of the room as a lecture room, storage of consumables and other supplies. A logging system must be developed in order to monitor the use of the room and the equipment. Where microbased systems are used, some attempt should be made to prevent students from copying programs. Students should always keep their drawing files on their own floppy disks. System managers are also advised to upgrade systems at the end of the academic year to avoid frustrations resulting from any changes to the system.

The final stage of this model involves staff training. Students tend to use systems more creatively and usually they are quick to discover the remote corners of the system. It is essential that the staff become conversant with all facilities of the system and be fluent in its use. It takes a great deal of personal effort. Staff members are urged to share experiences in using the system. A logbook could be used to write down difficulties experienced and discoveries made on the CAD system. Training is better if staff work in pairs. This avoids staff keeping techniques to themselves and makes progress faster. This approach also helps staff to share responsibilities for operating the system and recording findings. Any member of the staff who attends a course outside the college should be asked to train two members of staff upon his or her return. The two members are also expected to train two other members each and so on. This avoids the 'sole repository of information' effect which is never beneficial to any learning and training environment (Ingham, 1988).

Zimbabwe and its Economy

Zimbabwe is a landlocked country in Sub-Sahara Africa whose neighbors include Mozambique to the east, South Africa to the south, Botswana to the west and Zambia to the north. Over 70% of Zimbabwe's 11 million people live in rural areas (Hubbard, 1997). The country has a mixed economy with agriculture as the dominating industry.

The agriculture sector employs three quarters of the labor force. The manufacturing industry which, is primarily based on agriculture and mining products contributes to 35% of the Growth Domestic Product (GDP). The manufacturing industry produces more than 5000 different products. The dominant manufacturing products are foodstuffs (24%), metal products (17%), chemicals (15%) and textile (12%) (Zimweb, 1996). The mining industry accounts only five percent of both GDP and employment (Theodora, 1995).

Under the export-led structural adjustment program launched in 1990, the manufacturing sector, being dynamic and diversified was targeted to engineer economic growth (Zimweb, 1996). Industrialists in Zimbabwe are calling for the restructuring of the education and training curricula. They are advocating for more emphasis on new technology, notably computer technology, in all economic sectors (Bloch, 1998).

Education and Training in Zimbabwe

The major goal of the Zimbabwe Government is to develop and promote tertiary institutions, which provide education and training opportunities that meet the diverse needs of all citizens (Mambo, 1998). The two education ministries, Ministry of Education and Ministry of Higher Education and Technology, have since launched a 'rationalization' plan aimed at providing vocational and technical education to its youth in order to prepare them to become healthy and productive citizens (Farmer, Taylor and Hwang, 1999).

The primary and secondary education in Zimbabwe consists of 7 years of primary education (from age 5-6), 2 years of Junior Secondary education (Zimbabwe Junior Certificate), 2 years at Senior Secondary (O-levels), and 2 years at High School (A-levels). In 1996, Zimbabwe had around 2,500 000 primary school students and 661 000 secondary school students (Munetsi, 1996).

When students have completed "O" levels or """ levels they can go for training and be awarded Diplomas in Teaching, Agriculture, Nursing and many other technical courses. Those with good "A" level passes can enroll at University for undergraduate studies (UNESCO, 1996). There are around 300 technical and vocational institutions, and 5 universities used by about 90,000 students each year (Munetsi, 1998).

The financing of university, technical or vocational education is generally shared among the State, the private sector, and donor resources. Donor funding packages are usually targeted at specific institutions. The USA, Germany, Canada, France, Switzerland, Yugoslavia, Holland, and Denmark have greatly supported technical and vocational education by providing the necessary infrastructure, equipment and training of locals (Munetsi, 1996).

Drafting and Design courses in most vocational and technical programs are still using the traditional 'board and T-square' technique to prepare design drawings (Ministry of Higher Education Syllabi, Zimbabwe, 1999). Most technical and vocational institutions offer computer courses. There is need to explore the feasibility of integrating CAD courses into Drafting and Design programs by making use of existing computer hardware in the various colleges. There should also be a rational approach to introduce and implement CAD technology to the curriculum regardless of the availability of computers or not, in view of the global competition in manufacturing and service industries (Hawkridge, 1991).

Chapter 3

METHODOLOGY

This chapter describes the methodology for this qualitative research study. The rationale for this approach was that, the study focused more on insights, discovery and interpretation rather than hypothesis testing (Farmer, Taylor and Hwang, 1996). Qualitative research investigates the quality of relationships, activities, situations, or materials (2000).

Three models on how some colleges in USA and Great Britain integrated CAD technology into Industrial Technology programs were reviewed, analyzed, and evaluated. Two educational institutions were selected from USA, Linn Technical College (Missouri) and Iowa State University. This was due to the availability of literature on the models adopted by the colleges. This study also reviewed literature on Zimbabwe's economy and tertiary education.

The criterion for analyzing and evaluating the literature was based on the following questions:

- What are benefits of CAD technology to the industry?
- Is there any need of integrating CAD technology into Drafting and Design programs at tertiary institutions in Zimbabwe?
- How can Zimbabwe integrate CAD technology into Industrial Technology programs at tertiary institutions?

A library research in this qualitative study was the primary source of information. No data on reliability or validity was provided due to the open-ended research questions. The primary method for data analysis in qualitative research studies is content analysis.

Data was collected mainly in the form of words over figures or numbers (Fraenkel and Wallen, 2000).

After careful review and study of data gathered during this study, conclusions and recommendations were formulated. The observations put forth were based solely on the information obtained from the literature review.

Chapter 4

FINDINGS

Findings reported in this chapter are results from this library-based research. The study focused on the integration of CAD technology into technical and vocational education programs in Zimbabwe. Comprehensive, but concise summaries of the findings are provided in the next three sections of this chapter.

CAD Technology and the Industry

There has an unprecedented growth in CAD technology in industry since its introduction in 1968. In a survey conducted 1987, 65,3% of major manufacturing firms in the world were already using CAD technology as a design and drafting tool.

The introduction of the personal computers in the early 1980s facilitated the production of low-cost CAD programs. As of 1985, the industry has been purchasing CAD workstations at a rate of over 10,000 per month worldwide.

The significant benefit from CAD technology is the increase in productivity. Use of CAD technology by draftspersons increases productivity by between 200 and 6000 percent, with 500 percent as the average. Industrialists cited the following reasons for switching on to CAD technology:

- Speed.
- Ease of editing.
- Use of stored symbols.
- Accuracy
- Less tediousness
- Less manual work

- Easy modification of designs.
- Provision of more time to experiment with designs
- CAD with 3D enhancement cuts costs and time in model building.
- The flexibility of CAD technology to create drawing views on different layers.

The use of CAD technology has spread into all engineering and technical fields. The manufacturing and the construction industries are the leaders in the use of CAD technology.

CAD technology is split into two broad categories, 2D CAD and 3D CAD. 2D CAD is basically a two-dimensional drafting technique. 3D CAD is an upgrade of 2D CAD, which allows designers to create three-dimensional surface and solid models as they work on their drawings. With 3D CAD technology, designers are able to conduct math and finite analysis on the three-dimensional solids. 3D CAD technology can also be integrated with CAM and Computer Integrated Manufacturing systems. By 1996, 66% of the CAD users were already using 3D CAD technology. Automotive, aerospace and construction industries are leaders in the use of 3D CAD technology. The use of any CAD system in industry is based on the type of product the industry is producing. There is no documented evidence available on the use of CAM technology by Industries in Zimbabwe.

CAD Technology in Zimbabwe

Research findings indicate that Zimbabwe is looking at the manufacturing and construction industries to spearhead and engineer economic growth in the export-led structural adjustment program launched in 1990. The manufacturing sector in Zimbabwe is so diversified and produces over 5000 different products. Zimbabwe has the second most developed manufacturing sector after South Africa in the Southern Africa region.

Industrialists in Zimbabwe are advocating for more emphasis on new technologies in the manufacturing and construction industries if the country is to survive the stiff competition, which the industry faces from other countries in the region, particularly South Africa. Major manufacturing and construction companies in Zimbabwe are already using CAD technology as a design tool as evidenced by records of sales of CAD equipment by vendors in the USA and Europe.

Evidence from reviews of Drafting and Design curricula in Zimbabwe's technical and vocational education programs show that drafting and design courses are using the 'traditional manual techniques' for preparations of drawings. Findings from this research could not yield any documented data on the use of CAD technology by colleges and universities in Zimbabwe.

Large technical and vocational colleges in Zimbabwe have computer departments, which in most instances are satisfactorily equipped. Public funds, the Zimbabwe Manpower Development Fund (ZIMDEF), which is based on 1% of an employer's wage-bill, and donor funds have been used to purchase computer equipment for technical and vocational institutions. However, most colleges do not have adequate computer equipment to cater for many educational and training programs.

<u>Integration of CAD Technology into Educational Institutions</u>

Findings from the three models used by educational institutions in the USA and Great Britain to Integrate CAD technology into the curriculum are described below.

Information about the original sources for the three models is available in the reference section.

Linn Technology College (Missouri)

Linn Technical College developed a 3-step model for integrating CAD technology into the Drafting and Design Department. The three steps are:

- Review of existing CAD systems
- Establishment of a criteria for evaluating existing CAD systems
- Selection of the optimum system

The research team in this study was comprised of experts from the industry, the faculty, and representatives from the Missouri State Department of Elementary and Secondary Education. It took six months for the research team to come with recommendations on the CAD system Linn Technical College had to purchase. A list of CAD systems reviewed and vendors consulted in provided the college report.

The 108-item evaluative instrument designed to evaluate CAD systems in this model is so comprehensive and it examines almost all issues and concerns related to CAD technology. Of the three models discussed in this study, the evaluation instrument developed at Linn Technical College emerges as best approach to the actual selection of a CAD system

Iowa State University (Iowa)

Iowa State University adopted a 5-step model to integrate CAD technology for its Industrial Technology Department. The 5 steps in this approach are:

- Collection of information.
- Observation of CAD systems in use.

- On-site demonstrations
- Selection of CAD ware.
- Choosing the vendor.

This model stresses the need for would-be buyers of any CAD system to demand that vendors and suppliers demonstrate the capability of each possible choice. Faculty should always-select simple but unique designs from its own sources and ask vendors to prepare drawings while they observe. This model suggests that the selection of the vendor of any CAD system should not be on the price but rather accessibility, reputation, experience, stability, and the type of services provided.

One significant issue, which this model fails to address, is the composition of the research team. The other two models do provide detailed accounts on who should be included in the CAD integration projects at each institution. The model emphasizes the selection of CAD software before hardware. It can also be used for the selection of software which, has to be compatible with existing computer systems in educational institutions.

CAD for Colleges in Great Britain

The Further Education Unit in Great Britain developed a seven-stage systematic procedure for integrating CAD technology into British College programs. The seven steps are listed below.

- Organizing a CAD task group.
- Analysis of departmental needs.
- Choosing possible solutions.
- Invitation to tender

- Selecting a system.
- Managing the system
- Staff training

This model provides a comprehensive section on the management of CAD systems. The model provides a detailed proposal on staff training. This model tends to investigate more issues pertinent issued related to the integration of CAD technology to educational curriculum than the other two models. The model emphasizes the need for the Task Group to be time conscious in carrying out the exercise due to the frequent and continuous changes in CAD technology. Lists of reputable CAD systems and vendors are provided in the appendix section of the Further Education report.

The model does not spell out clearly the criterion for choosing possible CAD systems to evaluate. There is need to develop a standardized instrument which, can be used to evaluate existing CAD systems. This has been left to individual institutions to develop their own means and methods of evaluating CAD systems.

Chapter 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This chapter includes a brief summary of the problem as well as the research procedures followed. A discussion of the findings along with conclusion and recommendations is also presented.

Summary

The purpose of this study was to determine the most effective means of integrating and implementing CAD technology in technical colleges and universities in Zimbabwe. The study reviewed how two educational institutions in the USA, Linn Technical College (Missouri) and Iowa State University (Iowa), and colleges in Great Britain have integrated CAD technology into the education system. The study also reviewed Zimbabwe's economy and its education system.

The research questions were: 1) Is there a need for CAD technology in Zimbabwe? 2) Does the industry in Zimbabwe require CAD technology as Drafting tool or a Design tool?, and 3) How can educational institutions in Zimbabwe integrate CAD technology into technical and vocational programs?

Data analysis in this qualitative library-based research study was based on content quality. No statistical data was used to validate and verify the implications of the findings.

Conclusion

The following conclusions were drawn from the findings of this study:

1. The overwhelming benefits of CAD technology to all engineering fields warrant all tertiary institutions in Zimbabwe to integrate CAD technology into the vocational and technical programs.

2. Colleges in Zimbabwe need to invest in 2D CAD technology, which is cheap and relevant to the level of technology prevalent in industry.

3. The CAD integration models developed by Linn Technology College (Missouri, USA) and the Further Education Unit (Great Britain) may be used on institutions in Zimbabwe, which intend to invest in both CAD software and hardware.

4. The CAD integration model developed by Iowa State University is ideal for Zimbabwe's educational institutions which, already have computer hardware, but need to select CAD software compatible with computer systems available in the colleges.

Recommendations

The following recommendations are based upon the findings:

1. Colleges and universities in Zimbabwe are encouraged to work closely with the local industry to integrate CAD technology into technical, vocational and engineering programs.
2. Tertiary institutions in Zimbabwe need to develop a standard instrument for evaluating CAD system. The use of this instrument can be extended to evaluating CAM systems.

3. Future studies should review more CAD integration models.
4. Future studies may trace the development of CAD/CAM technology in Zimbabwe.
5. There is need to explore the introduction of CAD technology to technical and vocational subjects in Zimbabwe's secondary education system.

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