A STUDY ON INTEGRATION OF COMPUTER ASSISTED INSTRUCTION WITH A TRADITIONAL TEACHING LEARNING PROCESS IN THE AREA OF MECHANICAL ENGINEERING EDUCATION

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Declaration

I declare that this thesis is my own investigation, and is not being concurrently submitted in candidature for any other degree.

Salah Mahdi Ahmad Abdulrasool al hamad

ABSTRACT

This study presents the design, implementation and evaluation of a CAL package included in the teaching and learning methodology of CAD-CAM-CNC modules at Sheikh Khalefa Institute in Bahrain. The CAL package contains CAD tutorial, CAM tutorial and Power Point slides for CNC operations. The study has been carried in response to internal departmental audit which highlighted some issues which need to be dealt within the subject area of Mechanical engineering.

Three groups of students with similar pre-abilities (similar average marks and standard deviations) were exposed to different teaching methodologies:

a) Traditional classroom lectures and laboratory sessions;

b) Classroom teaching including unsupervised computer simulation (hybrid learning approach)

c) Unsupervised CAD tutorials and supervised CAM-CNC computer simulation

The effectiveness of these three methods was determined by questionnaires (data collection methods) completed by Lecturers and students. Their answers were analysed from quantitative and qualitative points of view. The questionnaires were designed by taking into consideration the issues of reliability, validity and bias and concentrating on specific research questions. The Lecturers' questionnaires aim to find out Lecturers' opinions about the various aspects of educational process. The students' questionnaires intend to ascertain how well the CAD-CAM-CNC modules meet the stated learning outcomes and to identify the main strengths and weaknesses of various methods.

The students were assessed at the end of the term based on an engraving operation task which includes all elements of CAD-CAM-CNC operations. The author links the levels of cognition from Blooms' taxonomy with the activities which should be completed by students. The quantitative and qualitative analysis of students' marks versus learning ability indicators was performed and the results have been discussed.

The second evaluation method is based on quantitative analysis of the three groups of students' marks for assignments and exams. Also an analysis of time and material resources is performed and the main conclusion was that the group of students taught with a combination of CAL package and traditional method were more effective, efficient and satisfied with their learning experiences. So the proposed hybrid learning method (CAI plus traditional teaching method) is most suited for CAD-CAM-CNC teaching because the students find it easier and enjoyable to explore the subject area through various opportunities of learning.

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Glossary of Terms

TVE : Technical and Vocational Education

CAD : Computer Aided Design

CAM : Computer Aided Manufacturing

NC : Numerical Control

CNC : Computer Numerical Control

T&L : Teaching and Learning

CAL : Computer Aided Learning

CBI : Computer Based instruction

CAI : Computer Aided Instruction

DXF : Data Export File

CHAPTER 1

Introduction

The engineering education procedures and requirements are shifting rapidly in the modern era and practices being adopted therein are changing at a very fast rate. The visual and simulation capabilities of computer aided teaching materials and inherent flexibility in their use are contributing to the increase in quality of modern education.

Keeping with the international trend, the Kingdom of Bahrain has also embarked on reforming educational practices. The author has been involved in this process as the Head of Centre of Excellence within Ministry of Education in Kingdom of Bahrain. Also he has been a University Lecturer for fifteen years in the field of Mechanical Engineering.

The students willing to study engineering subjects are attending the A-level courses (Diploma level courses) offered by Technical and Vocational Education (TVE) department from Ministry of Education. Afterwards they can continue their studies at HE level and can obtain HNC or HND degrees.

Sheikh Khalifa Institute provides courses at TVE level in the engineering field: mechanical, telecommunications, electronics. The CAD-CAM-CNC module is common for Automotive, Welding, Manufacturing, Carpentry and Refrigeration students. It is a part of mechanical engineering subject area and has four stages during one academic year (see Figure 1.1).

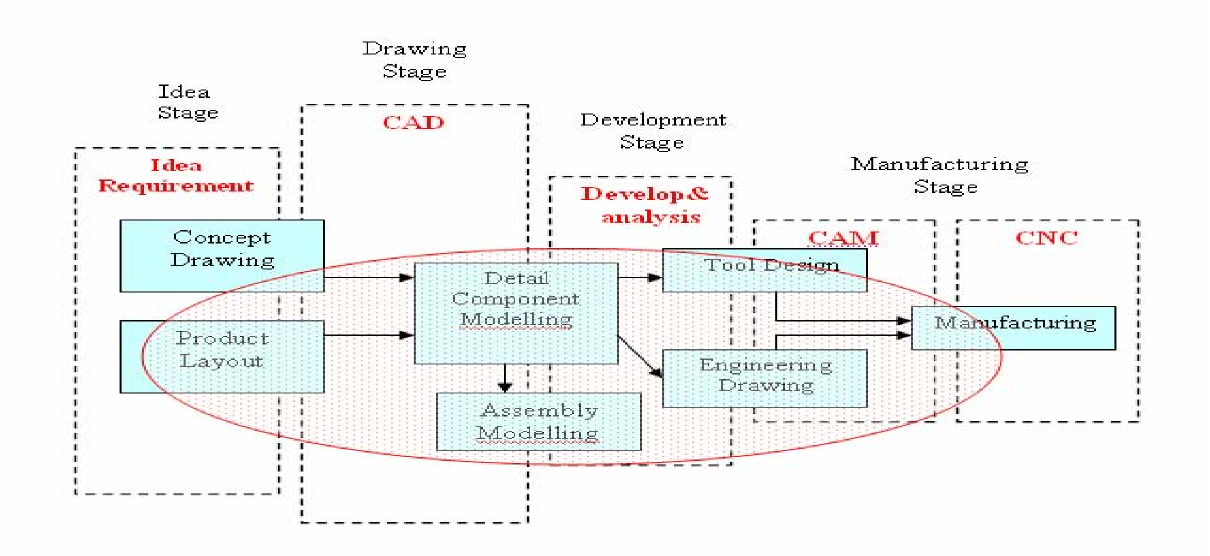

Figure 1.1 – The stages of CAD-CAM-CNC module

The students will be able to manufacture physical 3D components by understanding the concepts linked to product design, engineering drawing, product layout (Toogood and Zeeher, 2004). A learner must be able to take an idea to the product stage and hence teaching and learning (T & L) methodology should have embedded knowledge transfer elements. The learning outcomes for this module can be classified in two categories:

a) General engineering outcomes - The student will be able**:**

- To design and conduct experiments; identify and solve engineering problems
- To design a system, component or process to meet desired needs
- To use the techniques, skills and tools for modern engineering
- To design, analyze, implement, and manage effective production and service systems
- To integrate processes involving people, material, equipment, information, and controls.

b) Specific outcomes required by the manufacturing process: The student will have the ability:

- To design the part geometry, create engineering drawing for parts and assemblies.
- To enter the cutting parameters and generate tool paths for different layers.
- To load the machining program and verify it.
- To set up the machine for manufacturing process.

1.1 EXISTING PROBLEMS OF THE EDUCATIONAL PROCESS

UNESCO made an audit about the quality of education in Kingdom of Bahrain in 1994 and the results were published in a specialised report (UNESCO Report Bahrain, 1994). The educationalists in Curriculum Department from Ministry of Education have analysed the factors which influence the quality of T&L in engineering courses. Then they have suggested some changes into the education system in order to ensure that the engineering graduates have the appropriate level of knowledge, understanding and skills required by employers.

Even though changes have been implemented, the author (in his capacity of University Lecturer) has examined the educational process and curriculum for CAD-CAM –CNC course and realised that several problems have not been solved yet because retention rate is low. About 30 % gave up in the first semester and another 15 to 20 % left during the second semester (Ministry of Education -Kingdom of Bahrain Report 2001 – 2004) These are costly failures for the student, student's family, educational system and to the society in general. The students’ departure due to academic failure represented a very traumatic and unpleasant experience. In some cases the student never completely recovered and the damage imparted was permanent (Zywno, 2002).

Teaching methodology of engineering curriculum is traditional and significant changes have not been implemented for about 40 years (Shahati et al, 1999). The students used to produce manual drawings for CAD-CAM purposes until year 2000 so modern technologies were not implemented in the course content and /or delivery. Afterwards some practitioners have made innovations in employing new technologies in course offerings but these examples were local. Generally the students' marks remained low so the reform of whole educational system was still required. Bourne, Brodersen, Daw (2000) underlined that studies about revitalizing undergraduate engineering education have done more than add to the growing body of literature. They emphasised that innovations leading to lasting improvements in the educational process for engineers would be slow and difficult.

The CAD-CAM-CNC learning materials include different tasks and projects so the students should gain knowledge of manufacturing process and be able to perform practical tasks due to their developed skills. But the students are asked to memorise all the procedures for the sake of passing exams rather than understanding. Every lesson has some questions to measure the students' comprehension, but they do not test the students' manufacturing skills. The teaching becomes a routine affair with more theoretical inputs rather than practical application. Little attention is paid during practices sessions while using the CAD-CAM software by the students.

The employed methodologies used in delivering CAD-CAM-CNC materials do not match all students' learning styles. In CAD-CAM applications including complex manufacturing tasks without any instructor support (due to the shortage of technicians), it is noticed that students' skills are inadequate. The students feel that their instructors are not motivated and also they fail to encourage the class (Toogood, Zeeher, 2004; Abdulrasool et al, 2006; Shahati et al, 1999). Therefore the students exposed to the traditional T & L approach have generally low marks in mechanical engineering subjects and they are not capable to apply their knowledge and skills in practical applications.

The computer technology plays a great role in improving the T & L methodology in mechanical engineering subject area (Hmelo et al, 1995; Hill, Bailey, Reed, 1998; Cookman, 1998). The computer as medium of instruction can be used to manipulate and combine CAD and CAM operations. Visual effects offered by computers contribute to the easy design of mechanical components and assemblies (Bourne, Brodersen, Daw, 2000; Mikell et al, 2002). The author has decided to investigate the impact of Computer Assisted Learning (CAL) on the effectiveness of educational processes employed in the delivery of CAD-CAM-CNC subject due to the advantages of using technology in pedagogical practices.

Also this study describes the design, implementation and evaluation of an improved T &L strategy based on *hybrid learning*. The students are asked to study themselves computer tutorials about CAD and CAM module and are taught CNC materials with the traditional T&L method. Then they have to produce technical drawings for an engraving operation task and the Lecturers evaluate manually these drawings and complete a checklist.

The *user-centred design* of this proposed pedagogy practice is based on the findings of questionnaires evaluating the quality of existing T&L methods. The surveys were formulated by taking into consideration the issues of *reliability, validity and bias* and completed by the Lecturers and students. Then the evaluation of this proposed approach is done by students' self-evaluation based on a checklist, Bloom's taxonomy, students' marks, time and task management analysis.

The report has seven chapters as follows:

Chapter 1 - outlines the requirements of modern engineering education in CAD-CAM-CNC area at Sheikh Khalifa Institute and the proposed T&L strategy to overcome the shortcomings of teacher-centred approach (traditional).

Chapter 2 - highlights the findings of literature review about teaching methods, Bloom's taxonomy, CAL, teacher-centred approach, student centric learning.

Chapter 3 - presents the development of the proposed CAL tool and its implementation into the new T&L approach based on hybrid learning technique.

Chapter 4 - investigates the Lecturers' and students' perception of three T&L methods for CAD-CAM-CNC modules. The questionnaires' answers are analysed quantitatively and qualitatively.

Chapter 5 – describes the evaluation of the proposed CAL tool and T&L approach done by students' self-assessment checklist.

Chapter 6 - focuses on the evaluation of investigation of the proposed CAL tool and T&L approach based on Bloom's Taxonomy, students' marks, time and task management analysis.

Chapter 7 – contains conclusions and suggestions for further work.

The next chapter is showing the findings of the literature review on several topics.

CHAPTER 2

Literature Review

This chapter contains the critical appraisal of existing publications (books, journal papers, conference papers, websites) about Bloom's taxonomy, teaching methods, CAL, teacher-centred approach and student centric learning.

2.1. BLOOMS' TAXONOMY TO EVALUATE THE EFFECTIVENESS OF LEARNING PROCESSES

The main aim of any T&L process is to provide maximum learning effectiveness. There are a number of models to quantify the effectiveness of learning process (Weller, Repman, Rooz, 1995). **Bloom's taxonomy** is a framework that can be used for evaluation of effectiveness of different learning processes. It includes three learning domains accordingly to Anderson, Krathwohl, Bloom (2000):

- The *cognitive domain* relates to thinking and knowledge skills in literacy, numeracy, problem solving, spatial/visual literacy, inquiry based learning, productivity (see Figure 2.1).

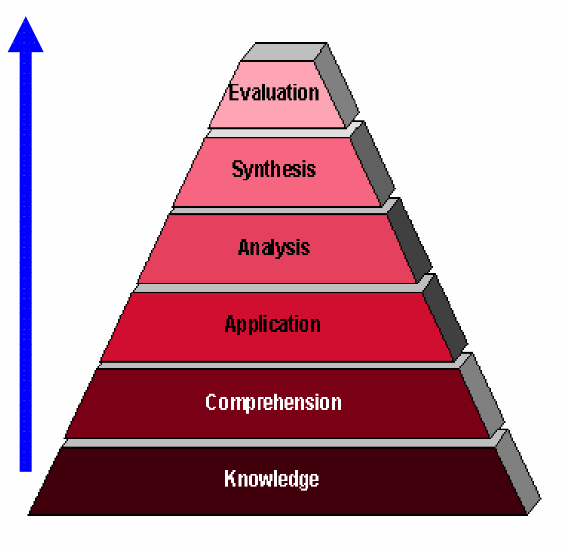

Figure 2.1- Bloom's Taxonomy (1956)

- The *affective domain* relates to emotions, attitudes, relationship with others, and values.
- The *psychomotor domain* is about physical skills, coordination, and interpersonal skills with others and the categories are ordered in degree of difficulty and they contain levels of learning development. In psychomotor domain the categories in the increasing order of difficulty are Imitation / Observation, Manipulation, Precision /Competent, Articulation / consolidation and Naturalization & Mastery.

Knowledge levels were re-classified because of the need to evaluate skills in traditional assessment methods (Abdulrasool, Mishra, 2006). So the new classification of knowledge, derived from Bloom's taxonomy, contains the following dimensions: recall, comprehension and routine application, and non-routine application, analysis, synthesis and evaluation. So by re-arranging levels of Bloom's taxonomy has helped Lecturers to effectively design and implement T&L and assessment strategies so the learning outcomes are achieved.

Abdulrasool and Mishra (2008) renamed the six levels of taxonomy to: remember, understand, apply, analyse, evaluate, and create. Create was the highest level of learning skill (and not evaluation as shown earlier in the process). Therefore, adaptation on Bloom's taxonomy is allowed in order to be used for specific learning purpose.

2.2. BLOOM'S TAXONOMY AND ENGINEERING EDUCATION

Wankat and Oreovicz (1993) provide a good example of an adaptation of Bloom's taxonomy to the needs of engineering education:

- Recall - entails routine information, definitions, descriptions and generalisations.
- Comprehension – is about understanding of technical representations, including translation, interpretation and extrapolation.
- Application - refers to the use of abstractions in particular situations, such as rules, procedures and theories to perform computations, and to find solutions.
- Analysis – is about breaking down a problem to its constituent parts so that the hierarchy, connections and structure are explicit, the problem is clarified, and its properties determined. Many engineering problems fall into the analysis category, because complex engineering systems must be repeatedly analysed.
- Synthesis - involves putting together elements to form a whole system or solution. Many students find synthesis difficult because the process is open-ended and there is no single answer.
- Evaluation - involves making judgements about the value of material or methods for given applications, about satisfying specific criteria, or about using the standard of appraisal. A major part of engineering work involves synthesis and evaluation. The former brings together problem solving, analysis, design, development of a plan, and implementation of the proposed solution. The latter may require external criteria such as economics or environmental impact. In most engineering problem-solving, determining the precise level of the taxonomy is difficult, as the use of several categories is typically required to complete an engineering task. Defining learning outcomes and designing objective tests so that higher level thinking is in evidence is thus complicated. As many engineering educators point out, while teaching/ learning process is purported to engage higher-level thinking and reasoning skills, standard evaluations usually rely on knowledge acquisition or routine knowledge-

application (Abbott, Greenwood, Yolanda, Tapia, 2006). Questions and projects that elicit synthesis and evaluative skills and deep learning strategies are under-represented (Heather, Steve, Stephanie, 2003; Anderson, Krathwohl, Bloom, 2000; Heywood, 1999). It is said that it is not done enough to encourage a deep approach to learning among engineering students (Domin, 1999). Zywno (2003) established a relationship between hypermedia and Bloom's Taxonomy levels of learning. The results showed that the knowledge achievement is better when hypermedia instruction was implemented. It was also found that low ability learners gained more when using hypermedia in lower cognitive categories. The high ability learners benefited more at the higher cognitive categories.

2.3. COMPUTER AIDED INSTRUCTION (CAI) IN CAD-CAM-CNC AREA

The interactive teaching in engineering education represents an alternative approach to lecturing **(**Dijk, Berg, and Keulen, 1999**)**. Studies have shown the positive effect of *interactive teaching* on learning effectiveness. An interactive computer technology system with CAD and multimedia software can be used as a tool to make the traditional lecture more effective and have a positive influence on student's motivation (Emory, Groover, Zimmers, 2002). Computers are increasingly employed for classroom instructions as also for individualised and distance education (Kumar 2006). Computer based instruction (CBI) is variously known as Computer Aided Learning (CAL) in the UK and Computer Assisted instruction in the USA. Either of these refers to on-line direct interactive learning experience through the computer. It can be done in many different modes of instruction, some of which are:

- Tutorial mode
- Drill and practice mode
- Simulation mode
- Discovery mode
- Gaming mode

CAD, CAM, CAI, reverse engineering and rapid prototyping are tools that play an important key role within product design, and technical knowledge that must be part of engineering and industrial design courses **(**Roger and Jack, 2004**)**. This study seeks to understand how the addition of a computer tool to CAD, CAM and CNC application in mechanical engineering subject area affect students in several dimensions. For example their achievement, their attitudes, their interaction and action in the classroom and laboratory affect their achievements **(**Bourne, Brodersen and Daw, 2000; Heather, Steve and Stephanie, 2003**)**.

As technology has been introduced in classrooms over the last twenty years, research on the effects of technology has also been necessary. Much of the research on the use of computers has focused on the achievement of students (Bhavnani, Suresh, Bonnie, 2000).

Hill, Bailey, and Reed (1998) have looked at different aspects of using computers: group work, gender, attitudes, and problem solving, among others**.** Yet this field of research is characterized by a technological approach rather than a pedagogical approach.

Therefore in this research project, the computerised data collection and analysis tool will be align to a structured pedagogical approach and the CAI tool will be carefully designed so the instructional goals of the CAD-CAM-CNC modules are achieved.

Engineering drawing and manufacturing CAD-CAM tools represent a medium to link all Mechanical Engineering subjects so the Lecturers should pay special attention to these (Toogood, Zeeher, 2004). CAD-CAM tools can therefore be seen as the medium for understanding the mechanical engineering subjects and developing students' flexible vision by incorporating ICT in instructional process. Zywno (2002) has underlined that the development of engineering subjects (specifically mechanical engineering issues) has only been possible because of the medium of instruction with technology tools.

There are several advantages of Computer aided Instruction (CAI) and Computer Aided Learning (CAL) packages: Based on Kumar (2006, 1995).

- Computer instructions (commands) are sent individually to each student.
- The student can respond to instructions continually when he/she receives it so reinforcement is learning is easily achieved.
- Student gets fast feedback to his/her response.
- According to Skinner's approach, learning units are divided into small elements of learning.
- Learning sessions are manageable by proper time duration (30 minutes – 1 hour)
- The student can access computers any time and place.
- The student has many options to learn - through case studies, solving problems, etc.
- Self- assessment/ evaluation can be done by the student at the end of each learning chapter or at any stage of learning progress.

Computer technology plays a great role in developing the methodology of T & L in mechanical engineering subject (Gall, James, 2001-2002; Schott, 1991). Use of computers revolutionised traditional drawing and manufacturing subjects and a new module of CAD-

CAM-CNC came in existence. The teaching methodologies for this subject however remained unchanged (Bourne, Brodersen, Daw, 2000).

Guidelines for educational instruction software design have traditionally adopted a transmissive view of instruction derived from behaviourist and information-processing learning theories (Catalano, and Catalano, 1999). Software designed under an objectivist paradigm (Kadiyala, Crynes, 2000; Lonka, Ahola, 1995) tends to view the learner as a passive recipient of instruction accordingly to (Liao, 1999):

Interactive computer instruction based on instructivist pedagogy generally treats learners as empty vessels to be filled with knowledge.

These types of computer instruction-based environments are usually designed for individual students working separately on computers and ignore group learning goals in these designs. The following steps have been introduced by Kumar (1995) for design of CAI:

- Needs analysis and identification.
- Goals and objectives definition.
- Alternative methods for identifying the needs.
- System components design.
- Resources analysis including resources required, available and constraints.
- Action required for modifying constraints.
- Instructional materials selection.
- Development of student assessment procedures.
- Field testing including formative evaluation.
- Adjustment and improvement, and further evaluation.
- Summarise evaluation.
- Operational installation.

The use of CAI allows flexibility to instructor to incorporate *student-centric approach*. The student centric approach is based on the empirically proved hypothesis (Aspy, 1972) that the students achieve superior academic results and even personal growth in terms of higher self-confidence, openness to experience, etc., if they learn in an atmosphere or climate that can be characterized by three basic attitudinal conditions: realness, acceptance, and empathic understanding. Unlike *teacher centric approach*, the student centric learning allows learners to explore their full potential. Because of the importance of the drawing and manufacturing in the process of teaching and learning engineering subjects, the teaching of drawing CAD with the use of computer technology has been recommended in the vocational curriculum of Bahrain (Abdulrasool et al, 2007). In this way the instructors are expected to modify their teaching methodology to make it more student centric. With the advent of the National Curriculum, however, CAD with computer technology is well and truly immersed on the agenda in Bahrain curriculum, both in the school classroom, laboratories and at Teacher Training institutions. Engineering students in Bahrain have basic proficiency levels set for them and trainee Lecturers are now required to acquire a basic level of competence in explaining drawing and manufacturing process with integrating computer technology (Tennyson, Elmore, Snyder, 1991; Schott, 1991). The Curriculum for drawing and manufacturing requires that pupils should be taught how to solve engineering problems and be given opportunities to develop their understanding and use of standard skills in industrial work. The integration of CAI with mechanical subject enhanced the effectiveness of T&L methods (Toogood, Zeeher, 2004; Bourne, Brodersen, Daw, 2000). The drawing and manufacturing program used in T & L process was CAD with the use of Auto Desk Inventor features as standard program. This program allows students to import these drawing features on CNC machine for manufacturing.

The expectation from mechanical engineering Lecturers in Bahrain is that they should be capable to adopt teaching methods which combine traditional teaching with simulation in order to provide an optimal learning environment for most (if not all) students in classroom and laboratories. The most common methods used in universities all over the world are (Wankat, Oreovicz, 1993; Wankat, et al, 2002; Abdulrasool et al, 2007):

- simulation learning without teacher supervision
- simulation learning with teacher supervision
- computer assisted learning (CAL)

Traditional ways of teaching in engineering education situation show the existence of a step-by-step process of learning which begins with the exploring the theoretical content of the subject. Then students need to perform practical tasks in the laboratory or workshop to understand more about the theoretical concepts. However, the shortage of suitable aids for teaching and lack of curriculum review have contributed to students' difficulties. This has been highlighted by previous researches where the problems of Mechanical Engineering education through lecture occur due to unsuitable teaching aids or approach. Most of the contents of mechanical engineering subjects consist of theories about moving components (Toogood, Zeeher, 2004; Emory, Groover, Zimmers, 2002). Hence the explanation about these components should be included with demonstration or use suitable teaching aids to make sure students can observe the relation between theory and reality (Rowe, 2002).

Further there is need for a structured integration of traditional teaching methods with computing resources. The specific advantages offered by computing resources to traditional teaching are quick calculations, data storage and dynamic simulations. However the interaction between man (teacher) and machine (computer) needs to be managed in a structured way in class room environment for optimum benefits (Crosby, Inding, 1997).

This section has clearly reviewed the need to have computer assisted instructions in the CAD-CAM-CNC module. It is proposed to develop a teaching methodology which will include CAI in order to facilitate structured acquisition of knowledge. The effectiveness of the CAI would be assessed by comparing students exposed to traditional teaching with students exposed to CAI (Weller, Lan, Repman, Rooze, 1995). Since CAD-CAM-CNC involves drawing as well as manufacturing aspects, it is proposed to integrate CAI in two different ways as explained in Chapter 3.

2.4. SUMMARY

The aim of this study is to investigate the impact of CAL on T&L effectiveness for CAD-CAM-CNC modules which are integral to mechanical engineering related courses.

Based on the extensive literature, the following research tasks have been identified:

- Estimate the effectiveness of the T&L facilities, processes and instruction material.
- Determine the Lecturers and students' attitudes about three T&L methods for CAD-CAM-CNC topics
- Evaluate the efficiency of tools (course materials, training manuals, software packages) used in T&L process to enable the transfer knowledge
- Observe the time and tasks management when students' perform practical exercises.
- Identify different points of view of those involved in T&L processes for CAD-CAM-CNC topics, namely Lecturers and students.

Next chapter discusses about the rationale and development of CAL package.

CHAPTER 3

Development of Computer Assisted Learning (CAL) Package

The learning outcomes of the CAD-CAM-CNC modules in mechanical engineering subject area include the students' ability to understand and apply the basics of design and manufacturing processes as well as use specialist computer programs and CNC machines.

UNESCO performed a survey on the Engineering Education in Bahrain (UNESCO, 2005). The report findings have been taken into consideration by the TVE Directorate from Ministry of Education in Kingdom of Bahrain which has organised an audit in 2006. Their conclusions have been included in an official report (TVE Directorate, 2006) and showed that there is a need to improve T&L strategy in Engineering Education to increase the skills level of Engineering students (especially in Mechanical engineering subject area).

The author has decided to develop an effective CAL package to improve the existing T & L methodology in CAD-CAM-CNC modules in his capacity of Head of Centre of Excellence within Ministry of Education and as a University Lecturer. The CAL package contains CAD tutorial, CAM tutorial and Power Point slides for CNC operations.

The prototype of CAL package was evaluated by experts (Course Area Leader and two Lecturers). The product was changed in accordance with their comments and then the CAL package was tested on students and Lecturers teaching the modules.

Information processing theory can be used to design CAL packages for educational purposes (Mikell, Groover, Zimmers, 2002; Jony and Sarti, 1994). Lecturers and students have various ways of thinking about learning process and they have to be taken into account in the design of CAL packages. Also the designer should decide how one wants to guide the learner (teaching) and how the learner will process the information (cognition). The packages should be user friendly so the information should be presented in a useable and supportive manner.

Generally the CAL packages are designed for: being used independently on computers by individual students; achieving learning objectives; measuring and assessing individual's abilities and competencies; integrating new technology into the educational system (Oliver, Omari, Herrington, 1998). These packages provide several representations of reality, avoid oversimplification by representing the complexity of their tasks, and provide real projects and case-based learning environment. Also they have to support student's combined construction of knowledge in meaningful reliable environments (Tennyson, Elmore, Snyder, 1991; Skinner, 2000). Zywno (2003) suggests that CAI should generate cognitive learning (Bloom. et al

1956) by promoting opportunities for learners to express personal ideas and opinions, experiment with ideas, engage in complex environments which are representative of interesting and motivating tasks and receive opportunities for intrinsic feedback. In addition, this helps students to have the opportunity to submit their own work and ideas when required. Further, this will help to build good relationships among students and they will have the collaboration in different situations as there are constructed, debated and reformulated just like in the real scientific process (Wildt and Ahtola, 1978).

3.1. REASONS FOR DEVELOPING THE CAL PACKAGE

The elicitation of student's instructional drawing and manufacturing views is a key strategy in any teaching approach informed by constructivism (Zywno, 2003). The CAL package developed in this research project is designed to use the well-known OBSERVE – EXPLAIN – APPLY – MODIFY - JUDGE tasks strategy. Hence the package offers an alternative to other 'diagnostic instruments' such as student interviews, questionnaires, tests, assignment and concept project. Also CAL package offers the students opportunities for learning (Zywno, 2003) because the CAD-CAM learning strategy is more than an investigation of student's understanding. It has the potential to help students to explore and justify their own individual ideas (especially in the production and reasoning stages). If the observation phase of the CAD-CAM-CNC task provides some conflict with the student's earlier drawing and manufacturing, reconstruction and revision of initial ideas is possible during the simulation or explanation stage.

Several elements / areas which are generally used for quality assessment (Madhumita, 1995) have been taken into consideration in the CAL design process:

- Accuracy- extent to which data is correct, reliable and certified free of error;
- Consistency- extent to which information is presented in the same format and compatible with previous data for example transfer data from CAD to CAM-CNC
- Security- extent to which access to information is restricted appropriately to maintain its security.
- Timeliness- extent to which the information is sufficiently up-to-date for the tasks.
- Completeness- extent to which information is not missing and is of sufficient breadth and depth for the task at hand and help the user to bring the reality of the work in the classroom and laboratory.
- Concise- extent to which information of the computer aided instruction is compactly represented in proper way.

- Reliability and accessibility - it gives flexibility to the students using the computer aided instruction with out Lecturer instruction easily and quickly.
- Availability- extent to which information is available and accessible to all CAD-CAM-CNC students and Lecturers during the laboratory work.
- Relevancy- the standard of the computer aided instruction was designed to meet the CAD-CAM-CNC students' requirements of the study plan.
- Usability - extent to which computer aided instruction is designed clearly and easily to use.
- Understandability- extent to which computer aided instruction instructions are clear without ambiguity and easily prepared.
- Believability- extent to which information is believable to the learner.
- Navigation- extent to which data are easily used and linked the classroom work CAD with the laboratory work CAM-CNC.
- Usefulness - extent to which information of the computer aided instruction is designed overcomes the problems within the mechanical engineering subject area.
- Efficiency- how students can design and manufacturing the project using computer aided instruction tools without errors.
- Value-Added- extent to which computer aided instruction is beneficial, provides advantages from its use.

The CAL package is designed by the author to be used by students in collaborative groups. This is a significant change from the use of other methods of 'investigation of understanding'. For example, student interviews, questionnaires, tests, assignment, concept project and student journals are usually completed individually (Mayer, 1999; Zywno, 2003). By using this computer investigation in group, obviously ideas elicited and documented by the computer package are not necessarily an individual's views and indeed may be socially mediated ideas (within the small groups). Hence the detail of individual student's preconceptions is somewhat diminished by allowing the students to work in collaborative groups. However, most Lecturers do not have time to inspect and analyse individual results of these formative assessment tasks in the class. So students are asked to produce individual parts and then to combine them in assemblies which are evaluated by the Lecturers. So the collaborative uses of CAL package give students the opportunity to reflect on their own and others' ideas and construct meaning in a social setting. This represents an implementation of a social constructivist perspective on learning (Madhumita, 1995; Mayer, 1999; Zywno, 2003).

3.2. AIMS OF THE COMPUTER ASSISTED LEARNING (CAL) PACKAGE

- **Cognitive Learning Outcomes for Students**

The package is designed to elicit and promote discussion about student's drawing and manufacturing conceptions. The collaborative use of the CAD-CAM-CNC computer tasks is designed to facilitate these peer discussions, promote conceptual development and consensual meaning-making in the domain of Drawing and Manufacturing by one or more of the following:

a) Articulation, modifying and justification of a student's work before manufacturing.

b) Facilitates students work and reflect on the viability of student's ideas.

c) Simulate the CAD-CAM-CNC procedures and feature before lab work.

d) Students can construct, practice and share their new ideas on their free time.

The package also provides students with an opportunity to engage in 'mechanical field design' (Abdulrasool et al, 2007; Zywno, 2003) and a means of developing mechanical Drawing and manufacturing skills (e.g., Exploration, Justification, Practicing, Modifying, Negotiation and challenge).

- **Description of CAD Drawings and CAM-CNC Tasks**

The final CAL package is developed using the PowerPoint, digital video, (see tutorial Package in Appendix 1) software. It makes use of 40 drawings, 62 manufacturing PowerPoint slides and digital film of appropriate CAD-CAM-CNC demonstrations. The PowerPoint and video demonstrations depict scenarios that present real drawing features to the students. They include OBSERVE-EXPLAIN-APPLY-MODIFY-JUDGED tasks designed to act as instructional CAD-CAM-CNC views in the drawing design and manufacturing module (Mikell, Groover, Zimmers, 2002).

Also instructions for CAD-CAM-CNC tasks are designed to bring out students' instructional drawing and manufacturing views (Abdulrasool et al, 2007; Zywno, 2003), (see tutorial Package in Appendix 1). The package was designed to be used collaboratively in order to initiate student's ideas, reflection and consensual judgements and foster a social constructivist learning environment. The computer environment facilitates a move away from traditional whole class demonstrations, provides a suitable scaffold for CAD-CAM learning strategy and supports the use of the digital video medium to present complex features (Chen, and Ford, 1998). Like other instruments designed to elicit students' views (e.g., assignment, tests and concept design tasks), the package also offers the students an opportunity to learn and understand many features of the drawing generation process. These represent a new development in the use of the CAD-CAM-CNC strategy in mechanical engineering education (Toogood and Zeeher 2004).

Each CNC task requires students to use their drawing and manufacturing skills for achievement of learning outcomes and be able to explain any discrepancies between their product (their solution to the CNC task) and initial requirements. Therefore instead of observing real life demonstrations (traditionally conducted by the Lecturer in a whole class setting), in the observation phase of the CAD-CAM-CNC sequence the students collaborate in small groups at their computers to make detailed qualitative observations of the PowerPoint and video-based demonstrations (Abdulrasool et al, 2007; Zywno, 2003). These observations provide the intrinsic feedback on their earlier production.

In the laboratory environment the students make their technical drawings and manufacture workpieces using a checklist format. Then they compare the characteristics of workpieces with the initial CAD drawing (Emory, Groover, Zimmers, 2002; Toogood, Zeeher. 2004).

- **Rationale For Including CAD-CAM-CNC Tasks into CAL package**

The reasons for including CAD-CAM-CNC tasks into CAL package are aligned with general guidelines on the *constructivist design* of CAI process:

1) The computer environment permits more intimate, small group interactions where the students have control on the demonstrations and Lecturers have more time to interact with students.

2) The computer environment can scaffold the sequencing and presentation of the CAD-CAM-CNC tasks. For example, the package used in this study does allow the students to view the PowerPoint or video of a demonstration (the observation phase) during drawing and manufacturing phases. So they can change their responses after viewing the PowerPoint slides and video recordings. The CAL package can also help the learner to save the drawing and manufacturing CAD-CAM responses into a database.

3) The computer environment can support the use of the PowerPoint and video medium to present the physical scenarios that are the focus of the CAD-CAM-CNC tasks.

4) The PowerPoint and digital video clips can also provide realistic contexts for the students to consider (for example showing dangerous, difficult, and expensive or time consuming tasks). In this way the students become more aware that performing CNC tasks require a high degree of responsibility. The use of PowerPoint and digital video gives Lecturers and students sophisticated tools to observe dynamic processes and physical phenomena in intricate detail, the ability to repeat the procedures and replay exact replications of demonstrations.

- **Video research in education**

The author performed a critical review of existing publications regarding the best practices and guidelines for video research in education (especially about coding, collection, analyzing, archiving and sharing video data).

The use of video as visual aids in physics education dates back to the 1950's when the American Association of Physics Lecturers sponsored a set of films to bring together current film technology, the expertise of the film producer and the knowledge and experience of outstanding physics Lecturers. These were followed in the 1950' s by the well-known Physical Science Study Committee (PSSC) with series of films, parts of which survive today in the videodisc series *Physics Cinema Classics* (Emory, Groover, Zimmers, 2002). An important pedagogical limitation is the passive viewing of these films by the students without the opportunity of the Lecturer to respond immediately and appropriately to the students' needs (Toogood, Zeeher. 2004).

Video-based CAD-CAM laboratories have been reported positively in the engineering education literature (Abdulrasool et al, 2007; Zywno, 2003). In these learning sessions, interactive video presentations are used to help students make observations, measurements and gather data about tasks so the learning takes place in a social constructivist environment with integrated technology.

3.3.POWER POINT SLIDES AND DIGITAL VIDEO RECORDINGS

- **Selection criteria -** The Power Point slides and digital video demonstrations needed to contain interesting and relevant material and where appropriate, surprising outcomes suitable for inclusion in CAD-CAM-CNC tasks. The outcomes had to be clearly visible and preferably rely on student's direct observation skills rather than second hand observations using measurement instruments and machine tools (Zywno, 2003). The demonstrations had to be suitably challenging for students in an introductory drawing and manufacturing course but not too challenging to avoid students guessing and encourage personal reasoning. Commercial sources of CAL slides needed copyright permission.

  The author performed extensive investigations of existing commercial software packages. Also he consulted with TVE department and IT experts from the Ministry of Education. The copyright agreement was obtained for PowerPoint software and video packages.

CAD tasks have been included in the Power Point slides by the Lecturers teaching CAD topics. Also a video camera has recorded the practical actions of CAD lecturers when they were solving the examples.

The technical content of CAM tasks is included in a tutorial and CNC tasks have been included in the Power Point slides by the Lecturers teaching CAM-CNC subjects (including the author). Also a video camera has recorded the practical actions of CAM-CNC Lecturers when they were solving CAM tasks and performing CNC operations.

Examples of students' actions when using CAD tutorial

The students are asked to practice 2D sketch (Circle), adding dimensions, extrude, concentric hole in small bush. The tutorial provides verbal and written guidance to them. The learning tutorial contains the following steps (See Figure 3.1) for the specified task:

Step 1: Specify center of Circle (Center Point Circle)

Step 2: Select General Dimension

Step 3: To finish 2D sketching, Right Click & Select Done

Step 4: To finish 2D sketching, Right click & Select Finish Sketch

Step 5: Select Extrude, and then select the Profile that will be extruded**.** Finally add the require Distance and click OK

Step 6: Select 2D Sketch to create Sketch, Select Surface then Enter

Step 7: Repeat steps 1 to 4

Step 8: Select Profile, Operation Join), Distance,

Step9: Select Hole, Specify Placement (Concentric), Plane in which hole will start, Concentric Reference (Cylinder Edge), Diameter of the hole, Termination (Through All).

So the computer tutorial provides a multisensory experience which is controlled and managed by the users' actions or decisions. The students' interaction with information can have a positive effect on learning since people remember/internalize more information if they interact with it (e.g. hear, see, and do). The computer tutorial provides an excellent means of generating interaction through interfaces that require the user to make choices and perform actions and therefore the learning is promoted by association through interactive user interfaces.

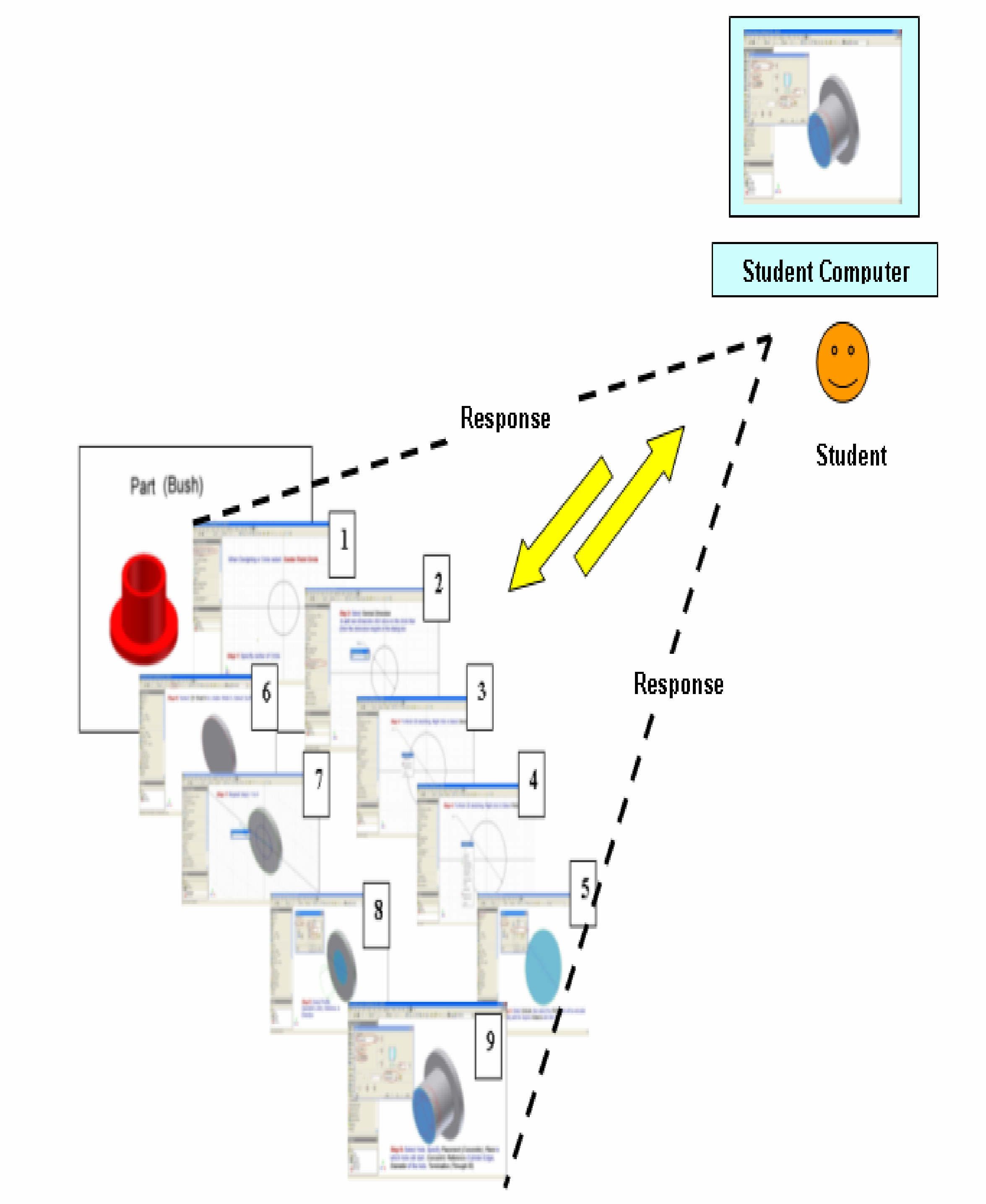

Figure 3.1. Actions for 2D sketch (Circle) from CAD tutorial

The students are asked to assemble together various parts and generate a 3D model. The CAD tutorial contains the following steps (See Appendix one CAL Packege):

Step 1 - Part modelling: Extrude, New Sketch Plane, Projection View.

Step 2 - Placed feature: Join, cut, Chamfer, hole, thread and fillet.

Step 3 - Shaft Generator: Gear Modeling.

Step 4 - Assembly Modeling: Set up Assembly Modeling, Assembly Catalog, Attaching Parts, and 3D Assembly Constrains, such as Mate, Flush, Angle, & Insert.

Step 5 - Engineering Drawing: Setting up the Layout, Setting up the Title Block, Setting the views, Setting up the Dimensions & Editing.

Step 6 - Image files of 3-D views for presentation purpose and save the shaft and the gear as DXF file.

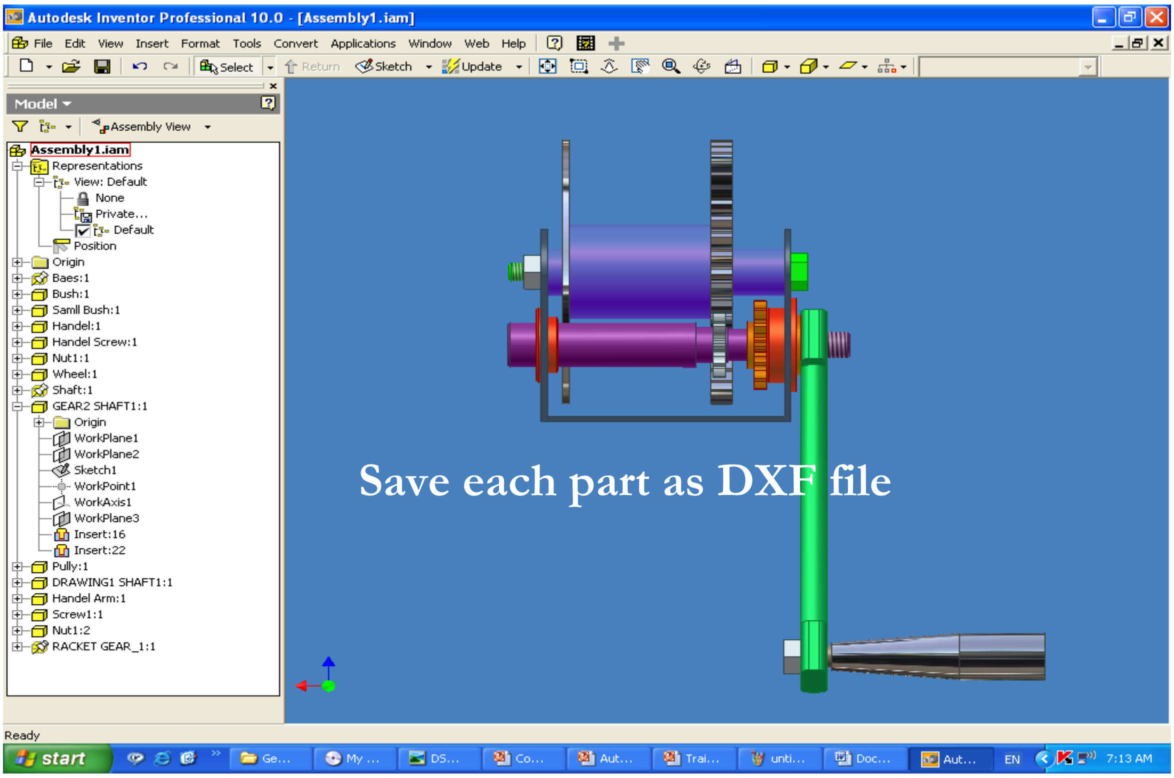

Figure 3.2. Actions for 3D modelling from CAD tutorial

Tutorial Packages from Appendix 1 contain the snapshots of the instructions for CAM tasks and CNC operations of mechanical shaft and gears. The Lecturer presents the CAM tutorial and CNC operations to the students in the laboratory environment (supervised learning).

3.4. IMPLEMENTATION OF THE DEVELOPED CAL PACKAGE

The prototype for CAL package containing the interactive CAD tutorial, CAM tutorial and CNC instructions (commands) was evaluated by the experts (Course Area Leader and two Lecturers). Then it was changed in accordance with their observations was tested on students and Lecturers.

Expert (heuristic) evaluation of the prototype for CAL package

The expert evaluation has been done by informal discussions between the three experts and the following aspects were targeted accordingly to Nielsen heuristics (Nielsen, 1994):

- Visibility of system status – the user knows what is going on through appropriate feedback.
- Match between system and the real world – the language is clear, with phrases and concepts familiar to the user. The information is presented in a natural and logical order.
- User control and freedom – the package support undo and redo and has "emergency exits"
- Error prevention – the package checks for error-prone conditions and present users with a confirmation option before they commit to the action.
- Flexibility and efficiency of use- the product can cater to both inexperienced and experienced users.
- Help and documentation - easy to search, focused on the user's task and have concrete steps.

The following changes have been made in the initial prototype after expert evaluation stage:

a) recordable user response was made more user friendly.

b) one tutorial was developed to help students gain familiarity with the QuickTime toolbar (see tutorial Package in Appendix 1).

c) the ability to go back to previous screens and edit or modify responses was added.

d) the background colour for Power Point slides was changed to white for ease of reading

e) arrows were included in order to point out important parts of technical drawings.

Then the modified CAL package was tested on students and Lecturers presenting the modules and their opinions were expressed by answering questionnaires. The results of quantitative and qualitative analysis of their answers are presented in Chapter 4 and Chapter 5.

3.5. SUMMARY

The author has decided to develop a CAL package in order to improve the existing T & L methodology in CAD-CAM-CNC modules at Sh. Khalefa Institute. The CAL package contains CAD tutorial, CAM tutorial and Power Point slides for CNC operations.

The reasons for developing the CAL package are explained and it is emphasised that CAD-CAM-CNC learning strategy is more than an investigation of student's understanding. It has the potential to help students to explore and justify their own individual ideas (especially in the production and reasoning stages). The design of CAL package is based on the cognitive learning outcomes introduced in the modules specifications. The CAD-CAM-CNC tasks are included in accordance with the general guidelines on the constructivist design of CAI process. Then the Power Point slides for CNC operations and digital video recordings for CAD and CAM tutorials are developed by considering the user-centred design approach.

The students are asked to study individually the CAD tutorial and the Lecturer presents the CAM tutorial and CNC operations to the students in the laboratory environment (supervised learning). The prototype of CAL package was evaluated by experts (heuristic evaluation) and the product was changed in accordance with their comments. Then the CAL package was tested on students and Lecturers teaching the modules.

Next chapter discusses about the User Evaluation of the education environment for CAD-CAM-CNC modules

CHAPTER 4

User Evaluation of the education environment for CAD-CAM-CNC modules

This chapter describes the structure of CAD-CAM-CNC sessions and three T&L methods. Their effectiveness was determined by questionnaires completed by Lecturers and students. Their answers were analysed from quantitative and qualitative points of view.

A typical flow chart explaining the operations required in a typical CAD-CAM-CNC session is shown in Figure 4.1.

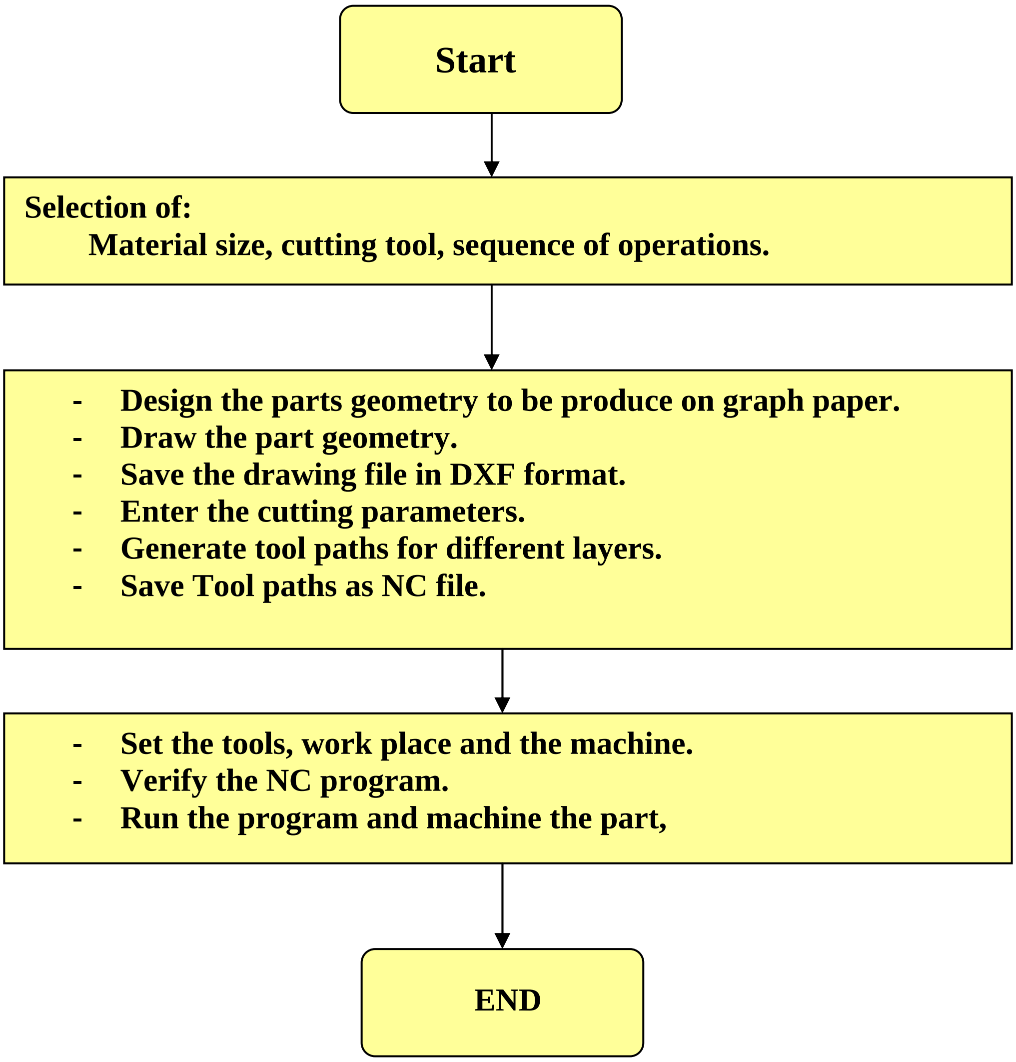

Figure 4.1 Planning a CAD-CAM-CNC session

4.1 TEACHING AND LEARNING (T&L) METHODS IN CAD-CAM-CNC MODULES

There are three T&L methods which have been studied:

a) Traditional classroom lectures and laboratory sessions;

b) Classroom teaching including unsupervised computer simulation

c) Unsupervised CAD tutorials and supervised CAM-CNC computer simulation

These three T & L methods are examined for their usefulness and acceptability with the Lecturers and students by questionnaires.

Method 1 - Traditional classroom lectures and laboratory sessions - The Lecturer explains various tasks that require memorization of factual information on routine procedures which include design and drawing (CAD) of an object and detailed description of manufacturing process (CAM-CNC). The Lecturer then shows students how the skills learned in classroom are used in practice by practical demonstrations of the procedures on actual CNC machine. Then students are encouraged to repeat these procedures in their own time without any support (Roger and Jack, 2004; Bourne, Brodersen, Daw, 2000; Emory, Groover, Zimmers, 2002). The Lecturer uses the computer interface of a projection unit (see Figure 4.2) in order to give theoretical background of the drawing process, explain standards and describe other activities. The resources available to students are CNC manual, exercise book and access to fifteen computers. The Lecturer supervises students continuously during this Lecturer-centred session.

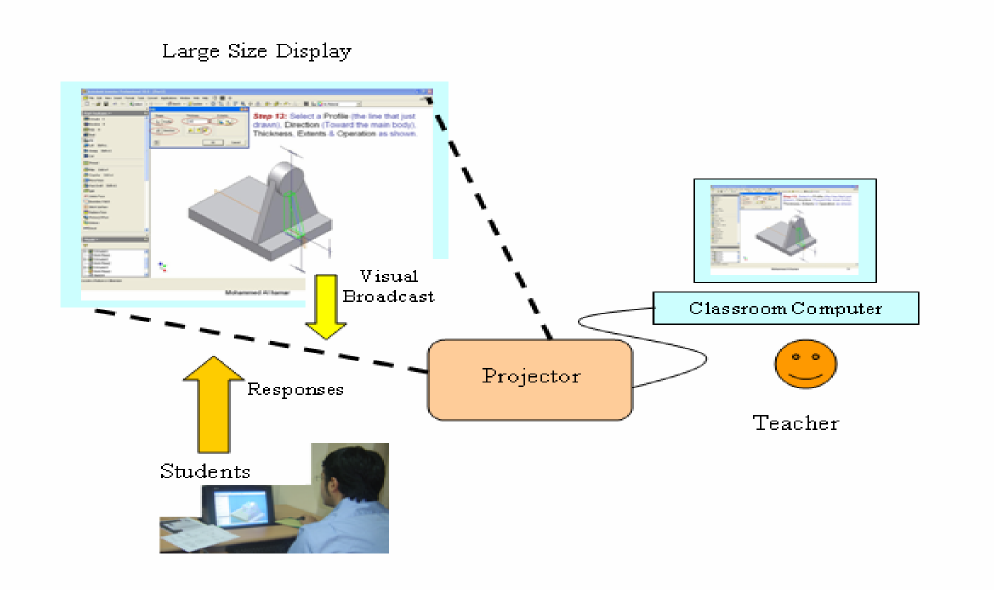

Figure 4.2. Method 1 – computer linked with projector for traditional delivery

Method 2 - Classroom teaching including unsupervised computer simulation – The Lecturer uses Autodesk Inventor (Wikipedia, 2009) to describe CAD-CAM applications and the students can follow the suggested procedures and be able to see the simulation results on the computer screen (see Figure 4.3). The Lecturer delivers the lecture with the use of computer interface linked with projector. The students are given are CNC manual, exercise book and access to computers to work in parallel with the Lecturer. The computer software describes the procedures step by step and in a dynamic way for CAD session.

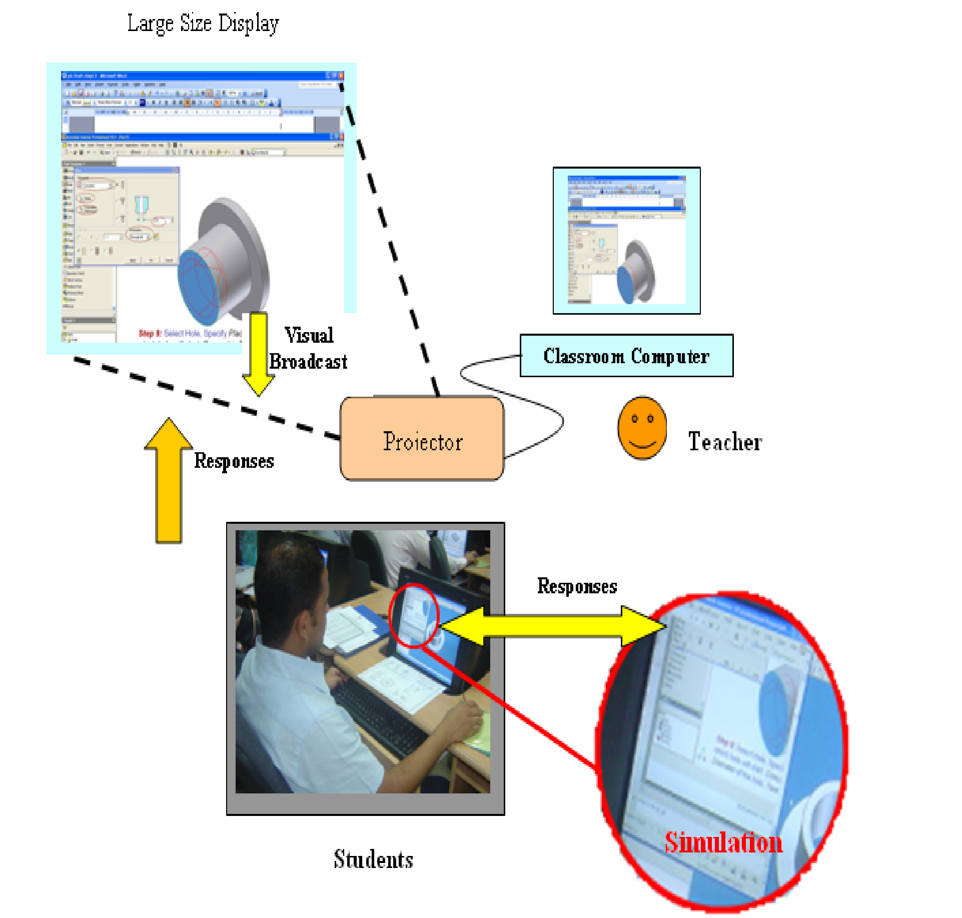

Figure 4.3. Method 2 – computer tutorials presented by Lecturer for CAD training

Various activities are included in the CAM-CNC part as for example: create cutting parameter for each part; generate tool paths for different layers for each part; generate final checklist for prototype etc. A software package is used to adapt a drawing file from a CAD program in DXF format and convert into an NC code (CAM part). Each computer used by students is connected to a CNC machine tool so the generated NC program is used to actually cut the real workpiece on the CNC machine (see Figure 4.4).

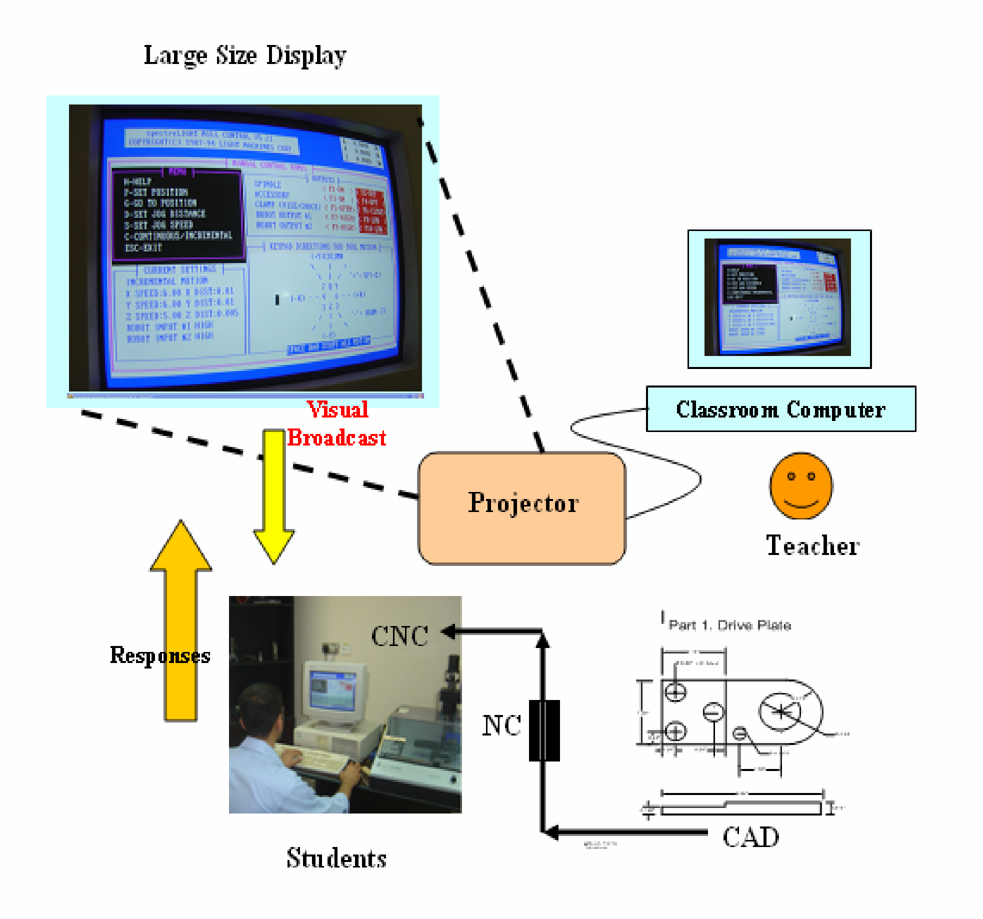

Figure 4.4. Method 2 – CAM-CNC sessions

Therefore the students are exposed to the laboratory environment for CM-CNC sessions and the Lecturers demonstrate to them the practical procedures applied to real CNC machines. Also the students are provided with computer simulation models of these procedures which can be used whenever they want (Toogood and Zeeher, 2004; Bourne, Brodersen, Daw, 2000; Abdulrasool et al, 2005; Shahati, Alsafar, Abdulrasool, 1999).

Method 3 - Unsupervised CAD tutorials and supervised CAM-CNC computer simulation

The Lecturer provides computer tutorials including video and animations which show the students how to use CAD (see Figure 4.5). They are asked to study these in their own time (unsupervised study) and they have to solve exercises which are assessed by the Lecturers on the basis of a checklist (see Checklist in Appendix two). Students have the opportunity to switch between CAD programme and Power Point slides and discuss the subject matter with each others (peer tutoring) so collaborative learning takes place.

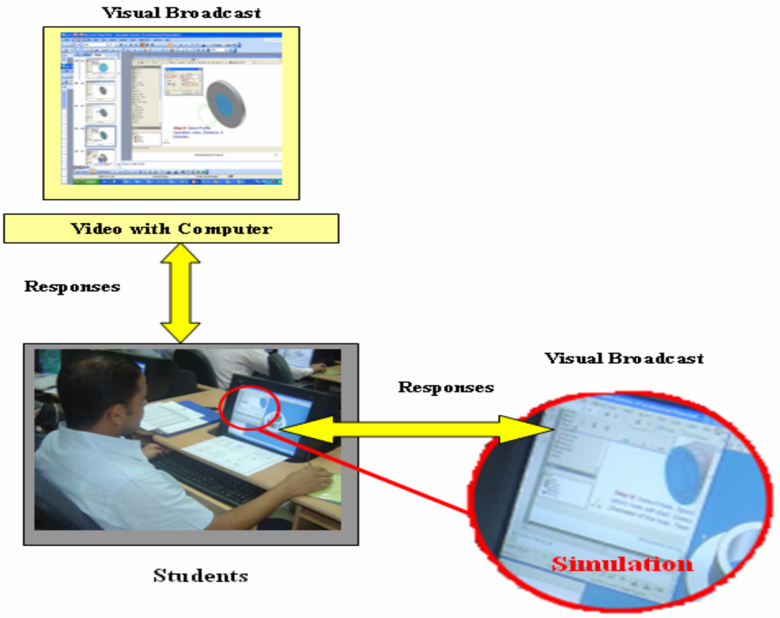

Figure 4.5. Method 3 - computer tutorials with video and animation for CAD training

After this formative assessment stage, the students are given supervised demonstrations of application of CAM –CNC so the regulations for health and safety are fulfilled (Figure 4.6).

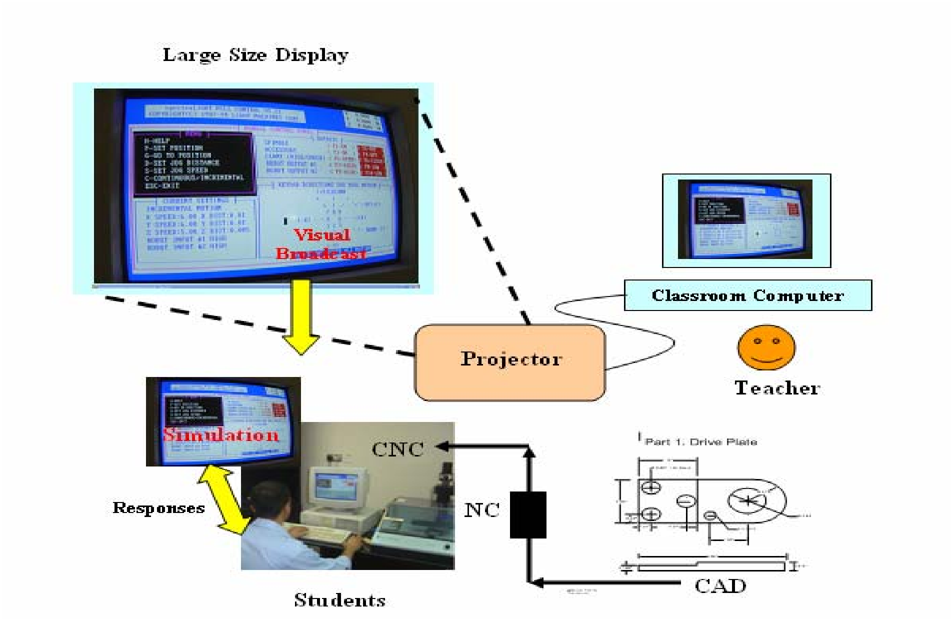

Figure 4.6. Method 3 – CAM – CNC sessions

4.2. USER ANALYSIS

A number of 45 first-year students are divided into three equal groups (see Table 4.1):

Group 1 - exposed to method 1 (traditional classroom lectures and laboratory sessions);

Group 2 – subjected to method 2 (classroom teaching with unsupervised computer simulation);

Group 3 – exposed to method 3 (unsupervised CAD tutorials and supervised CAM-CNC computer simulation).

Group number	No of students	Level of student marks	
		Average Marks	Standard Deviation
Group 1	15	67	5.84
Group 2	15	66.13	13.22
Group 3	15	66	12.57

Table 4.1. Characteristics of the three groups of students (users)

Group 1 has low standard deviation in marks which indicates a homogeneous group. Group 2 and Group 3 have high standard deviation marks so they are heterogeneous.

Video recordings for Group 2 have been made for 12 sessions (one term). The camera focused on individual students to record interactions and activities as well as finer elements such as reaction to recall of data, understanding information, applying knowledge to a new situation and dividing complex information into simple parts for better understanding. The video camera did not focus on the computer screens, but faced the students and monitored the Lecturer's physical movement and inter-group dynamics. This video footage carried a wealth of visual information that helped to reconstruct the social dynamics of the classroom and add meaning to audio recordings of Lecturer. All video and audio equipment were positioned to minimize intrusiveness on the students (*Hawthorne effect* - Jones and Northrop, 2006). These video recordings were automatically stored in text files and some snapshots are included in Figures 4.2. – 4.6.

The effectiveness of the three T & L methods described above is evaluated by questionnaires which have been completed by Lecturers and students. The data collection methods, questionnaire design and implementation and results analysis are presented in the next sections.

4.3. RESEARCH QUESTIONS WHEN FORMULATING QUESTIONNAIRES

The questionnaires intend to examine the effectiveness of the three T & L methods versus the learning objectives for CAD-CAM-CNC modules. The changes performed in the T&L strategy (see Method 2 and Method 3) aim to make learning personal, ensure learners get the information in the way they need it, their knowledge is immediately applied in the context of realistic working situations and can make mistakes in safe environments (simulation).

Method 2 and method 3 are shifting the emphasis from Lecturer-centred to student-centred learning by including computer tutorials that encourage learning through problem solving, discovery and enquiry. So the student-centred learning approach with interactive learning and teaching enables the development of employability skills (such as learning how to learn, understanding, evaluating and using knowledge and continuous improvement). This aspect was considered when formulating the questions addressed to Lecturers and students.

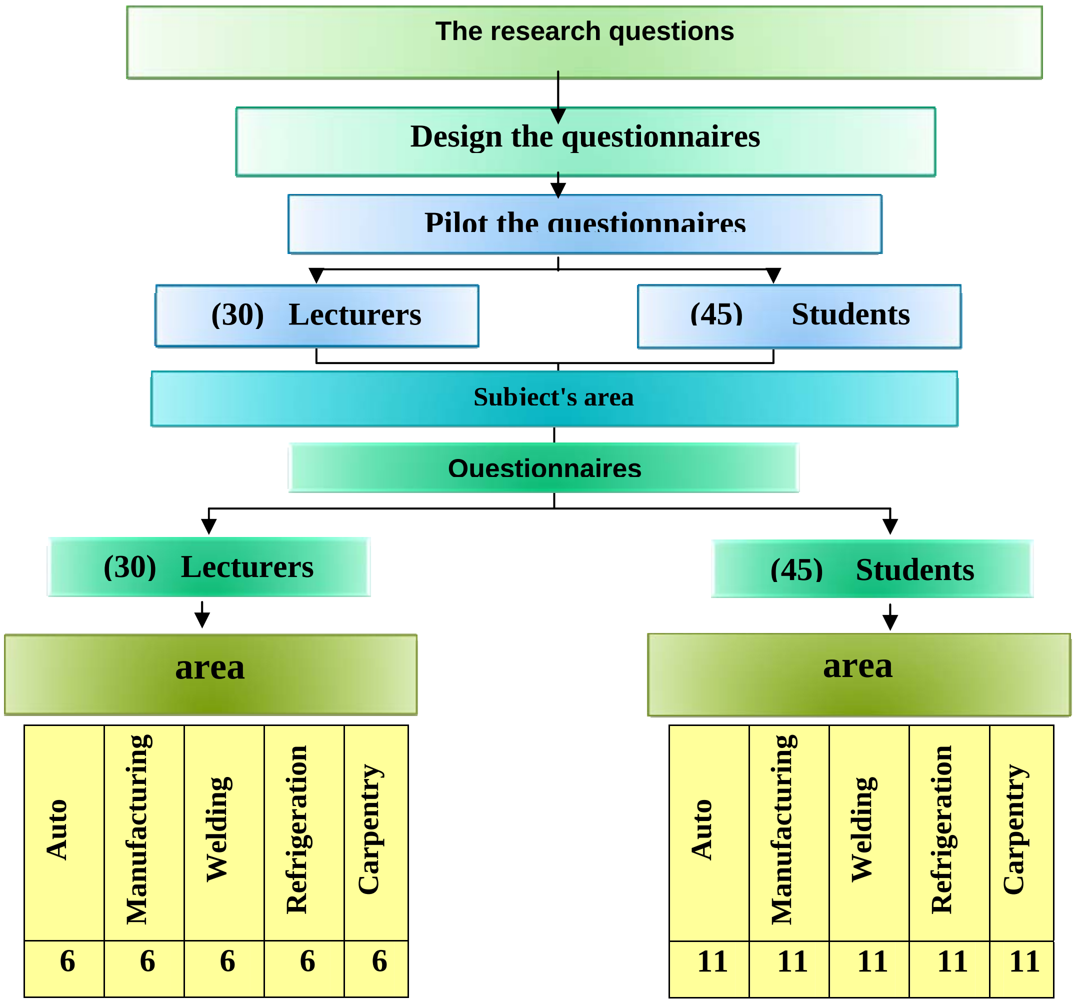

Figure 4.7- Evaluation methodolgy - questionnairse

4.4. QUESTIONNAIRE DESIGN PROCESS

Robson et al (1995) classify the enquiries in terms of their purpose and used research strategy. Tripartite classification distinguishes between the principles and techniques necessary to gain data analysis. It covers the main issues of the preparatory work, provides information to clarify the object and purpose of the enquiry.

The first step in designing the research was to identify the research purpose which dictates the selection of the research methods, bearing in our mind the dictum that "*the purpose of the research determines the methodology and design of the research*" (Felder, and Soloman, 2001). The second step was the design of questionnaires which was the main method of data collection. Then a pilot study was conducted for a number of students and Lecturers and the responses of the questionnaires were analysed.

The following research questions were considered when designing the questionnaires (see Table 4.2.)

Questions	Methods used
What is the CAD-CAM-CNC Lecturer's teaching methodology from Lecturers and students point of views?	Lecturer (see appendix 3) Questionnaire / Interviews
What are the student's views about teaching and learning CAD-CAM-CNC?	Students (see appendix 4) Questionnaire / Interviews
What are the student's opinions about teaching CAD-CAM-CNC?	Students (see appendix 4) Questionnaire / Interviews
What are the student's attitudes towards CAD-CAM-CNC?	Students (see appendix 4) Questionnaire / Interviews
What are the Lecturer's views about classroom management and organisation?	Lecturer (see appendix 3) Questionnaire / Interviews
What are the Lecturer's views about assessment?	Lecturer (see appendix 3) Questionnaire / Interviews
What are the Lecturer's attitudes towards CAD-CAM-CNC?	Lecturer (see appendix 3) Questionnaire / Interviews

Table 4.2. Research questions considered in the design of questionnaires

The main advantages of using questionnaires to evaluate a certain situation or product are:

- An efficient use of time.
- Anonymity (for the respondents)
- The possibility of a high return rate.

- Standardised questions (Felder and Soloman 2001).
- A clear idea of what is supposed to be measured.

The Lecturers' questionnaire looks at the critical attributes of the learning process and assist in the identification of elements which need to be in place to promote learners progress and achievement. The design of Lecturers' questionnaires aim to find out Lectures' opinions about the following aspects of educational process:

a) Planning and organising the teaching session;
b) Delivering the instructional material;
c) Management of students within the classroom;
d) Assessment of students' performance;
e) Lecturers' attitudes towards various T & L methods.

The students' questionnaires intend to ascertain how well the CAD-CAM-CNC modules meet the stated learning outcomes and to identify the main strengths and weaknesses of various T&L methods. Also it is intended to improve students' learning experiences by increasing the student involvement in education process. So the questions referred to the following topics:

- Student's attitudes towards learning CAD-CAM-CNC subjects;
- Student's opinions about their Lecturers' approaches to teaching process;
- Student's opinions and views about various aspects of T&L the CAD-CAM-CNC subjects such as: session planning and organising; delivery of course material; classroom management; assessment and feedback strategy; students' interaction.

Introductory Letter – explains that the questionnaires should be completed by the Lecturers who teach CAD-CAM-CNC modules and the final year students from Mechanical Engineering courses. The research aim and importance and confidentiality reassurance are included in it (Cohen et al, 2000). The letter also thanks the respondents for their co-operation (see appendix 3 Lecturers Questionnaire).

Questionnaire Sampling – Three groups of 15 students from automotive, manufacturing, welding, refrigeration and courses (see Table 4.3) have been taught by three T & L methods:

Group 1 - traditional classroom lectures and laboratory sessions;
Group 2 - classroom teaching including unsupervised computer simulation;
Group 3 - unsupervised CAD tutorials and supervised CAM-CNC computer simulation

Table 4.3. also contains the expertise of Lecturers who are teaching the CAD-CAM-CNC modules. It has been decided to select final year mechanical engineering students because:

- They are more confident in expressing their views in comparison with junior students;
- They have been taught the basics of CAD-CAM-CNC subjects in the previous year.

The present study was not carried out for whole population of mechanical engineering students of the institute due to factors such as expenses, time and accessibility (Cohen et al, 2000). This research employed the *probability sample* because it draws randomly from the wider population and allows the generalisation of questionnaire findings.

Groups	Area									
	Lecturers					Students				
	Auto	**Manufacturing**	**Welding**	**Refrigeration**	**Carpentry**	**Auto**	**Manufacturing**	**Welding**	**Refrigeration**	**Carpentry**
Group 1	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
Group 2	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
Group 3	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
Total	**6**	**6**	**6**	**6**	**6**	**9**	**9**	**9**	**9**	**9**
	30					**45**				

Table 4.3. Lecturers' expertise and students' courses

Analysis methods – generally the author (researcher on this case) analysed most of the items separately to provide specific information that contributes to the overall picture that is obtained. The use of one item test is quite satisfactory when one is seeking out specific fact (Bell, 1999; Boon, 1997). The students' and Lecturers' answers were ranked according to the following scale:

Agree – Neutral (Undecided) - Disagree

The agreement and disagreement of each answer was calculated by the summation of frequencies and summation of percentages of the positive perceptions (agree), and the negative responses (disagree), and the third category is undecided.

4.5. LECTURERS QUESTIONNAIRE

The aim is to find out the Lecturers perception of the teaching experience while teaching

CAD-CAM-CNC topics and the effectiveness of the three T&L methods. Previous studies (Bhavnani, Suresh, Bonnie.2000; Dye, 2003; Gall, and James 2002; Borg, And Gall, 1979), suggested that a part of the problem in CAD-CAM-CNC subject area is the use of inappropriate teaching methods which affect student's achievement. Through this questionnaire an attempt has been made to understand Lecturer's experience of the T&L process and the questions were divided into five categories (Figure 4.8.)

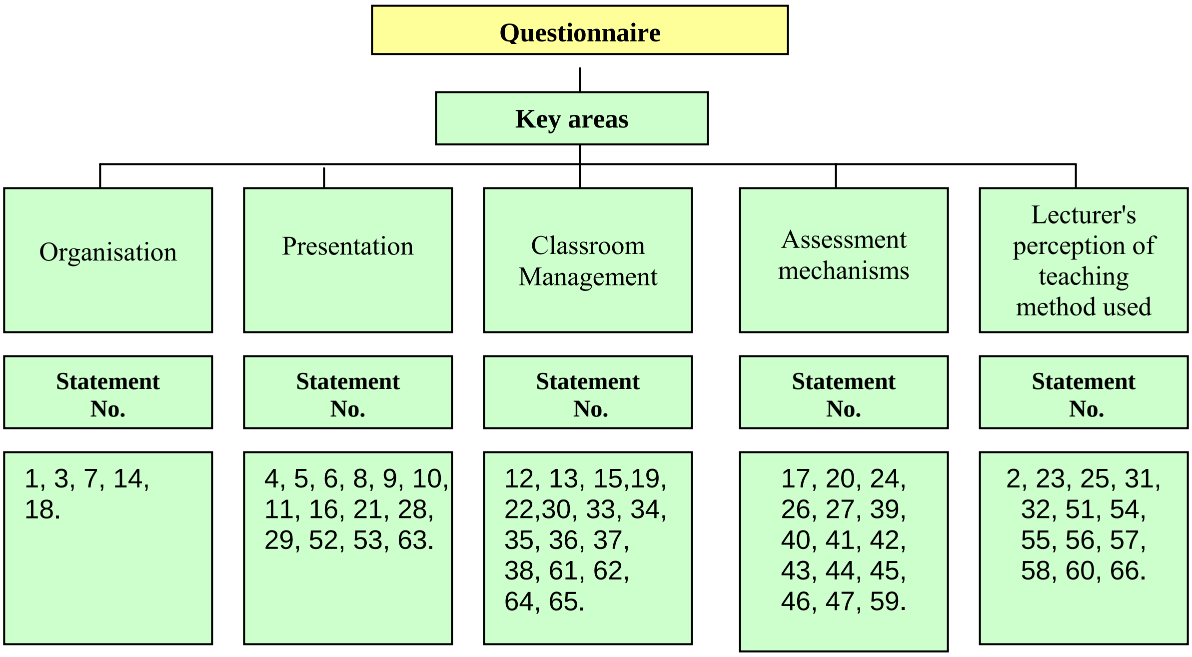

Figure 4.8. Key areas for Lectures' questionnaire

The distribution of Lecturers' responses to the questionnaire is presented in Appendix 3 teacher Questionnaire and the results of quantitative data analysis for Lecturers' responses divided in the five key areas are included in Appendix 5 teacher data analysis.

The qualitative analysis of relevant Lecturers' responses is done by observation as follows:

Key area 1 - Planning and organising the teaching session

- Only 20% of the Lecturers teaching Group 3 have their own techniques to prepare their lessons so the rest are using some written guides in order to design their T&L sessions which is understandable because they are dealing with computer simulation activities.
- All Lecturers teaching Group 1 (traditional T&L approach) are using the Lecturer's guide because this method does not require the introduction of ICT in teaching.
- It is difficult to explain various tasks involved in CAD-CAM-CNC subject area without using a number of examples. So 90% of Lecturers teaching Group 1, 70 % of Lecturers teaching Group 2 and 100 % of Lecturers teaching Group 3 agreed that they use many examples to explain lessons.

Key area 2 – Delivering the instructional material

- 90% of the Lecturers for Group 2 and Group 3 use visual aids as a normal part of their repertoire, where as only 50% of the Lecturers for Group 1 do it. The Lecturers were asked earlier in the current research if they have adequate teaching aids at institute, like TV, video, computer and handouts. 90% per cent of them said the support is inadequate. This indicates that there is not enough provision in the institute in terms of using these teaching aids.
- 80 % of Lecturers for Group 1 recognised that they have difficulties in presenting CAD-CAM-CNC topics because the traditional T&L method is not the most suitable one for discussing modern subjects. However 40 % of Lecturers for Group 2 and 30 % of Lecturers for Group 3 have difficulties in presenting the subjects because the computer technology is helping them to explain the difficult drawing or manufacturing tasks with ease.
- 80 % of Lecturers for Group 1 agreed that the students find it difficult to see the relevance of what they learn in CAD-CAM-CNC modules because it is difficult to make the connection between theory and practical applications with traditional T&L approach. Only 50% of Lecturers for Group 2 and 30% of Lecturers for Group 3 have the same problems combining the teaching with simulations gives a lot of opportunities to link theory with practice.

Key area 3 - Management of students within the classroom

- 40 % of Lecturers for Group 1 agreed that group learning is an effective method but students have limited freedom in choosing activities in the traditional T&L approach. A number of 80 % of Lecturers for Group 2 and 90 % of Lecturers for Group 3 agreed with this concept because the unsupervised study of computer tutorials encourages better communication between students.
- 100% of Lecturers for Group 1 find it difficult to encourage the students to participate in classroom activities because the traditional T&L approach is not conducive to students' interaction. However 70 % of Lecturers for Group 2 and 80 % of Lecturers for Group 3 were happy with their teaching methods and effective students' interaction when teaching with computer assisted simulations.
- 20% of Lecturers for Group 1 agreed that the traditional T&L method is suitable for a large group of students while 60% of Lecturers for Group 2 and 70% of the Lecturers for Group 3 agreed that the computer assisted teaching methods are suitable for classes with large numbers of students. Once again the use of CAL package and CAI approach increases the effectiveness of T&L processes.

Key area 4 - Assessment of students' performance

- 100 % of Lecturers for Group 1 and for Group 2 are reinforcing the transmitted knowledge by asking relevant questions at the end of sessions. Only 90 % of Lecturers for Group 3 are doing the same thing because the extensive use of computer tutorials is helping students to understand better and solve various exercises.
- Only 60% of Lecturers for Group 1 encourage the students to express their opinions and judge their drawing and manufacturing parts for their usefulness because T&L approach is teacher-centred. A number of 80 % of Lecturers for Group 2 and 90 % of Lecturers for Group 3 are supporting students to have their own views because the student-centred approach is conducive to this type of behaviour.
- Only 10 % of Lecturers for Group 1 find it easy to rate the students' knowledge, understanding and abilities because the traditional T&L method does not offer a lot of opportunities to perform formative assessment. But 70 % of Lecturers for Group 2 and 60% of Lecturers for Group 3 find it easy to assess the students' work by using computers.
- No Lecturers for Group 1 consider that the traditional T&L method increases the students' performance while 70 % of Lecturers for Group 2 and 80 % of Lecturers for Group 3 sustain that the use of CAI in educational process increases students' performance.

Key area 5 - Lecturers' attitudes towards various T & L methods.

- 60 % of Lecturers for Group 1 and 70 % of Lecturers for Group 3 have friendly relationships with students so the students do not find it difficult to ask the Lecturers for more explanations as needed during the lesson time. However 90% of Lecturers for Group 2 communicate in a friendly manner with students because Lecturers' attitudes became friendlier when using computer technology.
- 70 % of Lecturers for Group 2 and 80 % of Lecturers for Group 3 mentioned that the teaching method with support of computer technology encourages the students to learn. A number of 70% of Lecturers for Group 1 found it difficult to do the same thing because the traditional T&L approach with face-to-face lectures and Lectures' explanations for CAD-CAM tasks and CNC operations are not so appealing to students.
- 80 % of Lecturers for Group 2 and Group 3 mentioned that CAL encourages the students to think logically (not only to memorise) since the structure of the drawing and manufacturing lessons is built rationally according to the students' needs. All Lecturers for Group 1 disagreed

with this statement because in the traditional teaching the students are following Lecturers' logic rather than thinking for themselves and Lecturers' main concern is to finish their lesson rather than giving students time to think.

The overall effectiveness of teaching methodology incorporates all answers and is presented in Appendix 5 (Data Analysis of Lecturers' Answers to Questionnaires).

4.6 STUDENT'S QUESTIONNAIRES

The aim is to find out the learning experience of students in the CAD-CAM-CNC module and effectiveness of the three T&L methods. The study has been carried out to explore problems during teaching and learning process in the subject area of CAD-CAM-CNC. The questionnaires have been formulated to understand the mechanics of the learning process from student's perspective. Previous studies (Bhavnani, and Bonnie, 2000**;** Dye, 2003; James. 2002; Borg, and Gall 1979) suggested that a part of the problem in CAD-CAM-CNC subject area is the use of inappropriate T&L methods which affects students' achievement. Through this student's questionnaire has been attempted to elicit student's views and opinions about teaching and learning process. A number of categories have been used to analyse student's learning experience. These categories have been designed to generate the interpretation and explanation of the student's response to the questionnaire. Also, various categories used in the questionnaire have been shown in the figure 4.9.

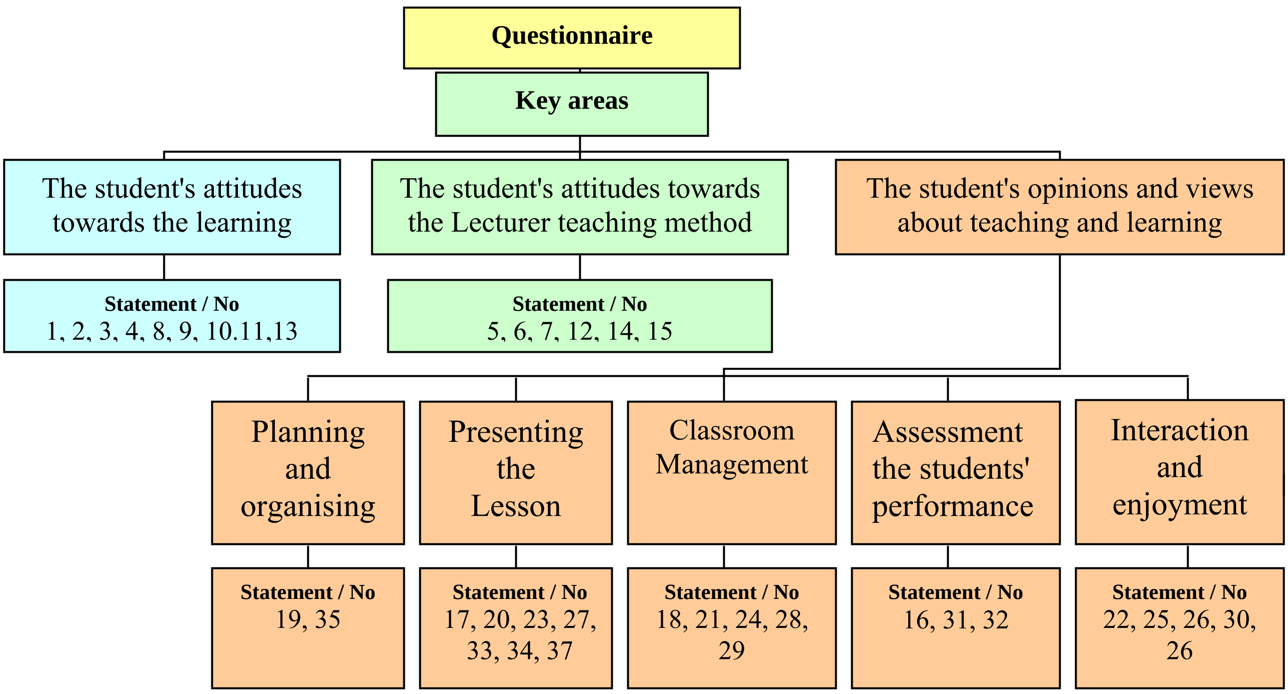

Figure 4.9. Key areas for students' questionnaire

The distribution of students’ responses to the questionnaire is presented in Appendix 4 (Students Questionnaire) and the results of quantitative data analysis for students responses divided in three key areas are Appendix 6 (Students data analysis).

- Student’s attitudes towards learning CAD-CAM-CNC subjects;
- Student’s opinions about their Lecturers' approaches to teaching process;
- Student's opinions and views about various aspects of T&L the CAD-CAM-CNC subjects such as: session planning and organising; delivery of course material; classroom management; assessment and feedback strategy; students’ interaction.

Key area 1 - Student’s attitudes towards learning CAD-CAM-CNC subjects

- 93.3% of the traditional teaching students in group1 do not like engineering drawing and manufacturing as a subject. Also, the entire group 2&3 (teaching with support of computer technology) said they like T&L with computer package CAI subject. This could be because of the necessity of learning CAD-CAM with learning package that enables them to draw and manufacture correctly. Also 87% to 93% of the students agreed that learning with the help of computer technology helps to develop their learning abilities in engineering drawing and manufacturing.
- Most of the students in Group 2&3 agreed that learning CAD-CAM-CNC will improve their engineering skills in CAD-CAM-CNC of Mechanical Engineering subject area. The students value the subject matter taught but they have problems with the way it is taught. In traditional teaching group 67% students said will improved their skills because there is no enough time for interaction with subject activities. And most of the students in the three methods agreed that the knowledge of drawing and manufacturing features will help them to improve their practical skills. Also this will reduce their mistakes when they are practicing their drawings.
- The students explain one of the reasons why they have negative attitudes towards teaching of CAD-CAM-CNC using traditional teaching method. 80% of the Group 1 (traditional method) students find it difficult to understand the material in the CAD-CAM-CNC book. The material itself sometimes does not suit the students' ability or their capability. Author’s experience indicates that there are a few lessons in the CAD-CAM student's book which are higher than their level of understanding. The author believes that the complexity of drawing

and manufacturing material could cause negative attitudes to learning. At the same time 58% to 70% of Group 2 and 3 said they do not have any difficulty in understanding the CAD-CAM-CNC material in the book because the computer technology facilitates easy learning of even complex drawing for the students with all levels of abilities.

Key area 2 - Student's opinions about their Lecturers' approaches to teaching process

- All of the students in the Group 1 (traditional teaching method) do not like to have more CAD-CAM-CNC lessons. This indicates how much the students do not like engineering drawing and manufacturing lessons because they not understand the subject and they find difficulties in application of CAD-CAM-CNC subject (Complex tasks) and they considered as waste of time to work in it. 73% to 93% of the students in simulation and computer assisted instruction methods would like to have more CAD-CAM-CNC lessons, because the computer technology facilitates easy learning of complex tasks and they can communicate with each other.

Key area 3 - Student's opinions and views about various aspects of T&L the CAD-CAM-CNC

- CAD-CAM-CNC subject area requires a careful integration of theoretical knowledge and laboratory work. In traditional teaching method it is difficult to manage teaching in a satisfactory manner. 93% of the students in group1 feel that theory and practical works are not linked properly. Whereas 80% to 87% of the students in the group 2 and 3 mentioned that their Lecturers link theoretical knowledge with practical work. For example, the Lecturer may ask one group or two groups of students to draw the CAD examples in the class and carry out in laboratory work and then find how they link information. Lecturers who teach group 2 and 3 have enough time to try and make a real connection between theoretical knowledge manufacturing operations (applying) with CNC machine.

a) session planning and organising

- 80% to 100% of the students in Group 2 and 3 agreed that the Lecturer keeps motivating the students and attract them toward to the subject matter because of the tutorial Package CAI. The students feel that the atmosphere is friendly when they work with support of computer technology and this keeps students motivated.
- 93%of traditional the students mentioned that their Lecturers always follow the same method when they teach CAD-CAM-CNC and rely on the CAD-CAM-CNC book and over head projector which is difficult for learners to see movement of 3D task. 47% to 53 % of

group 2 and 3 students said that the Lecturers bring educational aids and variety of teaching pattern to keep students interested.

- 67% to 73% students of all groups said that their Lecturers have adequate knowledge about engineering drawing and manufacturing teaching method than those who feel they have not. Lecturers need to be confident and know the system and methodology of teaching engineering subject.
- delivery of course material; classroom management; assessment and feedback strategy; students' interaction.

b) classroom management

- The Lecturer's ability to keep the students in control during their lesson means directing the students and explaining to them what to do. The majority of the students in Group 2 and Group 3 agree that the Lecturers have good control of their classes because the students from Group 2 and Group 3 work with the help of CAI package. So the computer simulation and computer assisted instructions give support to the students to understand the subject and they are occupied for the whole session. 73% of students from Group 1 (traditional teaching) said it is difficult for the Lecturer to control the class because students need to discuss with each other working in groups during lectures and laboratory classes.
- The result shows 60% to 80% of group 2&3 of the students mentioned that the CAD-CAM-CNC Lecturer works with less effort than other Lecturers. Because of the use the computer technology CAI to teach different aspects of drawing and manufacturing in the classroom and laboratories. The Lecturers are busy explaining the drawing and manufacturing lesson, working hard with of efforts to enable the students to understand. This is not perceived by 20% of students only who believe that the engineering drawing and manufacturing Lecturer is working with less effort than the other Lecturers.
- 73% of the traditional students also mentioned that their Lecturers do not explain the target of their lesson and do not deal with them according to their ability. 67% of the students in computer simulation and computer assisted instruction method mentioned that the tutorial Package deal with individual differences when the Lecturer divides his students into groups of work and give them different activities to test their abilities.
- 80% of the traditional students mentioned that their Lecturers do not follow up their work and providing them with feedback which is important. 53% 73% of the students in group 2 and 3 mentioned that their Lecturers follow up their work and check it. They also provide

them with feedback because of CAI database (Saved database).

c) Assessment and feedback strategy

- The above statement revealed that 73% to 80% of the group 2 & 3 students mentioned that CAD-CAM Lecturer corrected their mistakes during the lesson. This Lecturer's help is still an important issue by concerning on how the Lecturers do it. All the other surrounding circumstances of the teaching process indicate that the Lecturers do not have time to do corrections effectively. The Lecturers correct the student's work while they are busy with their drawing or machining using computer simulation and computer assisted instruction with help of verification checklist rather than afterwards. All students' of traditional teaching said we know that the Lecturer of the CAD-CAM-CNC is always busy and overloaded with students and this makes it difficult for Lecturers to pay the kind of attention they need to support the constant correction to the pupils' work.
- 80% of the traditional students believe there is no justice, in terms of correcting their work. Such a view suggests that the Lecturers discriminate between their students, some times due to lack of time. There are many things to do in order to estimate the students' average in their subject. The assessment of the students' performance depends mainly on the assignment and exams, the students try to work very hard to get a good or at least a pass mark. If the Lecturer ignores that effort, the students lose their opportunity to pass. In such cases the students feel unfairness this will occur negative attitudes among students towards CAD-CAM Lecturers.
- 73% of the students in both groups 1&2 said their Lecturers are fair when they mark the students' work. The reason for that is, while the students work in group or individually using computer technology, it gives Lecturer an opportunity to correct their work during the drawing or manufacturing lesson.
- 73% to 80% of the students in group 2 and 3 mentioned that their Lecturers use different ways of assessing their performance during evaluation stage. These can include hearing students talk, marking work, testing them in lessons, submitting their assignments and examining them formally. Lecturers concentrate more on assignment and exam, specifically, on the questions which measure the students' application and analysis. In traditional group, it is demonstrated from the answers of the students that it is not easy to evaluate students work and assess their performance. The Lecturers do not always correct student's mistakes as a part of their task of helping to improve the students' skills in both engineering drawing and manufacturing.

d) delivery of course material and students' interaction.

- 60% of students from Group 2 and 67% of students from Group 3 recognised that learning with simulation and CAI is interesting to them. All students from Group 1 are either unconvinced or do not believe that the traditional T&L method is interesting.
- All students from Group 3 and 93% of students from Group 2 perceived that the Lecturers encourage them to learn. Only 53% of students from Group 1 (traditional T&L methods) mentioned that the Lecturers try to encourage them during their CAD-CAM-CNC lesson by asking them to use their manuals or to follow Lecturer's procedure from the board. This conclusion ties up with the Lecturers' opinion that they find it difficult to encourage their students during their lessons.
- The result revealed that 73% of the students in group 2&3 mentioned that their Lecturers respect them. This answer is consistent with the Lecturer's answer when they were asked if they have friendly relationships with their students. But it is worth mentioning here that not all the Lecturers believe in friendly communication with their students; there are some Lecturers who remain formal with their students.
- All of the students in traditional teaching mentioned that their Lecturers do not encourage them to work with computer support. It seems that it is not a popular method in teaching CAD-CAM-CNC for some Lecturers. Such a situation might be because a lack of training in using this method. At the same time 67% to 87% of students in group 2 and 3 mentioned that Lecturers in their group are aware that teaching with the computer technology can be very effective and successful if carried out properly.

The overall effectiveness of students' learning experience incorporates all students' answers and is presented in Appendix 6 (Data Analysis of Students' Answers to Questionnaires).

4.7.SUMMARY

This chapter describes the structure of CAD-CAM-CNC sessions and three T&L methods. Their effectiveness was determined by questionnaires (data collection methods) completed by Lecturers and students. Their answers were analysed from quantitative and qualitative points of view. The questionnaires were designed by taking into consideration the issues of reliability, validity and bias and concentrating on specific research questions. The Lecturers' questionnaires aim to find out Lecturers' opinions about the various aspects of educational process: planning and organising the teaching sessions; delivering the instructional material;

management of students within the classroom; assessment of students' performance; Lecturers’ attitudes towards various T & L methods.

The students’ questionnaires intend to ascertain how well the CAD-CAM-CNC modules meet the stated learning outcomes and to identify the main strengths and weaknesses of various T&L methods. Also it is intended to improve students’ learning experiences by increasing the student involvement in education process. So the questions referred to the following topics: student’s attitudes towards learning CAD-CAM-CNC subjects; student’s opinions about their Lecturers' approaches to teaching process. Also the questionnaires asked students about their opinions regarding the three T&L methods focusing on: session planning and organising; delivery of course material; classroom management; assessment and feedback strategy; students’ interaction.

The next chapter shows qualitative student self assessment of various learning outcomes.

CHAPTER 5

Qualitative Student Self Assessment of Various Learning Outcomes

The chapter discusses about the results of students self-assessment exercise where the three groups of students were asked to evaluate themselves against prescribed criteria. The author determines in this way the students' competence levels and knowledge gained after T&L processes at the individual task level and complex task level (objectives are achieved by combining simple tasks and applying integrative skills).The CAD-CAM-CNC modules contain six sets of activities presented in Table 5.1. and representing learning outcomes. The summative assessment is done by individual projects so the students should perform all the tasks in order to produce the required prototypes.

Set	Activities
Set 1	**Computer sketching (creation of design & drawing).** Set up the sketch plane units and grid parameters; demonstrate all 2-D sketching primitives; demonstrate all line editing features; make simple extrusions and revolutions to get 3-D geometry Demonstrate the creation and editing of dimensions; set geometric constraints; make simple extrusion and revolution to get 3-D; render the parts.
Set 2	**Computer sketching (modelling utilities).** Create 3-D parts; add feature-based, parametric design features; use advanced sweep operations; edit the geometry in 3-D; render the part.
Set 3	**Computer sketching (assembly modelling and mating).** Create individual 3-D parts; assemble parts as mechanical assembly; mate features as appropriate; check for clearance and interference of parts; create colour rendering of assembly.
Set 4	**Computer sketching (engineering drawing).** Create section views in 3- D and 2-D; create individual 3-D parts; make different 3-D section views of the parts; export acceptable colour image files of 3-D section views for presentation purpose. Project 2-D section views of model; incorporate the 2-D section views into a technical drawing. Generate and dimensioning three-view drawing on a suitable drawing sheet style; add centrelines where appropriate; dimension the drawing; add a title block and appropriate notes. Save each part as DXF file.
Set 5	**Rapid prototyping (using data exchange format- DXF and setup check and final manufacturing).** Create cutting parameter for each part (cutting tool, tool size, tool materials, and work materials). Generate tool paths for different layers for each part (X, Y, Z direction, cutting loop, and depth of cut, feed and speed). Save each part as numerical control (NC) file and send the file to the prototyping machine. Set the work piece; set the tool at zero position; check direction of rotation for the chuck and the cutter; check the work piece and the cutting tool is securely clamped; verify the NC program for any shaft and any gear, and simulate the motion of assembly file of the shaft and gear; start the machine and then the program.
Set 6	**Prototype specification and manufacture** Generate final checklist for prototype (dimensions, assembly, motion, tolerance and fit). Submit final report of the project.

Table 5.1. CAD-CAM-CNC activities required for individual projects

The initial sets of activities aim to build up the student's confidence in going from 2-D to 3-D solid geometric modelling. Once their confidence in computer graphics modelling is established, the students explore many design applications for the 3-D model. In doing so, they experience the concurrent engineering paradigm that underscores the course. Several computer graphics exercises are available for each laboratory module, thus allowing the students some choice in the objects they model and analyze. All objects selected for the exercises are taken from commercial catalogues or actual parts from the workshop.
The students were asked to complete a survey before they start to study every set of activities and their answers were stored in a database named **Pre-ranking**.
The response scale for the answers to the questions was:

5 - Exceptional, 4 - Good, 3 - Average, 2 - Below Average, 1 - None

The author has added up the grades given by students for each concept and divided the sum to the number of students (15 students for each group). The students were taught by 3 methods:
Group 1 - Traditional classroom lectures and laboratory sessions;
Group 2 - Classroom teaching including unsupervised computer simulation
Group 3 - Unsupervised CAD tutorials and supervised CAM-CNC computer simulation
Then the students are asked to evaluate themselves after they finish the set of activities and the responses are stored in a database called **Post-ranking** and the average self-assessment marks are calculated again.

5.1. SET 1 AND SET 2 OF ACTIVITIES - 3-D SOLID MODELLING (LEARNING OUTCOME 1)

The learning objectives for these activities are as follows: learn basic 3-D features like extrude and revolve; create advanced 3-D features like shell and sweep; insert reference geometry planes; mirror 3-D features; create linear and circular 3-D patterns; create 3-D parts; add feature-based, parametric design features; use advanced sweep operations; edit the geometry in 3-D and editing features like fillets.
Typical objects for these student exercises are shown in Figures 5.1 (Bracket) and 5.2 (Pulley).

Figure 5.1 bracket

Figure5.2 Pulley

The survey required the students to rank their *level of understanding o*f the concepts:

1. Types of design features available in 3-D solid modelling,
2. Creating design features in 3-D modelling,
3. Editing design features in 3-D modelling.

4- Set up the sketch plane units and grid parameters;

5- Demonstrate all 2-D sketching primitives

6- Demonstrate the creation and editing of dimensions.

7- Make simple extrusion and revolution to get 3-D drawing; create the assembly.

Results of the two surveys are included in the Table 5.2. and they represent the average ranking of the students' self-assessment before and after completing the prescribed activities. Group 2 taught by traditional classroom teaching and unsupervised computer simulation considered to have the greatest gain of knowledge and understanding (Figure 3).

No	Pre-Ranking			Post-Ranking			Difference (Post-Pre)		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	0.14	0.20	0.18	0.16	0.26	0.22	**0.02**	**0.06**	**0.04**
2	0.16	0.20	0.21	0.16	0.25	0.24	**0.00**	**0.05**	**0.04**
3	0.13	0.23	0.22	0.14	0.28	0.25	**0.01**	**0.05**	**0.04**
4	0.18	0.23	0.26	0.17	0.27	0.28	**-0.01**	**0.04**	**0.03**
5	0.15	0.28	0.28	0.14	0.31	0.29	**-0.00**	**0.03**	**0.01**
6	0.15	0.29	0.29	0.16	0.32	0.32	**0.01**	**0.03**	**0.02**
7	0.19	0.26	0.26	0.19	0.30	0.29	**0.00**	**0.04**	**0.03**

Table 5.2. Students' self-assessment for Set 1 and Set 2 of activities

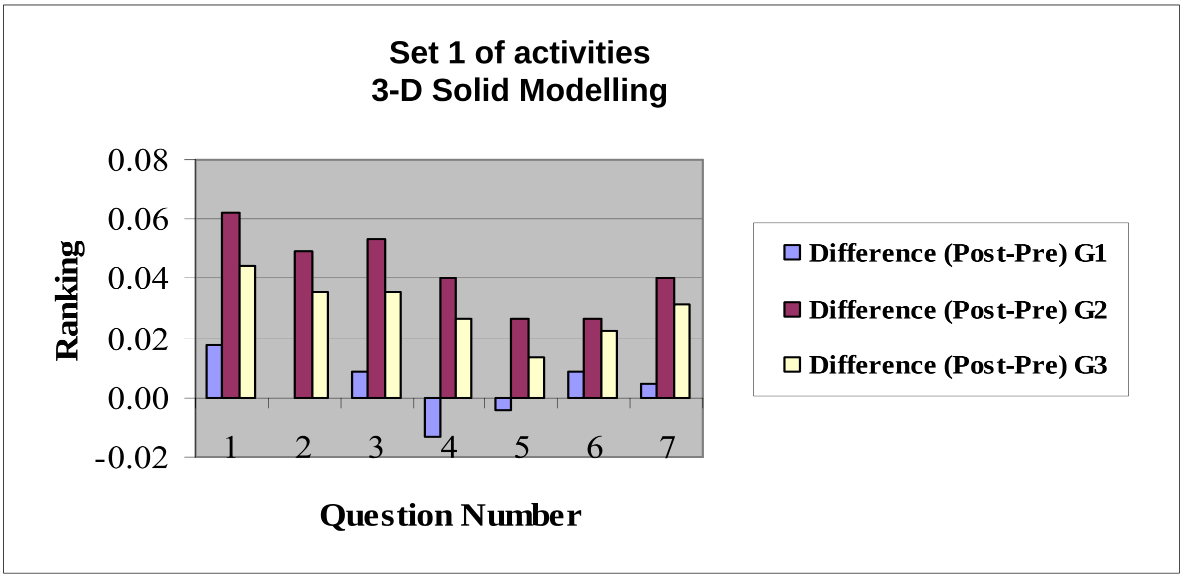

Figure 5.3. Graphics for Set 1 and Set 2 of activities

Also the students were asked to rank their *level of understanding* for these concepts:

1- Create 3-D parts;

2- Add feature-based, parametric design features;

3- Use advanced sweep operations; edit the geometry in 3-D

The comparison between pre- and post-ranking self-assessment is shown in Table 5.3 and the graphical representation of these results is displayed in Figure 5.4.

Also they were questioned about what they have liked and disliked from the T&L methods. Group 2 and Group 3 listed several common themes about what they liked about the exercises and software used to support their learning:

- They were real-world examples, not abstract.
- The software was easy to use and many features were learned.
- The visualization controls were very useful with computer technology support.
- Easy to follow the task procedure in simulation and computer assisted instruction methods.
- Easy to link classroom work during practicing time in the laboratories.
- Computer guide allowed the students to work extra time without Lecturers' supervision.

No	**Pre-Ranking**			**Post-Ranking**			**Difference (Post-Pre)**		
	G1	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
1	0.15	0.26	0.26	0.16	0.30	0.29	**0.02**	**0.04**	**0.03**
2	0.13	0.24	0.22	0.16	0.30	0.27	**0.03**	**0.06**	**0.04**
3	0.17	0.25	0.23	0.20	0.30	0.27	**0.03**	**0.05**	**0.04**

Table 5.3. Students' self-assessment for supplementary concepts

Group 1 underlined that the some of the written notes and projector slides were not quite clear. This aspect regarding instruction material has affected their final results - their marks for the projects were lower than for Group 2 and Group 3 of students.

Also they did not have the possibility to study extra time without Lecture's supervision because they did not have the computer tutorial for CAD section.

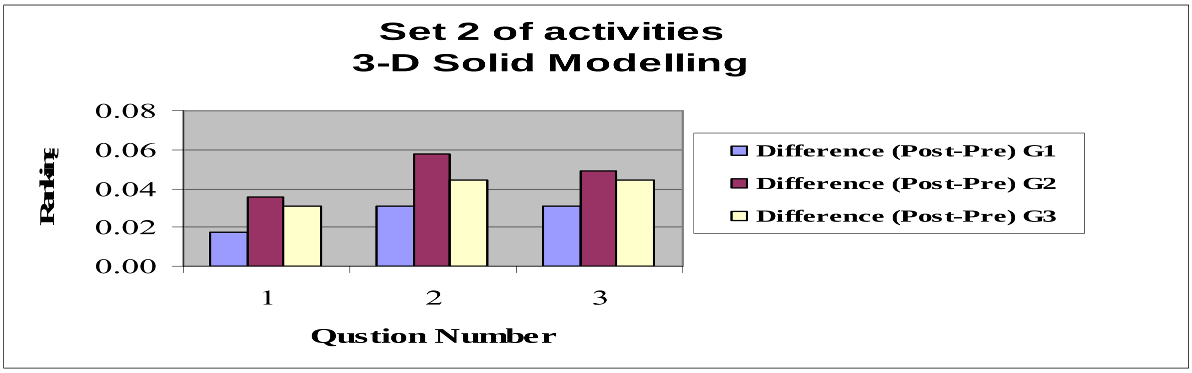

Figure 5.4. Graphics for students' self-assessment for supplementary concepts

5.2. SET 3 OF ACTIVITIES - ASSEMBLY, MATING MODELLING AND KINEMATICS ANIMATION (LEARNING OUTCOME 2)

The learning objectives for this laboratory exercise were: building multiple 3-D parts that will mate together; starting a new assembly file; dragging and dropping parts into the assembly; moving and rotating components; and mating the parts with different mate types.

The student outcomes study was concerned with kinematics animation. For this module, the students either build a new assembly of solid model parts or use a previously built assembly. While the software offers complex tools for creating motion pathways for animating 3-D models, a simple approach was taken in this exercise. Once the parts are properly mated into an assembly, the students use an "Explode Assembly" command available in the software. The parts are then exploded along nominal pathways and a new animation schedule is created with an "Edit Path". Finally the students play the animation on an external viewer, and then save it in a universal .DXF file format. Figure 5.5. shows the assembly built before and after mating.

Figure 5.5. Pulley bracket assembly and Kinematics Animation

For this assembly module, the students learn how to change the colours of the assembly components and how to apply several mate conditions: parallel, concentric, coincident, and distance. They can also get a colour hardcopy of the whole assembly once the exercise is completed. As before, a pre- and post- survey was conducted for the student learning outcomes (*level of understanding*) posed by the following seven concepts:

1. Building individual and multiple parts in 3-D solid modelling and render the part.
2. Building an assembly of parts in 3-D solid modelling.
3- Mating parts in 3-D solid modelling.
4- Check for clearance and interference of parts.
5- Create colour rendering of assembly.
6- Exploding a 3-D assembly of solid model parts.
7- Creating a kinematics animation of a solid model assembly.

The same ranking scale of 5 (Exceptional) to 1 (None) was used again. Results of the pre- and post ranking averages are shown in Table 5.4. and Figure 5.6.

No	Pre-Ranking			Post-Ranking			Difference (Post-Pre)		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	0.15	0.26	0.26	0.16	0.30	0.28	**0.01**	**0.04**	**0.02**
2	0.14	0.27	0.26	0.16	0.30	0.29	**0.02**	**0.04**	**0.03**
3	0.16	0.28	0.28	0.19	0.31	0.30	**0.02**	**0.03**	**0.02**
4	0.15	0.27	0.27	0.14	0.29	0.29	**-0.00**	**0.02**	**0.02**
5	0.16	0.30	0.31	0.17	0.32	0.32	**0.01**	**0.03**	**0.01**
6	0.15	0.26	0.25	0.16	0.28	0.27	**0.01**	**0.03**	**0.02**
7	0.16	0.28	0.28	0.18	0.31	0.31	**0.02**	**0.03**	**0.02**

Table 5.4. Students' self-assessment for Set 3 of activities

Again the difference between pre- and post- average rankings indicates a positive trend (except Group 1 answers for concept 4) for all seven concepts. The students commented that the exercise was real-life and that they liked assembly, mating modelling and kinematics animation mating for mechanical parts. The results show that most of the students in Group 2 and Group 3 were familiar with these activities because of CAD tutorial and Lecturer's presentation. Group 1 found it extremely hard to rotate some mating surfaces without any guide or support during practicing because it was not an intuitive skill for the students.

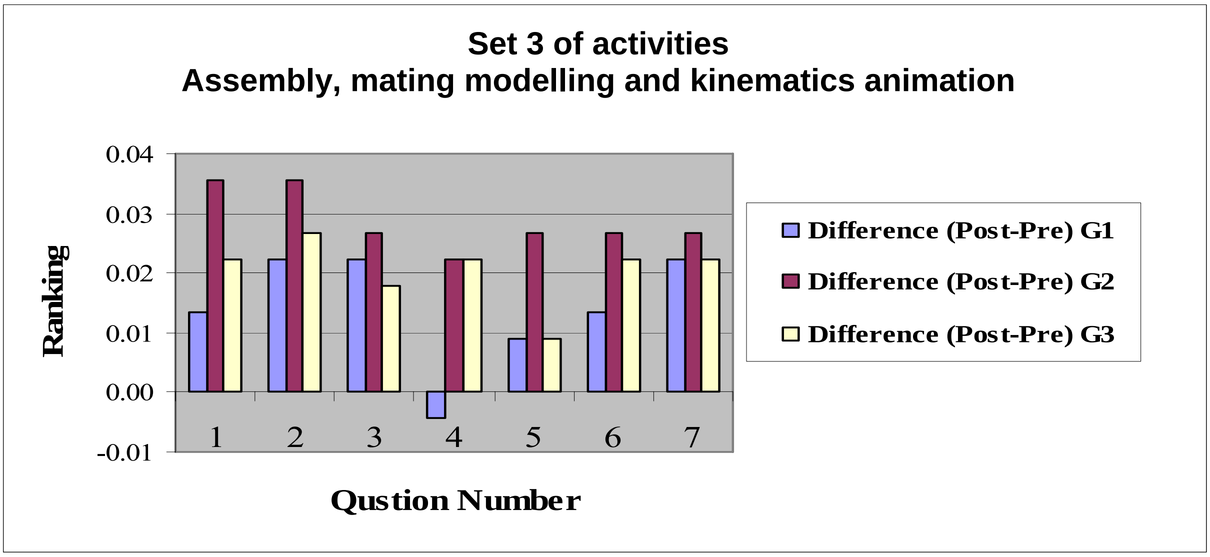

Figure 5.6. Graphics for Set 3 of activities

Once again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning activities, averaging almost +0.03 point for group 1, +0.05 for group 2, and +0.04 for group 3 increases for all seven questions except question 4 which shows post-ranking average lower than the pre-ranking average.

5.3. SET 4 OF ACTIVITIES - GENERATING AND DIMENSIONING 2D AND 3D DRAWINGS AND SECTION VIEWS (LEARNING OUTCOME 3)

The third study focused on the need to generate an engineering drawing for final design documentation. The learning activities and objectives for this module included: inserting a drawing sheet onto the screen; setting the drawing sheet options; projecting three orthographic views of a solid model onto a drawing sheet; adding centrelines; dimensioning the drawing; adding title block and annotations; printing the drawing and then save it as DXF file format.
A typical student computer modelling exercise is shown in Figures 5.7 and 5.8.

Figure 5.7. 3D model for bracket

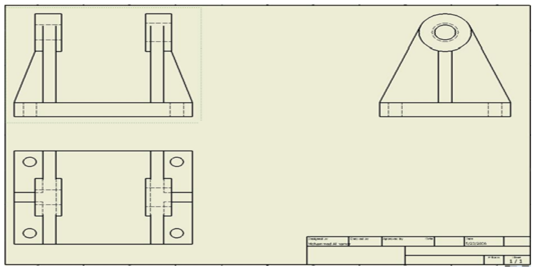

Figure 5.8: 3D drawing of the same bracket

The study also focused on the topic of 2D and 3D techniques for section views. This included: viewing 3-D section views of solid models; projecting orthographic views onto a drawing sheet; setting hatch pattern options; creating the cutting plane line; making a 3-D section view; printing a section view drawing As showing in fig 5.5. An example of a 3-D student exercise is shown in Figure 5.6, and a 3-D section view student example is shown in Figure 5.7.

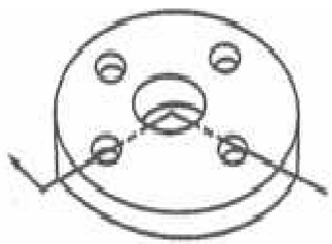

Figure 5.9: 3D model of a flange

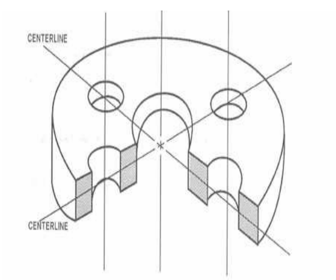

Figure 5.10: 3D section view of flange

The pre- and post-surveys concentrated on the following aspects:

1- Making a 3-D section view of a 3-D solid model.

2- Making a 2-D section view from a 3-D solid model.

3- Detailing a 2-D section view drawing.

4- Arranging the three-view layout on a drawing sheet.

5- Dimensioning a three-view drawing.

6- Generate suitable drawing sheet style.

7- Add a title block and appropriate notes.

8- Save each part as DXF file.

Results of the pre- and post- ranking averages are shown in Table 5.5. and Figure 5.11.

No	Pre-Ranking			Post-Ranking			Difference (Post-Pre)		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	0.14	0.26	0.25	0.12	0.30	0.27	**-0.02**	**0.04**	**0.02**
2	0.15	0.29	0.28	0.13	0.31	0.29	**-0.02**	**0.02**	**0.01**
3	0.14	0.30	0.29	0.15	0.32	0.30	**0.00**	**0.02**	**0.01**
4	0.17	0.26	0.26	0.17	0.30	0.29	**0.00**	**0.04**	**0.03**
5	0.16	0.29	0.29	0.14	0.32	0.31	**-0.02**	**0.04**	**0.02**
6	0.16	0.28	0.29	0.16	0.31	0.31	**0.00**	**0.03**	**0.02**
7	0.18	0.30	0.30	0.19	0.32	0.32	**0.01**	**0.02**	**0.01**
8	0.28	0.32	0.32	0.29	0.33	0.33	**0.01**	**0.01**	**0.01**

Table 5.5. Students' self-assessment for Set 4 of activities

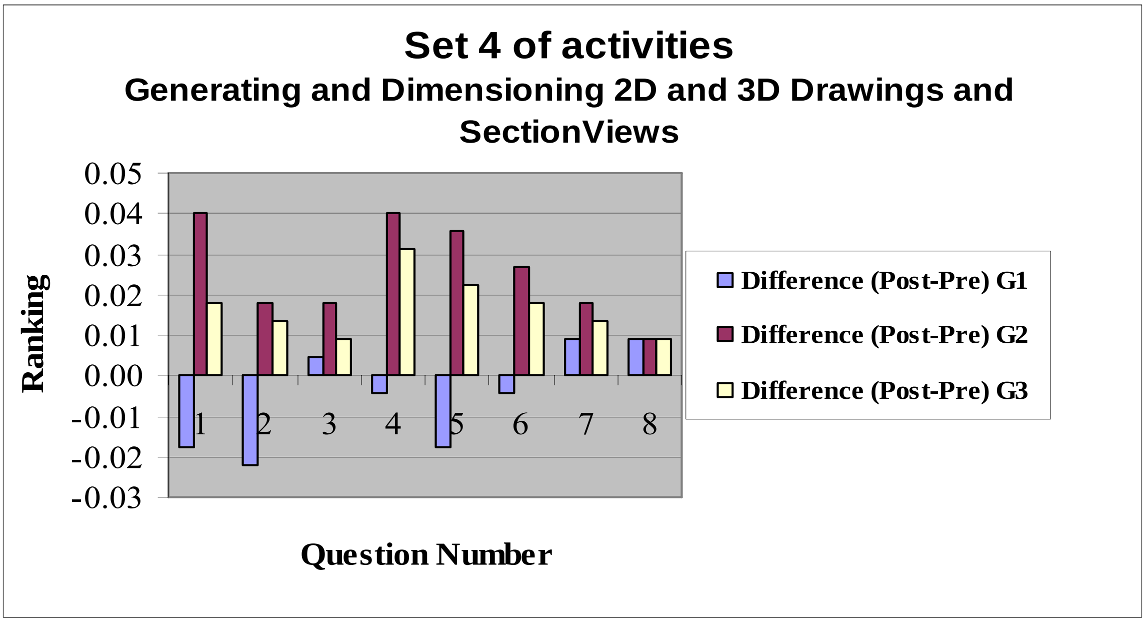

Figure 5.11. Graphics for Set 4 of activities

Again, the differences between the pre- and post-rankings averages indicate a positive increase in the general learning activities in simulation and computer assisted instruction (Group 2 and Group 3). Also the students in Groups 2 and 3 were generally receptive to learning activity and they commented on the "ease" of creating three-views from a solid model with the current software. They also felt that the last Set 2 and Set 3 of activities reinforced the basic concept of deriving design documentation from a solid model, rather than creating the documentation from scratch. The one consistent negative comment was the degree of difficulty in applying details to the final engineering drawing, particularly in placing centrelines and in deciding which dimensions to select. The final comment was that the software packages able to develop student's skills and improve learning experience.
Students from Group 1 (taught by traditional method) said that it was difficult to develop their knowledge in complex drawing (especially in learning outcomes 1, 2, and 5). However the instructions were easy to follow, due mainly to the" Animation Wizard" and accompanying tools that were available in the software.

5.4. SET 5 OF ACTIVITIES - RAPID PROTOTYPING IN THE LABORATORY (LEARNING OUTCOME 4)

The learning activities for this module included: building a solid part; creating NC file from the solid model data; transferring the DXF file to a rapid prototyping machine as NC file; and completing the rapid prototype. Some example of parts used as student exercises are shown in Figure 5.12.

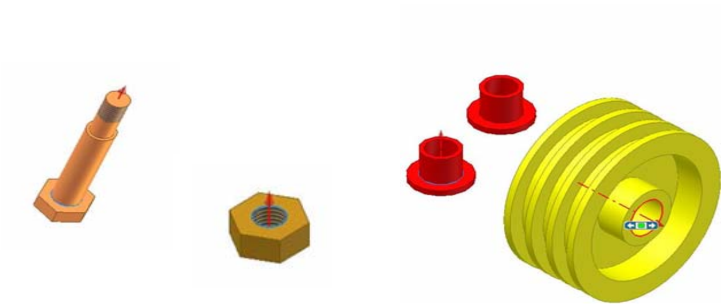

Figure 5.12: Examples of parts used as student exercises

The pre- and post- surveys looked at the following aspects of students' understanding:

1. Generating DXF and NC file from a 3-D solid model.
2. Building a rapid prototype of a 3-D solid model.
3. The role of rapid prototyping in the design process.
4- Create cutting parameter for each part (cutting tool size and material, part material).

5- Generate tool paths for different layers for each part (X, Y, Z direction, cutting loop, and depth of cut, feed and speed).
6- Save each part as numerical control (NC) file and send the file to the prototyping machine.
7- Set the work piece; set the tool at zero position.
8- Check direction of rotation for the chuck and the cutter; check the work piece and the cutting tool are securely clamped.
9- Verify the NC program for simple shaft complex prototype.
10- Simulate the motion of assembly file.
11- Start the machine and then run the part-program.

Results of the pre- and post- ranking averages are shown in Table 5.6 and in Figure 5.12 . Once again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning activities, averaging around +0.03 point for Group 2 (teaching with computer simulation tutorials) +0.02 point for Group 3 (unsupervised CAD tutorials and supervised CAM-CNC computer simulation). So the introduction of computer simulation has increased the level of students' understanding when dealing with complex tasks.

No	**Pre-Ranking**			**Post-Ranking**			**Difference (Post-Pre)**		
	G1	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
1	0.16	0.25	0.25	0.18	0.28	0.28	**0.02**	**0.03**	**0.03**
2	0.14	0.24	0.24	0.12	0.28	0.27	**-0.03**	**0.04**	**0.02**
3	0.15	0.28	0.28	0.16	0.31	0.31	**0.02**	**0.04**	**0.03**
4	0.14	0.21	0.21	0.12	0.25	0.25	**-0.02**	**0.04**	**0.04**
5	0.11	0.20	0.20	0.12	0.28	0.25	**0.01**	**0.08**	**0.05**
6	0.20	0.31	0.31	0.19	0.33	0.32	**-0.01**	**0.02**	**0.01**
7	0.13	0.26	0.26	0.13	0.29	0.28	**0.00**	**0.04**	**0.02**
8	0.20	0.31	0.31	0.17	0.33	0.32	**-0.03**	**0.02**	**0.01**
9	0.16	0.26	0.26	0.14	0.29	0.28	**-0.02**	**0.04**	**0.02**
10	0.18	0.29	0.29	0.16	0.32	0.31	**-0.02**	**0.03**	**0.02**
11	0.30	0.32	0.32	0.30	0.33	0.33	**0.00**	**0.01**	**0.01**

Table 5.6. Students' self-assessment for Set 5 of activities

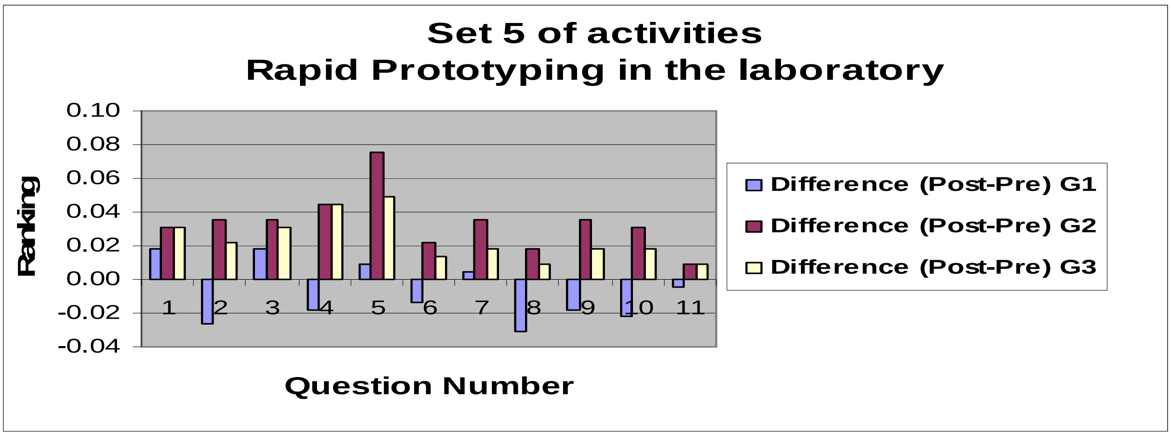

Figure 5.13. Graphics for Set 5 of activities

In general, the students enjoyed these activities module even though it was time-consuming due to the manual assembly requirements of the rapid prototyping system. They clearly enjoyed building a real part when they tried to match with a computer model. As one student simply stated that *"seeing the CAD drawings turning into actual workpiece was very impressive"*. Most of the students in this module recognised that the CAL software allowed them to deal with complex components by simple methods.

5.5. SET 6 OF ACTIVITIES - PROTOTYPE SPECIFICATION AND MANUFACTURE (LEARNING OUTCOME 5)

The students have to apply FEA (Finite Element Analysis) when manufacturing the workpiece. An assembly gear-shaft was used to illustrate how to build and assemble the solid parts as 3D CAD model and then produce the real mechanical components in the lab.

They assigned different type of measurements with different measuring tools to compare between engineering drawing sheet and the real components.

The checklist for the drawing is always available to show the areas that need improvement in the shaft-gear design. The students then complete the exercise by modifying the design. In this case, they need to repeat the above procedure to improve manufacturing design. Some example parts used as student exercises for this module are shown in Figure 5.13.

Figure 5.14. FEA representations for gear and shaft

The pre-and post-surveys checked the students' level of understanding about:

1- Read the dimensions in accordance with a prescribed checklist.

2- Read the details for assembly in accordance with a prescribed checklist.

3- Read the motion errors for the parts which are assembled together.

4- Generate final checklist for tolerance and fit.

Results of the pre- and post ranking averages are shown in Table 5.7. and in Figure 5.14.

No	Pre-Ranking			Post-Ranking			Difference (Post-Pre)		
	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	0.16	0.26	0.26	0.13	0.29	0.27	**-0.03**	**0.03**	**0.01**
2	0.13	0.25	0.25	0.15	0.28	0.27	**0.02**	**0.03**	**0.01**
3	0.16	0.25	0.25	0.13	0.28	0.27	**-0.02**	**0.03**	**0.02**
4	0.12	0.20	0.20	0.14	0.24	0.22	**0.02**	**0.04**	**0.02**

Table 5.7. Students' self-assessment for Set 6 of activities

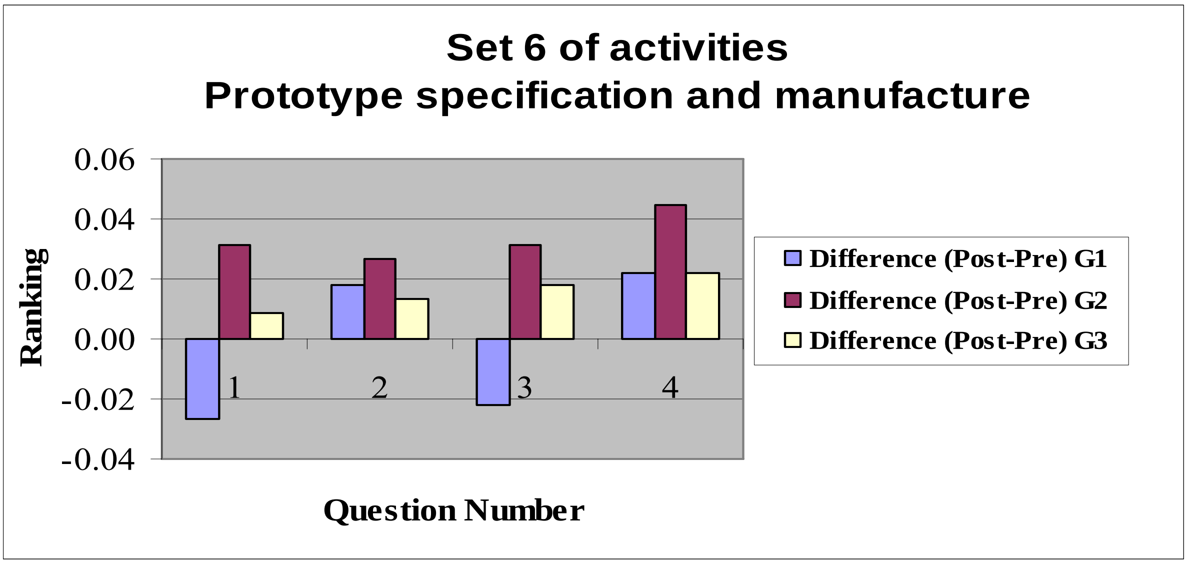

Figure 5.15. Graphics for Set 6 of activities

Again, the differences between the pre- and post- average rankings indicate a positive increase in the general learning of element analysis of 3D solid model and manufacturing components (at least in the context of exercise as self-reported by the students).

The average ranking indicate a positive increase in the learning activities averaging around +0.03 point for Group 2 and +0.02 point for Group 3. These students mentioned that the teaching methodology gives them the following opportunities:

- Carry out complex design tasks systematically and read technical drawings and diagrams;
- Produce comprehensive engineering drawings with all the elements form the checklist.
- Analyse an assembly and divide it into parts so the associated CAD-CAM-CNC tasks can be allocated accordingly.

Also the students appreciated that the computer software allowed them to visualize detailed engineering drawing and manufacturing, dimensions, assembly, motion, and tolerance.

5.6. SUMMARY

The three groups of students were asked to evaluate themselves against prescribed criteria before and after performing six sets of activities included in the CAD-CAM-CNC module. The results from each column representing the difference in students' post-ranking and pre-ranking have been added up for each set of activities. The final values are presented in Table 5.8. and generally they show a positive trend in students' learning.

Set of activities	Average		
	Group 1	Group 2	Group 3
Set 1 and Set 2 - 3-D Solid Modelling	0.00	0.04	0.03
Set 3 - assembly, mating modelling and kinematics animation	0.03	0.05	0.04
Set 4 – Generate and Dimensioning 2D and 3D Drawings and Section Views	0.01	0.03	0.02
Set 5 - Rapid prototyping	- 0.01	0.03	0.02
Set 6 - Prototype specification and manufacture	0.00	0.03	0.02

Table 5.8. Summary of students' self-assessment results

The positive trend is expected since the students gained some additional knowledge and skills doing each exercise. The following conclusions can be drawn:

- Group 2 of students (taught by classical method plus unsupervised computer simulation) ranked Set 3 of activities with the largest gain in self-reported learning (+ 0.05 ranking points). Also Group 3 of students ranked Set 3 of activities with the highest gain. So it is obvious that the introduction of CAI as a supplement to the traditional T&L method produces higher achievement than the use of conventional T&L method alone.
- Group 1 of students (taught with the traditional approach) ranked Set 4 of activities with an average negative gain (-0.01 ranking points). So the students considered themselves to be quite knowledgeable before performing a complex task and they have found out that their simulation results did not match the required values so they got despondent about it. This results shows that the traditional method (teacher-centred approach) comprising only Power Point slides and Lecturer's presentation is not good enough for explaining complex tasks.

The combination between CAI and traditional approach generated a positive learning experience for students which was reflected in their post-ranking results of students' self-assessment exercise.

The next chapter shows evaluation of the three T & L techniques

CHAPTER 6

Evaluation of the three T & L techniques

The students learn in CAD-CAM-CNC modules how to build computer models, mate assemblies of parts, perform various analyses, create kinematics simulations, generate final design drawings, import engineering drawing as DXF file, generate NC file to build rapid prototypes. The first evaluation method uses Bloom's framework to assess learning effectiveness of different student groups exposed to three T&L methods.

The second evaluation method is based on quantitative analysis of the three groups of students' marks for assignments and exams. Also an analysis of time and material resources is performed and the conclusions are included here.

6.1 BLOOM'S TAXONOMY USED FOR EVALUATION OF T&L TECHNIQUES

The three groups of students have been taught using three T & L methods:

Group 1 - Traditional classroom lectures and laboratory sessions;

Group 2 - Classroom teaching including unsupervised computer simulation

Group 3 - Unsupervised CAD tutorials and supervised CAM-CNC computer simulation

The students are tested for their abilities in the CAD-CAM-CNC area by asking them to produce four workpieces (see Figure 6.1). The evaluation sheet and the checklist are included in Appendix 2. The author links the levels of cognition from Blooms' taxonomy with the activities which should be completed by students.

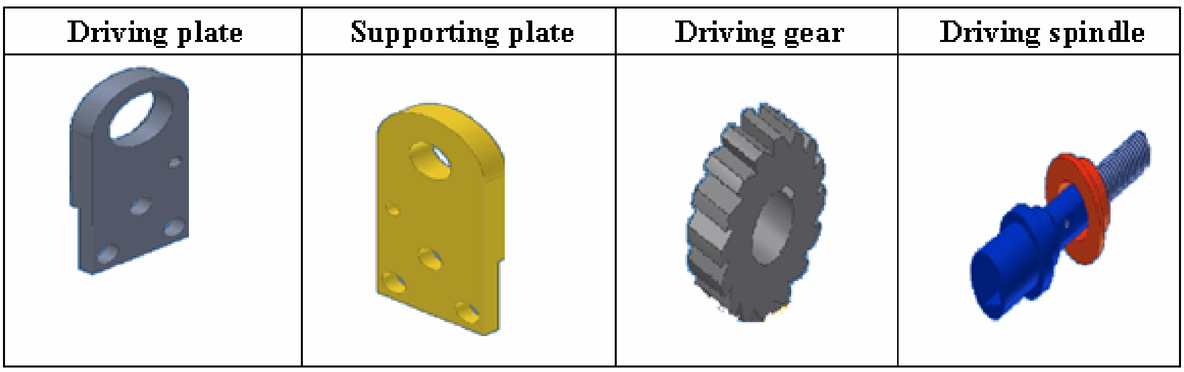

Figure 6.1: Workpieces which should be produced by students

So the learner should achieve proficiency in lower levels of cognition and then progress through higher levels. This analysis is similar to the one carried out by Zywno (2003) for electrical engineering students. In CAD-CAM-CNC module various levels have been identified as per the Blooms Taxonomy for easy analysis and are explained below. It can be clearly seen that the activities listed are in taxonomical order and require proficiency in the lower level skill before learning higher level skill.

Level 1: Knowledge (Recall Data)

Examples of activities: Memorizing program operations, features used in part creation, saving DXF file, creating NC file, set up the machine and run the machine for manufacturing.

Level 2: Comprehension (Understanding Information)

Examples of activities: Select program feature, locate design and drawing geometry, select and locate cutting parameters, setting the tools and the work piece.

Level 3: Application (Applying knowledge to a new situation)

Examples of activities: Sketching, applying, demonstrating, modelling, assembly, demonstrating and verifying the manufacturing operations.

Level 4: Analysis (Separates information into part for better understanding)

Examples of activities: Analyzing drawing parts during assembly drawing and using program facilities to calculate missing dimensions of engineering drawing analyzing verifying the manufacturing operations.

Level 5: Synthesis (Builds a pattern from diverse elements)

Examples of activities: Arrange the view of the engineering drawing 1^{st} angle and 3^{rd} angle, assemble different parts to create project in final shape, design a new shape and modify the shape to another shape, arranging machine tools, materials and instruments for final manufacturing.

Level 6 : Evaluations (Judges the value of information)

Examples of activities: Attached assembly drawing with the engineering drawing to judge final shape of the drawing with given dimension also to judge final products fitness, shape, movements and quality.

Lecturer is marking the students during the design and production of the four workpieces. The quality of students' results for each activity is determined by comparing their products with the checklist and awarding learning ability indicators for each student and task. The *learning ability indicator* shows how well the student has performed a certain task by comparing his/her application results with the checklist.

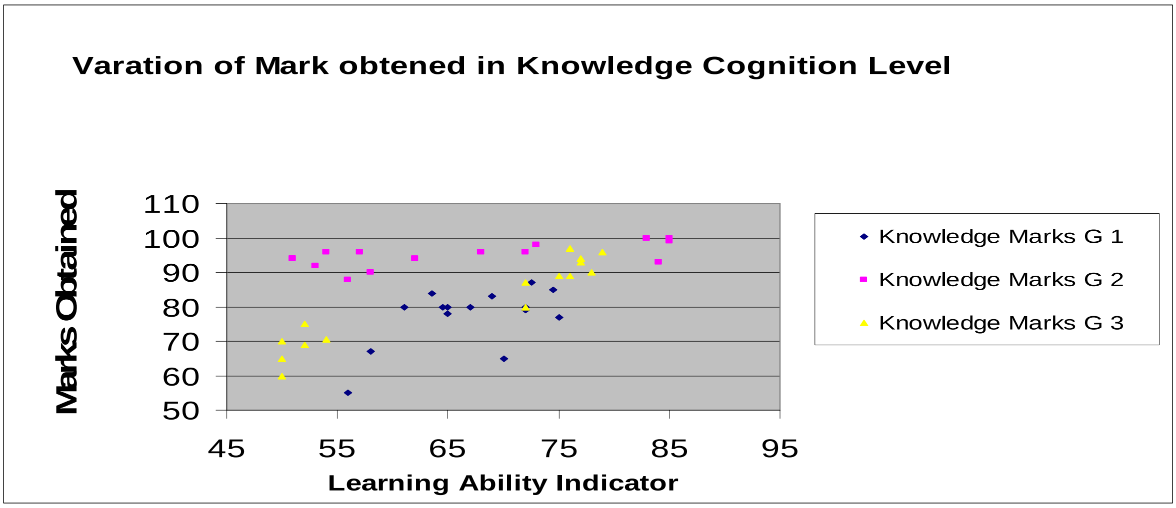

Figure 6.2. Comparison between teaching methods in knowledge cognition level

Figure 6.2 shows the correlation between learning ability indicator (average marks obtained in the examination before entering this course) and the marks obtained for the three groups in the knowledge cognition level. All groups show considerable improvement in knowledge but final marks for Group 2 of students is uniformly distributed between 85 and 100 % . This indicates that CAL package has increased the level of achievement of learning outcomes for this heterogeneous group of students. The final marks for Group 1 are spread between 55 % and 86% so the traditional T & L methods have produced a slight increase in the final marks but not so much like the combination between traditional method and CAL package.

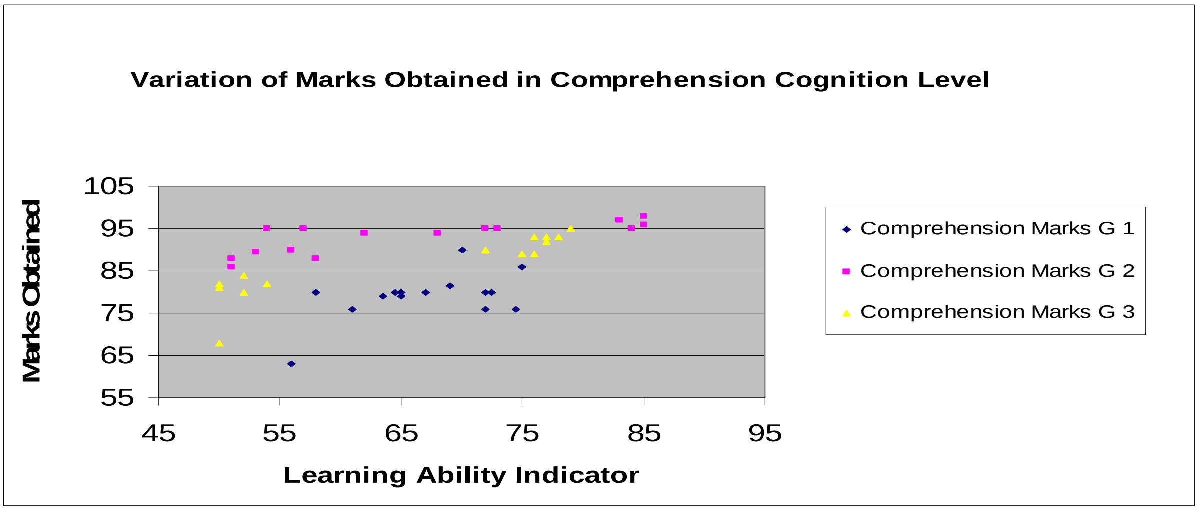

Figure 6.3. Comparison between teaching methods in comprehension cognition level

Figure 6.3 shows variation of marks obtained in comprehension cognition level where students were required to understand the information like drawing geometry, selecting and locating cutting parameters, setting the tools and the work piece. The figure indicates that the overall trends are similar to that seen in knowledge cognition level although the scatter in the marks has increased for the three groups. So once again method 2 (combination between traditional method and CAL package) has produced the highest increase in students' marks.

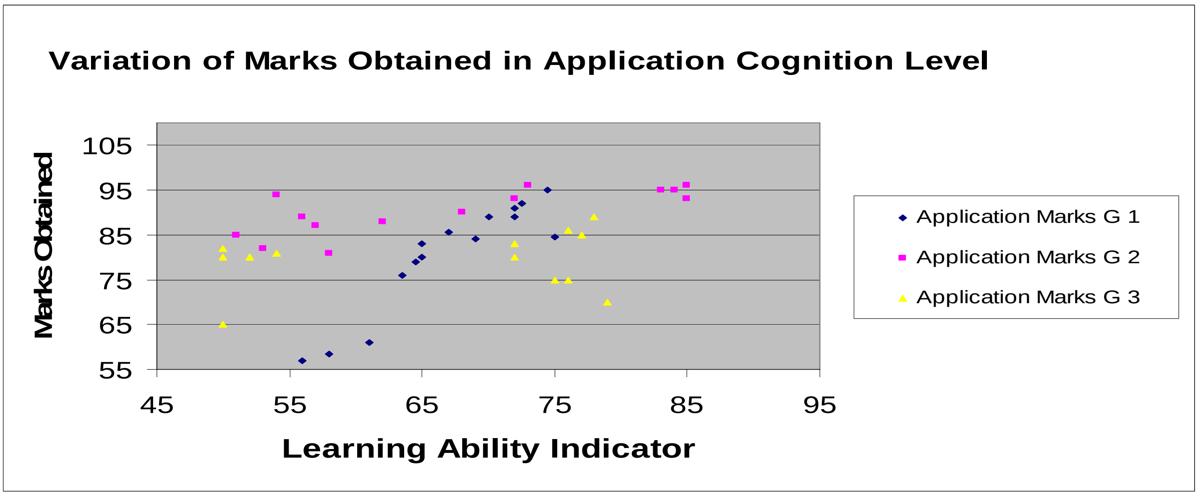

Figure 6.4. Comparison between teaching methods in application cognition level

Figure 6.4. shows the variation of marks in application cognition level where students are evaluated for their ability to sketch, apply, demonstrate, model, assemble the parts as well as perform and verify manufacturing operations. The final marks for Group 2 are concentrated more in the interval 77 % to 95 % so their level of achievement is lower than for the previous cases (knowledge, comprehension).

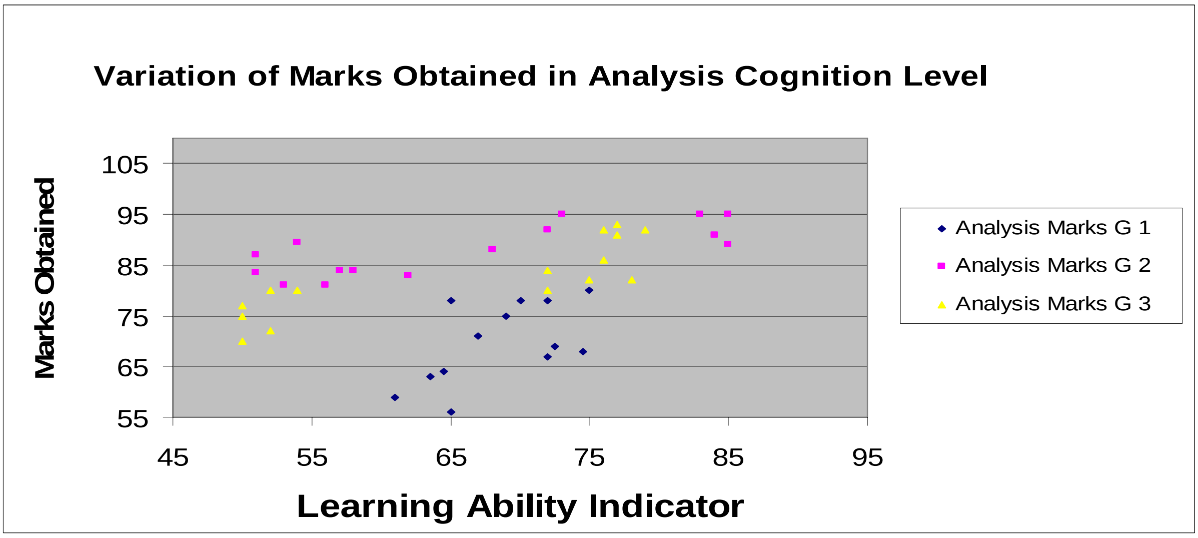

Figure 6.5 Comparison between teaching methods in analysis cognition level

Figure 6.5. presents the variation of students' marks in analysis cognition level. The final marks for Group 2 are concentrated in the interval 77 % to 87 % so their level of achievement is lower than for the previous cases (knowledge, comprehension, application). Also the students' final marks from Group 1 are grouped around the interval 55 % to 78 % so the traditional T & L methods do not generate a high increase of marks at analysis cognition level.

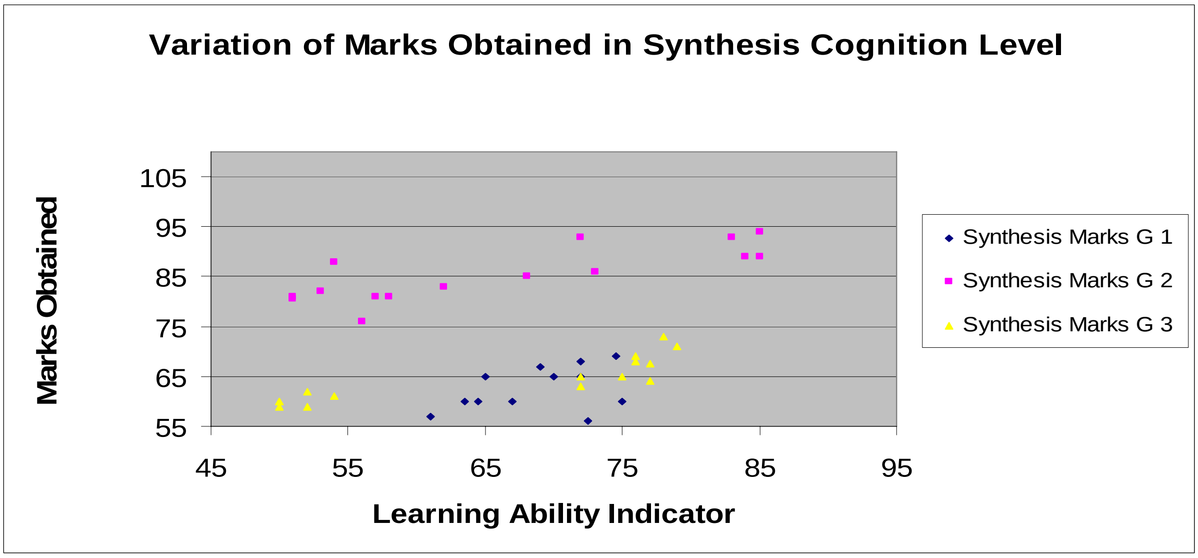

Figure 6.6. Comparison between teaching methods in synthesis cognition level

Figure 6.6. presents the variation of students' marks in synthesis cognition level. The students were evaluated for their abilities in analyzing drawing parts during assembly drawing and using program facilities to calculate missing dimensions of engineering drawing. This also requires students to be capable in analyzing and verifying the manufacturing operations, assembling different parts to create prototype in final shape, designing a new shape and modifying one shape to another shape, arranging machine tools, materials and instruments for final manufacture. The students' final marks from Group 1 are clustered around the interval 55% to 67 % so the traditional T&L methods do not enable the development of appropriate students' skills for synthesis level. Also students from Group 1 obtained the lowest marks in comparison with those from Group 2 and Group 3. This shows that the combination between CAI and traditional T&L methods are far more useful in delivering learning outcomes at higher level of cognition from Bloom's taxonomy.

Figure 6.7. presents the variation of students' marks in evaluation cognition level. This cognition level tests student's ability to **j**udge the value of the information with regard to final products fitness, shape, movements and quality.

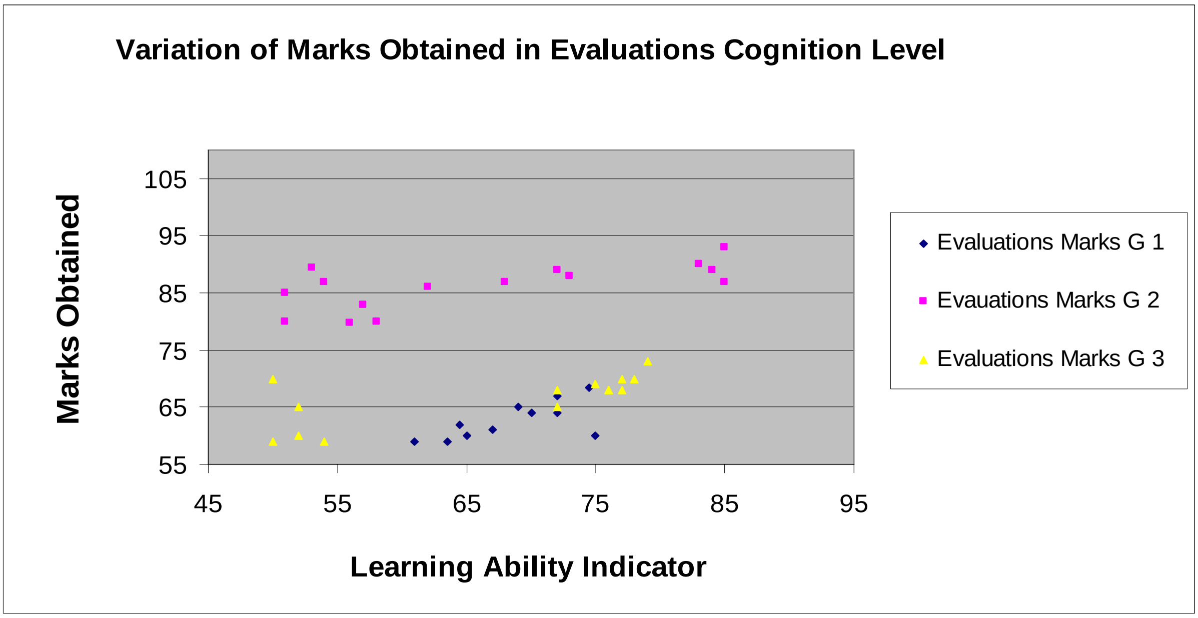

Figure 6.7. Comparison between teaching methods in evaluation cognition level

Students from Group 2 have the highest marks and those from Group 3 obtained higher marks than the for the previous cognition level (synthesis) so introducing CAL package has helped the students with various learning abilities to achieve learning outcomes at high level and the differences between lowest marks and highest marks within every group are small.

6.2. EVALUATION OF T&L METHODS USING STUDENTS' PRE-TEST ABILITY AND POST-TEACHING ASSESSMENT

The three T &L methods were also analysed for their effectiveness in rapport to specific learning outcomes:

a) Creation of drawing and design using CAD software

b) Using data exchange format (DXF) to create numerical control file

c) Final setup check of CNC machine

d) Final manufacturing of the product using CNC.

e) Qualitative evaluation of the workpiece.

The subject of T&L process was the design and manufacture of a gear box assembly (see Figure 6.8 a) consisting of several parts (see Figure 6.8. b). The stages for T&L process are presented in Appendix 5.

To evaluate effectiveness of different teaching methods against various learning outcomes, marks obtained by students for every outcome have been plotted against marks obtained by students in the preparation module from previous academic year (pre-learning indicator).

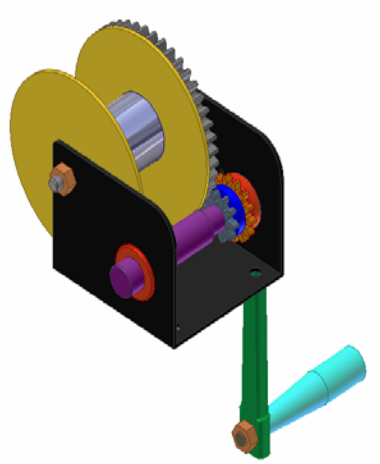

Figure 6.8 a Gear box assembly

Figure 6.8 b Gear box parts

Figure 6.9 shows that the students from Group 1 (blue colour) did not register a great improvement of final marks (post teaching assessment) after performing the activities related to learning outcome (a). The students from Group 2 (magenta colour) scored the highest marks and have a uniform distribution of marks typical for a heterogeneous group. Also it is obvious again that half of the students from Group 3 (yellow colour) has reduced capabilities and the other half are more able to obtain good results.

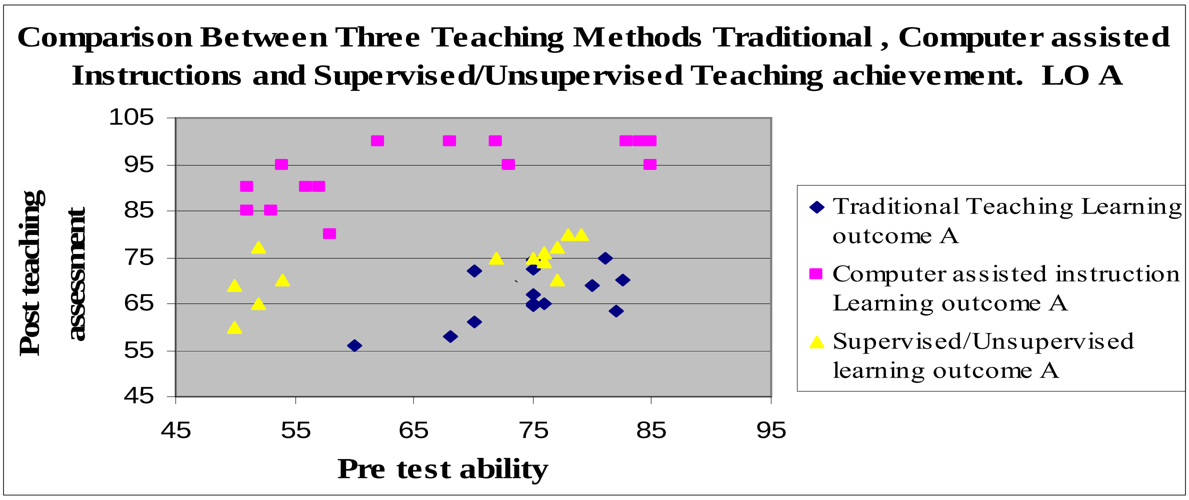

Figure 6.9 Variation of final marks for learning outcome (a)

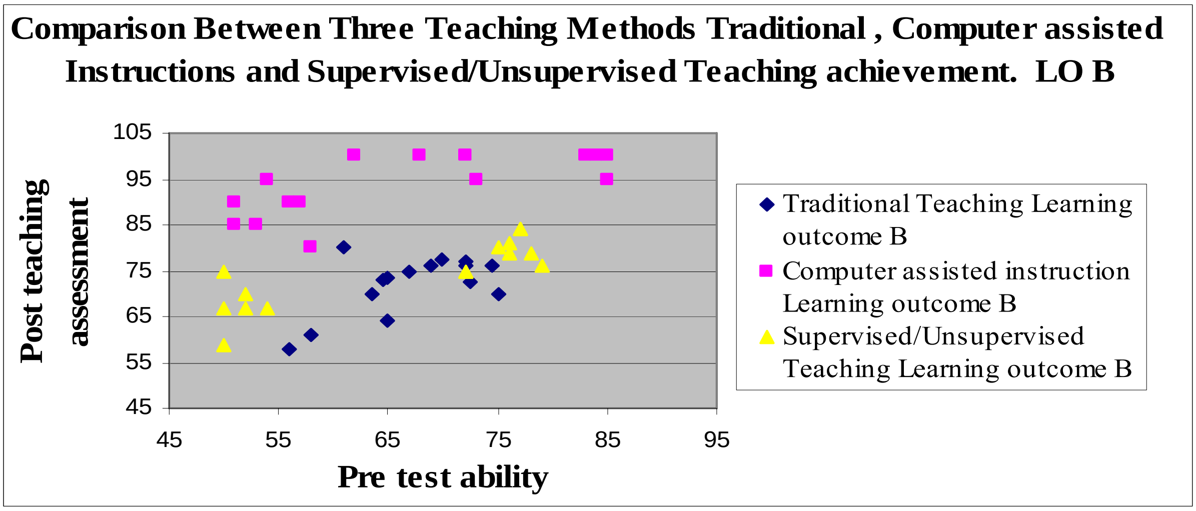

Figure 6.10 Variation of final marks for learning outcome (b)

Figure 6.10. shows that the students from Group 1 (blue colour) obtained good marks (clustered around 75 %) which are much higher than those corresponding to learning outcome (a). This could be due to the fact that the students got the training on how to use the CAD software and using DXF to create numerical control file is not so difficult anymore.

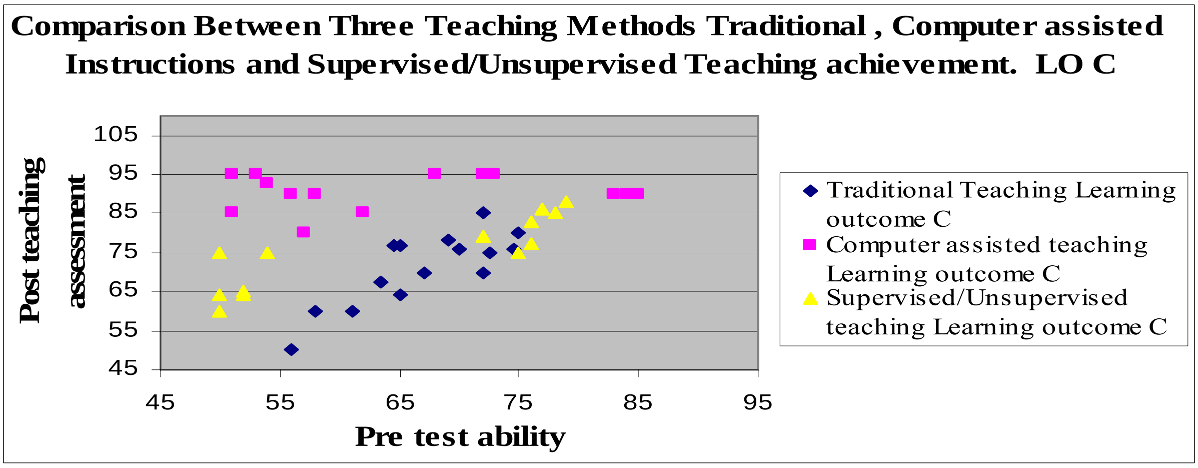

Figure 6.11 Variation of final marks for learning outcome (c)

Figure 6.11. shows that the distribution of final marks for the students from Group 1 (blue colour) is really scattered now with the lowest mark 47 %. So the students who were struggling to achieve learning outcomes (a) and (b) have more difficulties to reach learning outcome (c). The students from Group 2 (magenta colour) obtained lower marks and the students from Group 3 (yellow colour) got marks with a wider spread. So their abilities to do

the final setup check of CNC machine are diverse and all T&L methods should be improved to enable students to perform better.

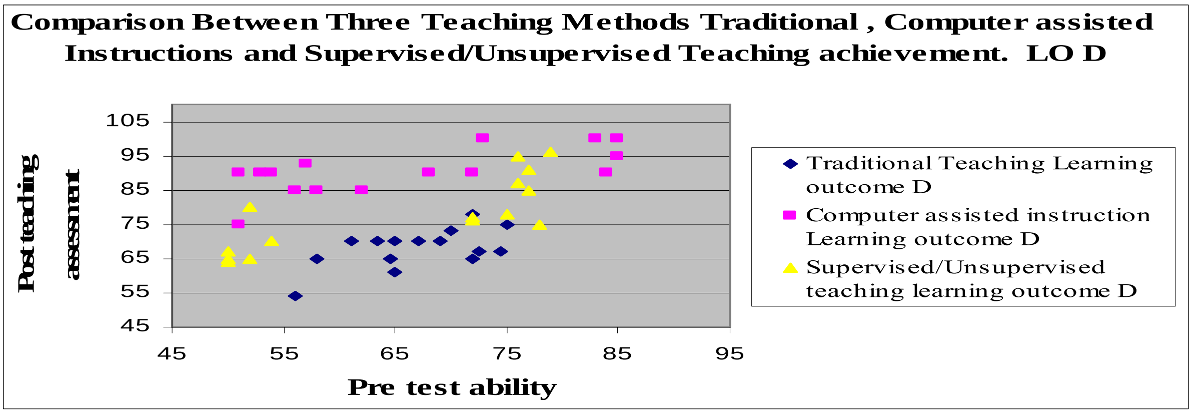

Figure 6.12. Variation of final marks for learning outcome (d)

Figure 6.12. shows that the marks for students from Group 1 (blue colour) have improved (grouped around 67 % value) so it seems that hey have practiced more after obtaining lower marks for the previous learning outcome and now they were capable to manufacture the final product using the CNC machine tool. This conclusion is applicable for all groups because all marks have increased in comparison to those corresponding to the previous learning outcome.

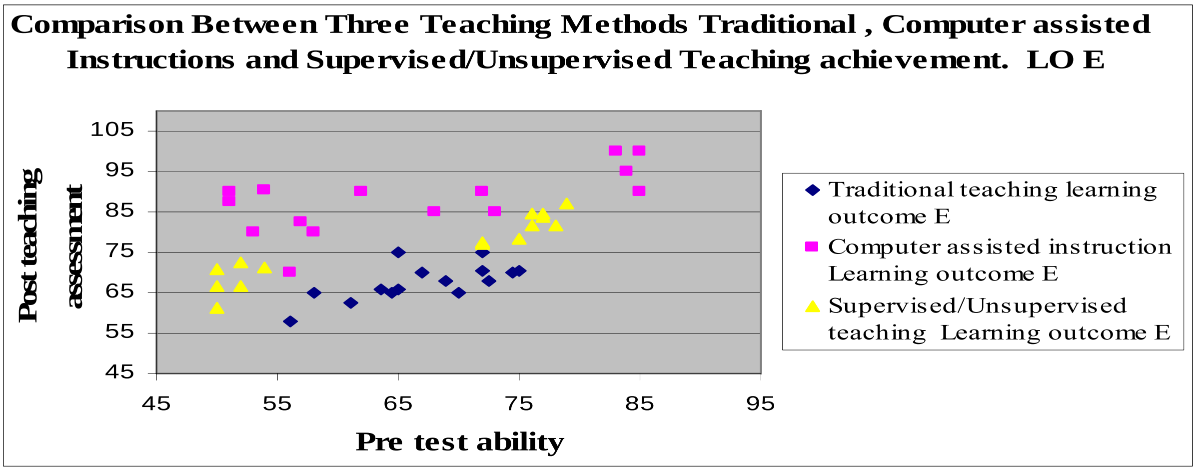

Figure 6.13. Variation of final marks for learning outcome (e)

Figure 6.13. shows that the students from Group 2 (magenta colour) have some difficulties in evaluating the quality of the produced workpiece because their marks have decreased in comparison with those for the previous learning outcome.

Per total the marks of students from Group 2 taught with a combination of CAI package and traditional T&L methods were higher than those for the other two groups so the conclusion is that the use of CAL package is increasing the effectiveness of T&L process (Figure 6.14).
It is obvious that CAI helps all students in achieving all the learning outcomes with a good success rate whereas traditional teaching and supervised/unsupervised teaching do not enable students who have difficulties in their understanding to obtain good marks.

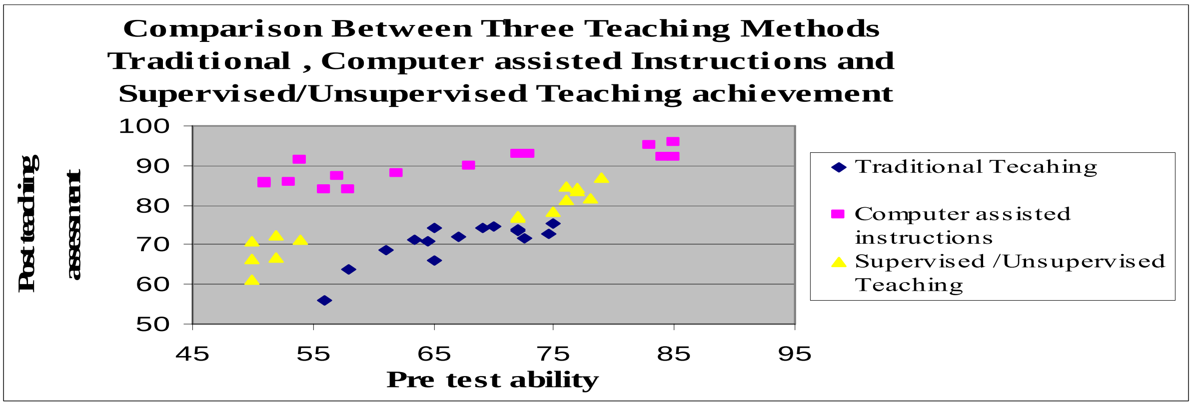

Figure 6.14 Variation of average marks for all groups and learning outcomes

Also the traditional T&L methods increase the difference in levels of achievement for low and high ability students whereas CAI reduces this gap.

6.3. TIME MANAGEMENT ANALYSIS

The previous sections presented the analysis of T&L effectiveness based on Bloom's taxonomy and specific learning outcomes. Table 6.1. presents the correlation of these results plus the link between the achievement levels and time and number of the trials required to complete the tasks successfully. The achievement level of 100% means that all students from the specified group are completing the tasks in the allocated time.

Once again it is obvious that the achievement level for students from Group 2 is the highest in comparison with those for Group 1 and Group 3. Also the students from Group 2 needed less time to complete all the tasks – between 75 % and 84 % of the allocated time therefore the introduction of CAL package into the T&L approach is making the students more efficient and effective (they gain the appropriate knowledge and understanding in less time).

Six levels of cognitive learning domain	Students achievement														
	Creation of drawing and design using Computer aided design software			Using data exchange format (DXF) to create numerical control file			Final setup check of computerised numerical control machine			Final manufacturing of the product using CNC			Quality evaluation		
	G1	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
Knowledge	11	15	12	10	15	11	10	15	12	12	13	12	12	15	12
Comprehension	11	15	12	10	15	11	11	15	11	12	13	12	12	15	11
Application	10	15	13	9	14	10	12	14	13	12	13	12	11	14	12
Analysis	10	12	11	9	11	10	11	14	13	11	12	12	10	13	10
Synthesis	10	13	11	9	13	11	12	14	12	12	13	13	10	13	10
Evaluation	10	14	11	9	11	10	11	13	12	10	12	11	9	13	10
Achievement % for each group	**69%**	**93%**	**78%**	**62%**	**88%**	**70%**	**74%**	**94%**	**81%**	**77%**	**84%**	**80%**	**71%**	**92%**	**72%**
Average time	**108%**	**80%**	**93%**	**106%**	**84%**	**96%**	**108%**	**81%**	**89%**	**111%**	**75%**	**89%**	**109%**	**80%**	**91%**
Average number of trials	**36%**	**11%**	**22%**	**38%**	**16%**	**30%**	**26%**	**10%**	**19%**	**27%**	**13%**	**23%**	**31%**	**10%**	**26%**

Table 6.1. Achievement levels, average time and number of trials for the student groups

The achievement levels of students from Group 2 were higher than for Group 1 and Group 3 in rapport to higher levels of Bloom's taxonomy (analysis, synthesis and evaluation). So the students are more capable to perform the following tasks in comparison with their colleagues:

1- Analyzing and comparing during generation of tool path for different layers (direction, depth of cut, cutting loop, feed and speed).

2- Combine existing elements in order to create something original and modifying the file after verifications in case some errors are present.

3- Judge the product using a standard like when verifying the drawing the students judged and agreed according to the standard criteria using manufacturing checklist.

The other indicator for student's performance was the number of trials used by groups in completing the given tasks (Figure 6.15.). It is advisable in CAD-CAM-CNC applications to have a reduced number of trials to build the correct CAD model and use the right procedure in manufacturing operations. The numbers of trials taken by groups to achieve the prescribed learning outcomes indicate the level of skills acquired during the T&L process.

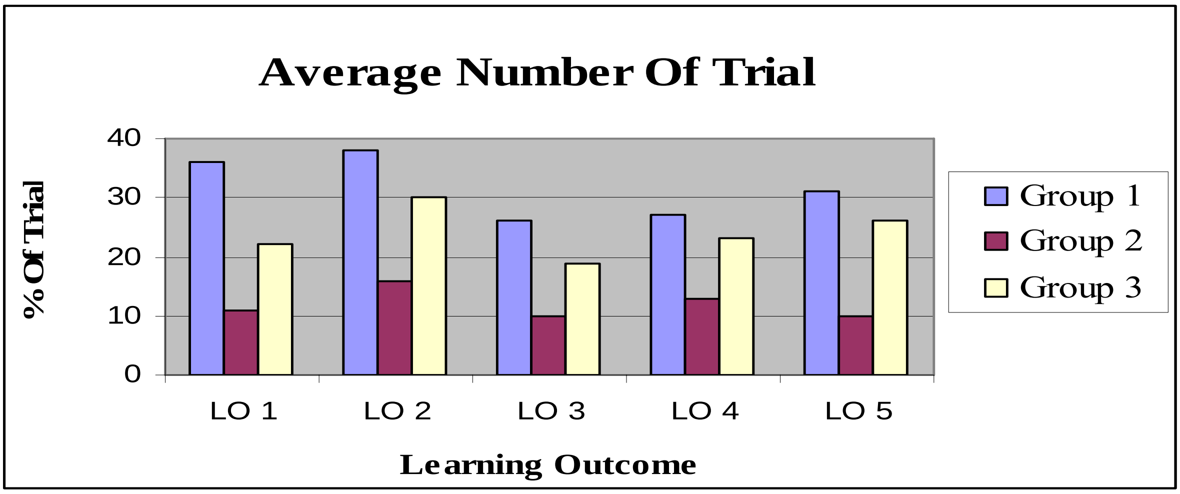

Figure 6.15: Number of trials used by groups in achieving learning outcomes

Figure 6.15 shows the comparisons between numbers of trials used by the groups in achieving various learning objectives. It can be seen that the students from Group 2 made fewer mistakes than those from Group 1 and Group 3 so they have used less material and time to achieve all five learning outcomes.

In CAD-CAM-CNC applications it is necessary to build the correct CAD model and use the correct procedures for the drawing and manufacturing operations within the given time. The periods of time taken by students groups to achieve the stipulated learning objectives indicate the level of acquired skills and student's performance for various T&L methods.

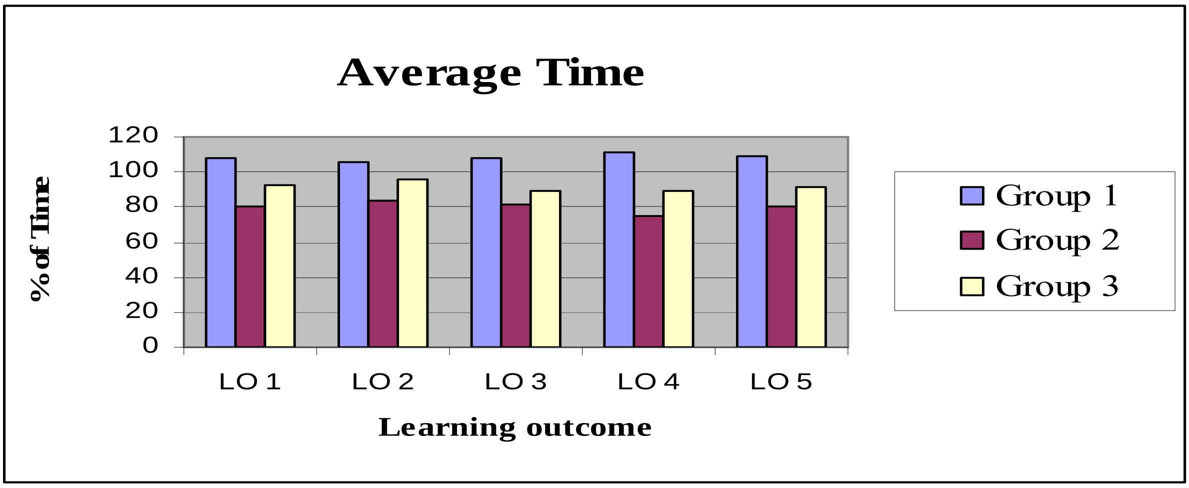

Figure 6.16. Average Time used by groups in achieving learning outcomes

Figure 6.16. shows the average time used by the student groups in achieving various learning objectives. It can be seen that students from Group 2 needed less time to complete their tasks in comparison with students from Group 1 and Group 3.

The students from Group 2 were offered the opportunity to learn themselves about CAD using computer tutorials. Then they were taught with traditional T&L methods the CAM-CNC topics. So they could acquire the skills related to independent critical learners and their efficiency has increased afterwards.

6.4. SUMMARY

The first evaluation method uses Bloom's framework to assess learning effectiveness of the student groups exposed to three T&L methods. The students are tested for their abilities in the CAD-CAM-CNC area by asking them to produce practical workpieces. The Lecturer is marking the students during the design and production of these workpieces. The quality of students' results for each activity is determined by comparing their products with the checklist and awarding learning ability indicators for each student and task.

The author links the levels of cognition from Blooms' taxonomy with the activities which should be completed by students. The six levels of Bloom's taxonomy are:

Knowledge - Comprehension - Application - Analysis - Synthesis - Evaluation

The quantitative and qualitative analysis of students' marks versus learning ability indicators was performed and the results have been discussed.

The second evaluation method is based on quantitative analysis of the three groups of students' marks for assignments and exams. Also an analysis of time and material resources is performed and the main conclusion was that the students from Group 2 and Group 3 taught with a combination of CAL package and traditional method were more effective, efficient and satisfied with their learning experiences.

The next chapter shows conclusions and further work

CHAPTER 7

Conclusions and Further Work

The chapter contains the conclusions of this research report and recommendations for changes in educational policy at Sh. Khalefa Institute.

- The shortcomings of the educational processes used for teaching CAD-CAM-CNC modules at Sh. Khalefa Institute were determined from UNESCO reports and author's reflections in his capacity of Head of Centre of Excellence within Ministry of Education and as a University Lecturer. The main conclusion was that the shortage of suitable aids for teaching and lack of curriculum review have contributed to reduced effectiveness of T&L processes.

- A hybrid CAL package (Power Point slides and digital video recordings) was developed to improve the existing T & L methodology in CAD-CAM-CNC modules at Sh. Khalefa Institute. The CAL package contains CAD tutorial, CAM tutorial and Power Point slides for CNC operations. The prototype of CAL package was evaluated by experts and then it was changed in accordance with their comments. After that the CAL package was tested on users (students and Lecturers teaching the modules). So the author has used action research (plan-implement-observe-reflect) for this application.

- The structure of CAD-CAM-CNC sessions and three T&L methods was analysed. Their effectiveness was determined by questionnaires completed by Lecturers and students. Their answers were analysed from quantitative and qualitative points of view.

- The three groups of students were asked to evaluate themselves against prescribed criteria so their competence levels and knowledge gained after being taught with various T&L methods could be estimated. Group 2 (taught by unsupervised CAD tutorial plus classical methods) had the largest gain in self-reported learning (+ 0.05 points) in comparison with their colleagues. The combination between CAI and traditional approach generated a positive learning experience for students, reflected in their post-ranking results of students' self-assessment exercise.

- Group 1 (taught with the traditional approach) ranked Set 4 of activities with an average negative gain (-0.01 ranking points). So the students considered themselves to be quite knowledgeable before performing a complex task and they have found out that their simulation results did not match the required values so they got despondent about it. These results show that the traditional method (teacher-centred approach) is not suitable for explaining complex tasks.

- Students from Group 2 (taught by unsupervised CAD tutorial plus classical methods) became more effective and efficient requiring shorter times and reduced number of trials for achieving various learning objectives. So their skills related to independent critical learners (acquired while studying independently the CAD tutorials) have increased their performance.

- The study has analyzed the impact of technology-enabled instruction on students' levels of learning from Bloom's taxonomy as contrasted with the conventional approach. It has been observed that hybrid learning method (CAI plus traditional methods) is most suited for CAD-CAM-CNC teaching because the students find it easier and enjoyable to explore the subject area through various opportunities of learning.

7.1. RECOMMENDATIONS FOR CHANGES IN EDUCATIONAL POLICY AT SH. KHALEFA INSTITUTE

Some recommendations can be made on the basis of this study to improve the quality of the teaching engineering drawing and manufacturing in Sh. Khalefa Institute from Bahrain.

a) The course material should be designed so the students are motivated and stimulated in a higher degree and they can develop/ apply the appropriate skills when dealing with complex problems from Mechanical Engineering area.

b) The transition from teacher-centred approach to student-centred approach should be finalised and student's views should be taken into consideration when planning, evaluating and updating the curriculum and teaching methods.

c) More attention should be given to support every staff member how best to use CAL in their practice so the student experience is substantially improved by encouraging creativity and reflection (characteristics of lifelong learners).

d) Video and computer footages of real life contexts should be seriously considered in CAD-CAM-CNC modules (especially when the real situations are dangerous, time consuming, difficult to observe or expensive to be set up in the laboratory environment). The introduction of these pseudo-experiments (supported by video, animations, simulations) will facilitate small group learning and give students the control over their learning and increase their motivation, knowledge, understanding and performance.

e) Student critical thinking skills should be fostered through problem-based learning opportunities and innovative approaches to student-centred instruction (education). The developed CAL package needs some refining and afterwards could be used to achieve the above mentioned goals in Mechanical Engineering education.

f) More research should be performed regarding the effectiveness of technology-enabled instruction in engineering education, students' learning styles, preferences and attitudes toward asynchronous and synchronous learning and course management. In this way Sh Khalefa Institute will become a leading education institution in Bahrain in terms of using efficiently ICT in modern education environment.

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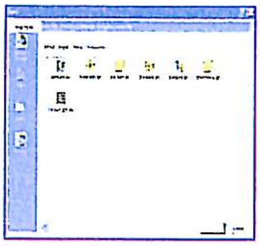
Appendix One

Computer Assisted Learning (CAL) Package

(CAD – CAM-CNC Tutorial)

CAD Tutorial

Getting Started



- Part Modeling.
- Assembly Modeling.
- Presentations Modeling.
- Engineering Drawing.

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Part Modeling (Bush)

- 2D sketch (Circle).
- Adding Dimensions.
- Extrude.
- Concentric Hole.

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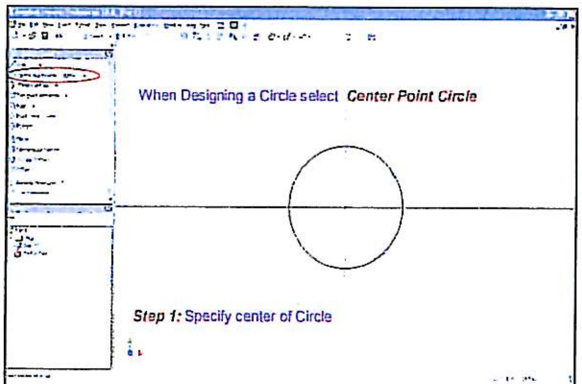

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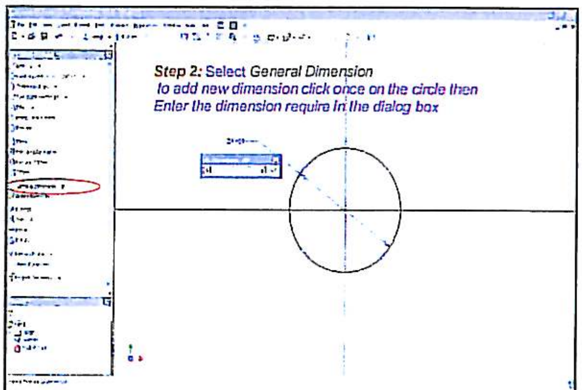

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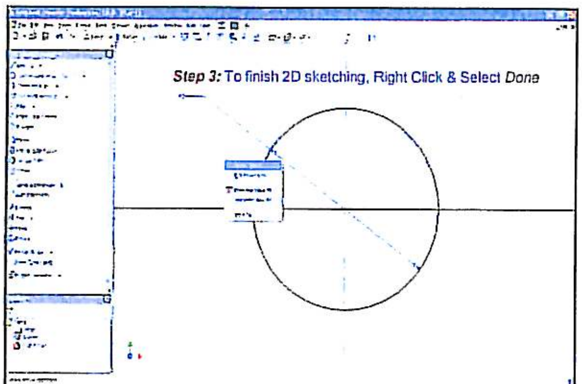

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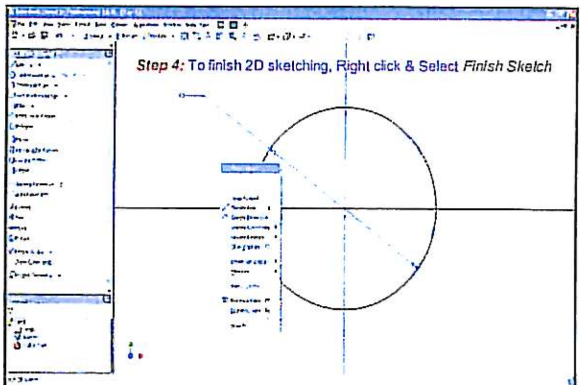
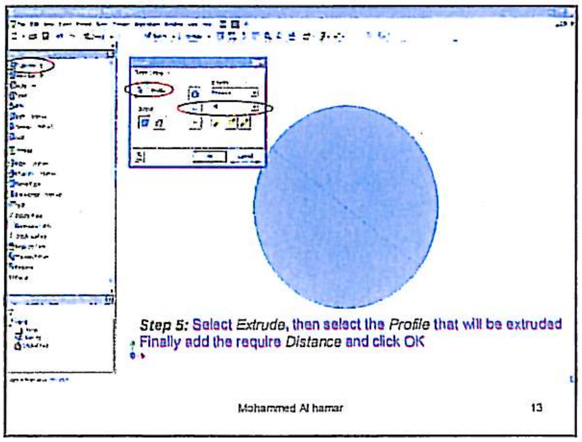
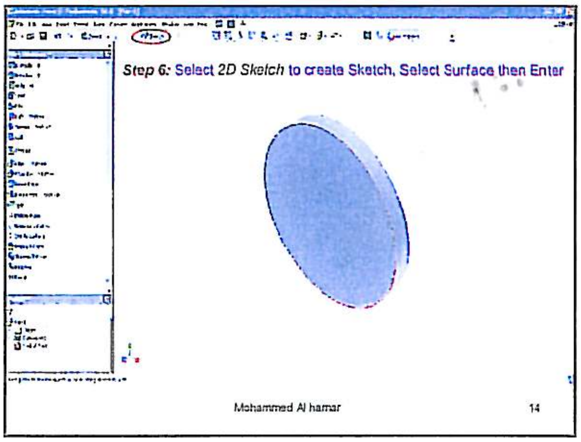
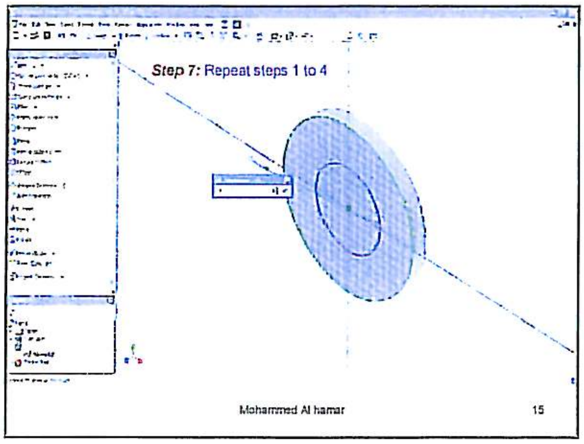
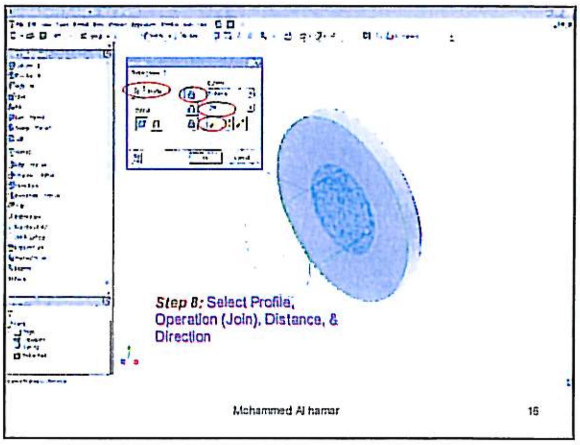


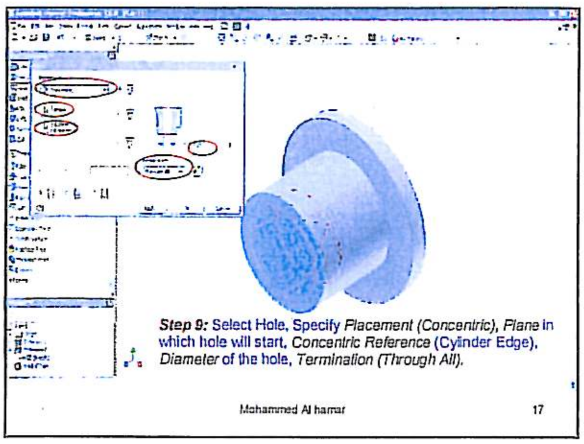
Mohammed Al hamar 12











Part Modeling (Bracket)

- 2D sketch (Rectangle).
- Add Dimensions.
- Extrude.
- Extend, Trim & Tangent.
- Work Plane.
- Rib (web).
- Mirror.
- Hole (Two edges).
- Rectangular Pattern .
- Hole Concentric.

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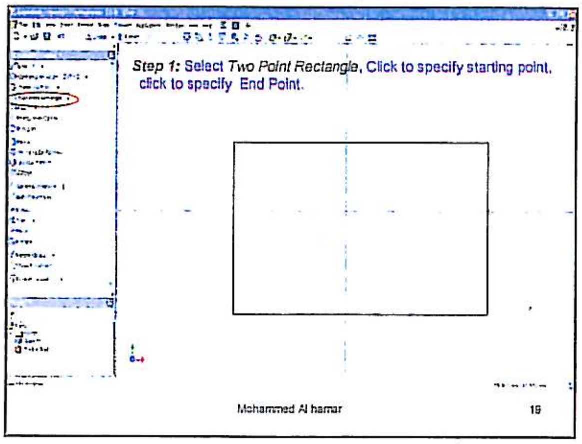
Step 1: Select Two Point Rectangle, Click to specify starting point, click to specify End Point.
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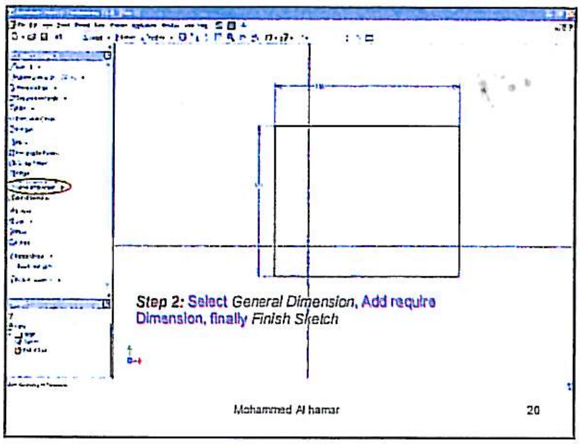
Step 2: Select General Dimension, Add require Dimension, finally Finish Sketch
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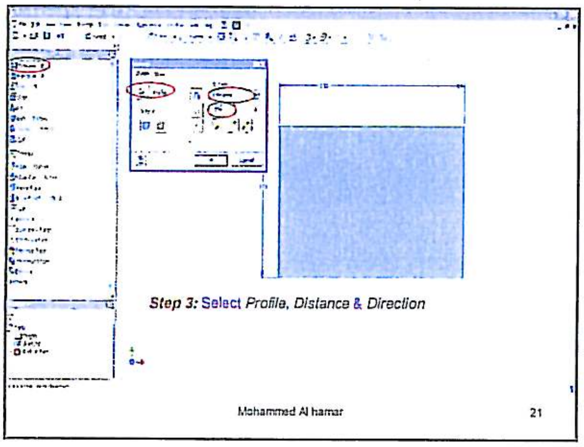
Step 3: Select Profile, Distance & Direction
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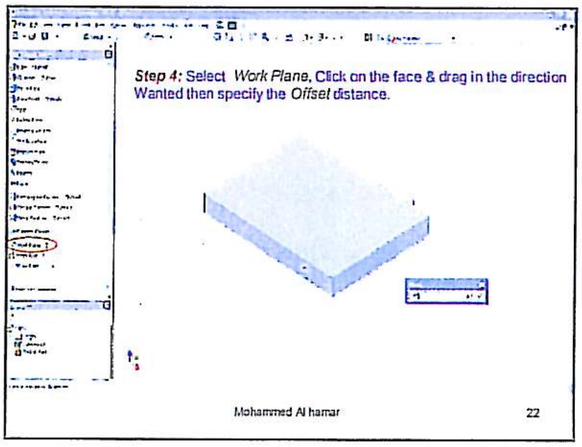
Step 4: Select Work Plane, Click on the face & drag in the direction Wanted then specify the Offset distance.
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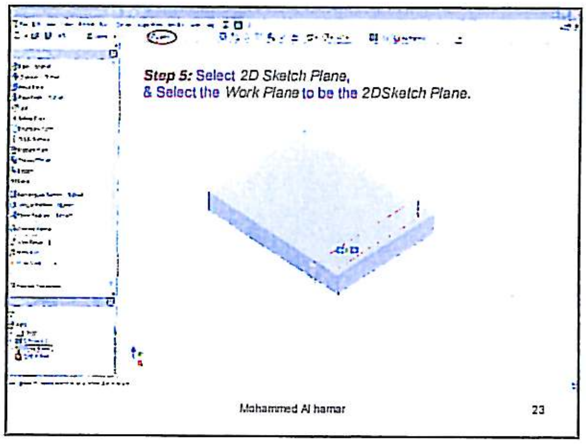
Step 5: Select 2D Sketch Plane,
& Select the Work Plane to be the 2DSketch Plane.
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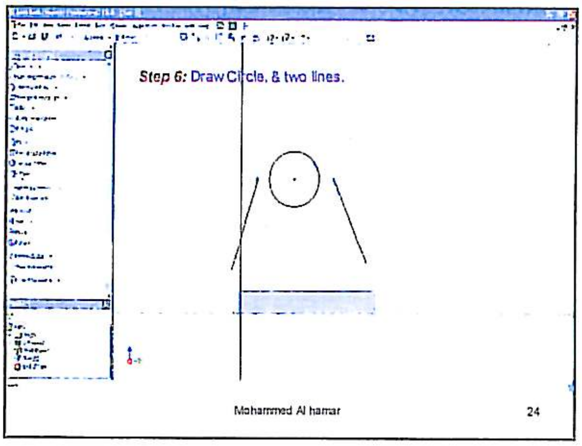
Step 6: Draw Circle, & two lines.
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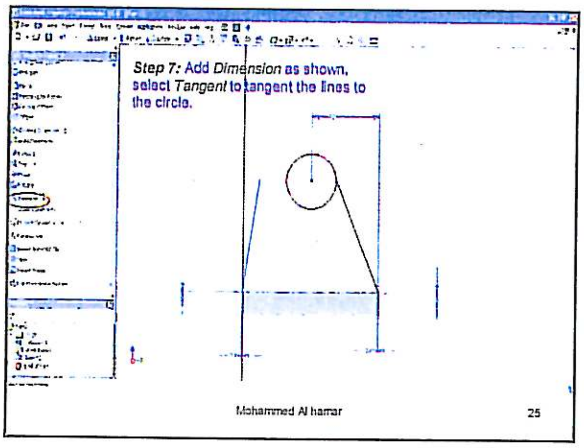
Step 7: Add Dimension as shown, select Tangent to tangent the lines to the circle.
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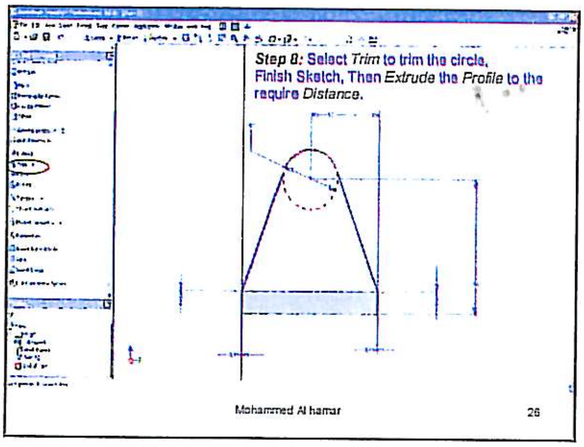
Step 8: Select Trim to trim the circle, Finish Sketch, Then Extrude the Profile to the require Distance.
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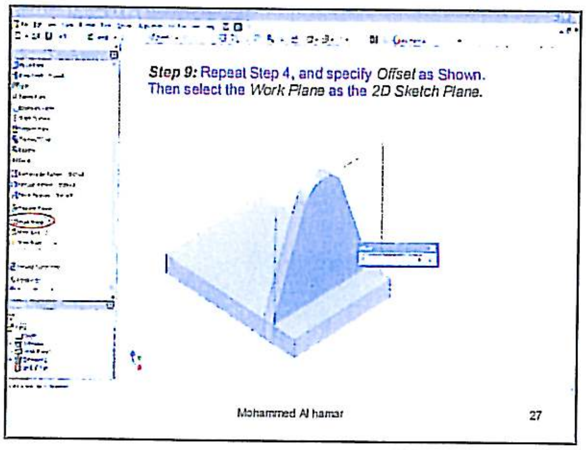
Step 9: Repeat Step 4, and specify Offset as Shown. Then select the Work Plane as the 2D Sketch Plane.
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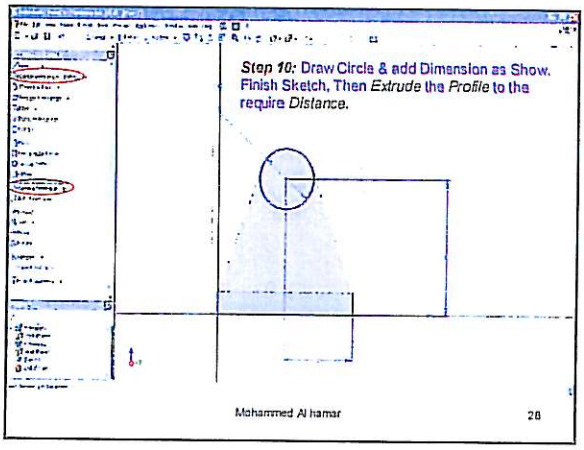
Step 10: Draw Circle & add Dimension as Show. Finish Sketch, Then Extrude the Profile to the require Distance.
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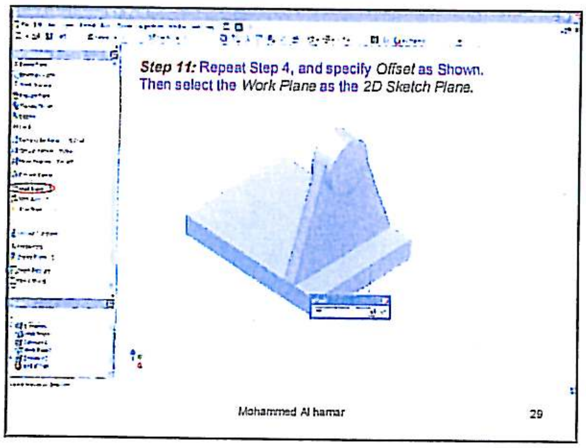
Step 11: Repeat Step 4, and specify Offset as Shown. Then select the Work Plane as the 2D Sketch Plane.
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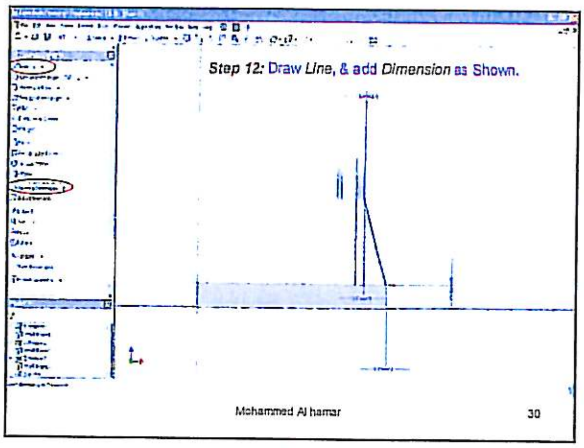
Step 12: Draw Line, & add Dimension as Shown.
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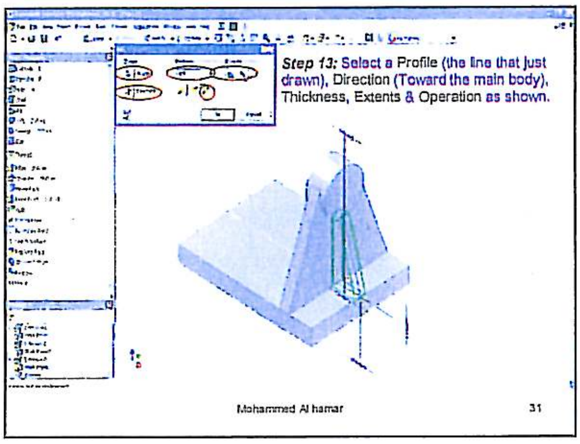
Step 13: Select a Profile (the line that just drawn), Direction (Toward the main body), Thickness, Extents & Operation as shown.
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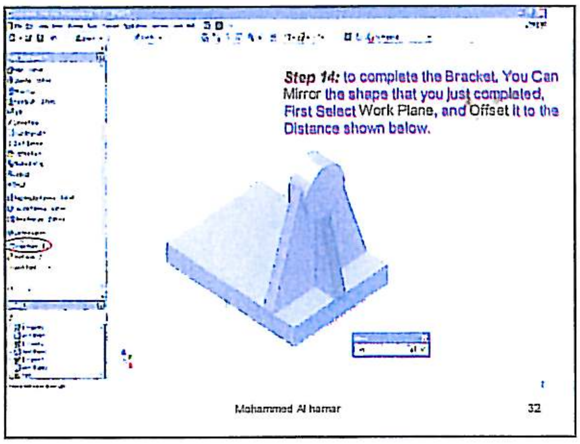
Step 14: to complete the Bracket, You Can Mirror the shape that you just completed, First Select Work Plane, and Offset it to the Distance shown below.
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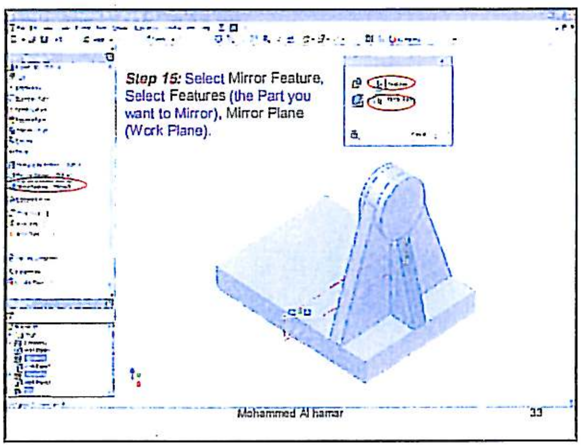
Step 15: Select Mirror Feature, Select Features (the Part you want to Mirror), Mirror Plane (Work Plane).
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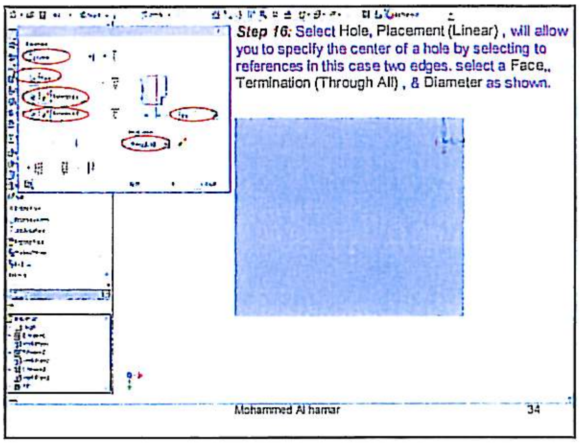
Step 16: Select Hole, Placement (Linear) , will allow you to specify the center of a hole by selecting to references in this case two edges. select a Face,, Termination (Through All) , & Diameter as shown.
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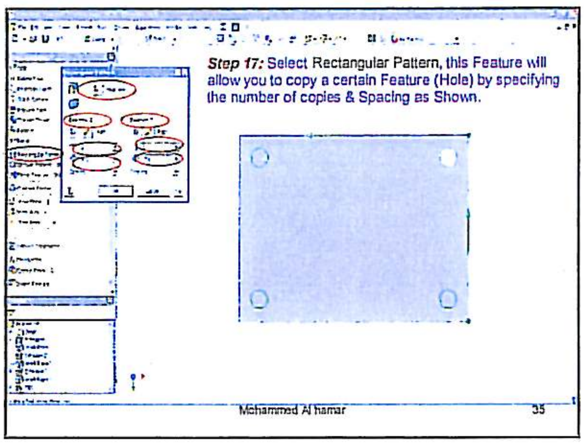
Step 17: Select Rectangular Pattern, this Feature will allow you to copy a certain Feature (Hole) by specifying the number of copies & Spacing as Shown.
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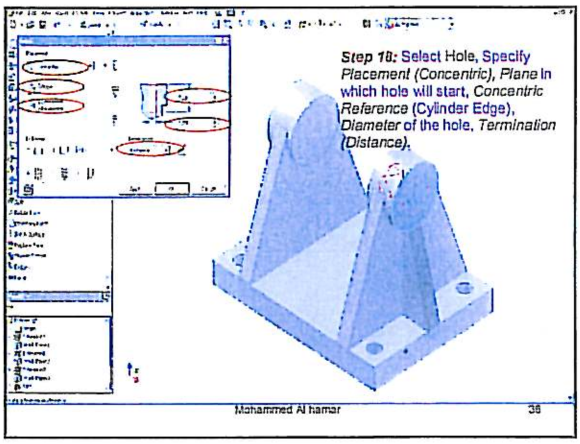
Step 18: Select Hole, Specify Placement (Concentric), Plane in which hole will start, Concentric Reference (Cylinder Edge), Diameter of the hole, Termination (Distance).
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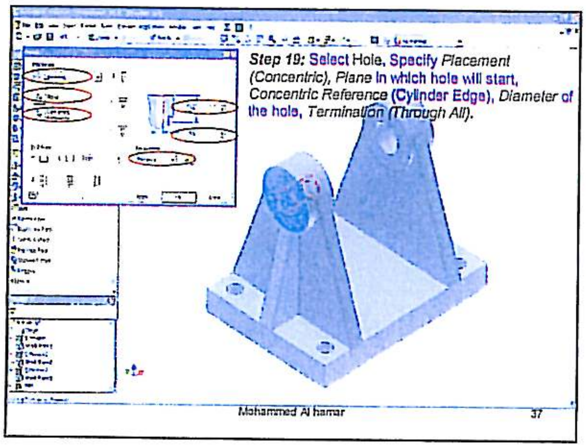
Step 19: Select Hole, Specify Placement (Concentric), Plane in which hole will start, Concentric Reference (Cylinder Edge), Diameter of the hole, Termination (Through All).
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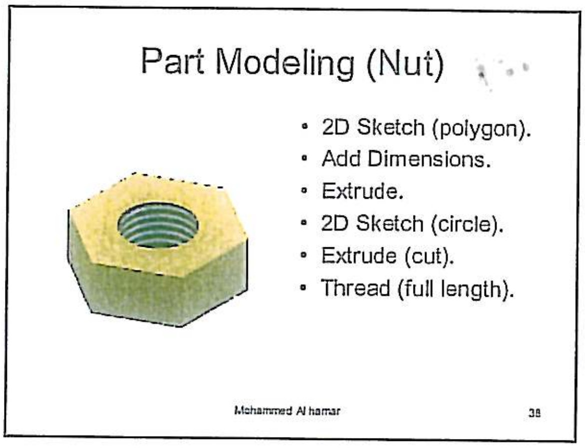
Part Modeling (Nut)
• 2D Sketch (polygon).
• Add Dimensions.
• Extrude.
• 2D Sketch (circle).
• Extrude (cut).
• Thread (full length).
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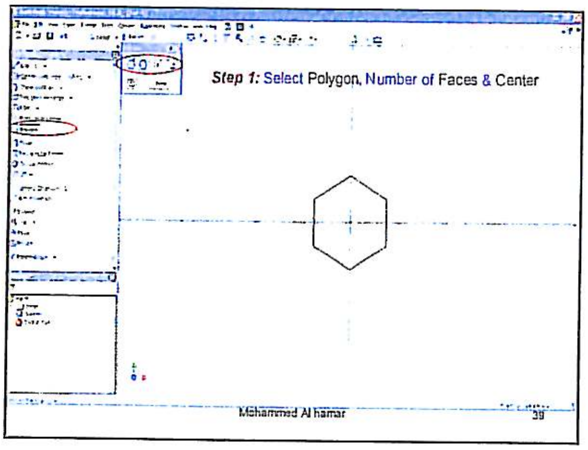
Step 1: Select Polygon, Number of Faces & Center
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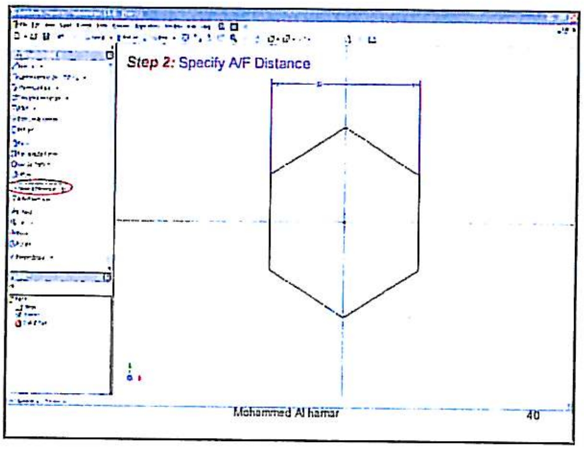
Step 2: Specify A/F Distance
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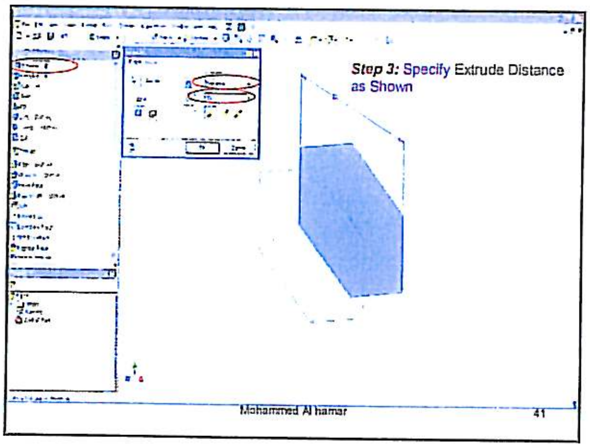
Step 3: Specify Extrude Distance as Shown
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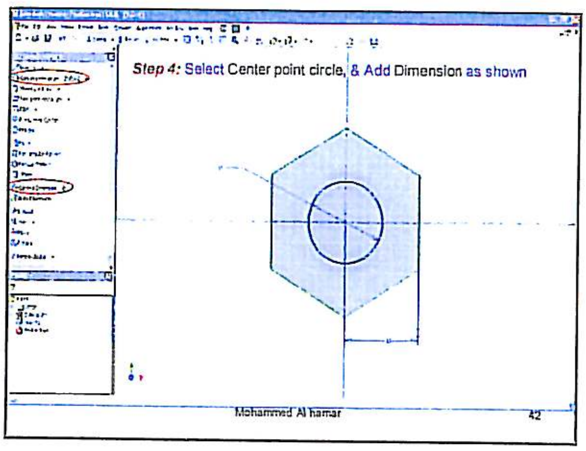
Step 4: Select Center point circle, & Add Dimension as shown
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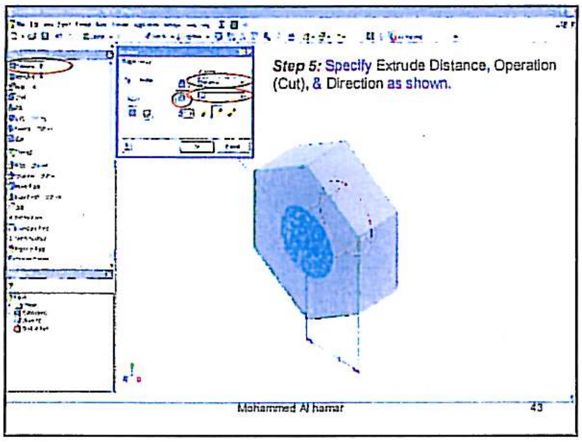
Step 5: Specify Extrude Distance, Operation (Cut), & Direction as shown.
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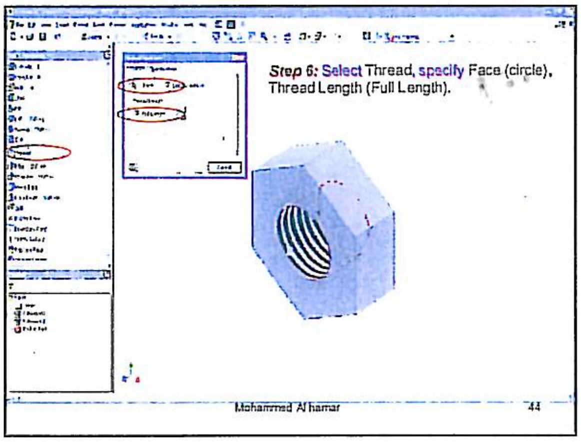
Step 6: Select Thread, specify Face (circle), Thread Length (Full Length).
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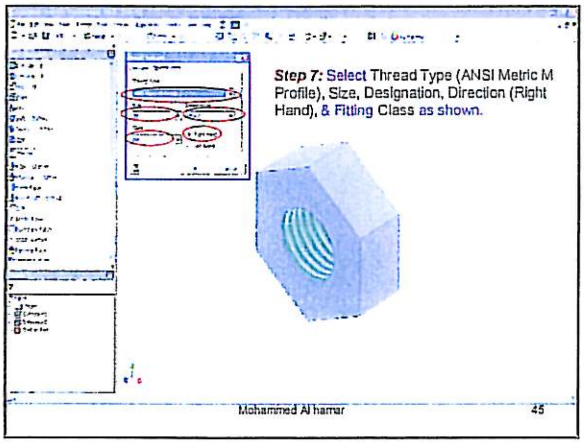
Step 7: Select Thread Type (ANSI Metric M Profile), Size, Designation, Direction (Right Hand), & Fitting Class as shown.
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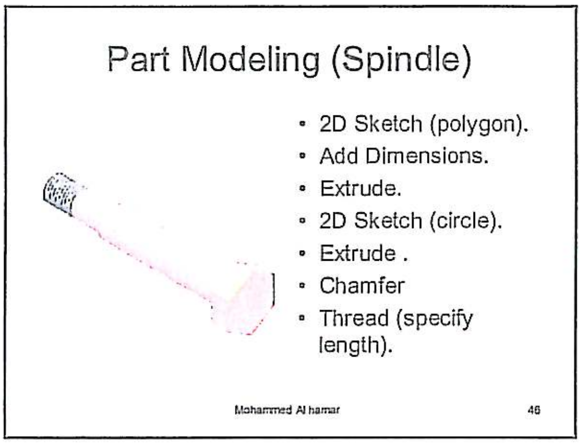
Part Modeling (Spindle)
• 2D Sketch (polygon).
• Add Dimensions.
• Extrude.
• 2D Sketch (circle).
• Extrude .
• Chamfer
• Thread (specify length).
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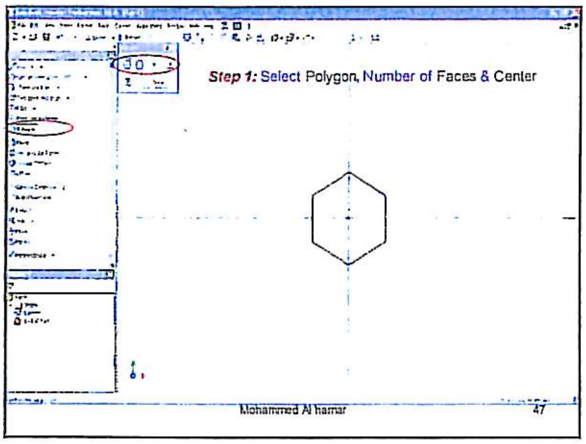
Step 1: Select Polygon, Number of Faces & Center
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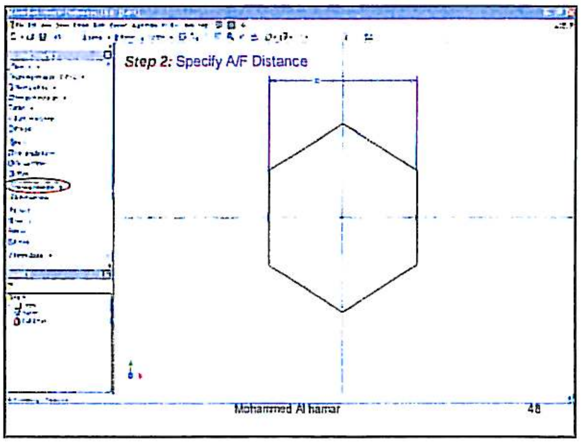
Step 2: Specify A/F Distance
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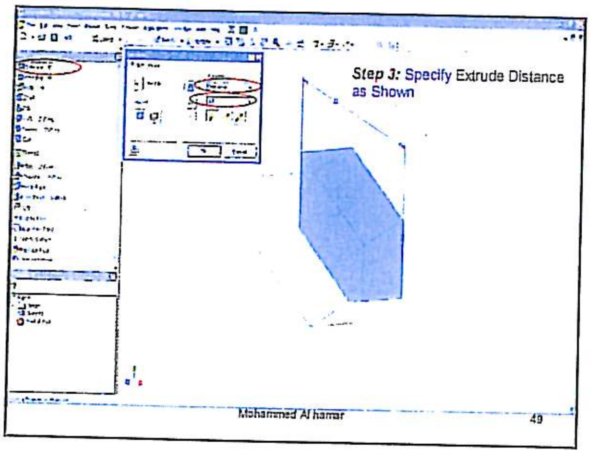
Step 3: Specify Extrude Distance as Shown
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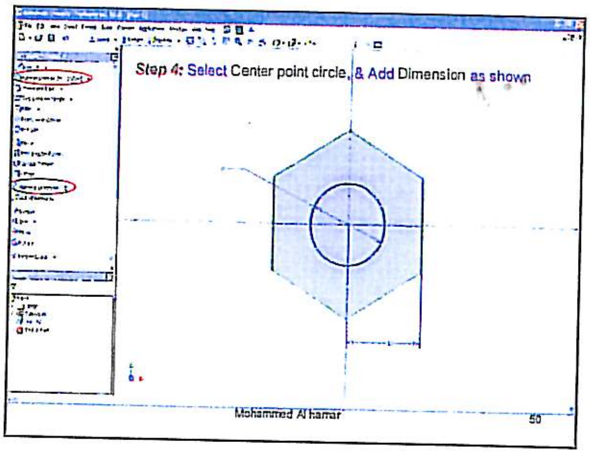
Step 4: Select Center point circle, & Add Dimension as shown
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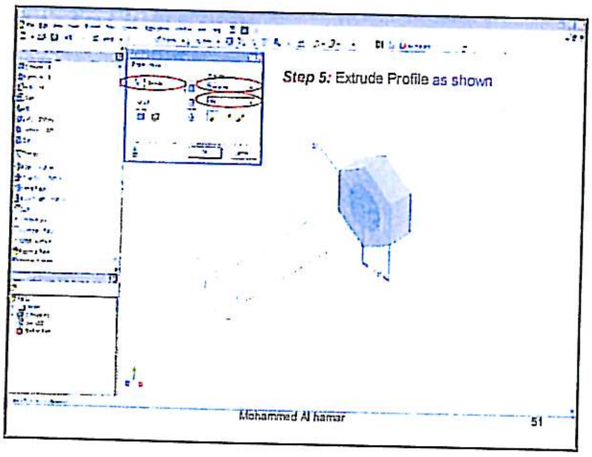
Step 5: Extrude Profile as shown
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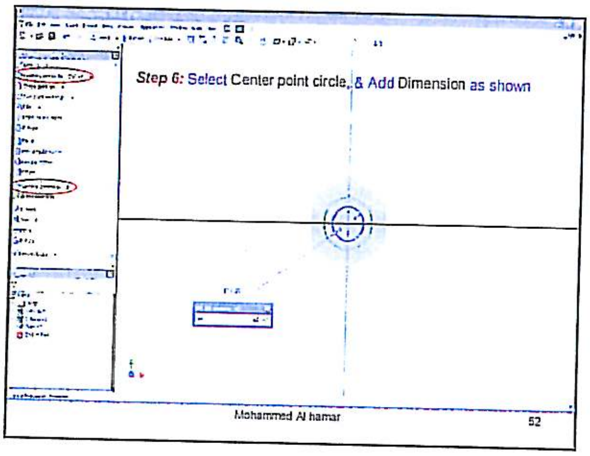
Step 6: Select Center point circle, & Add Dimension as shown
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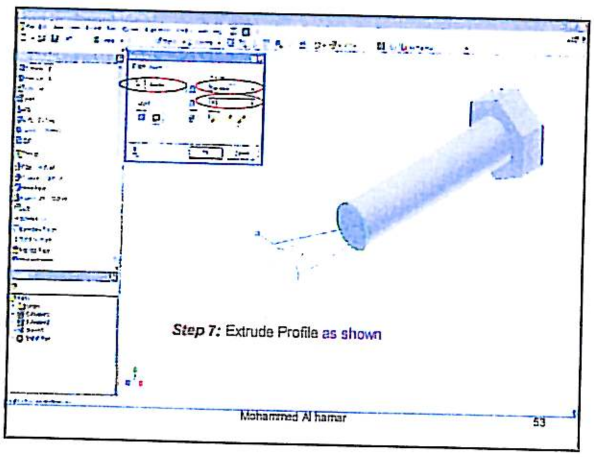
Step 7: Extrude Profile as shown
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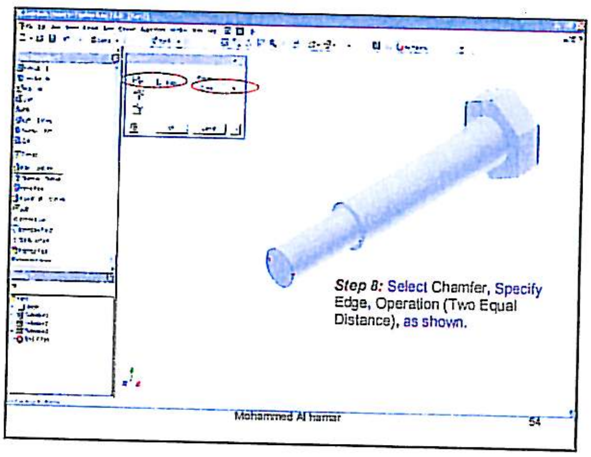
Step 8: Select Chamfer, Specify Edge, Operation (Two Equal Distance), as shown.
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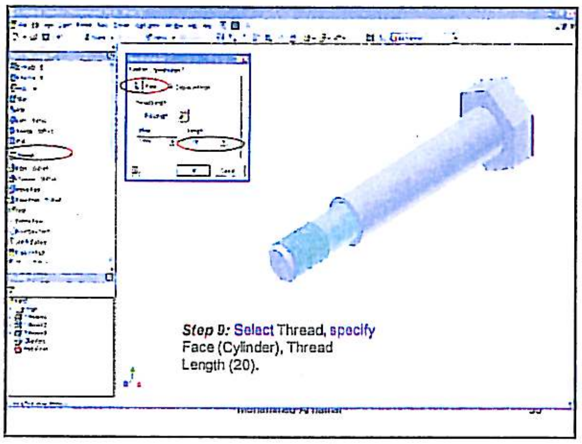
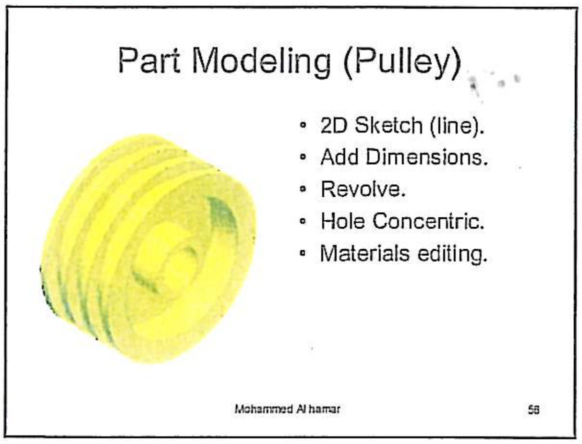

Step 9: Select Thread, specify
Face (Cylinder), Thread
Length (20).


Part Modeling (Pulley)
2D Sketch (line).
Add Dimensions.
Revolve.
Hole Concentric.
Materials editing.
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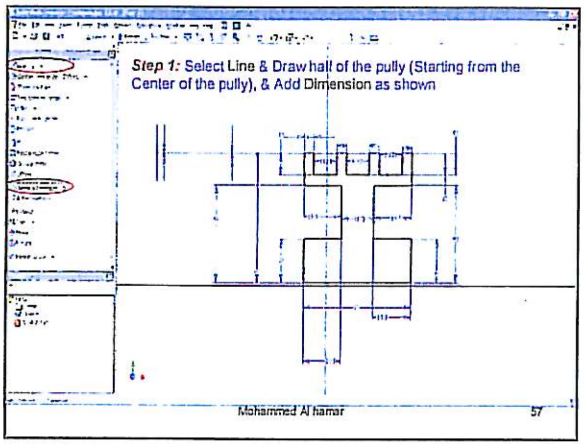
Step 1: Select Line & Draw half of the pully (Starting from the Center of the pully), & Add Dimension as shown
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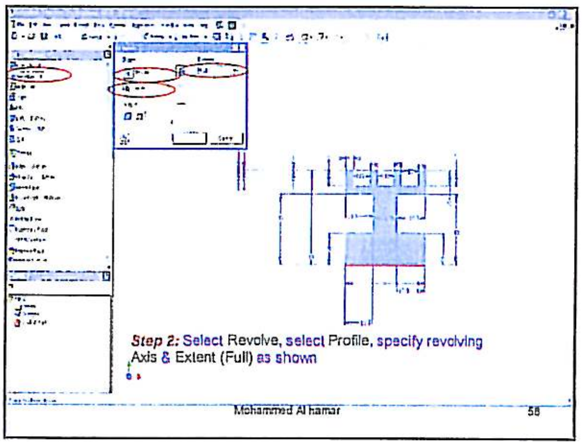
Step 2: Select Revolve, select Profile, specify revolving Axis & Extent (Full) as shown
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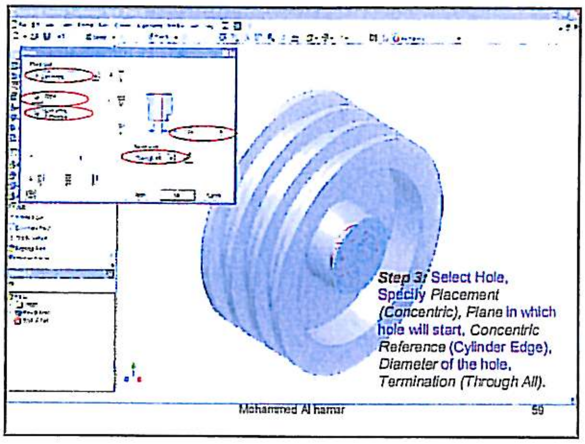
Step 3: Select Hole,
Specify Placement
(Concentric), Plane in which
hole will start, Concentric
Reference (Cylinder Edge),
Diameter of the hole,
Termination (Through All).
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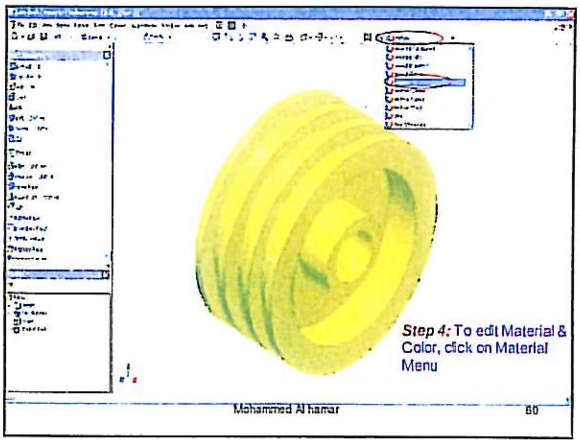
Step 4: To edit Material &
Color, click on Material
Menu
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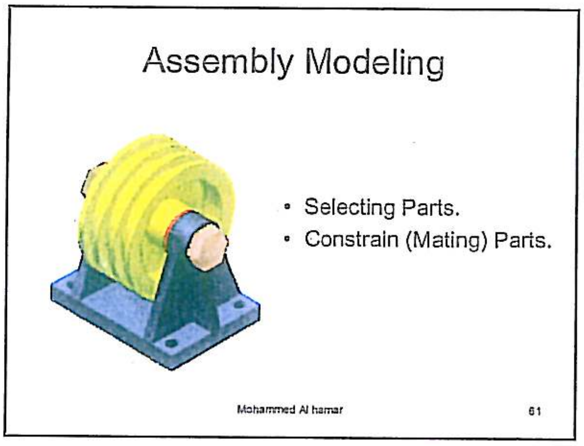
Assembly Modeling
• Selecting Parts.
• Constrain (Mating) Parts.
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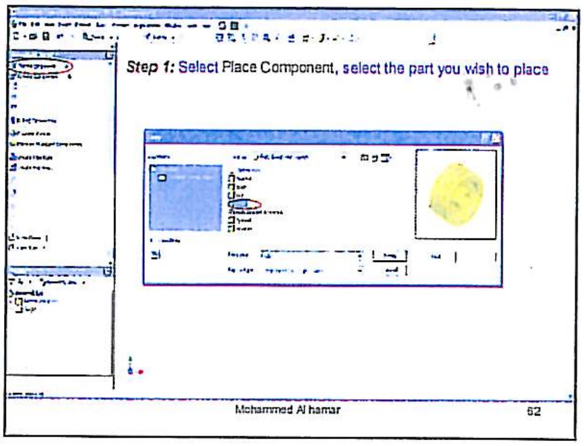
Step 1: Select Place Component, select the part you wish to place
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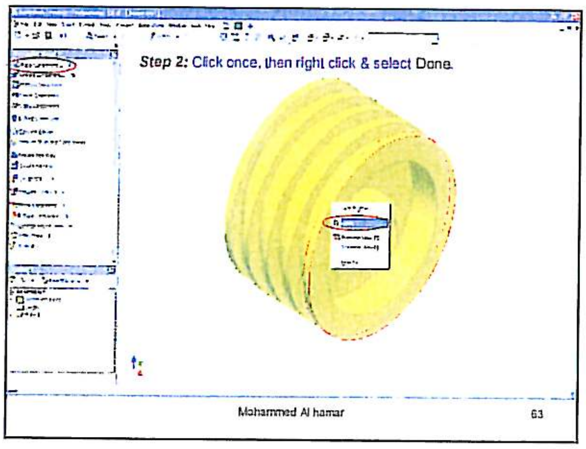
Step 2: Click once, then right click & select Done.
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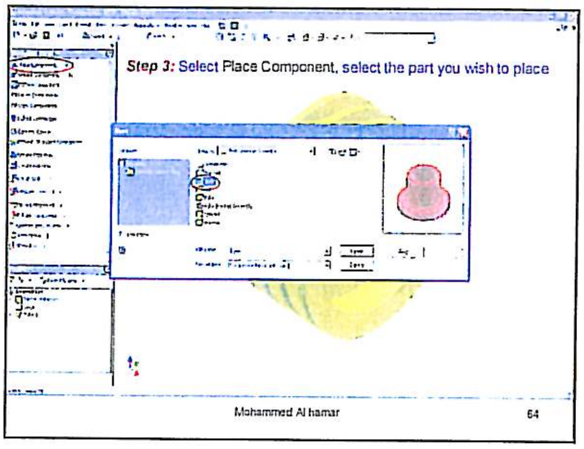
Step 3: Select Place Component, select the part you wish to place
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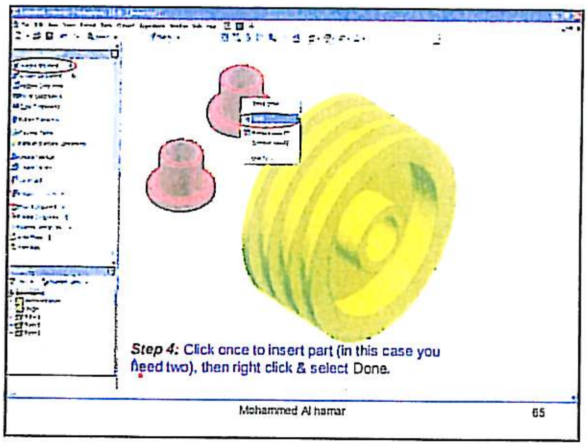
Step 4: Click once to insert part (in this case you need two), then right click & select Done.
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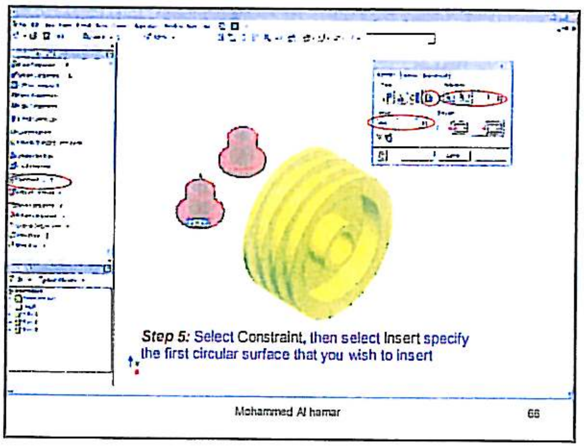
Step 5: Select Constraint, then select Insert specify the first circular surface that you wish to insert
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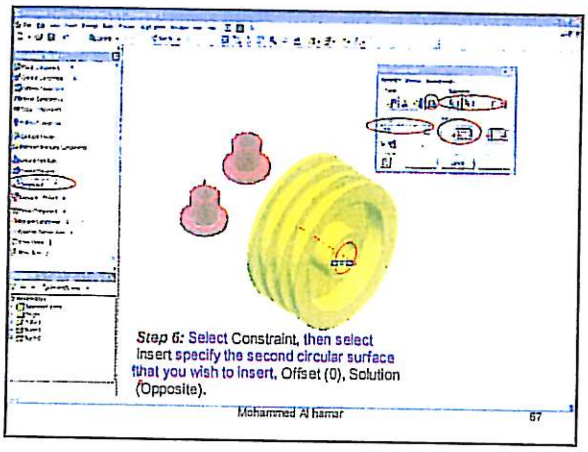
Step 6: Select Constraint, then select Insert specify the second circular surface that you wish to Insert, Offset (0), Solution (Opposite).
Mohammed Al hamar
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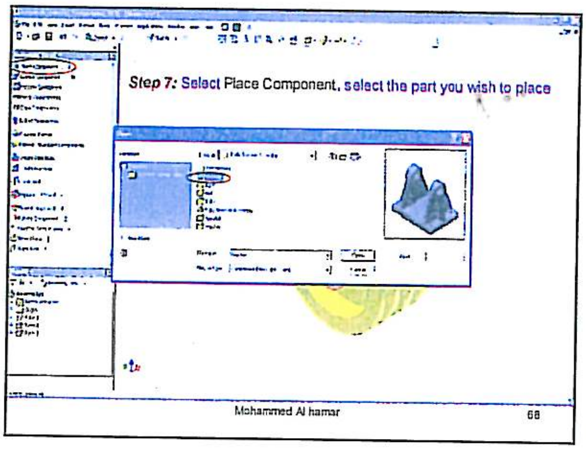
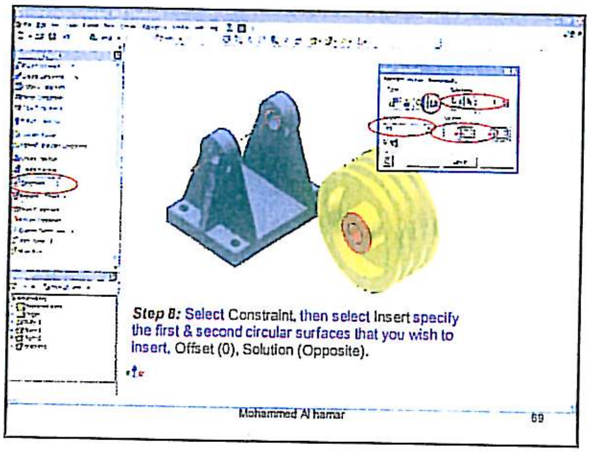
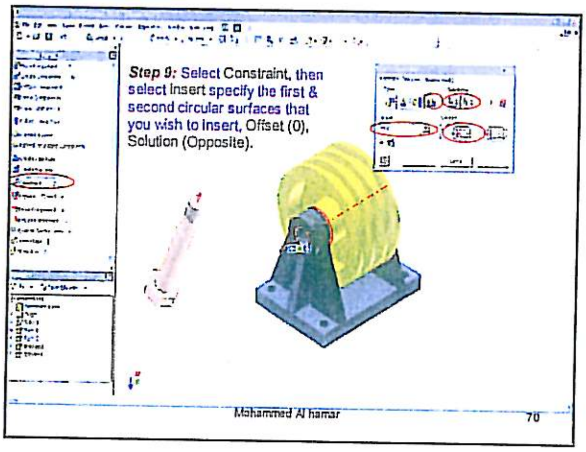
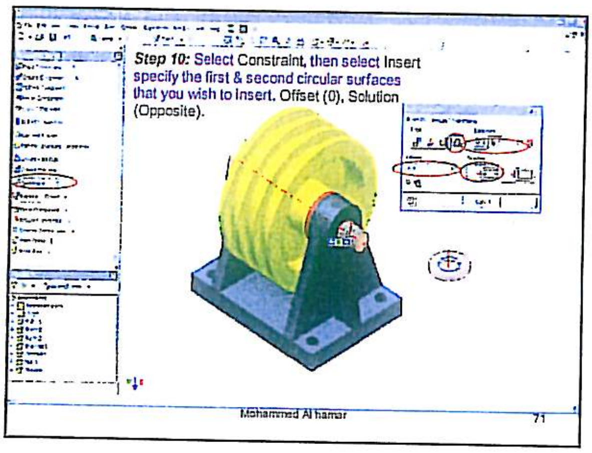
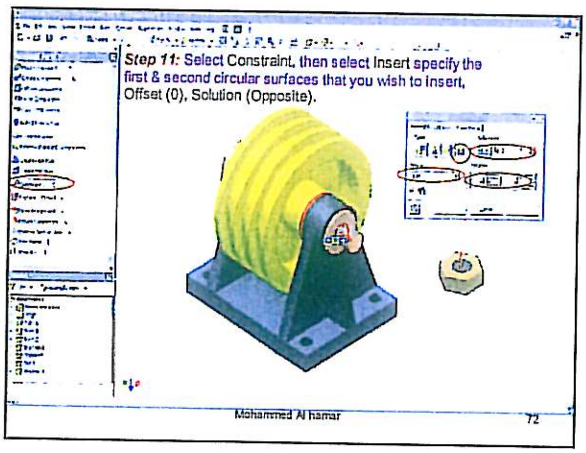
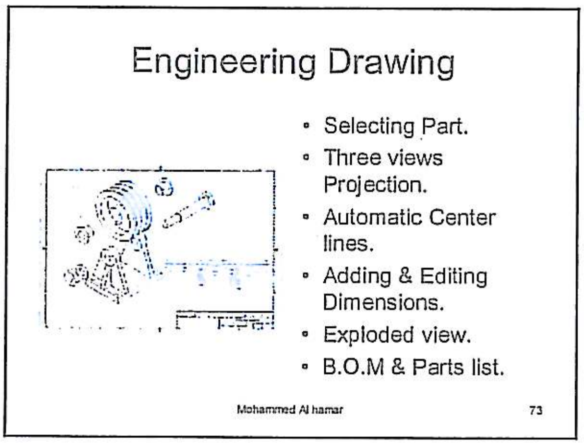

Step 7: Select Place Component, select the part you wish to place
Mohammed Al hamar
68

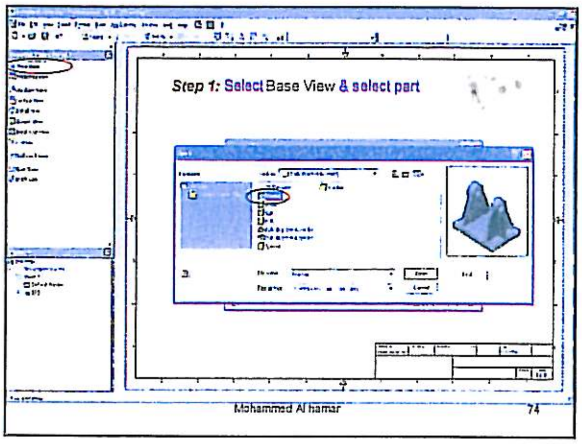

Step 8: Select Constraint, then select Insert specify the first & second circular surfaces that you wish to insert, Offset (0), Solution (Opposite).
Mohammed Al hamar
69

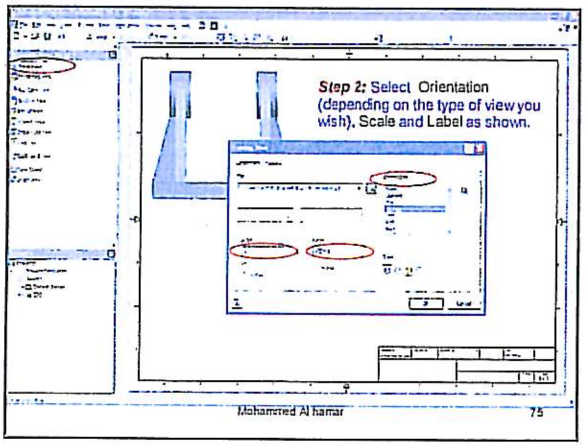

Step 9: Select Constraint, then select Insert specify the first & second circular surfaces that you wish to insert, Offset (0), Solution (Opposite).
Mohammed Al hamar
70

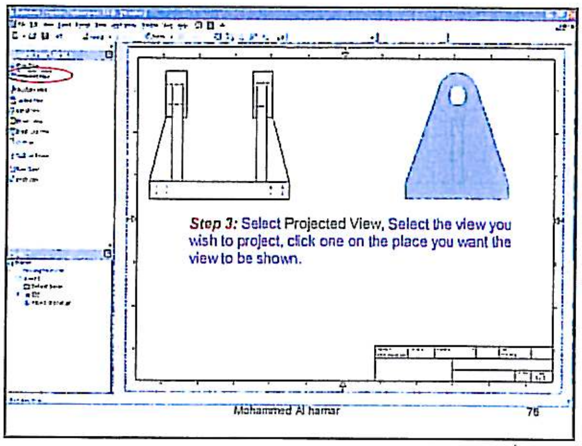

Step 10: Select Constraint, then select Insert specify the first & second circular surfaces that you wish to Insert, Offset (0), Solution (Opposite).
Mohammed Al hamar
71

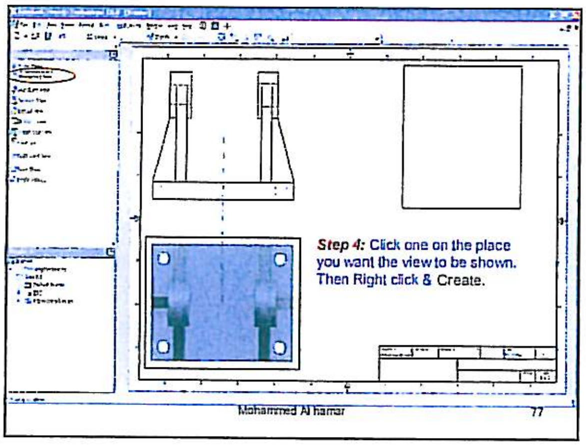

Step 11: Select Constraint, then select Insert specify the first & second circular surfaces that you wish to insert, Offset (0), Solution (Opposite).
Mohammed Al hamar
72

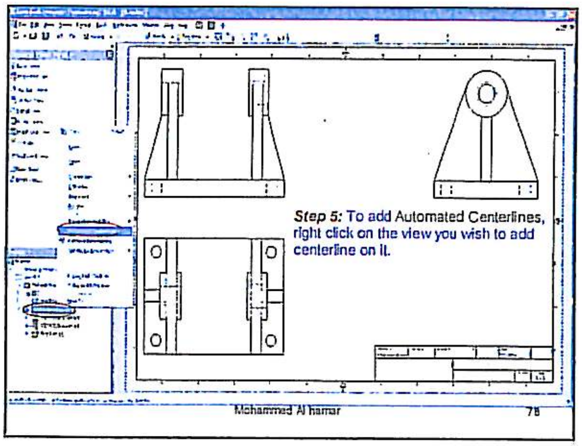

Engineering Drawing
Selecting Part.
Three views Projection.
Automatic Center lines.
Adding & Editing Dimensions.
Exploded view.
B.O.M & Parts list.
Mohammed Al hamar
73

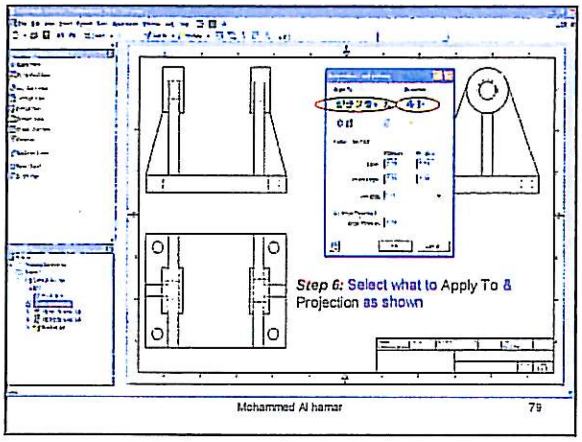

Step 1: Select Base View & select part
Mohammed Al hamar
74

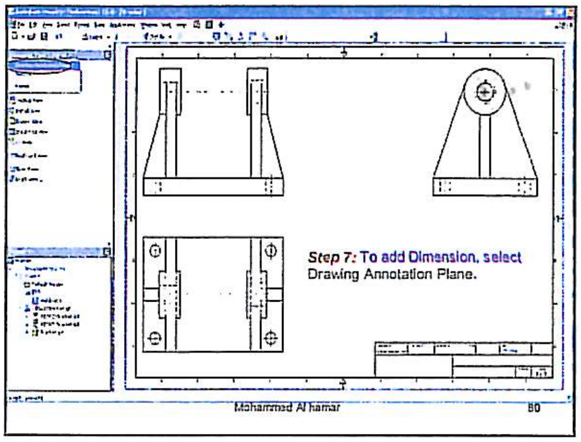

Step 2: Select Orientation (depending on the type of view you wish), Scale and Label as shown.
Mohammed Al hamar
75

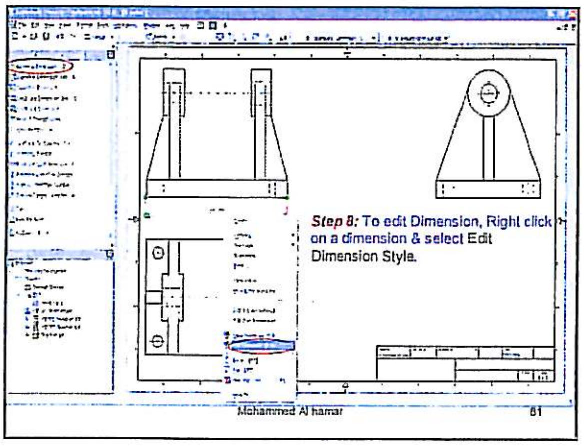

Step 3: Select Projected View, Select the view you wish to project, click one on the place you want the view to be shown.
Mohammed Al hamar
76

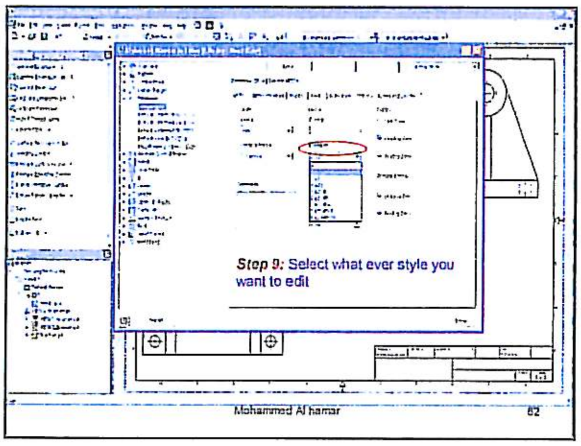

Step 4: Click one on the place you want the view to be shown. Then Right click & Create.
Mohammed Al hamar
77

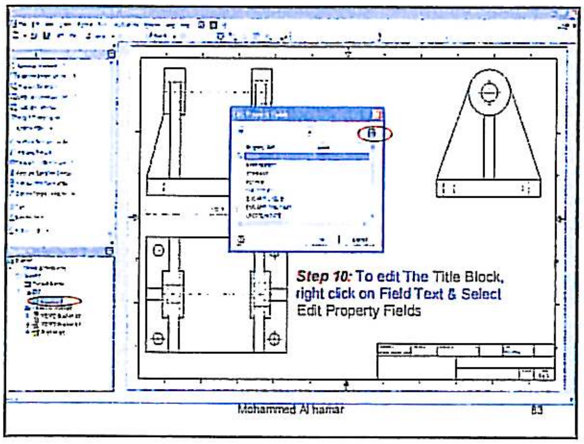

Step 5: To add Automated Centerlines, right click on the view you wish to add centerline on it.
Mohammed Al hamar
78

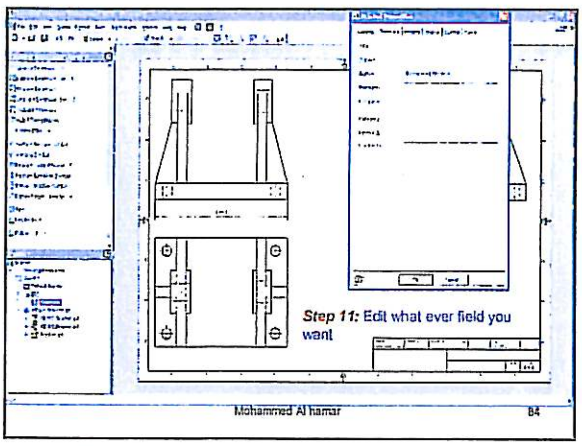

Step 6: Select what to Apply To & Projection as shown
Mohammed Al hamar
79

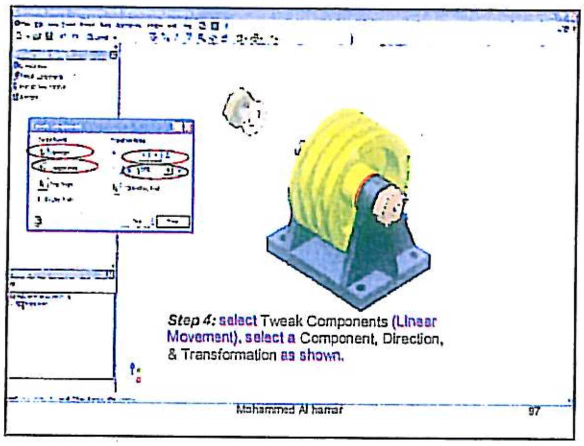

Step 7: To add Dimension, select Drawing Annotation Plane.
Mohammed Al hamar
80

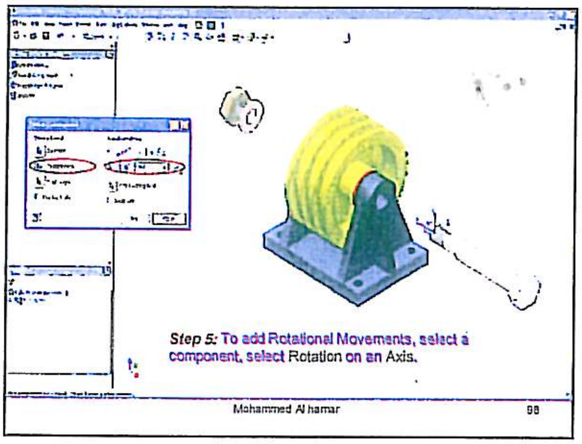

Step 8: To edit Dimension, Right click on a dimension & select Edit Dimension Style.
Mohammed Al hamar
81

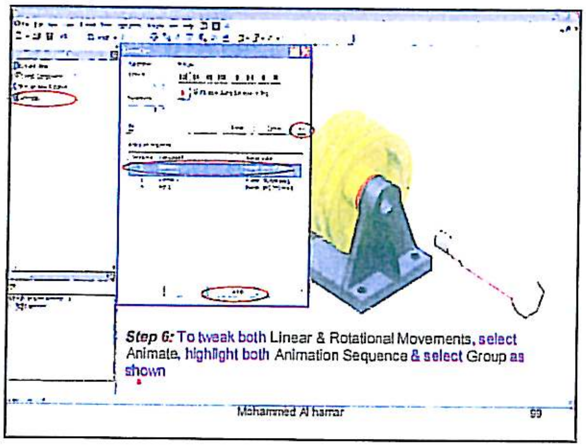

Step 9: Select what ever style you want to edit
Mohammed Al hamar
82

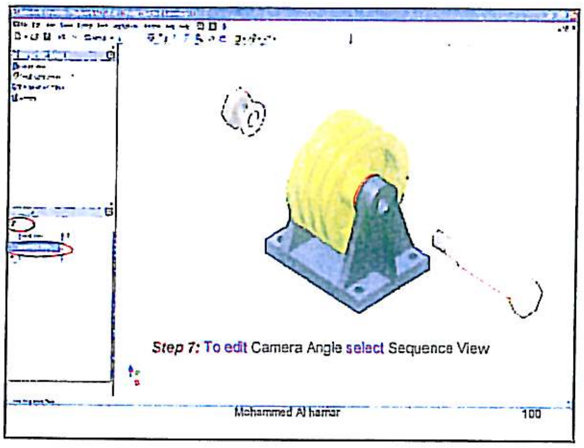

Step 10: To edit The Title Block, right click on Field Text & Select Edit Property Fields
Mohammed Al hamar
83

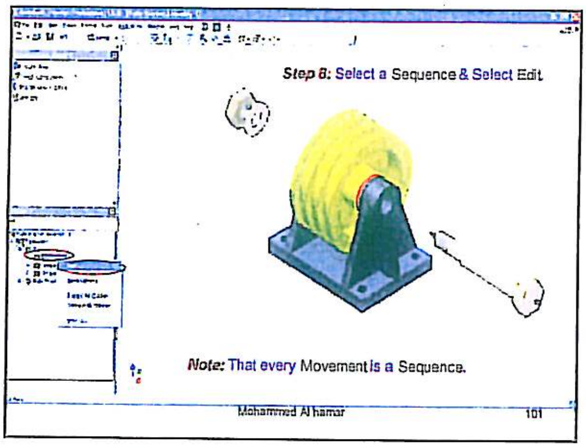

Step 11: Edit what ever field you want
Mohammed Al hamar
84

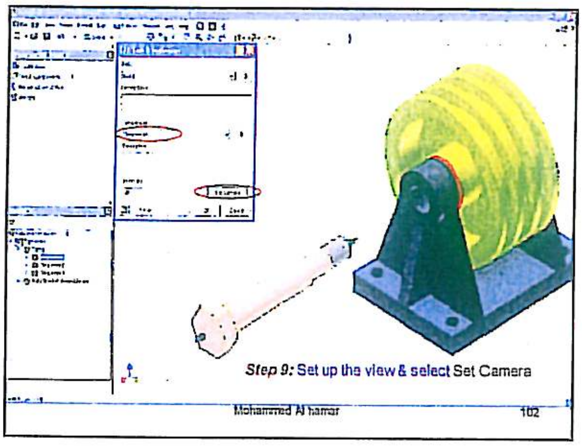

Step 4: select Tweak Components (Linear Movement), select a Component, Direction, & Transformation as shown.
Mohammed Al hamar
97

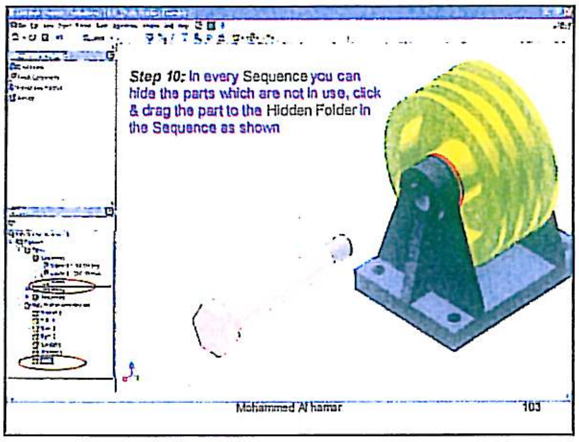

Step 5: To add Rotational Movements, select a component, select Rotation on an Axis.
Mohammed Al hamar
98

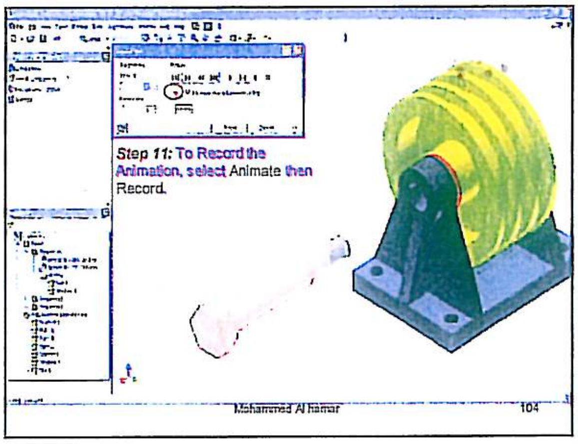

Step 6: To tweak both Linear & Rotational Movements, select Animate, highlight both Animation Sequence & select Group as shown
Mohammed Al hamar
99

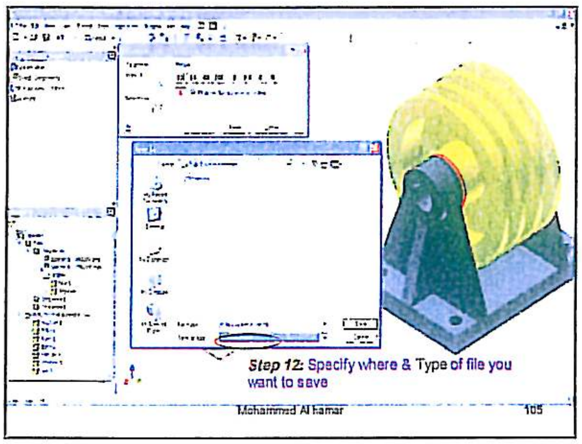

Step 7: To edit Camera Angle select Sequence View
Mohammed Al hamar
100

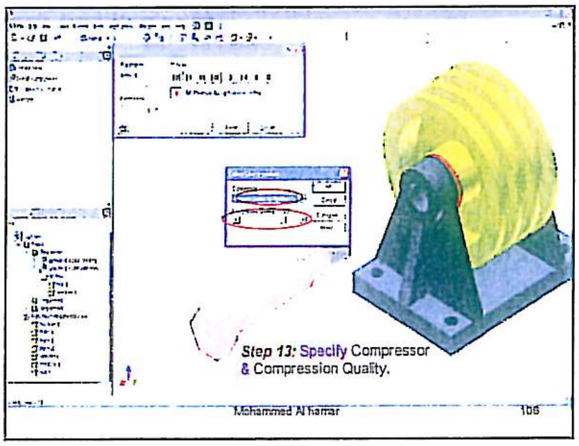

Step 8: Select a Sequence & Select Edit
Note: That every Movement is a Sequence.
Mohammed Al hamar
101

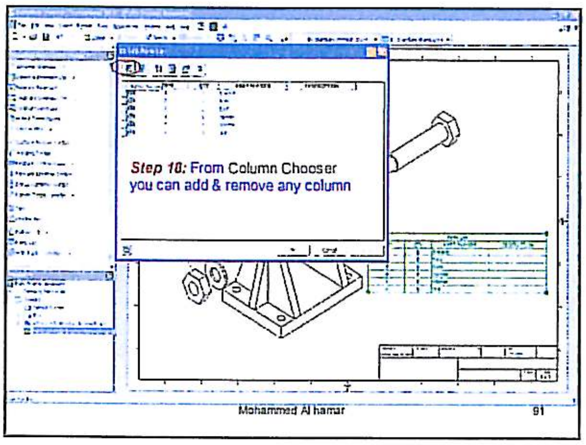

Step 9: Set up the view & select Set Camera
Mohammed Al hamar
102

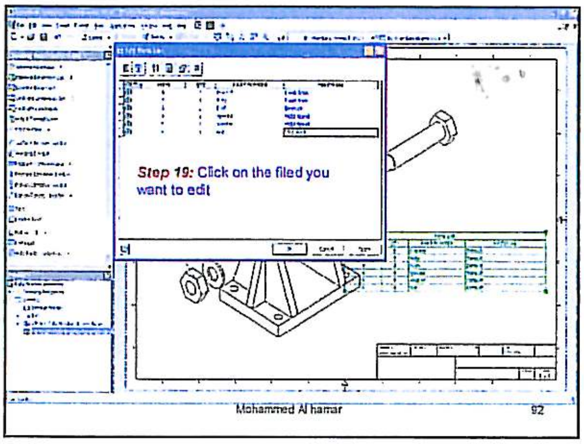

Step 10: In every Sequence you can hide the parts which are not in use, click & drag the part to the Hidden Folder in the Sequence as shown
Mohammed Al hamar
103


Step 11: To Record the Animation, select Animate then Record.
Mohammed Al hamar
104


Step 12: Specify where & Type of file you want to save
Mohammed Al hamar
105


Step 13: Specify Compressor & Compression Quality.
Mohammed Al hamar
106

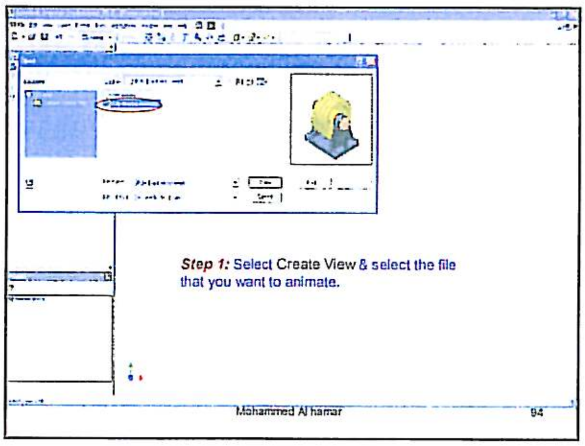


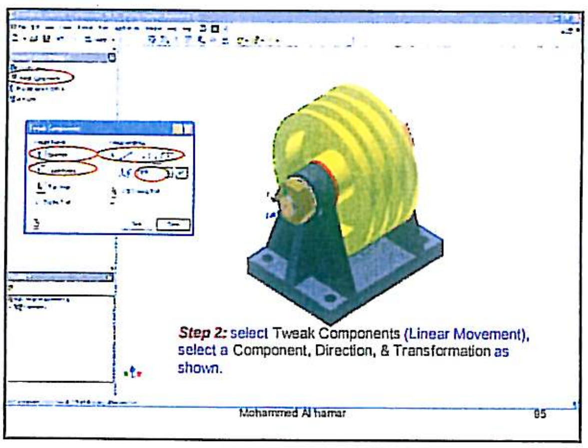


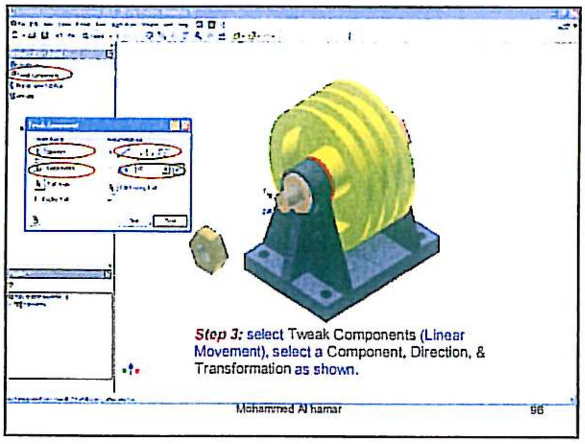
Presentation

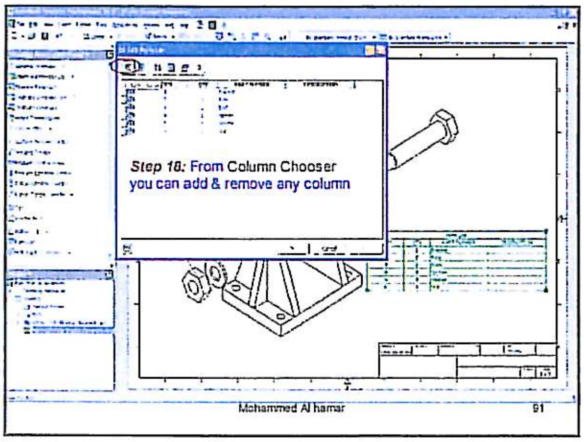
- Create View.
- Tweak Part (linear & rotational).
- Group Tasks.
- Editing sequence (camera Angle & Hidden Parts).
- Creating AVI File.

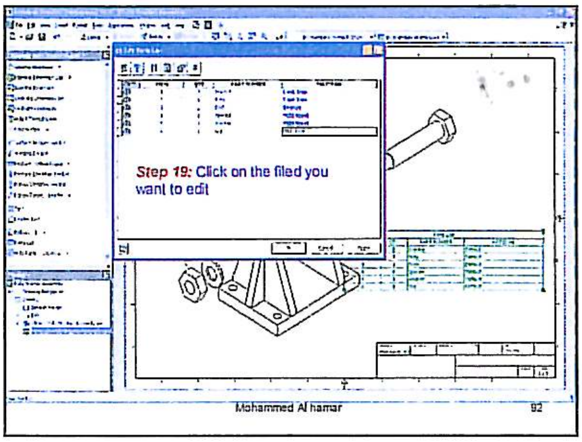
Mohammed Al hamar 93

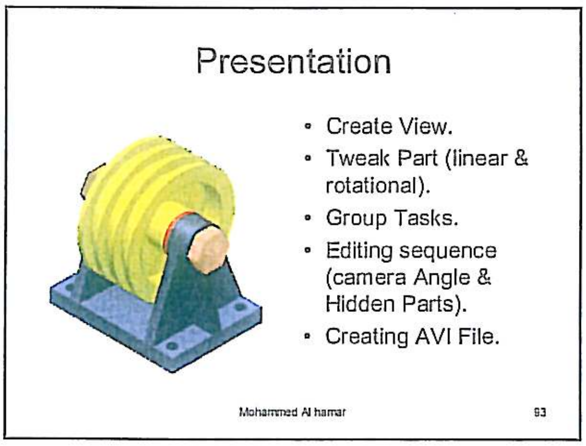


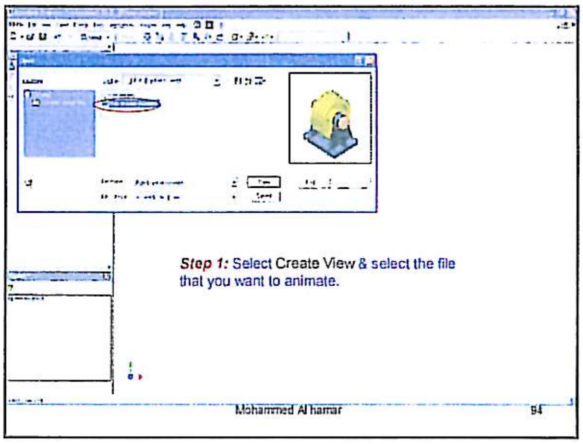


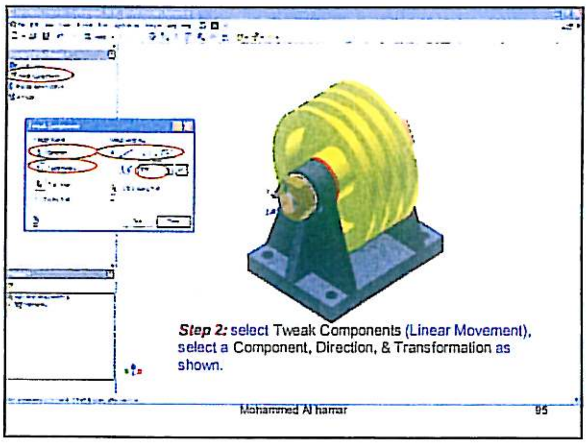


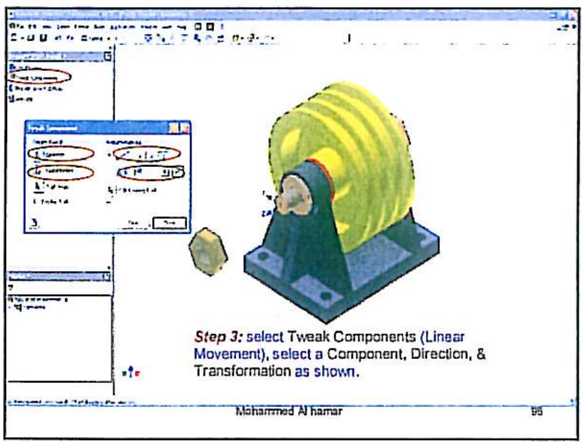

Step 18: From Column Chooser you can add & remove any column
Mohammed Al hamar
91


Step 19: Click on the filed you want to edit
Mohammed Al hamar
92


Presentation
Create View.
Tweak Part (linear & rotational).
Group Tasks.
Editing sequence (camera Angle & Hidden Parts).
Creating AVI File.
Mohammed Al hamar
93


Step 1: Select Create View & select the file that you want to animate.
Mohammed Al hamar
94


Step 2: select Tweak Components (Linear Movement), select a Component, Direction, & Transformation as shown.
Mohammed Al hamar
95


Step 3: select Tweak Components (Linear Movement), select a Component, Direction, & Transformation as shown.
Mohammed Al hamar
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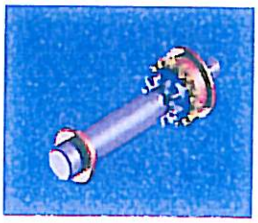
CAM Tutorial

Mechanical Desktop 2004

- Introduction to the software.
- Design different parts.
- Add design feature such as hole, thread & chamfer.
- Design a gear.
- Produces Engineering drawing.
- Produces Assembly Parts.
- Transfer data from CAM to CNC Machine.

Parts to be design.

- Gear Shaft which include:
- Shaft.
- Bush.
- Gear

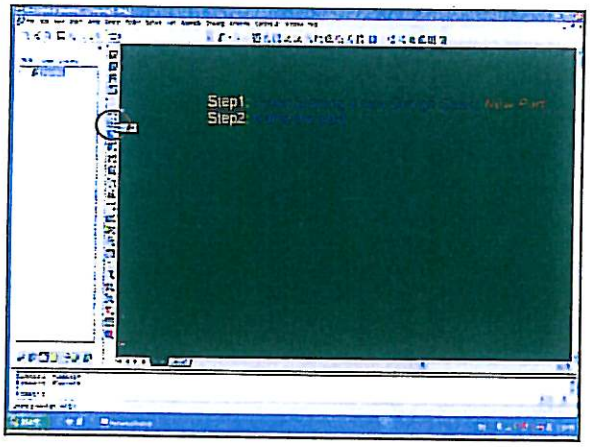


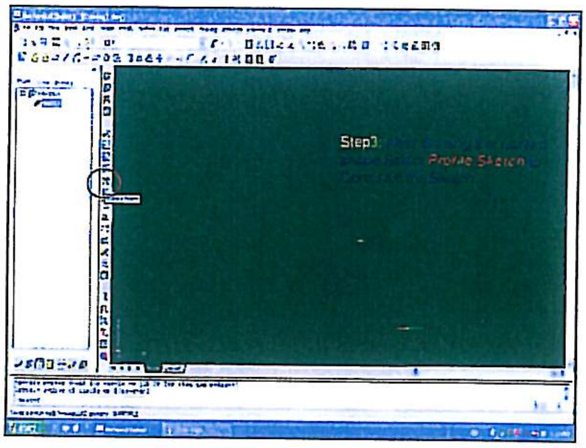
Getting Started

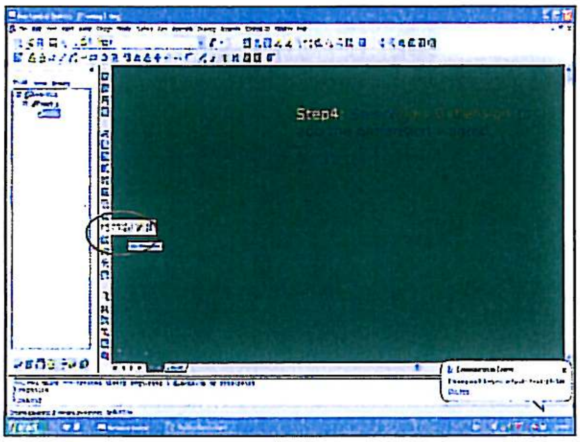
- Double click on MDT shortcut on the desktop.
- Select New.
- Draw a Step Shaft.

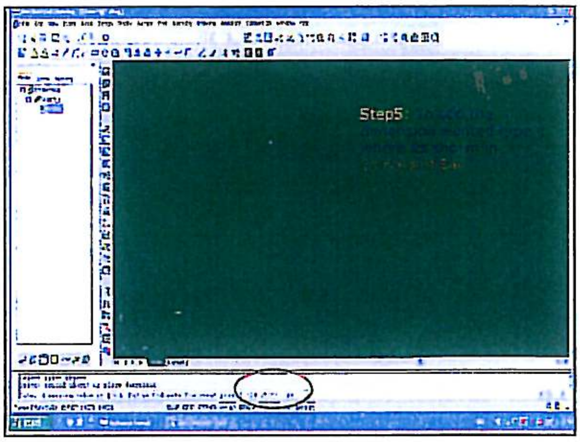
Part Modeling

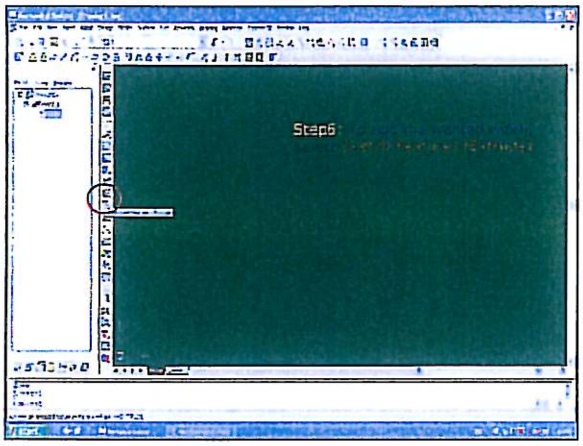
- Extrude.
- New Sketch Plane.
- Projection View.
- Join.
- Cut.

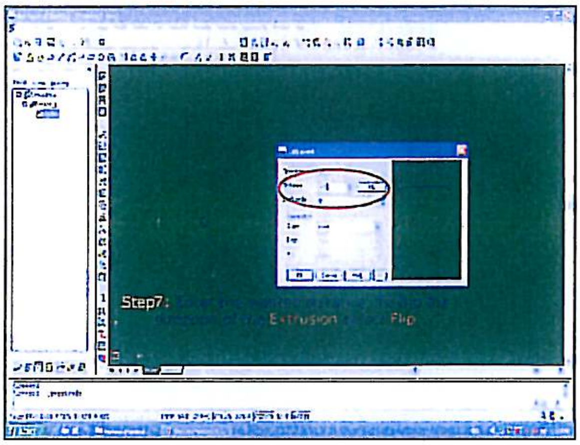


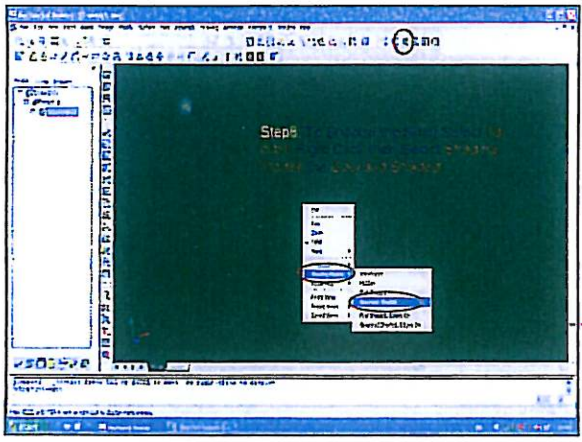


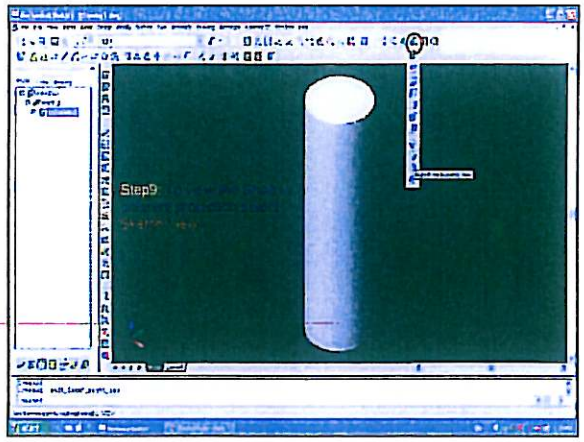

Step4

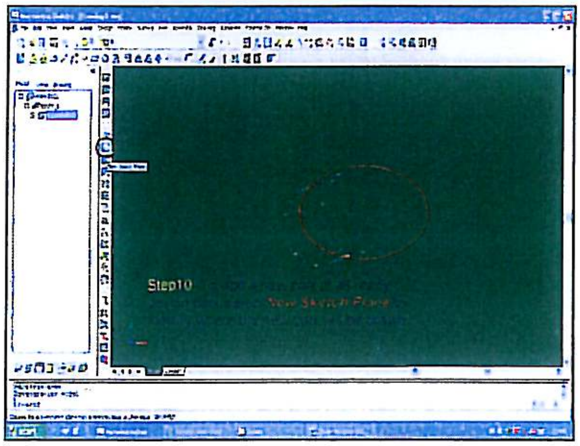

Step5:

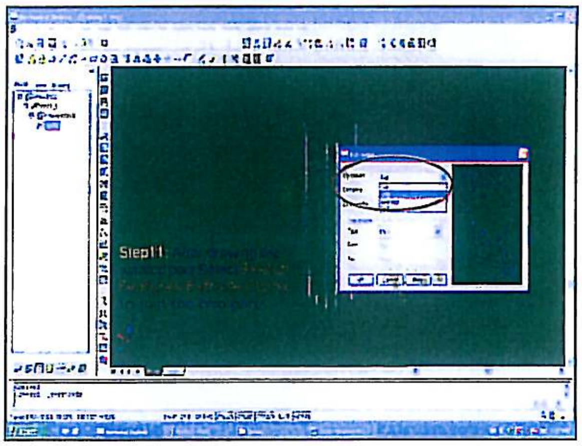

Step6:


Step7:


Step8

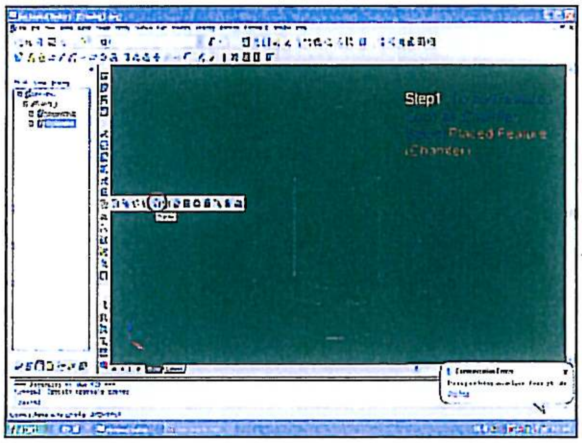

Step9

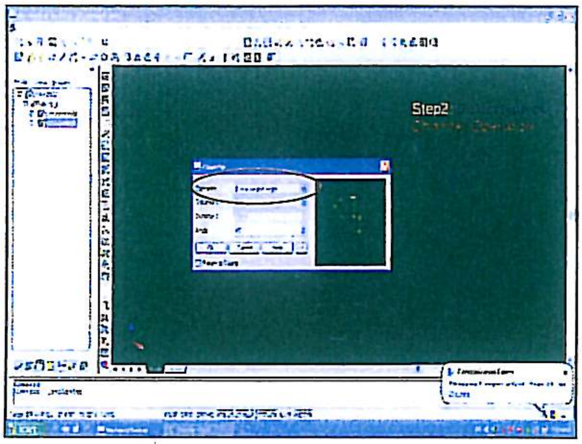


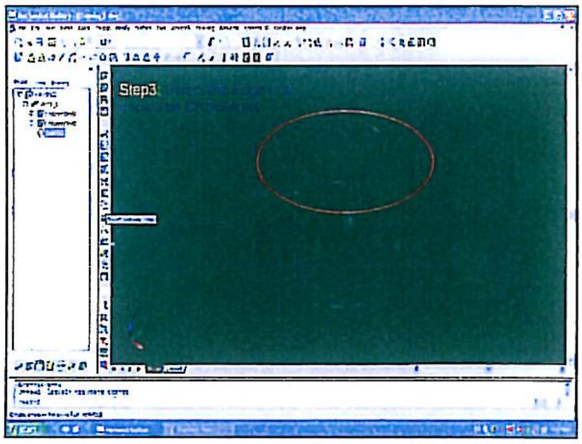


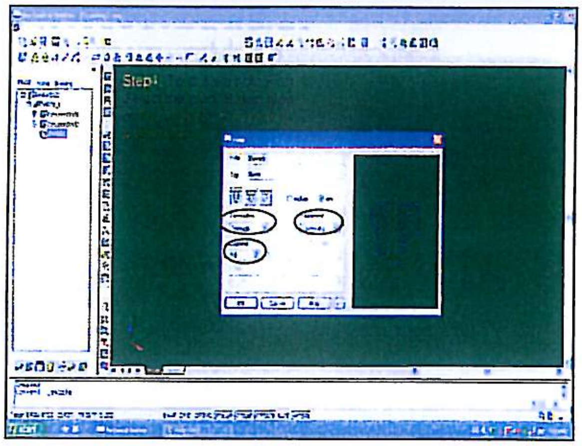
Placed Feature

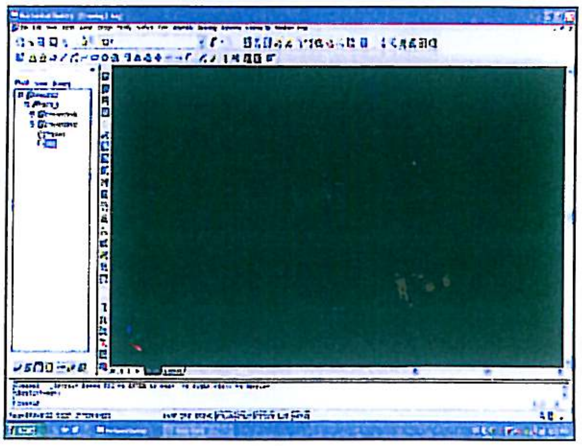
- ☐ Chamfer.
- ☐ Hole.
- ☐ Thread.
- ☐ Fillet.

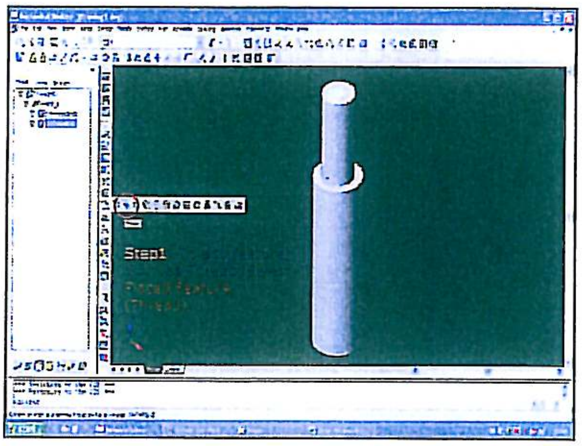


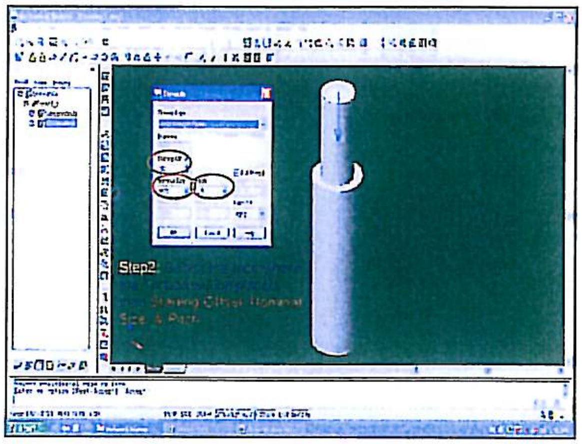






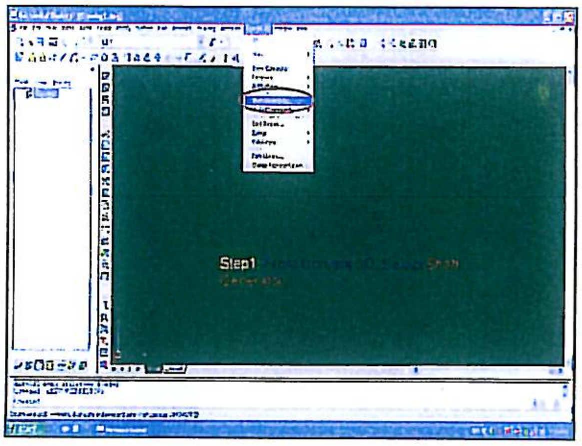


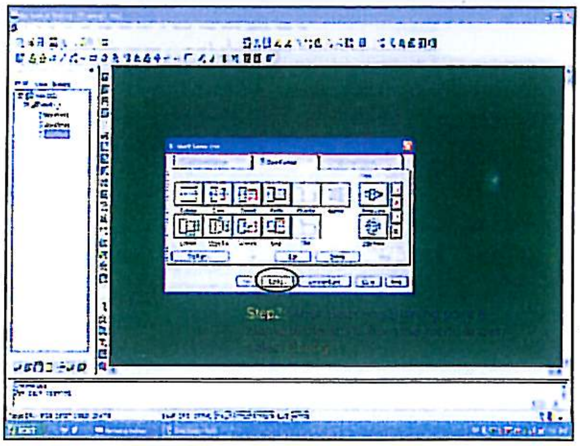


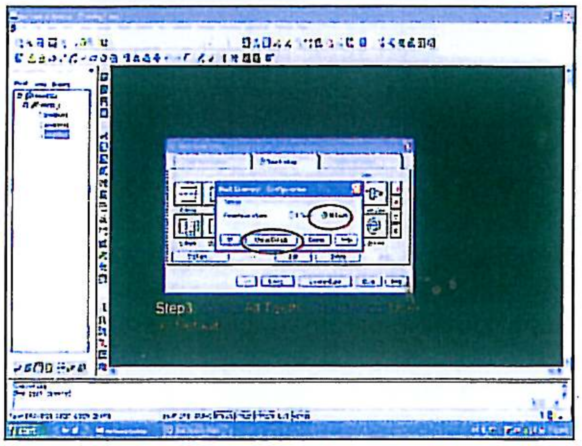


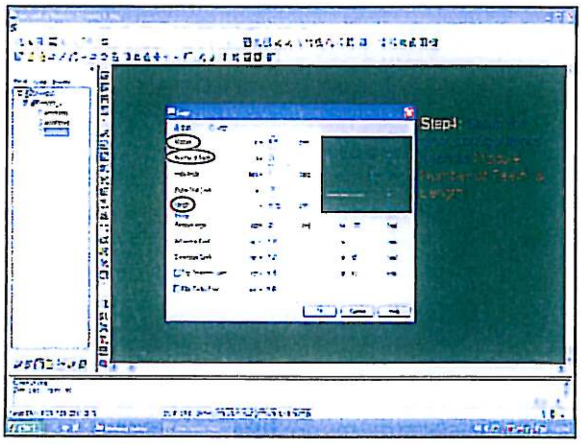
Shaft Generator.

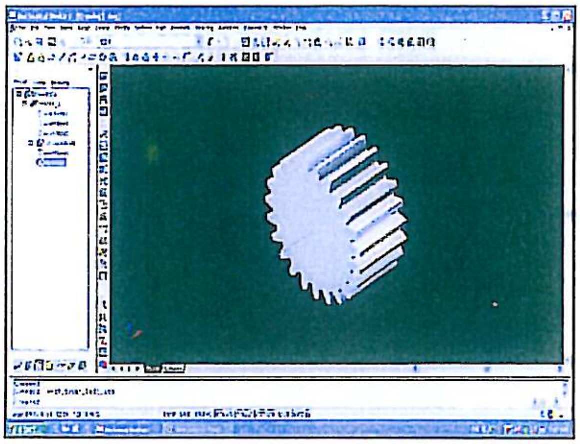
- ☐ Gear Modeling.





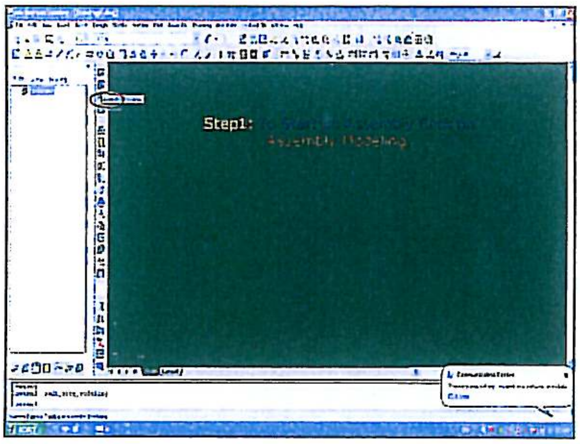


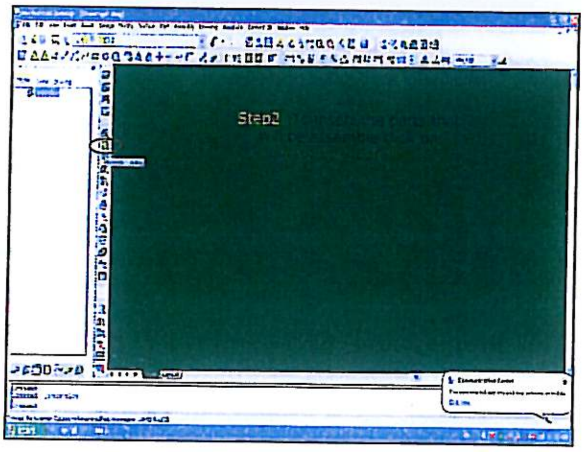


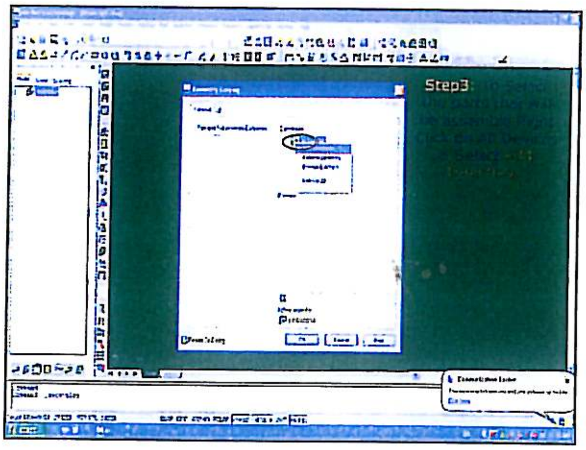


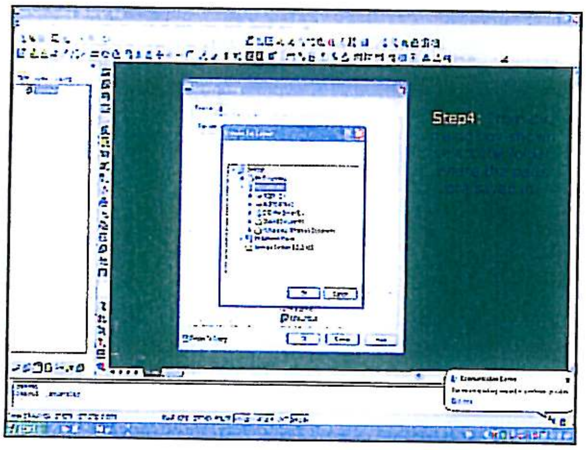
Assembly Modeling

- Set up Assembly Modeling.
- Assembly Catalog.
- Attaching Parts.
- 3D Assembly Constrains, such as Mate, Flush, Angle, & Insert.




Step2


Step3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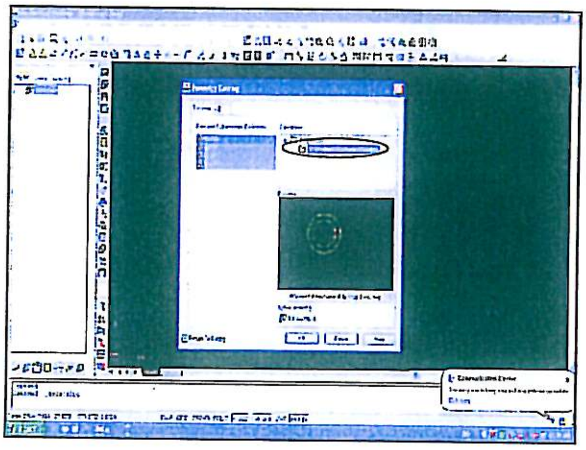

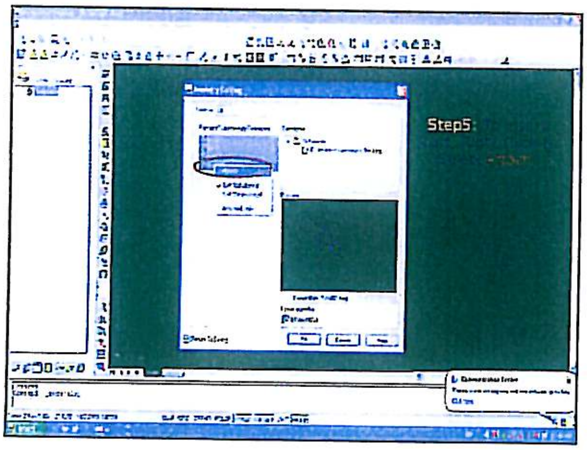
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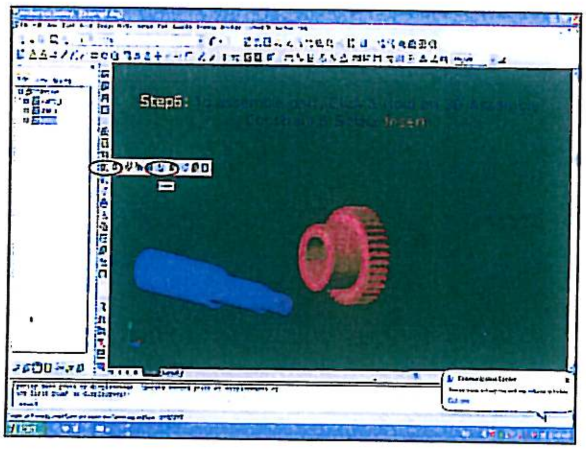
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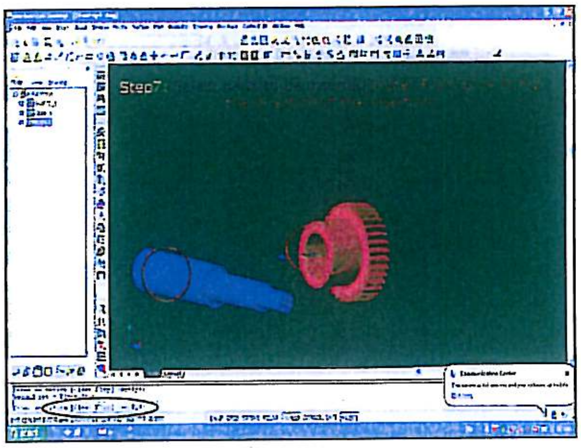
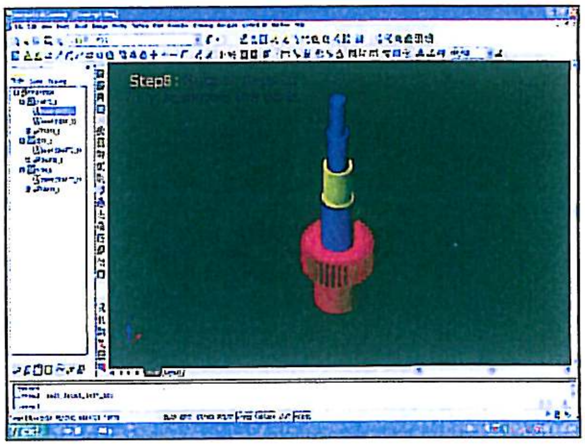
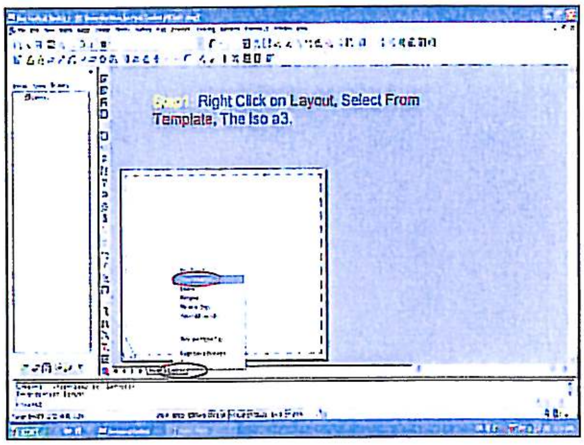
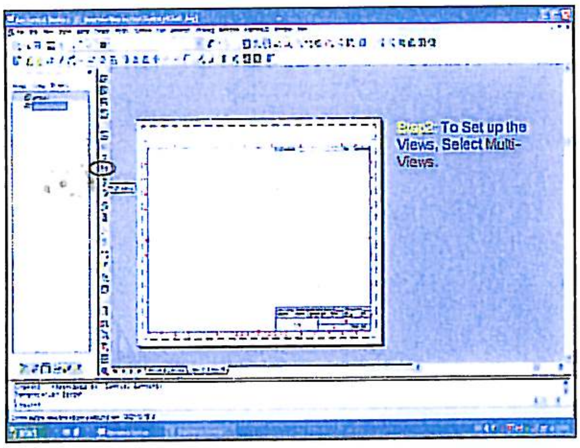


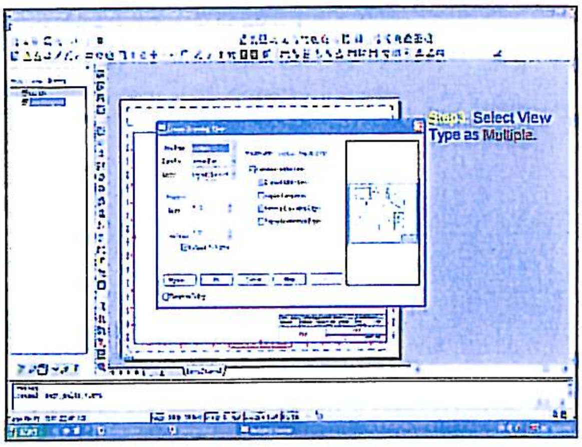


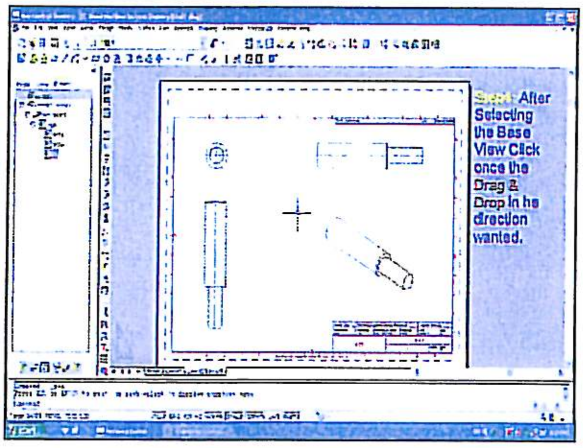
Engineering Drawing

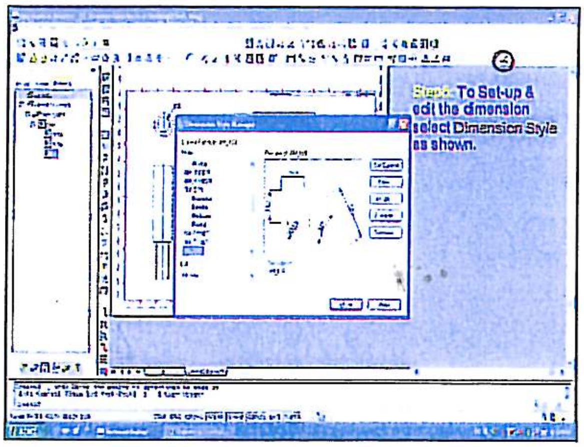
- Setting up the Layout.
- Setting the views.
- Editing & Setting up the Dimensions.
- Editing & Setting up the Title Block.

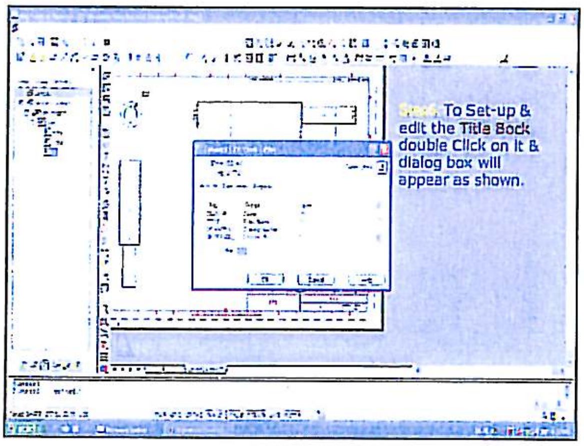


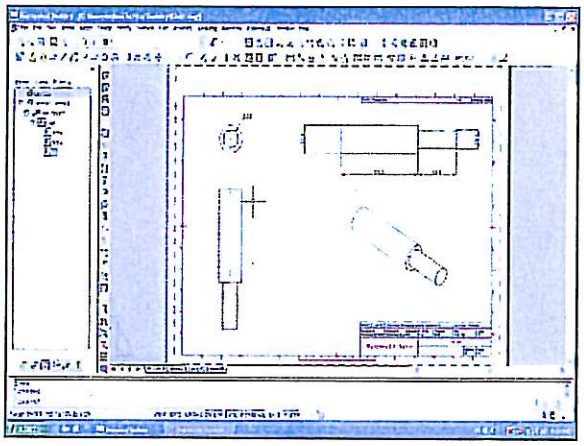












CNC Machines

- Spectra Light Milling Machine.
- Spectra Light Lathe Machine.

CAM (Computer Aided Manufacture)

- Auto Sketch.
- Spectra CAM.
- Spectra Light Machine.

Auto Sketch

- Develop the part drawing.
- Importing DXF file.

Spectra CAM

- Decide the Machine Tool.
- Choose the tooling required.
- Select machining parameters.
- Develop the CNC program.

Spectra Light Machine

- Load NC program.
- Verify the program.
- Set up the machine.
- Run the program to produce the part.

CNC Tutorial

Good Day to everyone!

WELCOME TO
CAM - CNC
TECHNOLOGY. . . . . . !

CAD - CAM - CNC

Using

Autosketch (R3.1)
Spectracam Milling Version3.21
Spectralight CNC Mill

By: Jesus L. Ybanez

Understanding the Basic Terms

- CAD
- CAM
- CNC

What is CAD ?

CAD stands for **C**omputer **A**ided **D**esign.
It refers to the process of developing drawings or graphics on a computer.

How about CAM, What does it mean ?

CAM - means **C**omputer
Aided
Manufacturing

It's a computer program that can take a drawing file from a CAD program and, with your help, turn it into an NC code. You can then use the NC code to machine parts on a CNC mill or other CNC machine tools.

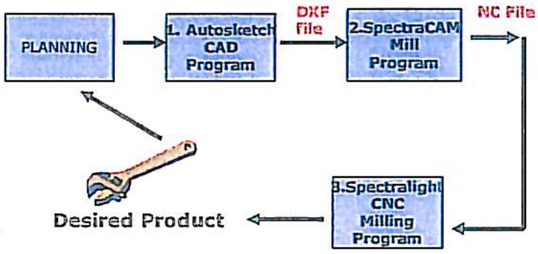
And how about CNC ?

CNC means **C**omputer **N**umerical **C**ontrol.
It refers to the process of producing machined parts by the use of CNC machine tools, automatically controlled by " pre-designed part programs" loaded into the computer.

The main focus of our study: . . . .

Integration
Of
CAD - CAM - CNC

Let's take a look at the CAD-CAM-CNC process. . . .



Remember:
CAD-CAM-CNC process includes four (4) stages

- Planning
- Computer Aided Design
- Computer Aided Manufacturing
- Computer Numerical Control machining

Planning Stage

- Determine design factors such as size & type of material, type of cutting tools, etc.
- Locate coordinates to be employed in the CAD program relative to the part shape & dimensions.
- Prepare sequence of operations and corresponding machining parameters such as speed, feed and depths of cut. . .

---

1. CAD stage

- Produce CAD drawing that corresponds to the part geometry and dimensions.
- Convert CAD drawing to data exchange format (DXF) file.

---

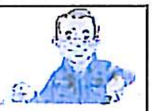
2. CAM stage

- Run SpectraCAM program
- Load DXF file into spectraCAM
- Select Layer
- Select the type of operation
- Enter cutting parameters
- Generate toolpaths
- Save NC file
- Quit spectraCAM

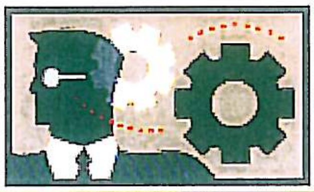
3. CNC stage

- Launch Spectralight CNC mill control program
- Load the part NC program
- Shift to manual control to set the part reference zero (datum)
- Initialize the program
- Verify the program, edit if necessary
- Run the program. . . Only after verification!

Let's try to do it NOW!

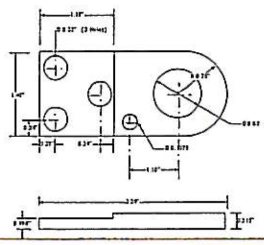


- Study the geometrical shape and dimensions of the required part



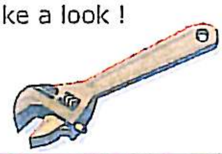
The Desired Product

Part 1. Drive Plate



What we should prepare while in Planning stage?

- In the next slide, we will see a list of activities that each one should be doing during his planning. .
- Let's take a look !

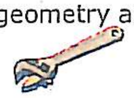


Planning your work!

- Study the part geometry & dimensions
- Prepare the table of coordinates
- Select Material
- Determine Cutting Sequence
- Determine Cutting Tools
- Calculate the machining parameters
- Etc.

Planning Ckecklist

- Study part geometry and dimensions



- Prepare a table of coordinates

- Prepare operations and tooling sheet

Working your PLAN!

- When you have prepared your perfect plan, then, you're now READY to sit in your respective CAD workstations!
- Go ahead. . . . And . . . Explore Autosketch3 for milling.

Autosketch3 for CNC milling

These will be our learning objectives.

You must be able to :

- Launch Autosketch
- Draw The required part
- Save the part drawing as file
- Convert the drawing as DXF file

Draw the Part

TABLE of COORDINATES

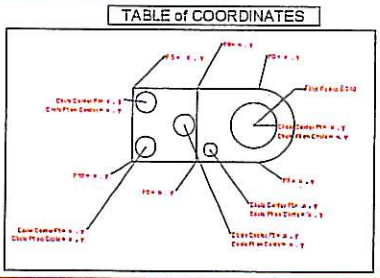


Table of Coordinates (continued)

Points	X	Y	Points	X	Y
Pt 1	0	0	Pt 11		
Pt 2	0	3.50	Pt 12		
Pt 3	5.00	3.50	Pt 13		
Pt 4	5.00	0	Pt 14		
Pt 5			Pt 15		
Pt 6			Pt 16		
Pt 7			Pt 17		
Pt 8			Pt 18		
Pt 9			Pt 19		
Pt 10			Pt 20		

Operations & Tooling Sheet

LAYER	OPERATIONS	TOOLS	MACHINING PARAMETERS	REMARKS
			Feed, Speed, Depths Cut	

MAN your CAD station!

- Launch Autosketch
- Set your work area, e.g. limits, grid, coordinates, etc.
- Select the layer you will work on. . .
- Create the part geometry based on your table of coordinates (if you don't have it, DO IT NOW!)
- Don't forget to save your part drawing when completed
- Make a DXF file of the part drawing

The AutoSketch R3.1 user interface

DRAW	CHANGE	VIEW	ASSIST	SETTINGS	MEASURE	FILE
•Arc	•Undo	•Last Plot Box	•Arc Mode	•Arrow	•Angle	•New
•Box	•Redo	•Last View	•Attach	•Attach	•Area	•Open
•Circle	•Group	•Zoom Box	•Coords	•Box Array	•Distance	•Part Clip
•Curve	•Ungroup	•Zoom Full	•Fill	•Chamfer	•Bearing	•Save
•Ellipse	•Box Array	•Zoom Limits	•Frame	•Color	•Point	•Save
•Line	•Break	•Zoom X	•Grid	•Curve	•Align Dimensions	•Pen I
•Part	•Chamfer	•Pan	•Ortho	•Ellipse	•Angle Dimensions	•Plot
•Pattern Fill	•Copy	•Redraw	•Snap	•Fillet	•Horiz.Dimension	•Print
•Point	•Erase		•View Icons	•Grid	•Vert.Dimension	•Make DXF
•Polyline	•Fillet		•Record/ End Macro	•Layer	•Show Properties	•Read DXF
•Quick Text	•Mirror		•Play Macro	•Limits		•Etc.
•Text Editor	•Move		•User Input	•Line Type		•Quit
	•Property			•Part Base		
	•Ring Array			•Pattern		
	•Etc.			•Poly Line		
				•Etc.		

How are you doing?

- ☐ Is your DXF file ready?

  If it's YES, then proceed to SpectraCAM. . . .

  If it's NOT, then review your work and continue. If you need assistance, contact your teacher and ask!

Squeeze your Brains for SpectraCAM milling

Performance objectives:

You should be able to

- ☐ Launch Spectracam Milling
- ☐ Import the required DXF file
- ☐ Setup the Layers, Tools, Material & Machine.
- ☐ Choose the appropriate milling operation
- ☐ Supply the cutting parameters
- ☐ Generate toolpaths
- ☐ Save the NC file

spectraCAM milling user interface

File	Display	Mill	Setup	Help
•New Session	•Repaint	•Face	•Layer ⟶ Edit Layers	
•Load Session	•Zoom in	•Contour	•Tool ⟶ Edit Tools	
•Import DXF	•Zoom out	•Pocket	•Material ⟶ Edit Material	
•Save NC	•Show All	•Drill	•Machine	
•List	•Pan	•Rev. Surf		
•Save Session	•Plan View	•Ruled Surface		
•Save DXF	•Isometric View	•Swept Surface		
•Quit				

SpectraCAM milling 1

- ☐ Import DXF file
- ☐ Setup Layer ⟶ Edit layer
- ☐ Setup Tool ⟶ Edit tool
- ☐ Setup Material ⟶ Edit material
- ☐ Select Machine

SpectraCAM milling 2

Select Mill Operation

- ☐ Face
- ☐ Contour
- ☐ Pocket
- ☐ Drill
- ☐ Rev. Surf
- ☐ Ruled Surf
- ☐ Swept Surf

SpectraCAM milling 3

- Enter Machining Operation parameters
  - Tool
  - Feed
  - Plunge
  - Cutter offset
  - Z steps & Size
  - XY steps & Size
  - Depth of Cut

SpectraCAM milling 4

- Generate toolpaths
  - Accept generated toolpaths
  - Reject generated toolpaths
- Save NC file
- Quit SpectraCAM

Layer 1-1 Contour Parameters

Tool: 3/16" End Mill   Dynamic display   Acc

Feed: 5.3   Speed: 2500   Plunge: 1.8

Cutter Offset: Left

Z Steps: 3   Size: 0.105   Finish   Size: 0.000

XY Steps: 7   Size: 0.094   Finish   Size: 0.000

Depths: Rapid: 0.070   Cutting: -0.315

OK   Cancel

Layer 1-2 Drill Parameters

Tool: 3/16" End Mill   Acc

Speed: 2500   Plunge: 1.8

Depths: Rapid: 0.070   Cutting: -0.315

OK   Cancel

Layer 1-3 Contour Parameters

Tool: 3/16" End Mill   Dynamic display   Acc

Feed: 5.3   Speed: 2500   Plunge: 1.8

Cutter Offset: Right

Z Steps: 3   Size: 0.105   Finish   Size: 0.000

XY Steps: 5   Size: 0.094   Finish   Size: 0.000

Depths: Rapid: 0.070   Cutting: -0.315

OK   Cancel

Layer 1-4 Pocket Parameters

Tool: 3/16" End Mill   Dynamic display   Acc

Feed: 5.3   Speed: 2500   Plunge: 1.8

Method: Spiral   Climb   Conventional

Z Steps: 3   Size: 0.105   Finish   Size: 0.000

XY steps: Size: 0.094   Finish   Size: 0.000

Depths: Rapid: 0.070   Cutting: -0.315

OK   Cancel

Layer 2
Contour Parameters

Tool: 3/16" End Mill ☐ Dynamic display ☐ Acc

Feed: 5.3 Speed: 2500 Plunge: 1.8

Cutter Offset: Left

Z Steps: 1 Size: 0.118 ☐ Finish Size: 0.000

XY Steps: 7 Size: 0.094 ☐ Finish Size: 0.000

Depths: Rapid: 0.070 Cutting: -0.118

OK Cancel

Layer 2-1
Pocket Parameters

Tool: 3/16" End Mill ☐ Dynamic display ☐ Acc

Feed: 5.3 Speed: 2500 Plunge: 1.8

Method: Spiral ○ Climb ○ Conventional

Z Steps: 3 Size: 0.105 ☐ Finish Size: 0.000

XY steps: Size: 0.094 ☐ Finish Size: 0.000

Depths: Rapid: 0.070 Cutting: -0.315

OK Cancel

Layer 2-2
Pocket Parameters

Tool: 3/16" End Mill ☐ Dynamic display ☐ Acc

Feed: 5.3 Speed: 2500 Plunge: 1.8

Method: Spiral ○ Climb ○ Conventional

Z Steps: 3 Size: 0.105 ☐ Finish Size: 0.000

XY steps: Size: 0.094 ☐ Finish Size: 0.000

Depths: Rapid: 0.070 Cutting -0.315

OK Cancel

Layer 2-3
Pocket Parameters

Tool: 3/16" End Mill ☐ Dynamic display ☐ Acc

Feed: 5.3 Speed: 2500 Plunge: 1.8

Method: Spiral ○ Climb ○ Conventional

Z Steps: 3 Size: 0.105 ☐ Finish Size: 0.000

XY steps: Size: 0.094 ☐ Finish Size: 0.000

Depths: Rapid: 0.070 Cutting: -0.315

OK Cancel

Do you have the part NC program now?

- ☐ If ever you have it now, CONGRATULATIONS!. Go ahead and proceed to Spectralight CNC mill.
- ☐ If you don't, however, review your work and go back to Autosketch3, if necessary. Ask help from your teacher if you have some troubles in SpectraCAM.

Spectralight CNC machining

Performance objectives:

- ☐ Launch Spectralight Mill
- ☐ Load the NC program
- ☐ Set the part reference zero (datum)
- ☐ Initialize the program
- ☐ Verify the program
- ☐ Run the program

The SpectraLight CNC mill control

MAIN MENU

- H-Help
- I-Initialize
- M-Manual Control
- E-Edit
- V-Verify
- R-Run
- N-New
- L-Load/Delete
- S-Save
- P-Print
- ESC-Exit to DOS

INITIALIZE MENU

- H-HELP
- P-POSITION ENTRY
- B-BACKLASH
- U-UNITS: INCH OR METRIC
- T-TOOL DEFINITIONS
- G-GRAPHICS PARAMETERS
- F-FACTORS AND SINGLE STEP
- S-SET SPINDLE SPEED
- ESC-EXIT TO MAIN MENU

INITIALIZE

The initialize function is for setting up the machine parameters outside the NC program.

POSITION ENTRY: used to set the current position of the tool in the X, Y, and Z axes.

BACKLASH: allows you to set the measured backlash on the machine to be compensated for automatically.

INITIALIZE (continued)

UNITS: Inch or Metric allows the machine to run in either inch or metric dimensions.

TOOL DEFINITIONS: used for setting the tool diameter and tool length offset for the Z axis.

GRAPHICS PARAMETERS: is used for setting up the simulation of the cutting operation.

INITIALIZE (continued)

FACTORS & SINGLE STEP: is used to set up the scale factors for the size of the part and the feed rates.

SET SPINDLE SPEED: Allows you to set the spindle speed.

EXIT TO MAIN MENU: returns you to the spectraLIGHT main menu.

MANUAL CONTROL panel

The manual control panel is used to move the cross slide during setup for a milling operation, and to toggle devices such as the spindle. The speed and distance can be changed and direction keys are used to position the cross slide and spindle.

MANUAL CONTROL MENU

- H-HELP
- P-SET POSITION
- G-GO TO POSITION
- D- SET JOG DISTANCE
- S-SET JOG SPEED
- C-CONTINUOUS/INCREMENTAL
- ESC-EXIT

MANUAL CONTROL

SET POSITION: sets the current position of the tool.

GO TO POSITION: moves the tool to the specified absolute coordinates.

SET JOG DISTANCE: sets how far the machine will move when a jog keypad key is pressed.

SET JOG SPEED: the feed that the machine will move at when jogged.

MANUAL CONTROL (continued)

CONTINUOUS/INCREMENTAL: Sets the jog mode. Continuous motion causes a move to happen until another key is pressed. Incremental mode causes the machine to move the distances specified in SET JOG DISTANCE. The space bar will stop all motion.

EXIT: Pressing the ESC key will return you to the spectraLIGHT main menu.

EDIT MENU

EDIT PROGRAM is used to change or add to existing programs in memory.

VERIFY menu

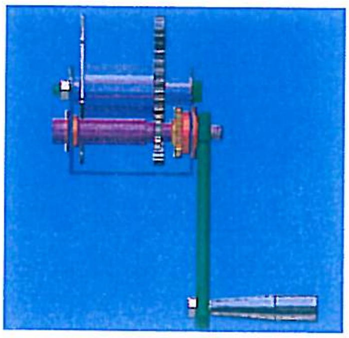
VERIFY PROGRAM runs a simulation of a part being cut using the NC program loaded in the memory.

RUN menu

This command executes the NC program on the mill.

Appendix two

Student's Checklist



Students task (1)

Gear Box

Students task (1)

No	Learning outcomes	Marks	Tasks														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
i Creation of drawing and design using CAD																	
1	Design the part geometry using Auto cad	5															
2	Draw the part geometry using auto cad	10															
3	Modeling Utilities	5															
4	Engineering drawing.	5															
5	Drawing dimensions.	5															
6	Save the parts as data exchange format (DXF) file.	5															
ii Using data exchange format (DXF) to create numerical control file																	
1	Import the DXF file	5															
2	Enter the cutting parameter (cutting tool, tool size, tool materials, work material, material).	10															
3	Generate tool paths for different layers (X, Y, Z direction, cutting loop, depth of cut, feed, and speed).	10															
4	Save it as numerical control (NC) file	5															
iii Setup check																	
1	Set the tool zero position.	5															
2	Set the work piece.	5															
3	Check the work piece and the cutting tool is securely clamped.	5															
4	Load the CNC program	5															
5	Verify the NC program.	5															
iv Final manufacturing																	
1	Run the program for machining	5															
2	Check the finished product for quality requirements	5															
Results		100															

Appendix Three

Lecturers Questionnaire

Lecturers Questionnaire

Dear teacher

The attached questionnaire aims to learn your opinion about the teaching style you adopt in the classroom, and your point view toward the teaching of Computer aided drawing (CAD), Computer aided manufacturing (CAM) and Computerise numerical control machining (CNC).

.

The questionnaire aims to identify the perceptions of Drawing, Design and Manufacturing teachers who teach CAD/CAM/CNC in institute.

There is no right or wrong answers to any question and so please feel free to respond to them in any way you like. Please do not miss any question.

The answer scales contain 3 items, Agree, Undecided, Disagree you reflect your answer by choosing the scale that you think it represents your opinion. Your answers will be treated in strict confidence.

There are some questions that need you to answer, yes or no, and others need you to write when the researcher interviewing you in the institute. .

Thank you for your co-operation

Salah Al - Hamad
Mphill /Ph.D. Student
Huddersfield University

Lecturers Questionnaire Results

Lecturers Responses on the Questionnaire

G: Group **N: Number**

NO	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
		F	F	F	F	F	F	F	F	F
1	You always plan your lesson	8	10	10	1	0	0	1	0	0
2	You rarely find subject matter in drawing and manufacturing you do not understand	2	7	6	5	0	2	3	3	2
3	You use your own techniques when you are preparing lessons	6	4	2	2	0	2	2	6	6
4	The majority of the students are interested in the way you present your lessons.	0	8	7	1	1	2	9	1	1
5	Most of your lessons have the same pattern	2	9	4	2	1	0	6	0	6
6	You use lots of practical examples in your teaching	3	8	9	2	2	1	5	0	0
7	The syllabus is crowded so it is difficult to do more task oriented work	8	2	2	1	0	0	1	8	8
8	You rarely use audio -visual aids	2	5	6	1	1	1	7	4	3
9	Only the most able students like your lesson	7	1	3	1	4	1	2	5	6
10	Students find it difficult to under stand some drawing tasks or manufacturing tasks lessons because those tasks cannot be presented simply	8	4	4	0	1	2	2	5	4
11	All the learning objective in your lesson can be presented simply	0	5	5	1	2	2	9	3	3
12	Group work is used as a strategy in your teaching	2	4	7	2	2	1	6	4	2
13	You want less time for theoretical explanation and more time for task oriented work.	10	6	6	0	1	0	0	3	4
14	When you prepare lessons you follow the techniques mentioned in the teacher's guide	10	4	4	0	2	1	0	4	5
15	You encourage the students to ask questions	6	8	9	1	2	1	3	0	0
16	The students have difficulty in finding the relevance of what you teach in CAD/CAM	8	4	3	0	1	0	2	5	7

17	You ask your students after the lesson if they understand the lesson or not	10	10	9	0	0	1	0	0	0
18	You add many examples to explain lessons	9	7	10	0	0	0	1	3	0
19	You find it difficult to encourage the students in your lesson	10	3	2	0	0	2	0	7	6
20	You repeat the lesson if the students still have difficulties in understanding	3	7	10	1	1	0	6	2	0
21	You concentrate on practical aspects of drawing and manufacturing features when you teach CAD/CAM/CNC lessons	7	2	2	1	1	3	2	7	5
22	You use dialogue with students during classroom activities	1	7	5	5	3	1	4	0	4
23	It is difficult to understand all the concepts in the subject textbook	10	2	2	0	2	1	0	6	7
24	You can use the instruction software as guideline for the standards when you teach CAD/CAM/CNC subject	9	4	3	1	2	1	0	4	6
25	You enjoy your teaching style	1	7	6	3	2	1	6	1	3
26	You use many shapes and different exercises to improve the student's skills	7	2	6	0	2	1	3	6	3
27	You use many mechanical exercises to measure students' performance.	8	1	2	0	1	1	2	8	7
28	You start the subject lesson by examples and then you explain the rules.	7	3	3	1	2	0	2	5	7
29	You start the lessons tasks by explaining the concept of the subject and then you present the examples	6	10	7	0	0	2	4	0	1
30	You use group learning when you teach CAD/CAM/CNC.	4	6	4	0	1	3	6	3	3
31	You have friendly relationships with students	6	9	7	4	1	2	0	0	1
32	You keep formal relationships with students	0	3	2	10	1	1	0	6	7
33	Students decide for themselves where they can sit in the classroom	7	6	2	3	0	2	0	4	6
34	Students are distributed inside the classroom to places or groups on the basis of their ability.	8	1	2	1	3	1	1	6	7
35	The desks are arranged in the classroom in rows for batter visualization.	4	8	7	1	1	1	5	1	2
36	The desks are arranged in the classroom in groups to learn from each others.	1	2	7	2	5	0	7	3	3

37	Your students work together co-operatively on work that you give to them	4	7	6	1	1	2	5	2	2
38	Your students work individually on work that you give to them	4	5	6	1	1	2	5	4	2
39	Most of your questions can be answered by remembering previous lessons	7	9	9	2	0	0	1	1	1
40	It is difficult to ask questions which require students to apply knowledge	8	4	3	0	2	2	2	4	5
41	You often ask questions that require students to make judgments	6	8	9	2	1	1	2	1	0
42	You evaluate the student's level of knowledge.	9	7	6	0	2	1	1	1	3
43	You help them to identify their weaknesses in CAD/CAM/CNC	9	5	4	1	3	2	0	2	4
44	Assessment feedback to treat their weaknesses.	9	8	6	1	1	1	0	1	3
45	You correct your students' mistakes	10	8	9	0	0	0	0	2	1
46	Easy mark the student's activities or exam tasks.	2	9	6	0	1	2	8	0	2
47	Easy to rate your students when they have the correct answer	1	7	6	0	1	2	9	2	2
48	It is easy for me to teach CAD/CAM/CNC by current method	0	8	8	0	1	1	10	1	1
49	I do not like to use an other teaching method to teach CAD/CAM/CNC	0	7	7	0	2	0	10	1	3
50	The present method does not help me to take into account the individual differences between students	10	5	5	0	1	1	0	4	4
51	The present method is successful in teaching CAD/CAM/CNC.	1	7	6	0	3	3	9	0	0
52	Students are bored when I use the present method of teaching CAD/CAM/CNC	10	0	0	0	4	4	0	6	6
53	When I use the present method I don't need to use lots of teaching aids.	0	7	9	0	1	1	10	2	1
54	The present method encourages the students to learn.	3	7	8	0	1	1	7	2	1
55	I like to have training about the present method	2	9	9	3	0	0	5	1	1

56	The present method strengthens the CAD/CAM/CNC rules in the student's mind	4	7	7	0	3	3	6	0	0
57	Part of student's weaknesses in CAD/CAM/CNC is caused by the teaching method	9	2	3	0	3	1	1	5	6
58	The present method encourages the students to think logically	0	8	8	0	1	2	10	1	0
59	The present method increases the student's achievement in CAD/CAM/CNC	0	7	8	0	2	0	10	1	2
60	Teaching by the present method helps the student's to understand subject.	0	8	7	0	1	2	10	1	1
61	The present method enables me to control the class.	0	8	7	0	1	1	10	1	2
62	The present method is suitable for a class with a large number of students.	2	6	7	0	1	1	8	3	2
63	The variety of the examples in the present method helps the students to understand	1	8	7	0	0	1	9	2	2
64	The present method helps me to finish the tasks textbook in time	2	7	7	0	2	1	8	1	2
65	The present method needs lots of time when I use it in teaching.	10	2	2	0	1	1	0	7	7
66	The present method does not encourage the students to have 'self-direct learning.	10	3	2	0	1	2	0	6	6

Appendix Four

Student's Questionnaire

Students' Questionnaire

DEAR STUDENT

The attached questionnaire was developed to identify how do you think about teaching learning (T.L) of Computer aided drawing (CAD), Computer aided manufacturing (CAM) and Computerise numerical control machining (CNC) in the classroom and laboratories.

The scales of the answers are Agree, Undecided, and Disagree.

The researcher will be dealing with your response confidentially and the information will used only for the research aims.

Thank you for your co-operation

Salah Al-Hamad

Mphill / Ph.D. Students

University of Huddersfield

Students' Questionnaire Results

Student's Responses on the Questionnaire

G: Group N: Number

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G3	G 1	G 2	G3	G 1	G 2	G3
1	I do not like CAD/CAM/CNC as a subject	93.3	0	0	0	0	0	6.67	100	100
2	I like participating in activities during CAD/CAM/CNC lesson	46.7	73.3	86.7	0	13.3	6.67	53.3	13.3	6.67
3	Learning style used in CAD/CAM/CNC developed my learning ability	6.67	86.7	93.3	0	0	0	93.3	13.3	6.67
4	I feel comfortable during CAD/CAM/CNC lesson	0	66.7	80	0	13.3	13.3	100	20	6.67
5	I like to have more CAD/CAM/CNC lessons using this methods.	0	73.3	93.3	0	20	6.67	100	6.67	0
6	Learning CAD/CAM/CNC with this methods is a waste of my time.	86.7	6.67	6.67	13.3	26.7	0	0	66.7	93.3
7	I feel bored in CAD/CAM/CNC lesson	80	13.3	6.67	6.67	13.3	0	13.3	73.3	93.3
8	Learning CAD/CAM/CNC improves my competencies	66.7	93.3	100	6.67	6.67	0	26.7	0	0
9	Learning CAD/CAM/CNC with computer improves my knowledge.	93.3	93.3	86.7	0	6.67	13.3	6.67	0	0
10	I like spending more time in practicing CAD/CAM/CNC.	13.3	93.3	100	0	6.67	0	86.7	0	0
11	I do not like watching simulation program in CAD/CAM/CNC	6.67	6.67	13.3	0	13.3	0	93.3	80	86.7
12	I like CAD/CAM/CNC more than other school subjects	33.3	73.3	80	20	13.3	6.67	46.7	13.3	13.3
13	It is difficult to understand CAD/CAM/CNC.	80	30	35	0	0	7	20	70	58
14	I like teaching methodology used in CAD/CAM/CNC.	6.67	60	86.7	0	33.3	6.67	93.3	6.67	6.67
15	I find other school subjects more enjoyable than CAD/CAM/CNC subject	93.3	20	20	0	20	13.3	6.67	60	66.7

16	In this method teachers correct my mistake very easily	0	73	80	0	27	7	100	0	13
17	The method of presenting CAD/CAM/CNC makes me feel bored.	100	40	7	0	20	13	0	40	80
18	My teacher is always controlling the class	20	80	93	7	13	0	73	7	7
19	Teacher makes links between the classroom teachings and laboratories work.	7	80	87	0	13	7	93	7	7
20	Teaching method motivates me and keeps my attention towards the subject matter.	13	80	100	0	13	0	87	7	0
21	Teacher in this method requires less effort than the other methods.	0	60	80	0	27	20	100	13	0
22	In this method my teacher teaches in an interesting way	0	60	67	0	27	27	100	13	7
23	The CAD/CAM teachers rely more on the text book	100	13	7	0	20	13	0	67	80
24	My teacher does not pay attention to the students' individual differences	73	27	20	0	7	13	27	67	67
25	My teacher enjoys teaching CAD/CAM	67	87	100	7	13	0	27	0	0
26	My teacher encourages me to learn CAD/CAM	47	100	93	0	0	7	53	0	0
27	My teacher always follows the same teaching method	93	47	53	7	27	40	0	27	7
28	The teacher does not explain the objectives of the lesson	13	13	20	0	0	7	87	87	73
29	My teacher does not follow up my work	80	20	40	0	7	7	20	73	53
30	My teacher respects me when I work with simulation work or computer assisted instruction.	0	73	73	40	27	27	60	0	0
31	My teacher is fair when he marks the students' work.	20	73	73	0	27	27	80	0	0
32	It is easy to evaluate students work and assessing their performance.	0	80	73	0	20	13	100	0	13
33	The teacher does not use educational aids when he teaches with this method	90	33	33	7	7	13	3	60	53

34	The teacher follows the textbook teaching method to teach CAD/CAM/CNC starting with examples and displaying the procedures.	100	20	20	0	15	10	0	65	70
35	My teacher always prepares his CAD/CAM lesson well	100	93	80	0	7	0	0	0	20
36	My teacher encourages the students to work in parallel with the simulation software	0	87	67	0	7	27	100	7	7
37	My teacher has adequate knowledge of this method.	73	73	67	7	20	27	20	7	7

Appendix five

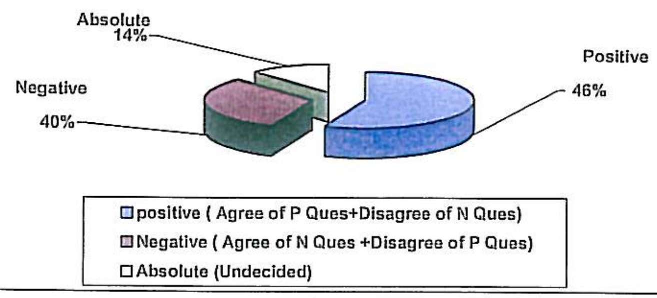
Data Analysis of Lecturers Answer to Questionnaires

Teachers Organisation

	NO	Statement	AGREE G 1 F	AGREE G 2 F	AGREE G3 F	UNDECIDED G 1 F	UNDECIDED G 2 F	UNDECIDED G3 F	DISAGREE G 1 F	DISAGREE G 2 F	DISAGREE G3 F			
1	1	You always plan your lesson	8	10	10	1	0	0	1	0	0			
2	3	You use your own techniques when you are preparing lessons	6	8	7	2	0	2	2	2	1			
3	7	The syllabus is crowded so it is difficult to do more tasks work	8	2	2	1	0	0	1	8	8			
4	14	When you prepare lessons you follow the techniques given in the teacher's guide	4	4	4	2	2	1	4	4	5	Questions		
5	18	You add many examples to explain lessons	9	10	7	0	0	0	1	0	3	Positive	Negative	Absolute
		positive	23	28	24	3	0	2	4	2	4	7.08333	4.5	0.6
		Negative	12	6	6	3	2	1	5	12	13			
		Absolute				0	0	0						
			35	34	30	6	2	3	9	14	17	150		

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N Ques)	28	40	37	105	
Negative (Agree of N Ques +Disagree of P Ques)	16	8	10	34	150
Absolute (Undecided)				11	

Group 1



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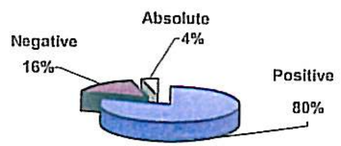

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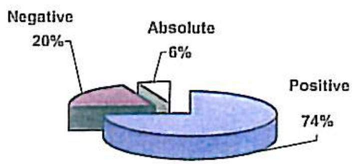


Teachers Presentation

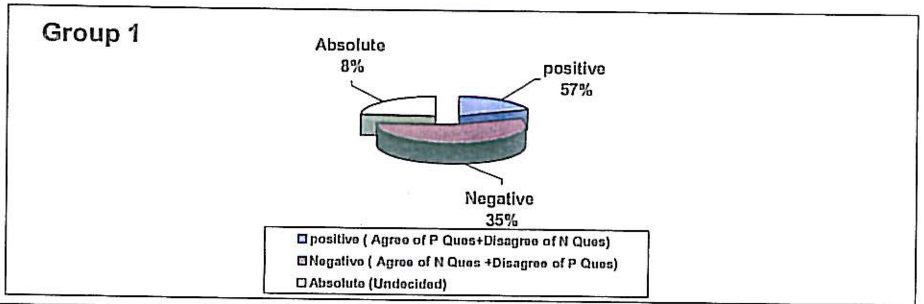
	NO	Statement	AGREE G1 F	AGREE G2 F	AGREE G3 F	UNDECIDED G1 F	UNDECIDED G2 F	UNDECIDED G3 F	DISAGREE G1 F	DISAGREE G2 F	DISAGREE G3 F	Questions: Positive	Questions: Negative	Questions: Absolute
1	4	The majority of the students are interested in the way you present your lessons.	0	8	7	1	1	2	9	1	1	1		
2	9	Only the most able students like your lesson	7	1	3	1	4	1	2	5	6		1	
3	6	You use lots of practical examples in your teaching	3	8	9	2	2	1	5	0	0	1		
4	8	You use audio -visual aids	5	9	9	1	1	1	4	0	0	1		
5	10	Students find it difficult to under stand some drawing tasks or manufacturing tasks lessons because they cannot be presented simply	8	3	3	0	0	1	2	7	6		1	
6	11	All the rules in your lesson can be presented simply	0	5	5	1	2	2	9	3	3	1		
7	16	The students find difficulties in seeing the relevance of what you teach in CAD/CAM	8	4	3	0	1	0	2	5	7		1	
8	5	Most of your lessons have the same pattern	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			1
9	28	You start the subject lesson by examples and then you explain the rules	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			1
10	29	You start the lessons tasks by explaining the concept of the subject and then you present the	6	10	7	0	0	2	4	0	1			1
11	21	You concentrate on drawing and manufacturing feature when you teach CAD/CAM/CNC lessons	7	2	2	1	1	3	2	7	5	1		
12	52	Students are bored when I use the present method of teaching CAD/CAM/CNC	10	0	0	0	3	3	0	7	7			
13	53	When I use the present method I don't need to use lots of teaching aids.	0	9	9	0	1	1	10	0	0			
14	63	helps the students to understand	1	8	7	0	0	1	9	2	2			
		Positive	22	59	55	0	0	11	52	0	10			
		Negative	33	6	7	1	0	5	6	31	30			
		Absolute	15	12	0	2	3	4	3	5	0			
			70	79	73	9	19	20	61	42	47			

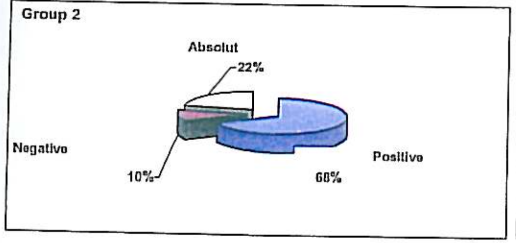
Questions: Positive (Agrred P + Disagreed N)	Negative (Agrred N + Disagreed P)	Absolute (UNDECIDED)
6.242424242	3.424242424	1.142857143

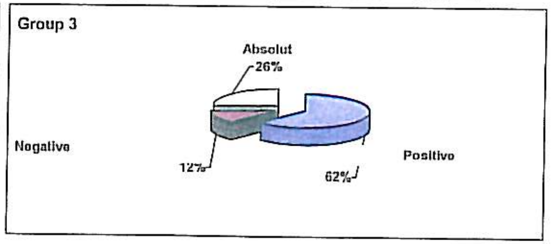
420

	G1	G2	G3	
positive (Agree of P Ques+Disagree of N Ques)	28	90	85	203
Negative (Agree of N Ques +Disagree of P Ques)	85	14	17	116
Absolute (Undecided)	35	30	35	101

420



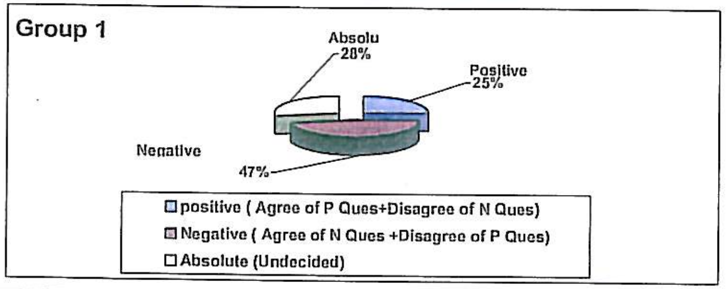


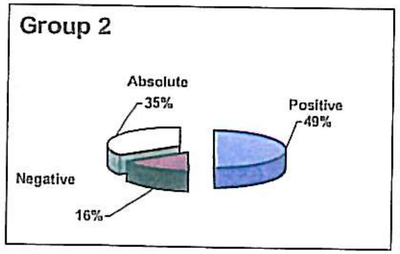


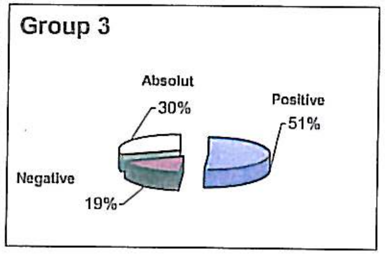
	NO	Statement	AGREE G1 F	AGREE G2 F	AGREE G3 F	UNDECIDED G1 F	UNDECIDED G2 F	UNDECIDED G3 F	DISAGREE G1 F	DISAGREE G2 F	DISAGREE G3 F
1	30	You use group learning when you teach CAD/CAM/CNC.	4	9	8	0	1	1	6	0	1
2	12	Group work is an effective way of your teaching style	2	9	8	2	1	0	6	0	2
3	13	You want the theory time of your lesson to end quickly so you can do more practicing.	10	3	3	0	0	0	0	7	7
4	15	You encourage the students to ask Questions	6	8	9	1	2	1	3	0	0
5	19	You find it difficult to encourage the students in your lesson	10	3	2	0	0	2	0	7	6
6	22	You use dialogue with students during classroom activities	1	7	5	5	3	1	4	0	4
7	33	Students decide for themselves where they can sit in the classroom	7	9	9	3	0	0	0	1	1
8	34	Students are distributed inside the classroom to places or groups on the basis of their ability	8	1	2	1	3	1	1	6	7
9	35	The desks are arranged in the classroom in rows for batter visualisation	4	8	7	1	1	1	5	1	2
10	36	The desks are arranged in the classroom in groups to learn from each others.	1	2	7	2	5	0	7	3	3
11	37	Your students work together co-operatively on work that you gave to them	4	7	6	1	1	2	5	2	2
12	38	Your students work individually on work that you gave to them	4	5	6	1	1	2	5	4	2
13	61	The present method enables me to control the class.	2	6	7	0	1	1	8	3	2
14	62	The present method is suitable for a class with a large number of students.	2	6	7	0	1	1	8	3	2
15	64	The present method helps me to finish the tasks in time	2	7	7	0	2	1	8	1	2
16	65	The present method needs lots of time when I use it in teaching.	10	2	2	0	1	1	0	7	7
		Positive	40	75	79	14	22	12	66	23	29
		Negative	10	3	2	0	0	2	0	7	8
		Absolute	29	20	21	3	0	0	0	15	15
			77	82	95	17	23	15	66	45	50

480

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	40	82	85
Negative (Agree of N Ques+Disagree of P Ques)	78	26	31
Absolute (Undecided)	46	57	50

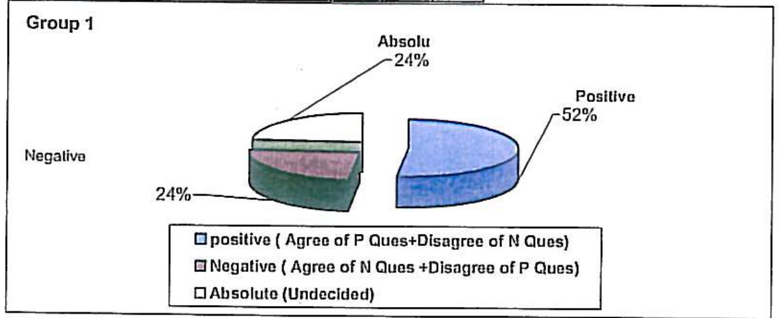


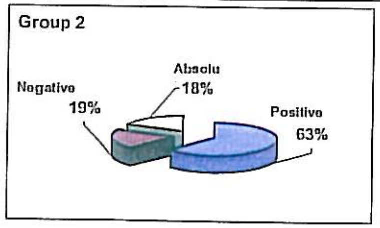


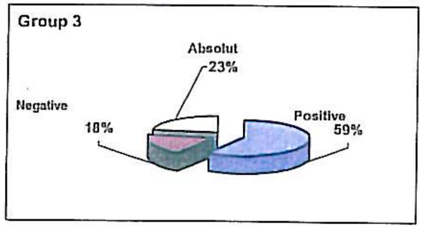


	NO	Statement	AGREE			UNDECIDED			DISAGREE		
			G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
			F	F	F	F	F	F	F	F	F
1	17	You ask your students after the lesson if they understand the lesson or not	10	10	9	0	0	1	0	0	0
2	20	You repeat the lesson if the students still have difficulties in understanding	3	7	10	1	1	0	6	2	0
3	24	You use standard when you teach CAD/CAM/CNC to judge the work	9	4	3	1	2	1	0	4	6
4	26	You use many shape and different exercises to improve the students' skills	7	2	2	0	2	1	3	6	7
5	27	You use many mechanical exercises to Measure student's performance.	8	1	2	0	1	1	2	8	7
6	39	answered by remembering previous lessons	7	9	9	2	0	0	1	1	1
7	40	It is difficult to ask questions which require students to apply knowledge	8	4	3	0	2	2	2	4	5
8	41	You often ask questions that require students to make judgments.	6	8	9	2	1	1	2	1	0
9	42	To evaluate the students' level in knowledge.	5	9	9	2	0	0	3	1	3
10	43	To help them to identify their weaknesses in CAD/CAM/CNC	4	9	9	1	1	1	5	0	0
11	44	Assessment feedback to treat their weaknesses.	9	9	9	1	1	1	0	0	0
12	45	You correct your students' mistakes	10	8	9	0	0	0	0	2	1
13	46	Easy mark the student's activities or exam tasks.	2	9	6	0	1	2	8	0	2
14	47	Easy to rate your students when they have the correct answer	1	7	6	0	1	2	9	2	2
15	59	The present method increases the students' achievement in CAD/CAM/CNC	0	7	8	0	2	0	10	1	2
		Positive	74	92	83	8	11	11	28	26	24
		Negative	8	4	3	0	2	2	2	4	5
		Absolute				2	2	0			
			89	103	103	10	15	13	51	32	36

	G1	G2	G3			
positive (Agree of P Ques+Disagree of N Ques)	76	96	88	260		90
Negative (Agree of N Ques+Disagree of P Ques)	36	30	27	93	450	
Absolute (Undecided)	35	28	34	97		



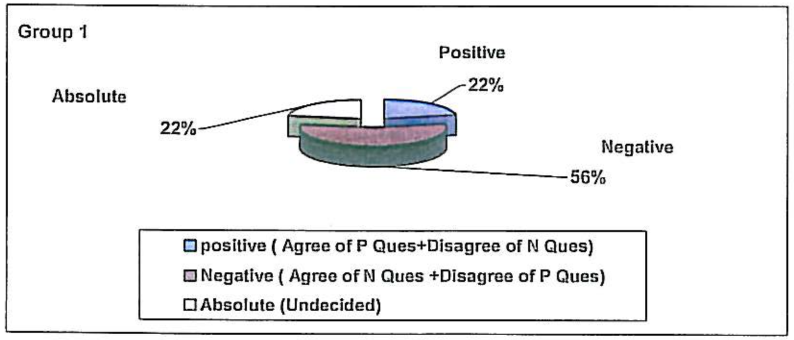


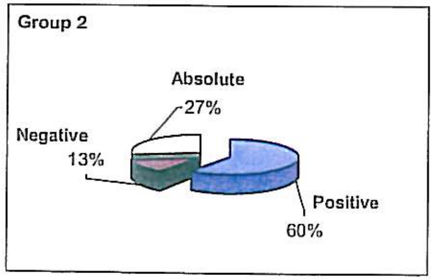


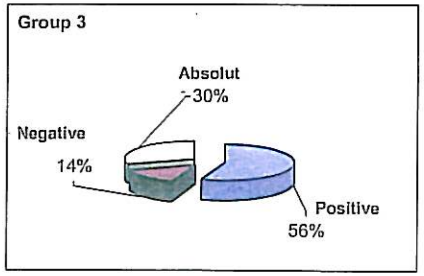
Teachers Perception

	NO	Statement	AGREE G 1 F	AGREE G 2 F	AGREE G 3 F	UNDECIDED G 1 F	UNDECIDED G 2 F	UNDECIDED G 3 F	DISAGREE G 1 F	DISAGREE G 2 F	DISAGREE G 3 F	
1	2	You find subject matter in drawing and manufacturing you do not understand	6	7	6	2	0	2	2	3	2	
2	23	It is difficult to understand every thing in the subject textbook	10	2	2	0	2	1	0	6	7	
3	25	You enjoy your teaching style	1	7	6	3	2	1	6	1	3	
4	31	You have friendly relationships with students	6	9	7	4	1	2	0	0	1	
5	32	You keep formal relationships with students	0	3	2	5	1	1	5	6	7	
6	51	The present method is successful in the field of teaching CAD/CAM/CNC	1	8	8	0	2	2	9	0	0	
7	54	The present method encourages the students to learn.	3	7	8	0	1	1	7	2	1	
8	55	I like to have training about the present method	2	9	9	3	0	0	5	1	1	
9	56	The present method strengthens the CAD/CAM/CNC rules in the student's mind	4	7	7	0	3	3	6	0	0	
10	57	Part of students' weaknesses in CAD/CAM/CNC is caused by the teaching method	9	2	3	0	3	1	1	5	6	
11	58	The present method encourages the students to think logically	0	8	8	0	1	2	10	1	0	
12	60	Teaching by the present method helps the student's to understand subject.	0	8	7	0	1	2	10	1	1	
13	66	The present method does not encourage the students 'self- direct learning.	10	3	2	0	1	2	0	6	6	
		Positive	27	65	62	10	10	10	53	12	14	
		Negative	19	5	5	0	4	3	1	11	12	
		Absolute				7	4	7				
			52	80	75	17	18	20	61	32	35	390

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N Ques)	28	76	74	178	
Negative (Agree of N Ques+Disagree of P Ques)	72	17	19	108	390
Absolute (Undecided)	29	35	40	104	



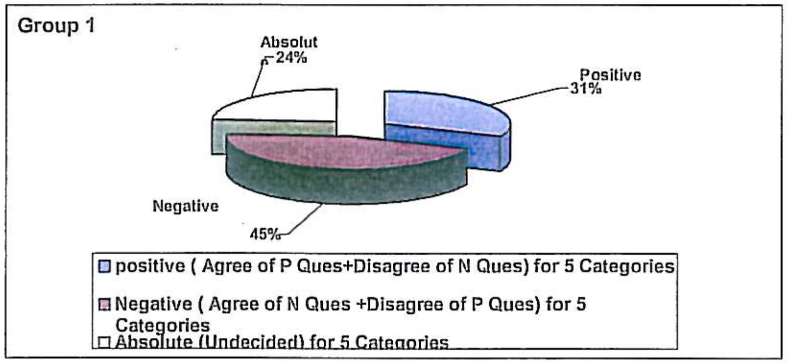


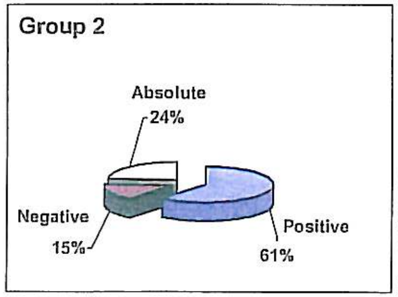


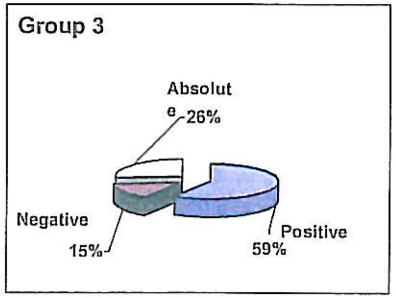
Teachers All Categories

	Organisation	Presentation	Classroom Management	Assessment mechanisms	Teacher's perception of teaching method used	G1
			Group 1			
positive (Agree of P Ques+Disagree of N Ques)	28	28	40	76	28	200
Negative (Agree of N Ques+Disagree of P Ques)	16	85	76	36	72	285
Absolute (Undecided)	6	36	46	35	29	152
		Group 2				
positive (Agree of P Ques+Disagree of N Ques)	40	90	82	96	76	384
Negative (Agree of N Ques+Disagree of P Ques)	8	14	26	30	17	95
Absolute (Undecided)	2	30	57	28	35	152
		Group 3				
positive (Agree of P Ques+Disagree of N Ques)	37	85	85	88	74	369
Negative (Agree of N Ques+Disagree of P Ques)	10	17	31	27	19	104
Absolute (Undecided)	3	35	50	34	40	162

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques) for 5 Categories	200	384	369
Negative (Agree of N Ques+Disagree of P Ques) for 5 Categories	285	95	95
Absolute (Undecided) for 5 Categories	152	152	162







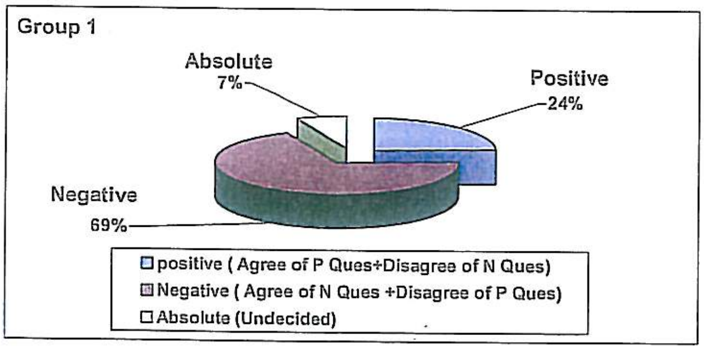
Appendix Six

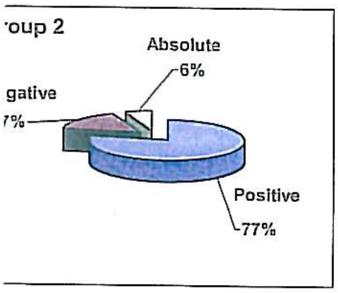
Data Analysis of Students Answer to Questionnaires

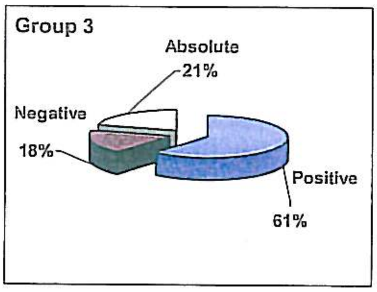
Students Attitude Towards Their Technology

		NO	Statement	AGREE G1	AGREE G2	AGREE G3	UNDECIDED G1	UNDECIDED G2	UNDECIDED G3	DISAGREE G1	DISAGREE G2	DISAGREE G3	Questions Positive	Questions Negative	Questions Absolute
0	1	5	I likes to have more CAD/CAM/CNC lessons using this method.	0	93	73	0	7	20	100	0	7	1		
0	2	6	Learning CAD/CAM/CNC with this methods wasting of time.	87	7	6	13	0	27	0	93	67			1
0	3	7	I feel bored in CAD/CAM/CNC lesson the teacher using this methods,	80	7	13	7	0	13	13	93	74			
0	4	12	I like CAD/CAM/CNC more than other institute subjects	33	80	73	20	7	13	47	13	14	Questions		
0	5	14	I like Teaching methodology of CAD/CAM/CNC.	7	87	60	0	7	33	93	6	7	Positive	Negative	Absolute
0	6	15	I find other institute subjects are more enjoyable than in CADS/CAM/CNC subject	93	20	20	0	13	20	7	67	60	(Agrred P + Disagreed N)	(Agrred N + Disagreed P)	(UNDECIDED)
0			Positive	133	260	226	20	34	86	247	86	88	53.25	45	11.11111111
			Negative	167	14	19	20	0	40	13	166	141			
			Absolute												

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N Ques)	146	466	367	979	
Negative (Agree of N Ques +Disagree of P Ques)	414	100	107	621	1800
Absolute (Undecided)	40	34	126	200	



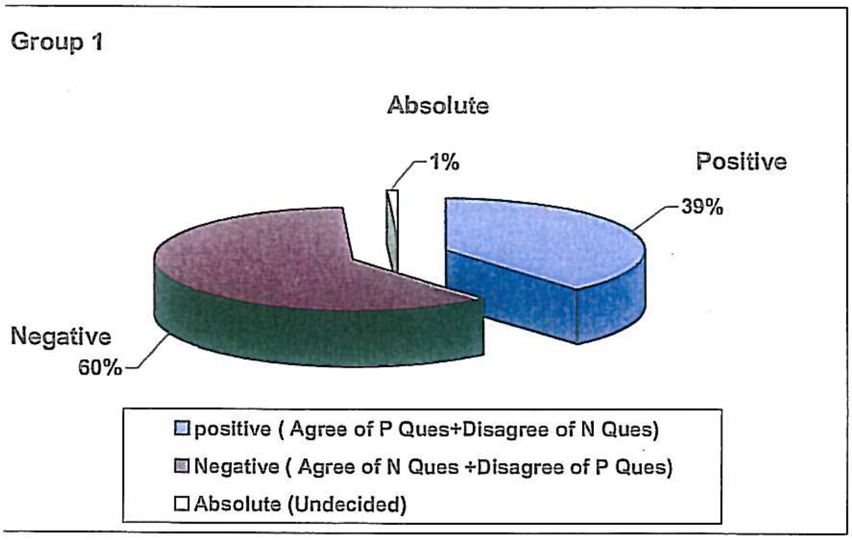


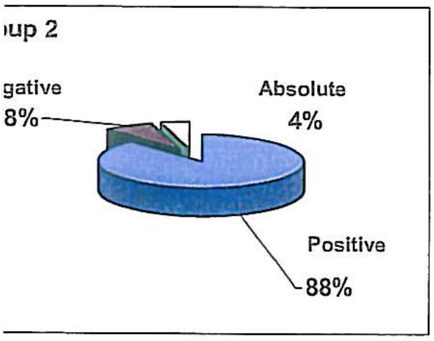


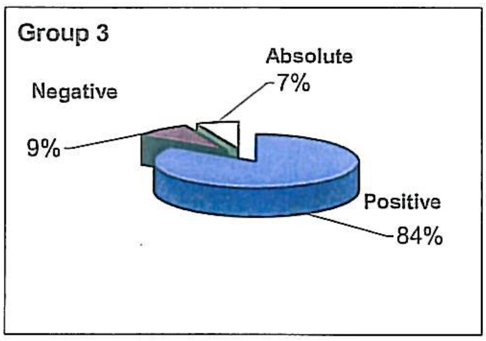
Students Attitude Towards the learning

		NO	Statement	AGREE G 1	AGREE G 2	AGREE G 3	UNDECIDED G 1	UNDECIDED G 2	UNDECIDED G 3	DISAGREE G 1	DISAGREE G 2	DISAGREE G 3
100	1	1	I do not like CAD/CAM/CNC as a subject	93	0	0	0	0	0	7	100	100
100	2	2	I like to participate in activities during CAD/CAM/CNC lesson	47	87	73	0	7	13	53	7	13
100	3	3	CAD/CAM/CNC developed my learning abilities	7	93	87	0	0	0	93	7	13
100	4	4	CAD/CAM/CNC lesson using the same style.	0	80	67	0	13	13	100	7	20
100	5	8	Learning CAD/CAM/CNC improves my skills	67	100	93	7	0	7	26	0	0
100	6	9	Learning CAD/CAM/CNC with computer improves my knowledge.	93	87	93	0	13	7	7	0	0
100	7	10	I like to spend more time in practicing CAD/CAM/CNC.	13	100	93	0	0	7	87	0	0
100	8	11	I do not like to watch simulation program in CAD/CAM/CNC	7	13	7	0	0	13	93	87	80
100	9	13	It is difficult to understand CAD/CAM/CNC.	80	35	30	0	7	0	20	58	70
			Positive	227	547	506	7	20	34	366	21	46
			Negative	180	48	37	0	7	13	120	245	250
			Absolute				0	13	13			
				407	595	543	7	40	60	486	266	296 2700

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N Ques)	347	792	756	1895	
Negative (Agree of N Ques +Disagree of P Ques)	546	69	83	698	2700
Absolute (Undecided)	7	40	60	107	





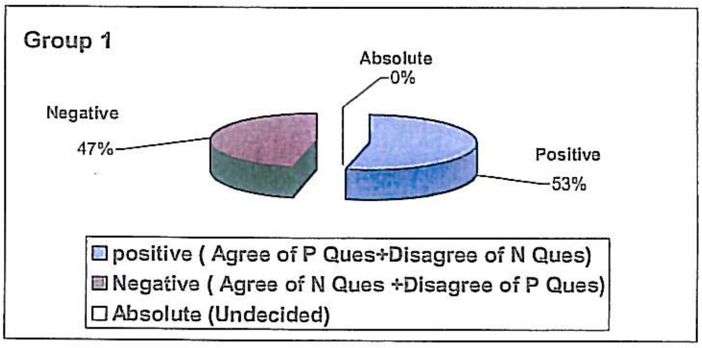


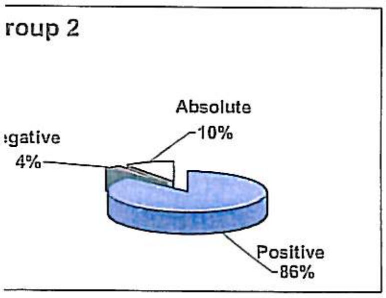
Students Opinion about Organis

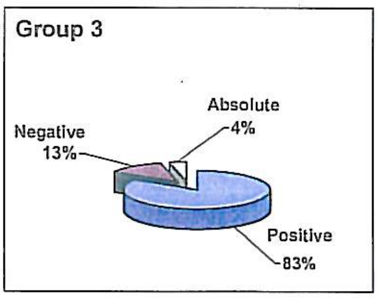
	NO	Statement	AGREE G1	AGREE G2	AGREE G3	UNDECIDED G1	UNDECIDED G2	UNDECIDED G3	DISAGREE G1	DISAGREE G2	DISAGREE G3	Questions: Positive	Questions: Negative	Questions: Absolute
0	19	Teacher makes links between the classroom teachings and laboratories work.	7	80	87	0	13	7	93	7	6	Positive	Negative	Absolute
0	35	My teacher always prepares his CAD/CAM lesson	100	93	80	0	7	0	0	0	20	(Agrred P + Disagreed N)	(Agrred N + Disagreed P)	(UNDECIDED)
		Positive	107	173	167	0	20	7	93	7	26	74.5	0	4.5
		Negative	0	0	0	0	0	0	0	0	0			
		Absolute	0	0	0	0	0	0	0	0	0			

0

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N	107	173	167	447	
egative (Agree of N Ques +Disagree of P Que	93	7	26	126	600
Absolute (Undecided)	0	20	7	27	







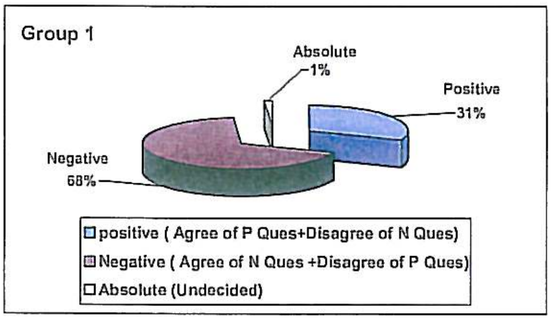
Students Opinion about Management

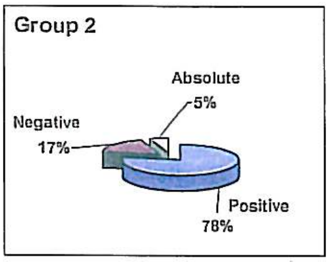
		NO	Statement	AGREE G 1	AGREE G 2	AGREE G 3	UNDECIDED G 1	UNDECIDED G 2	UNDECIDED G 3	DISAGREE G 1	DISAGREE G 2	DISAGREE G 3
300	1	18	My teacher is always in control of the class	20	80	93	7	13	0	73	7	7
300	2	21	Teacher in this methods work with less effort than the other methods.	0	80	80	0	0	0	100	20	20
300	3	24	My teacher does not pay attention to the students' individual differences	73	27	20	0	7	13	27	66	67
300	4	28	The teacher does not explain the target of the lesson	13	13	20	0	0	7	87	87	73
300	5	29	My teacher does not follow up my work	80	20	40	0	7	7	20	73	53
			Positive	20	160	173	7	13	0	173	27	27
1500			Negative	166	60	80	0	14	27	134	226	193
			Absolute				0	0	0			

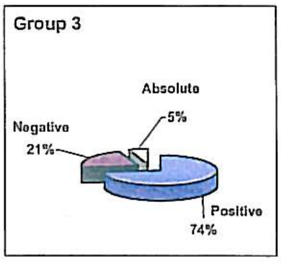
Questions		
Positive	Negative	Absolute

Questions		
Positive	Negative	Absolute
(Agrred P + Disagreed N)	(Agrred N + Disagreed P)	(UNDECIDED)
48.33333333	71.58333333	4.066666667

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N Ques)	154	386	366	906	
Negative (Agree of N Ques +Disagree of P Ques)	339	87	107	533	1500
Absolute (Undecided)	7	27	27	61	







Students Op- About Assessment

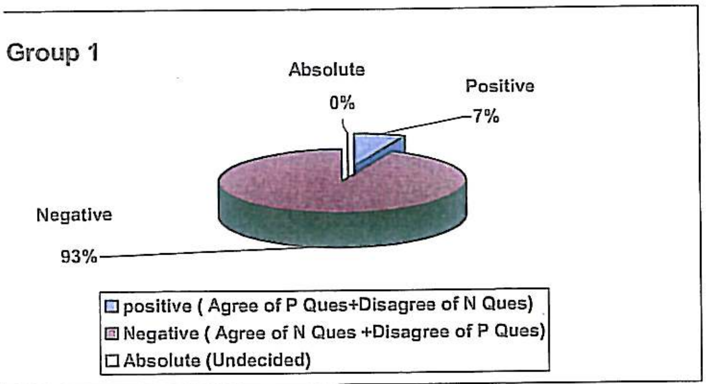
	NO	Statement	AGREE			UNDECIDED			DISAGREE		
			G 1	G 2	G3	G 1	G 2	G3	G 1	G 2	G3
1	16	In this methods teacher correct my mistake very easily	0	80	73	0	7	27	100	13	0
2	31	My teacher is fair when he marks the students' work.	20	73	73	0	27	27	80	0	0
3	32	Easy to evaluate students work and assessing their performance.	0	80	74	0	20	13	100	0	13
	Positive		20	233	220	0	54	67	280	13	13
	Negative		0	0	0	0	0	0	0	0	0
	Absolute										
			20	233	220	0	54	67	280	13	13

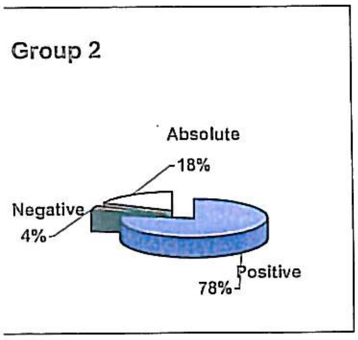
Questions

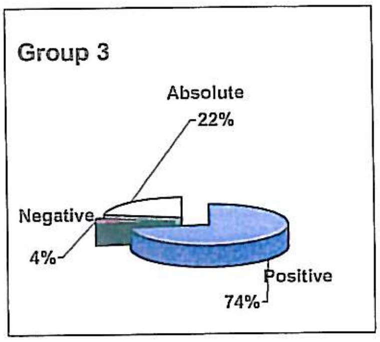
Positive	Negative	Absolute
(Agrred P + Disagreed N)	(Agrred N + Disagreed P)	(UNDECIDED)
52.55555556	0	13.44444444

900

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N	20	233	220	473	
egative (Agree of N Ques +Disagree of P Que	280	13	13	306	900
Absolute (Undecided)	0	54	67	121	



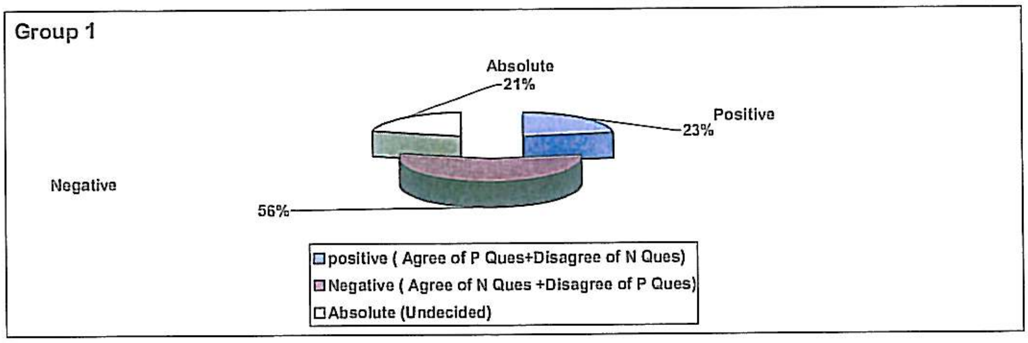


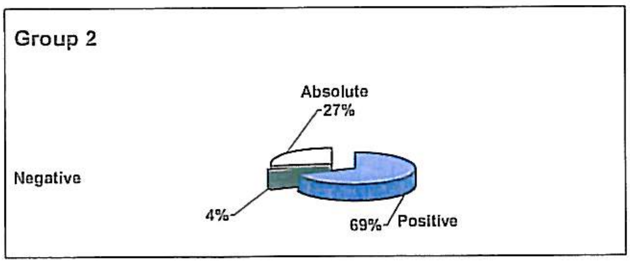


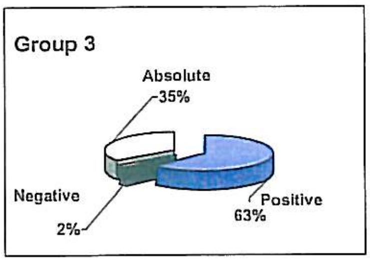
Students Op about Interaction and Enjo

		NO	Statement	AGREE G1	AGREE G2	AGREE G3	UNDECIDED G1	UNDECIDED G2	UNDECIDED G3	DISAGREE G1	DISAGREE G2	DISAGREE G3
300	1	22	In this methods my teacher teaches an interesting way	0	60	67	0	27	27	100	13	6
300	2	25	My teacher enjoys teaching CAD/CAM	67	100	87	7	0	13	26	0	0
300	3	26	My teacher encourages me to learn CAD/CAM	47	100	93	0	0	7	53	0	0
300	4	30	My teacher respects me when I work with simulation work or computer assisted instruction.	0	73	73	40	27	27	60	0	0
300	5	36	My teacher encourages the students to work in parallel with the simulation software or computer assisted instruction.	0	87	67	0	7	27	100	6	6
			Positive	114	347	314	7	34	74	279	19	12
1500			Negative	0	0	0	0	0	0	0	0	0
			Absolute	0	73	73	40	27	27	60	0	0
				114	420	387	47	61	101	339	19	12

	G1	G2	G3		
positive (Agree of P Ques+Disagree of N Ques)	114	347	314	775	
Negative (Agree of N Ques +Disagree of P Ques)	279	19	12	310	1500
Absolute (Undecided)	107	134	174	415	







Students All Categories

	The students 'attitudes towards the learning	The students 'attitudes towards the teacher teaching method	Organisation	Presentation	Classroom Management	Assessment mechanisms	Teacher's perception of teaching method used	G1	G2	G3
		Group 1								
positive (Agree of P Ques+Disagree of N Ques)	347	146	107	309	154	20	114	1197	2807	2611
Negative (Agree of N Ques+Disagree of P Ques)	556	414	93	377	330	280	270	2338	392	507
Absolute (Undecided)	7	40	0	14	7	0	109	177	412	581
								0		
positive (Agree of P Ques+Disagree of N Ques)	792	466	173	500	386	233	347	2807		
Negative (Agree of N Ques+Disagree of P Ques)	69	100	7	97	87	13	10	392		
Absolute (Undecided)	40	34	20	103	27	54	134	412		
roup 3								0		
positive (Agree of P Ques+Disagree of N Ques)	756	367	167	421	366	220	314	2611		
Negative (Agree of N Ques+Disagree of P Ques)	83	107	26	150	107	13	12	507		
Absolute (Undecided)	60	126	7	120	27	67	174	581		

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques) for 7 Categories	1107	2897	2611
Negative (Agree of N Ques+Disagree of P Ques) for7 Categories	2338	392	507
Absolute (Undecided) for 7 Categories	177	412	581