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Blended Learning System for Further and Higher Education Mechanical Engineering Courses in Bahrain

BLENDED LEARNING SYSTEM FOR FURTHER AND HIGHER EDUCATION MECHANICAL ENGINEERING COURSES IN BAHRAIN

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بِسْمِهِ تَعَالَى

ABSTRACT

Teaching and learning processes that are being followed globally by education providers consist of conventional face-to-face approach. Various socio-economic indicators have increased the pressure on Engineering Education in Bahrain in order to equip the students with both cognitive and psychomotor skills that are required by the labour market. The globalisation, along with the interdependence of various economies, has resulted in creating an extra dimension to the higher order of skills requirements. Hence, there is a need to develop new teaching and learning (T & L) methodologies that can comply with the ever increasing demands of the industry, regarding the skills of engineering students. In this study, the author has presented a comparison between various teaching and learning methodologies being implemented on the students of Higher National Diploma at Sheikh Khalifa Institute (SKI), Kingdom of Bahrain.

The author reviewed the effectiveness of the conventional teaching and learning methodology by comparing the pre-results with post-results. The same has been carried out on two novel T & L methodologies developed in these study i.e. computer-assisted instructions (CAI) and Blended Learning method, on imparting higher order of cognitive and psychomotor skills to engineering students. The study has been conducted on various groups of Higher National Diploma (HND) students at SKI. The study makes use of various questionnaires design especially for both the students and the teachers about their views on different T & L methodologies being implemented. It has been observed that computer-assisted instructions, when used with the conventional T & L methodology, perform superiorly than blended e-learning method or the conventional method alone. Hence, it has been recommended that this novel T & L method be used in the future to Higher National Diploma students at SKI.

Further to the development of a novel T & L methodology that performs better than the conventional T & L method, novel mathematical models have been developed for T & L methodology for both the cognitive and psychomotor domains. These mathematical models are based on the findings of the present study. These mathematical models explain the learning process of the students at microscopic level, in contrast to the conventional macroscopic evaluation method where only the marks obtained by the students indicate the quantitative learning. Furthermore, a novel Blended Learning package (containing tutorials for various Mechanical Engineering modules) has been developed based on the students-centred learning, considering institutional, pedagogical and technological contexts of service and product implementation. In this perspective, the novel Blended Learning package has been designed and developed in order to minimise/close the gaps between higher education at SKI and the requirements of the labour market.

DECLARATION

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For any errors or inadequacies that may remain in this work, of course, the responsibility is entirely my own.

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GLOSSARY

SKI	Sheikh Khalifa Institute
LLCS	Low Level of Cognitive skills
LOCS	Low Order of Cognitive skills
HLCS	Higher Level cognitive skills
HOCS	Higher Order cognitive skills
CAI	Computer-Assisted Instructions
T & L	Teaching and Learning.
BEV	Bahrain Economic Vision.
EDB	Economy Development Board
HNC	Higher National Certificate
HND	Higher National Diploma
LLTS	Lower Level of Thinking Skills
HLTS	Higher Level of Thinking Skills
FD	Foundation Year
MOE	MOE
SQA	Scottish Qualification Award
C&G	City & Guilds
ESP	English for Specific Purposes
BTEC	Business and Technology Education Council
OJT	On Job Training
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CNC	Computer Numerical Control
DXF	Data Export File
QAAET	Quality Assurance Authority for Education and Training
ICT	Information Communications Technology
ICT	Information Computer Technology
TCL	Teacher Centered of Learning
TCA	Teacher Centered Approach
STL	Student Centered of Learning
SCA	Student Centered Approach
CBI	Computer Base Instruction
UK	United Kingdom
3D	Three Dimensional
CAL	Computer-Assisted Learning
2D	Two Dimensional
ADDIE	Analyze-Design-Develop-Implement-Evaluate
TVE	Technical and Vocational Education
EF	Evidence File
IT	Information Technology
COE	Centre of Excellence
HLPCS	Higher level of psychomotor and cognitive skills
QAA	Quality Assurance Agency
AI	Automotive and Industrial Maintenance
AIM	Automotive, Industrial Maintenance and Manufacturing
AIMT	Automotive and Industrial Maintenance and manufacturing Technology
HLPS	High Level of Psychomotor Skills

ITD	Information Technology Department
PSSC	Physical Science Study Committee
ISD	Instructional System Design
PDCA	Plan-Do-Check-Act
KHLTC	King Hamad Learning Technologies Centre
CTTLE	Computer Technology with Traditional Learning Environment
LO	Learning Outcomes
CTP	Computer Tutorial Package.
W/B	Web/Base
W/S	Workshop
WBT	Web Base Technology
CM	Connectedness model
ICM	Integrated Connectedness Model
SCM	Simple Connected Model
PMM	Pure Memory Model
VLE	Virtual Learning Environment
CPD	Continuing Professional Development

CHAPTER 1
INTRODUCTION

1.1 Introduction to Education System in Bahrain

Bahrain Economic Vision (BEV 2030) calls for the development of its people in order to enable them to develop and sustain a prosperous society and to meet the needs of this and future generations. Bahrain continues to invest in its people so that all sections of the society can participate fully in the country's social and economic life and function effectively within a competitive knowledge-based international order. It is putting in place advanced education and training systems that meet the highest global standards. It is also supporting the productive participation of Bahraini men and women in the labour force, while attracting qualified workers in all fields, with a growing emphasis on the higher skills (Allen 2009).

The National Development Strategy in operation identifies the challenges in imparting education, training and productive work related skills. It also presents plans for meeting those challenges by building world-class knowledge and skills imparting institutions and developing capable and motivated workforce (EDB and MOE 2007). As Bahrain's economy diversifies from its reliance on gas and oil, its success depends increasingly on the ability to compete in a global knowledge economy. Continuing substantial investments in educating and training of Bahrainis is critical to achieving the goals of the National Development Strategy. Beyond preparing citizens to be part of the country's economic engine, education and training offer multiple benefits to society. Bahrain has developed a great education system, through the 'Education for a New Era' reforms which began after the Higher Education was established in 2005. Bahrain education system expanded and progressed over the past decades, with the establishment of a cluster of top-class international universities and institute that are helping to make Bahrain a regional leader in innovative education and research.

Bahrain education and training system is becoming more integrated; stretching from early childhood education through to higher education and additional work based training facilities. Engrained in this system is the concept of lifelong learning with individuals encouraged to acquire education and update their skills throughout their lives. This continuum spans three education sectors: general education, technical and vocational education, and higher education. While each sector has a distinct identity, mission and function, the three sectors need to operate within an overarching framework that embodies policy-related principles.

SKI was opened in 2005 for higher education and is fully equipped with supporting technological facilities. Multimedia laboratories have been prepared for e-learning and Blended Learning classes. Sheikh Khalifa Institute (SKI) contains sophisticated lecturing halls, laboratories and practical workshops equipped with state of the art equipment and technology. Besides, there is an internet laboratory that can be used by teaching staff, trainees and researchers. The stages of historical development of SKI, as shown in figure 1.1, depict the growth in the number of students per year. It can be seen that the number of students increased from 40 to 310 with opening of e further engineering specializations, such as Electronic Engineering, Telecommunication Engineering, Computer Network Engineering, Engineering Systems etc.

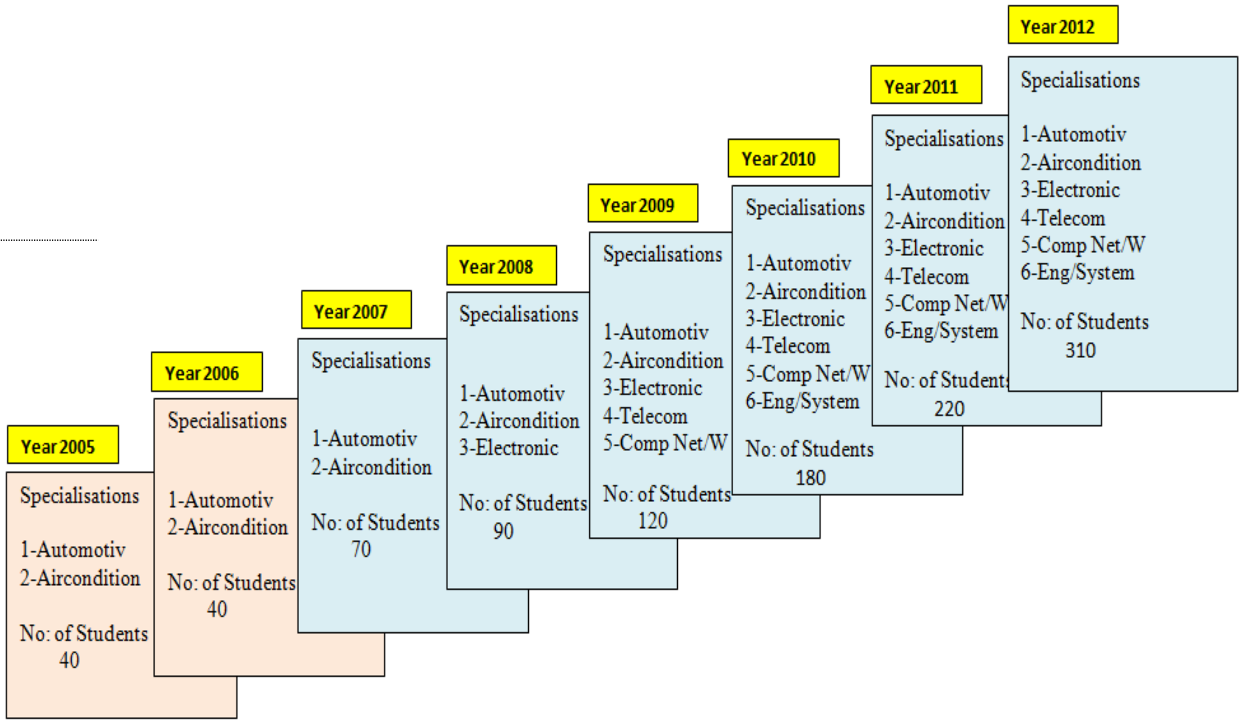


Figure 1.1 Historical development of SKI

1.2 SKI's Qualifications Framework

The qualification framework, shown in the figure 1.2, has been designed to equip the labour market with technicians with Higher National certificate (HNC) and Higher National Diploma (HND) .

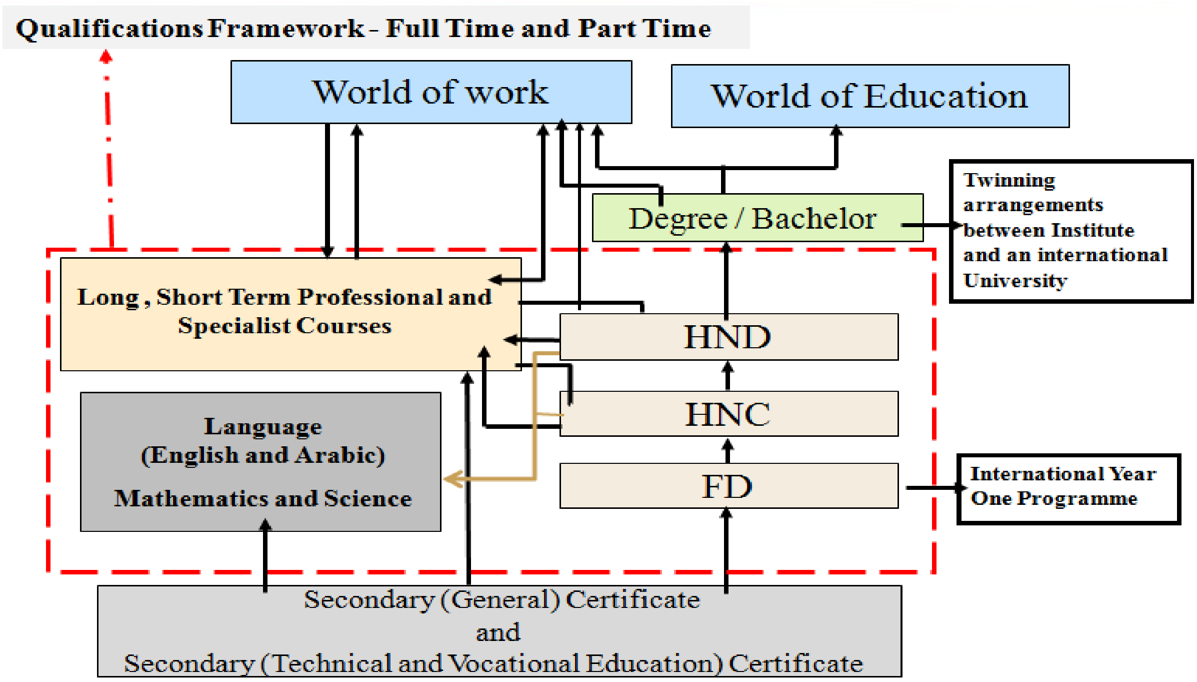


Figure 1.2 Institute Qualifications Framework

SKI has a three-year educational system that includes foundation, higher national certificate and higher national diploma courses. Students usually enter at the age of 18, after graduating from secondary schools, technical and vocational institutes. During the foundation year, a number of core modules are covered, such as English language, mathematics, science and basic mechanical/electrical engineering. The students join various mechanical and electrical practical sections to gain general knowledge and skills in various specialisations. On the completion of the first year, students may join either the Electronic route with different specialisations (Telecommunication, Computer Network, Electronic etc.) or the Mechanical route with different specialisations (Automotive, Industrial Maintenance, Manufacturing etc.) as per their performance, personal interests and aptitude (SQA and QAS, 2008).

Each route of HND contains three to four different engineering specializations, each of which include a number of subjects which are delivered through theoretical and practical sessions. The students with good performance at the HND level are encouraged to continue with further engineering studies (University level). Other students, who have good practical abilities, join the labor market. Each student has to undergo four weeks work placement, in order to qualify for the labour market (MOE and SQA 2009). In addition to HNC and HND, the institute offers a number of specialized short term and long term training programs that meet the needs of labour market. Short and long term programmes offered are accredited from EDECXEL/SQA/ City & Guilds / Cisco Network in Business, Engineering fields, and lead to Certificate, Diploma and Vocational licenses. The courses can be developed upon specific requests from business world as well (Corporate and Customized Training).

1.3 Institute's Characteristics

The courses in the engineering subject area have three stages of verifying the quality in one academic year, in order to enhance the quality of T & L process (K.L. Kumar, 2006). These are:

- **Input** is the data flowing into the system from outside
- **System** is the action of manipulating the input into a more useful form (processing)
- **Output** is the information flowing out of the system

All these stages are shown in figure 1.3. These stages may be optimised by the way of considering the variable alternative feedback. This happens when the outcome has an influence on the input and the storage of information often needs to be kept safe for later use (Input data, Output data and Processed data).

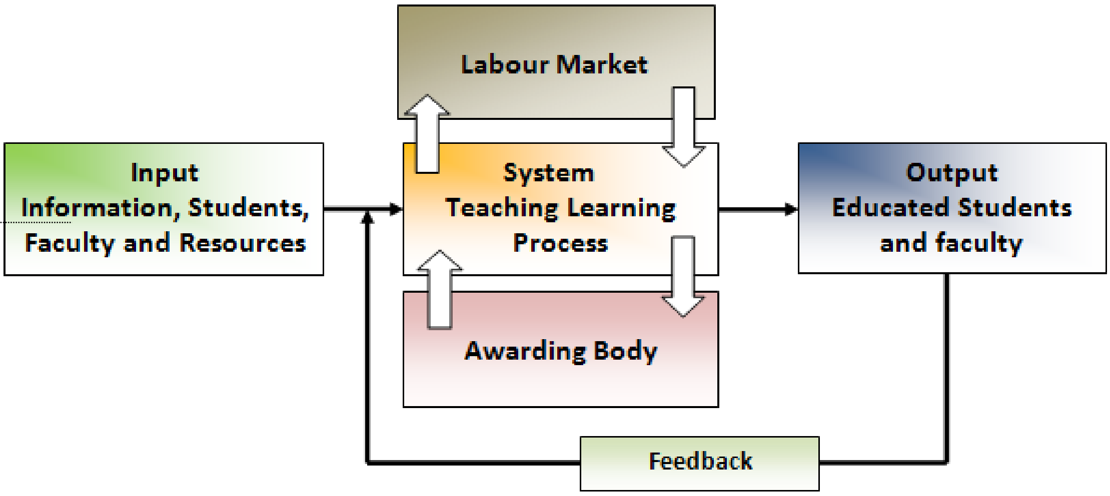
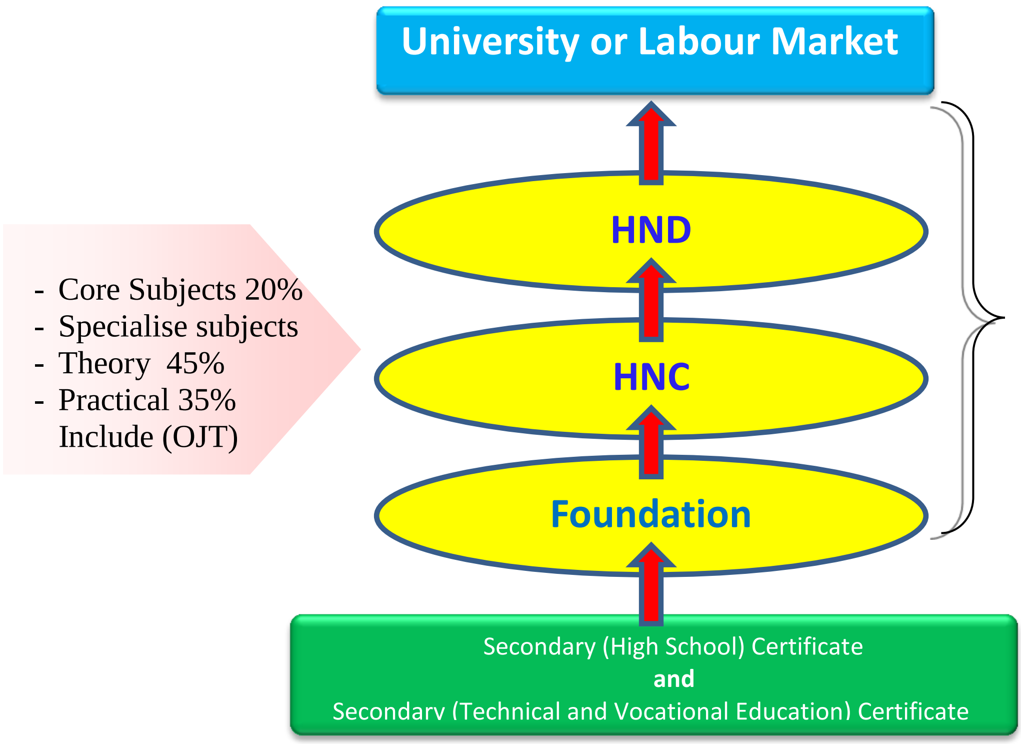


Figure 1.3 System Model of the Teaching – Learning Process adopted from (K.L. Kumar, 2006)

At SKI, Input is influenced by the MOE (Information, Students, Faculty and Resources), System (T & L Process) in cooperation with Labour Market and Awarding Body for monitoring and assessments and the Output of the system are the educated students and faculty which gives feedback to the MOE (MOE) and the System. Therefore, programmes are designed for continuous improvement through various feedback channels. The SKI system aims to increase the skills level of Bahrainis by developing a stronger alignment between the institute's curriculum and work requirements. The flowchart in figure 1.4 depicts the students' pathway (Input and Output) which indicates a comparison of local qualifications against international (SQA and EDEXCEL) qualifications.



Higher National Diploma (HND) Equivalent to SQA and BTEC qualifications

Figure 1.4 Students' Pathway

In the following detailed characteristics of the teaching and learning processes have been highlighted.

- First year students of Higher National Diploma (SQA level 5&6 or BTEC level 2&3) cover most of the core subjects (applied core), specialised subjects and institute based training

- Second year students of Higher National Certificate (SQA level 7 or BTEC level 4) cover the remaining of the core subjects (applied core), specialised subject and On Job Training (OJT)

- Third year students of Higher National Diploma (SQA level 8 or BTEC level 5) cover the specialised subject and On Job Training (OJT)

- The total contact hours of engineering courses are distributed as 20% for the core subject, 45% of the hours for specialised subjects and 35% of the hours for on job training

- The institute engages its students with the labour market, through a placement mechanism program or On-Job Training (OJT) in order to enhance their career skills and gain knowledge of the enterprises and work environment

- The institute builds a relationship between labour market and awarding body to improve the trainee's skills. Figure 1.5 depicts the joint venture relationships

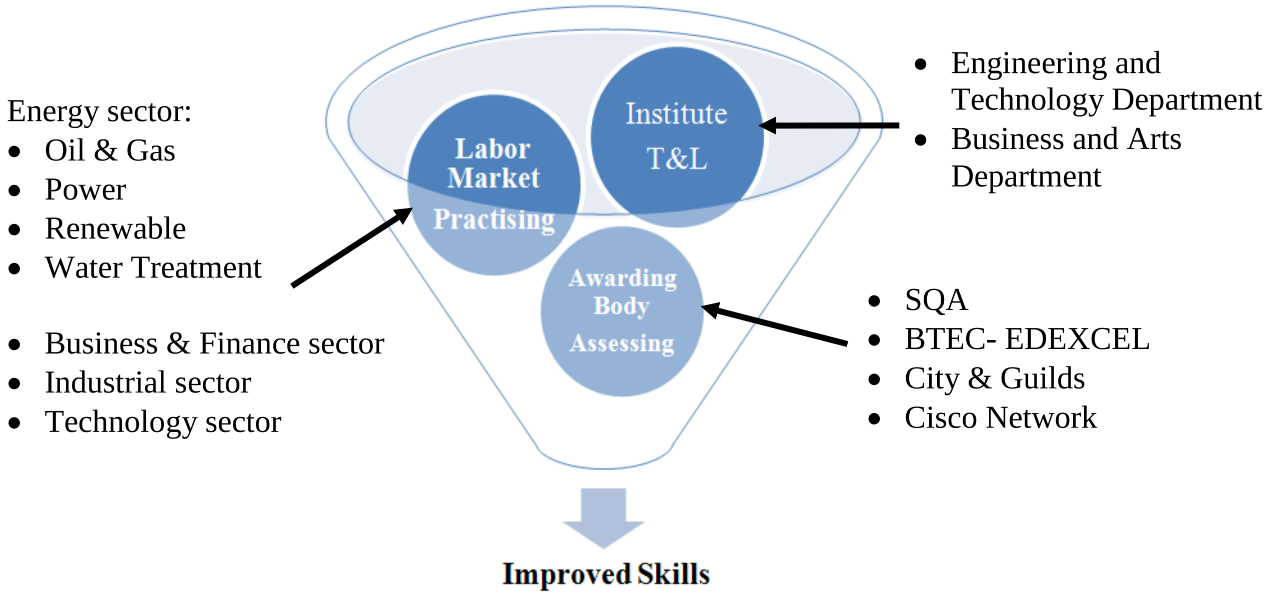


Figure 1.5 Joint Venture Relationships

In this thesis only the details of the works in mechanical engineering areas have been considered.

1.4 The Development of Higher Education at SKI

The major challenges of the engineering education environment at SKI, Kingdom of Bahrain, have always been to ensure that Higher National Diploma (HND) graduate students have the skills required by Bahraini labour market (Tamkeen 2009). At Sheikh Khalifa Institute (SKI), the T & L process must takes place effectively in the theory classes, practical sessions and work placement. Teachers in the classroom of theoretical subjects and instructors in the labs for practical sessions must contribute to increase the quality of T & L for Higher National Diploma students (MOE and SQA 2009).

The education system at SKI is mainly comprised of two factors. The first is substantial and includes many elements such as institutional environments, equipment, books and syllabuses. These are manageable elements, and in accordance with the direction of the leadership, the MOE in Bahrain supplies the educational system with the latest of these elements (MOE 2010). The second factor is the highly trained and qualified academic and technical staff. Students are the main beneficiaries of the educational system. The standard they reach does not reflect only their own achievements, but the quality of performance of all those who belong to the educational system.

Nowadays, the characteristics of engineering graduates required by the labour market are different from those needed two decades ago. Employing modern technology requires knowledgeable and skilful technicians who have Skills to achieve the necessary competencies in their professions (Zaharim, A et al., 2010). They should be willingly ready for regular training programmes that acquaint them with the latest development in equipment and production techniques. In addition to that they should be able to work with others, analyse and solve problems and must be aware of and capable of applying knowledge at workplace at all times.

Keeping with the international trend, the Kingdom of Bahrain has also embarked on reforming educational practices (MOE 2007). The author has been involved in this process as the Head of Centre of Excellence within Ministry of Education (MOE) in Kingdom of Bahrain. Also he has been institute Lecturer for fifteen years in the field of Mechanical Engineering.

SKI provides various specialisations at HND level in the Mechanical Engineering field such as Automotive, Industrial Maintenance and Manufacturing, as shown in figure 1.6. The modules that are common between these specialisations are a) Manufacturing Process – 2, b) Engineering Measurement and c) Power and Transmission System. The current state of Mechanical Engineering subjects at SKI is focused on lower levels of skills in both theory classes and lab sessions. Very little attention is being paid to the high levels of skills which are required by Bahrain's labour market. Figure 1.6 shows the various specialisations and the modules covered within these specialisations at SKI.

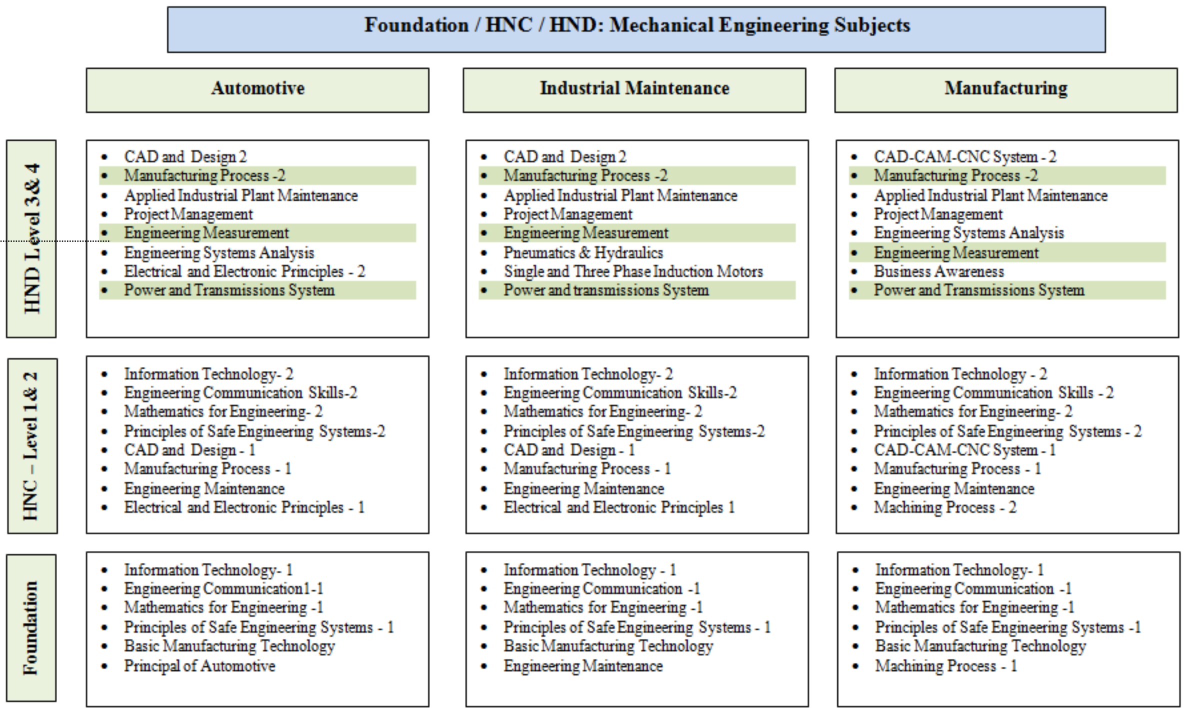


Figure 1.6 Specialisations and modules at SKI

In engineering education, cognitive domain is very important as it deals with imparting didactic information about knowledge and facts. The learning results in understanding learning objectives at a simple level to a more complex level (Dye, R.C.F. 2003; Bhavnani, K. Suresh and John, E. Bonnie. 2000; Gall, E. James 2001-2002). The knowledge transfer starts at a very low level, which requires memorization and recall. In engineering education, for a typical analytical module, this can be a simple equation describing a physical phenomenon. In the next level comes the comprehension, where students learn to interpret the information and understand the meaning behind the information (Kara, A 2009). Other levels of learning within the cognitive domain, which must be employed clearly, are application (application of information to real life situation), analysis (analysis of the system from whole to part), synthesis (combining the analysis results to model a new or existing system), and evaluation (being able to optimise the systems). This model is equally valid for an engineering pathway, a module within the pathway and a component of the module within the module (Bhavnani, K. et al., 2000; S, M. Zywno 2002).

The other domain of learning which is very important in engineering education is psychomotor domain. The psychomotor domain of learning equips the learner to do things in a particular way (Zaharim, A., et al., 2010). The hands-on approach of learning is covered in this domain.

In mechanical engineering classes, students are given an opportunity initially to imitate the demonstration and then allowed to explore the boundaries of the learning outcomes. In a typical engineering analysis module, there is always an overlap in learning outcomes to be achieved through lectures/tutorials and lab work. It helps lecturers immensely while describing a theoretical concept, for example, regarding dismantling or repairing gears and shaft, to explain the lab set up in the lecture class itself and interrelate overlapping outcomes to develop an integrated picture of the learning outcomes.

The present teaching methodology being used in engineering education is limited in the sense that students' final achievements are not up to the mark. In any teaching methodology, it is very essential to develop an integrated picture of the learning outcomes when moving from one learning objective to the other learning objective in a subject having different elements (maintenance and manufacturing subject) during classroom and lab sessions (Abdulrasool, S. et al., 2007). For example, while designing gear and shaft for a gear box, it is fairly important to explain how these parts work for assembly purpose; gear modules type and shape of teeth. A clear explanation of interrelation among learning objectives during the delivery process helps students in developing an integrated picture of the subject at high level of thinking skills.

1.5 Teaching and Learning of Mechanical Engineering subjects at SKI

At SKI, Automotive, Industrial Maintenance and Manufacturing specialisations are an integral part of Mechanical Engineering. These specialisations have been developed keeping local industrial requirements in view (Mikell et al., 2002). Engineering requirements of most of the Mechanical Engineering related industries is to:

- Design and conduct experience
- Analyse and interpret data
- Design a system, component or process to meet desired needs
- Identify, formulate and solve engineering problems
- Understand professional and ethical responsibility
- Use the techniques, skills and modern engineering tools necessary for engineering practice
- Design, analyse, implement, and manage effective production and service systems
- Integrate the engineering and business processes of an organization
- Integrate processes involving people, material, equipment, information, and controls
- Provide transferable skills, and have professional judgment during the stage of designing

The above engineering requirements enforce educationalists in curriculum department to analyse all the factors which affect T & L in mechanical engineering course and to enable mechanical engineering students to apply their knowledge with high performance after they gain undergraduate qualification (UNESCO Report Bahrain 1994; UNESCO Report Bahrain 2005; Tatakwski, M. & Duckett, I. 2011).

1.5.1 Required Educational Outcomes

The educational outcomes of the teaching/learning process, that are required, have been summarised as follows:

- Providing an educational environment that enables the students to learn how to learn on their own and learn by doing
- Providing an effective and intellectually challenging classroom and lab experience
- Providing an atmosphere to develop interpersonal skills
- Utilizing student evaluations of the mechanical subject, for improving teaching effectiveness
- Maintaining a strong teaching plan, with multiple assessment tools, that enables faculty to reflect and act on their teaching
- Providing an effective and dynamic curriculum and instruction system
- To equip teachers with skills related to lesson planning, teaching methods, classroom management and other related activities

1.5.2 Required Engineering Outcomes

The engineering outcomes of the teaching/learning process, that are required from the students, have been summarised as follows:

- To design and conduct experiments, analyse and interpret data
- To design a system, component or process to meet desired needs
- To identify, formulate and solve engineering problems
- To understand the professional and ethical responsibility
- To use the techniques, skills and modern engineering tools necessary for engineering practice
- To design, analyze, implement, and manage effective production and service systems
- To integrate the engineering and business processes of an organization
- To integrate processes involving people, material, equipment, information, and controls
- To provide transferable skills

1.6 Performance Characteristics

UNESCO's reports have clearly mentioned that the engineering students, at HND level, do not have adequate skills to meet the requirements of the industries in Bahrain, who want hands-on skills in their engineers at higher levels, such that they can:

- Infer on the basis of convincing evidence
- Understand and communicate
- Increase operating efficiency
- Rate the quality of the product
- Perform Procedures and operate systems
- Prepare the work map and Design product
- Analyse information to understand

In 2010, EDB and Tamkeen conducted a graduate tracking survey which was an adaption of the knowledge-based economy characterized by research, development and innovation. The survey has indicated that the recruitment of highly efficient Bahraini workers is required. Furthermore, the program of action of Population Policy in the Bahrain Economical Vision 2030 includes a knowledge-based economy as one of the key objectives though its achievements, which would involve a lot of time and effort. In Bahrain, the available data on the skill level of workers, during 2011, show that a quarter of economically active Bahraini workers are classified as skilled or highly skilled, whereas the other quarter is unskilled, and about half of them are semi-skilled, as shown in figure 1.7.

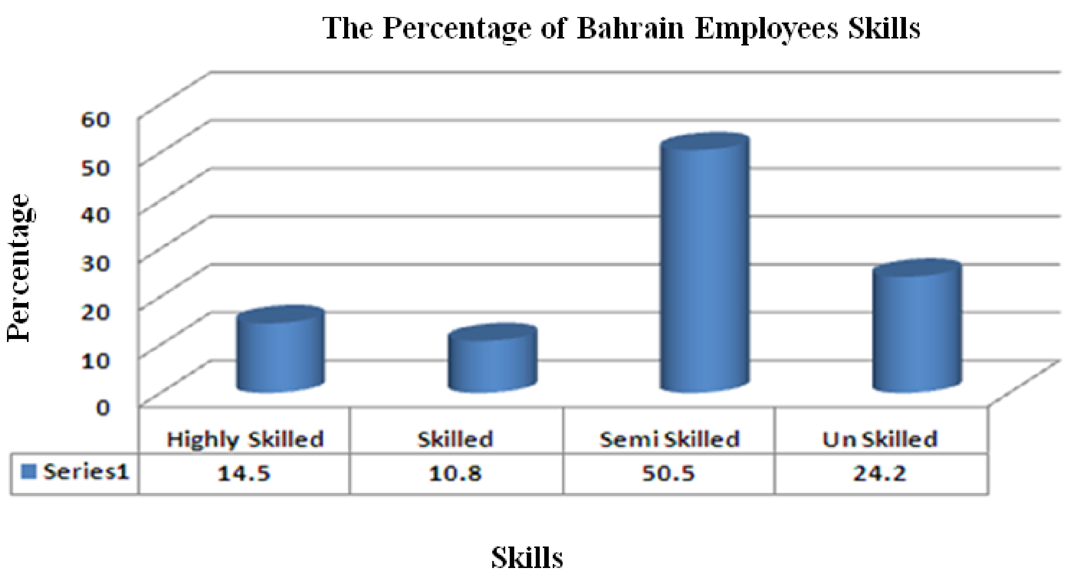


Figure 1.7 The percentage of Bahrain Employees from 2008 to 2010 (Tamkeen, 2010)

From the survey findings, it was observed that there were a number of issues that have been highlighted as:

- The SKI graduates might not be prepared efficiently for the labour market
- Job offers to SKI graduates might not be in the same field as that of the student's specialisation
- TVE graduates might not be mature and motivated enough to enter the job market

1.6.1 Need for Up-to-Date Engineering Course Material

MOE and SQA (2009) policy was to review SKI engineering courses and training programmes continuously to meet changing industry requirements. The Quality Assurance Authority for Education and Training examined the quality of the engineering courses (QAAET, 2010). It was indicated that:

- Most of the teachers confirmed that the existing engineering courses have not been updated for a long time
- The amount of information and the time allowed for delivering the existing engineering courses limits students' abilities and does not consider labour market needs
- The existing engineering courses are based on teacher- centred learning and focus on both theoretical learning in ordinary classrooms and practical applications
- The existing Mechanical Engineering courses have limited ability to link theoretical content and practical applications

Hence, there is a need to develop new course material for the modules being taught at SKI.

1.6.2 Need for Up-to-Date Teaching and Learning Process

In 2009, a diagnostic study was carried out to review the effectiveness of the teaching and learning processes (MOE and SQA 2009). The findings indicated that the existing teaching and learning methods took a traditional approach, which paid little attention to the motivation and feedback processes that might reflect students' academic achievements. The review also confirmed that there was a shortfall between the current teaching styles and the preferred learning styles of students. It was obvious that most SKI students were not able to practise analytical thinking skills, communicate effectively with others, feel confident, or show awareness and responsibility in their behaviour (Mumcu, F.K. & Usluel, Y.K. 2010). From the diagnostic study, it was indicated that there was a need to:

- Further investigate the teaching and learning styles practiced by SKI lecturers and preferred by SKI students
- Consider the individual learner's requirements in the teaching and learning processes

- Develop the quality of teaching and learning processes, in particular through the improved training of teachers.

1.6.3 Need for Using Technology into Teaching and Learning Processes

In 2004 (opening year of SKI), the concept of information technology was introduced in order to integrate information technology throughout the process of learning, in classrooms and labs and the SKI computer technology courses. After that, learning resource centers were opened, with personal computers linked to the Internet. More recently, a project entitled 'King Hamad's Project' was established (MOE, 2010). It aimed to:

- Meet the immediate needs of national development and modern industry
- Invest in ICT to achieve efficiencies in curriculum subjects at all stages of education
- Develop an e-learning culture in SKI and other institution named under MOE umbrella
- Provide students with the values and skills necessary for the information society and knowledge economy
- Develop curricula for various subjects gradually
- Deliver training for teachers and students in the use of e-learning systems

Hence, the technology should be integrated into the process of teaching and learning, for the engineering courses at SKI, in order to ensure that the required skills will be met in the future. Technology should be embedded in content of engineering courses in order to enhance teaching and learning processes. Furthermore, it is suggested that technology could be used for the appropriate delivery of the existing engineering courses with the required skills to meet the SKI aims and objectives.

1.7 Motivation

To meet with the SKI aims and objectives, the quality of the pedagogical and technological system at Sheikh Kalifa Institute is reviewed regularly every academic year (SQA and quality assurance, 2008). The aim is to improve the SKI quality performance including both the Cognitive and Psychomotor Skills. A recent quality review was carried out to indicate whether the existing SKI system meets the labour market expectations or not (SQA and quality assurance, 2008). The review indicated that a gap exists between modern industry's requirements and the work skills of the graduating students. More specifically, the factors that result in this gap have been identified as the need for up-to-date engineering courses, need for modern teaching and learning processes, and limited use of technology in learning. This has motivated the author to carry out an extensive research in which a Blended Learning system can be designed, developed, implemented and then evaluated. The learning system should be able to cope with the industrial requirements in Bahrain. Furthermore, an attempt has been carried out in this study to develop novel learning models based on the outcomes of the study.

The next section the research areas based on various reports and studies on SKI's system (MOE, 2009; Allen 2009; MOE and SQA 2009; MOE, 2007; MOE, 2010). It is also based on the researcher's experience, being the Head of Mechanical Department, Educational Specialists and External Verifiers, who reviewed and monitored the quality assurance system at SKI and issued periodic reports on the quality of the SKI system to the MOE and Higher Education. Furthermore, inputs have been taken from Project Advisers who assisted the educational experts from UK to provide information about the existing SKI system and contributed in suggesting solutions for improvements.

1.8 Research Aims

From the discussions presents in the previous sections, it is apparent that this research will be centered on the question "How can teaching and learning process be improved in delivering mechanical engineering subjects at HND Level?". The HND level has been focused in this study because it is the primary higher level engineering course being offered at SKI, Bahrain. In addressing the aforementioned question, a variety of elements have been identified, which forms the aims of this study. These elements are:

a) Design and Development of a Blended Learning System for Mechanical Engineering students

b) Implementation of the Blended Learning System

c) Evaluation of the Blended Learning System from both the teacher's and student's perspective

d) Development of a novel mathematical model for the developed Blended Learning System

Thus, the aim of this research is to develop an effective teaching/learning system to equip Bahraini labour market with high level of Hands-on skills in Mechanical Engineering by bridging the gap between the entry skills (skills at entry stage of HND) and the exit skills (required by labour market) by a well-constructed curriculum, delivery and assessment.

1.9 Organisation of Thesis

Chapter 1 highlights the developments in Higher Education at SKI and how they affect teaching/learning process. The three themes, which have been identified as being under-researched, are the pedagogical, technological and teaching/learning strategies. Furthermore, it includes the actual teaching and learning concepts, and the pragmatic issues of learning styles with technology. These have been further focused using research questions, and their interrelationship has been illustrated in the research aims. It is believed that an outline of the remaining chapters of this thesis will assist the reader in appreciating the structure of this work.

Chapter 2 presents an illustrated review of the published work in the specified research area. Influenced by the research aims, the focus is on the existing pedagogical research of the current state of teaching/learning (T & L) at SKI , and on the use of computer technology (blended learning) at higher levels of cognitive and psychomotor skills, for both theoretical and practical learning media. The research scope and research specific objectives presented are the guidelines of research implementation.

Chapter 3 describes the development of the pedagogical framework and the Blended Learning system. The development of this framework is based on the results of the teacher's questionnaires that describe the teacher's methodology at SKI. Based on the Blended Learning system, learning outcomes of various Mechanical Engineering modules have been developed in both cognitive and psychomotor domains. Furthermore, assessment criteria have also been developed for these modules. The effect of using technology in teaching/learning process, and the design of the website to incorporate e-learning method into teaching are the highlights of this chapter.

Chapter 4 describes the implementing of the developed Blended Learning system through various teaching/learning methods. In order to accomplish this, three different teaching methodologies have been adopted in this study. These methodologies correspond to the conventional face-to-face teaching (teacher-centered), teaching through the use of technology with supervision from the teacher (student-centered), and teaching through an interactive method in which students use the technology for learning purposes as per their convenience. The effectiveness of teaching methods has been determined by user evaluation method of questionnaires i.e. data collection method, completed by both the lecturers and the students. Their answers have been analysed from both quantitative and qualitative points of views.

Chapter 5 describes the assessment of the Blended Learning system at macroscopic level in both the cognitive and psychomotor domains. Three groups of students and three groups of mechanical engineering teachers have been selected for this purpose. The aforementioned T & L methods have been attempted on each group i.e. Group 1 was taught under the watchful eyes of the instructor (teacher-centered), Group 2 was taught under the watchful eyes of the instructor with the use of technology (student-centered), and Group 3 learned through interactive learning method. This chapter has clearly demonstrated the effectiveness of developed pedagogical package in a heterogeneous group learning activity. The results of time management of the students, working inside the labs, are the highlight of the chapter.

Chapter 6 presents the microscopic evaluation of the proposed teaching/learning method through the use of novel mathematical learning models that takes into account the results from the previous chapters. These models have been implemented on the three groups of students for three different teaching methods (teacher-centered approach, student-centered approach and interactive learning). The developed mathematical models have been validated using the data available from literature and used in the current study to quantify the improvement in skills in both the cognitive and psychomotor domains.

Chapter 7 presents the overall research synopsis and the main conclusions of this study. Furthermore, the novel contributions that this study presents are highlighted and future recommendations have been included.

CHAPTER 2
LITERATURE REVIEW

2.1 Design and Development of Blended Learning System

This section reviews the literature on the design and development of various teaching/learning methods for Mechanical Engineering area, in comparison with the current state of higher education at SKI. In the previous chapter, it has been observed that the current teaching/learning process at SKI is incapable of producing engineers with higher level of skills, and hence a new teaching/learning process needs to be designed and developed. It has therefore been proposed to design this novel teaching/learning package on the basis of Bloom's taxonomy, which is an established way of creating teaching/learning processes.

Bloom's Taxonomy model comprises of three main components (or overlapping domains). These components are:

- Cognitive domain (intellectual capability, i.e., knowledge, or think)
- Affective domain (feelings, emotions and behaviour, i.e., attitude, or feel)
- Psychomotor domain (manual and physical skills, i.e., skills, or do)

This has given rise to the short-hand variations on the theme which summarise the three domains; for example, Skills-Knowledge-Attitude, Do-Think-Feel etc (W, L Anderson, L and K, Krathwohl 2001). Various people have since built on Bloom's work, notably in the third domain, the psychomotor or skills, which Bloom originally identified in a broad sense, but which he never fully detailed. This was apparently because Bloom and his colleagues felt that the academic environment held insufficient expertise to analyse and create a suitable reliable structure for the physical ability. While this might seem strange, such caution is not uncommon among expert and highly specialised academics; they strive for accuracy as well as innovation. In Bloom's case, it is as well that he left a few gaps for others to complete the details; the model seems to have benefited from having several different contributors fill in the detail over the years, such as Anderson, Krathwhol, Masia, Simpson, Harrow and Dave (last three having each developed versions of the Psychomotor domain).

Each of the three domains of Bloom's Taxonomy is based on the premise that the categories are ordered in degree of difficulty. An important premise of Bloom's Taxonomy is that each category (or level) must be mastered before progressing to the next. As such the categories within each domain are levels of learning development, and these levels increase in difficulty. The simple matrix structure enables a checklist or template to be constructed for the design of learning programmes, training courses, lesson plans, etc. Effective learning, especially in organisations where training is to be converted into organisational results, should arguably cover all the levels of each of the domains, wherever relevant to the situation and the learner. The learner should benefit from development of knowledge and intellect (Cognitive Domain), attitude and beliefs (Affective Domain), and the ability to put physical and bodily skills into effect (Psychomotor Domain).

2.1.1 Cognitive Domain Skills

Lorin Anderson, a former student of Bloom, revisited the cognitive domain in the learning taxonomy in the mid-nineties and made some changes, with perhaps the two most prominent ones being changing the names in the six categories from noun to verb forms and slightly rearranging them (figure 2.1).

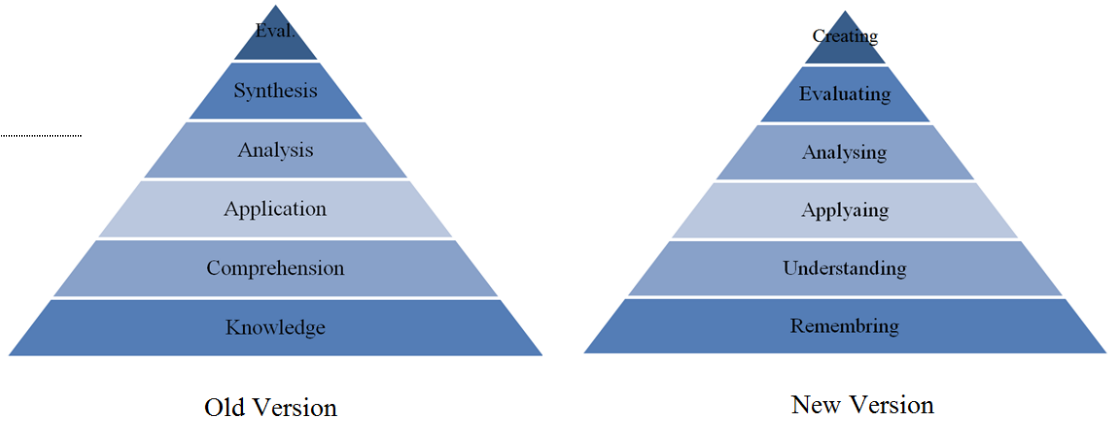


Figure 2.1 Bloom's Comparative Taxonomies

Note that the change from Nouns to Verbs [e.g., Application to Applying] to describe the different levels of the taxonomy (Pickard, M. 2007). Note that the top two levels are essentially exchanged from the Old to the new version. Evaluation moved from the top to Evaluating in the second from the top; Synthesis moved from second on top to the top as Creating (W, L Anderson, L and K, Krathwohl 2001).

Table 2.1 Bloom's revised Taxonomy

Remembering: can the student recall or remember the information?	define, duplicate, list, memorize, recall, repeat, reproduce state
Understanding: can the student explain ideas or concepts?	classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase
Applying: can the student use the information in a new way?	choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write.
Analyzing: can the student distinguish between the different parts?	appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
Evaluating: can the student justify a stand or decision?	appraise, argue, defend, judge, select, support, value, evaluate
Creating: can the student create new product or point of view?	assemble, construct, create, design, develop, formulate, write

2.1.2 Psychomotor Domain Skills

The psychomotor domain is commonly used in areas like laboratory science subjects, health sciences, art, music, engineering, drama and physical education. Bloom and his research team did not complete detailed work on the psychomotor domain as they claimed lack of experience in teaching these skills. However, a number of authors have suggested various versions of taxonomies to describe the development of skills and co-ordination as:

- Dave (1970) proposed a hierarchy consisting of five levels: Imitation, Manipulation, Precision, Articulation and Naturalization

- Simpson (1972) developed a more detailed hierarchy consisting of seven levels: perception, Set (mindset), guided response, mechanism, complex overt responses, adaptation and origination

- Harrow (1972) developed six levels: reflex movements, basic fundamental movement, perceptual, physical activities, skilled movements, non-discursive communication

- Ferris and Aziz (2005) developed seven levels: recognition of tools and materials, handling of tools and materials, Basic operation of tools, competent operation of tools, expert operation of tools, planning of work operations, evaluation of outputs and planning means for improvement

Table 2.2 shows the psychomotor skills and action verbs published and used by different authors for hands-on work (Lab).

Table 2.2 Psychomotor action verbs by different authors

No.	Author	Action verbs
1	Dave (1970)	Adapt, adjust, administer, alter, arrange, assemble, balance, bend, build, calibrate, combine, construct, copy, design, deliver, detect, demonstrate, differentiate (by touch), dismantle, display, dissect, drive, estimate, examine, execute, fix, grasp, grind, handle, heat, manipulate, identify, measure, mend, mime, mimic, mix, operate, organize, perform (skillfully), present, record, refine, sketch, react, use
2	Simpson (1972)	Observed, guide, action, practice, confidence, Responses, problem solving, creativity
3	Harrow (1972)	flexion, extension, stretch, postural adjustments, walking, running, pushing, twisting, gripping, grasping, manipulating, Visual, auditory, kinaesthetic, coordinated movements such as jumping rope, punting, catching, recreation, and dance, body postures, gestures
4	Ferris and Aziz (2005)	Recognize, handled, hold, perform, use efficiently, effectively and safely, specify, describe, identify, action

In general, all of the various taxonomies in the psychomotor domain describe a progression from simple observation to mastery of physical skills

Bahrain labour market is focusing on mastering a high level performance and coordination, and adapting a series of actions to achieve harmony, consistency and refinement for critical thinking and performing specific skills related to diagnostics and exploration, planning, designing, action, implementation, evaluation, improving, experiencing (work placement), naturalization, articulation and precision, and these skills should be critically sustained and justified (Allen 2009).

2.1.3 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 (W, L Anderson, L and K, Krathwohl 2001):

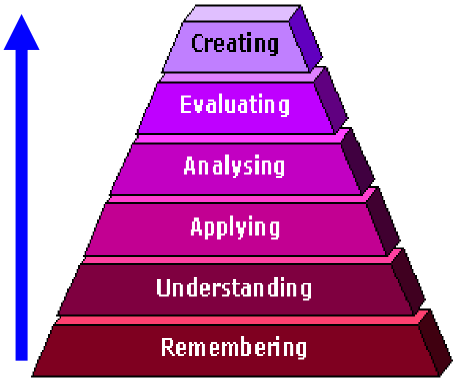


Figure 2.2 Bloom's Taxonomy (1956)

- The cognitive domain relates to thinking and knowledge skills in literacy, numeracy, problem based learning, productivity Pickard, M., (2007)

- 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.

2.1.4 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 (W, L Anderson, L and K, Krathwohl 2001). Questions and projects that elicit synthesis and evaluative skills and deep learning strategies are under-represented (Heather, Steve, Stephanie, 2003; Anderson, Krathwohl, Bloom, 2001; 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 (Pickard, M., 2007).

2.1.5 Bloom's Taxonomy Overview

Bloom's Taxonomy definitions are intended to be simple in modern day language, to assist explanation and understanding. This simple overview can help to understand and explain the taxonomy. It's helpful at this point to consider the conscious competence learning stages model, which provides a useful perspective for all three domains, and the concept of developing competence by stages in sequence (Pickard, M. 2007).

Table 2.3 The Cognitive, Affective and Psychomotor Domains (Bloom's Taxonomy)

Cognitive	**Affective**	**Psychomotor**
Knowledge	**Attitude**	**Skills**
1. Recall data	1. Receive (awareness)	1. Imitation (copy)
2. Understand	2. Respond (react)	2. Manipulation (follow instructions)
3. Apply (use)	3. Value (understand and act)	3. Develop Precision
4. Analyse (structure/elements)	4. Organise personal value system	4. Articulation (combine, integrate related skills)
5. Synthesize (create/build)	5. Internalize value system (adopt behaviour)	5. Naturalization (automate, become expert)
6. Evaluate (assess, judge in relational terms)		

The teaching/learning process is provided to maximise learning effectiveness. There are a number of models to quantify the effectiveness of learning process (G, H Weller, W, Lan J Repman. G, Rooze 1995). Bloom's Taxonomy provides a framework that can be used for evaluation of effectiveness of different learning processes (J, B. Bloom. D, M. Englehart. D, M. Furst. J, E. Hill. R, D Krathwohl; 1956). It includes verbs of six levels of cognitive domain related subject learning outcomes' (Anderson, Krathwohl; 2001).

Table 2.4 Blooms Taxonomy (Cognitive) lower and higher level

Knowledge Dimension	**Cognitive Processes Dimension**					
	Remember	***Understand***	***Apply***	***Analyse***	***Evaluate***	***Create***
Factual	Remember Facts	Understand Facts	Apply Facts	Analyze using Facts, Concepts, Principles and Procedures	Evaluate using Facts, Concepts, Principles and Procedures	Create using Facts, Concepts, Principles and Procedures
Conceptual	Remember Concepts	Understand Concepts	Apply Concepts			
Procedural	Remember Procedures	Understand Procedures	Apply Procedures			
Meta-cognitive	Remember Meta-cog Strategies	Understand Meta-cog. Strategies	Apply Meta-cog. Strategies	Analyze Meta-cog. Strategies	Evaluate Meta-cog. Strategies	Create Meta-cog. Strategies
	Knowledge		***Skill***		***Ability***	

LOCS HOCS

The Lower Order of Cognitive Skills (LOCS) and Higher Order of Cognitive Skills (HOCS) within cognitive domain relates to knowledge (recall data), comprehension (understanding information), application (applying knowledge to a new situation), analysis (separating information into part for better understanding), synthesis (building a pattern from diverse elements) and evaluation (judging the value of information). The cognitive domain focuses on the thinking and knowledge skills in literacy, numeracy, problem solving, spatial/visual literacy, inquiry based learning, and productivity (Bloom's Taxonomy, 1956).

Knowledge levels were re-classified because of the need to evaluate skills in traditional assessment methods (Abdulrasool et al. 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. Re-arranging levels of Bloom's taxonomy has helped lecturers to effectively design and implement T & L and assessment strategies so that the learning outcomes are achieved. Anderson & Krathohl; 2001 renamed six levels of taxonomy, which are remember, understand, apply, analyse, evaluate, and create. Create was the highest order of learning skill.

To explore the effect of learning achievements of attitudes, interactions and actions in the classroom and lab sessions on LOCS and HOCS of CAD-CAM-CNC, the following steps need to be followed (Salah et al 2010):

- Identify LOCS and HOCS skills required for CAD-CAM-CNC learning outcomes
- Evaluate the performance of the students on HOCS and LOCS
- Assess the performance of groups of students exposed to non-traditional and traditional teaching/learning strategies
- Determine whether non-traditional and traditional teaching/learning strategies used in teaching CAD-CAM-CNC activities can be used to distinguish students achievements in gaining LOCS and HOCS

There are a number of models to quantify the effectiveness of learning process (Weller, Repman, Rooz, 1995). Knowledge levels were re-classified because of the need to evaluate skills in traditional assessment methods (Abdulrasool, Mishra, 2006). Hence, 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. Therefore, re-arranging levels of Bloom's taxonomy has helped lecturers to effectively design and implement T & L and assessment strategies so that 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, the modified version of Bloom's taxonomy (remember, understand, apply, analyse, evaluate, and create) is adapted at higher level of thinking skills required for HND students at SKI to asses students performance before they join labour market. The developed cognitive and psychomotor module will be examined for their usefulness with different methods of teaching/learning.
Howard, J., (2007) confirmed the importance of skills related to cognitive and psychomotor domains. They conducted a study which indicated that employers preferred graduate students

with knowledge understanding (cognitive) and practical skills (psychomotor). In addition, the practical and physical skills included in the psychomotor skills are important as students would have the opportunity to practice different practical and physical skills in before they go to the labour market.

The extensive review has indicated that the available cognitive and psychomotor domains' skills could be used to benchmark the performance of students; however, they were developed for specific purposes and were not focused at the higher engineering education. The author suggests that further analysis should be conducted to identify the gaps in the students' skills developed by studying the modules engineering outcomes in mechanical engineering (Automotive, industrial maintenance and manufacturing) programmes and the skills required by industrial companies in Bahrain. A new psychomotor skills model should be developed specifically for the SKI system in Bahrain to satisfy both the SKI objectives and labour market requirements.

2.1.6 The Current State of Computer Aided Learning in Mechanical Engineering

The interactive teaching in engineering education represents an alternative approach to lecturing (Żywno S.M 2002). Studies have shown the positive effect of interactive teaching on learning effectiveness. An interactive computer technology system with three dimension (3D) 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 (Clare, D, Backwell, J.L 2006). Computers are increasingly employed for classroom instructions as also for individualised and distance learning (Uran, S., & Jezernik, K. 2008). Computer based instruction (CBI) is variously known as Computer Aided Learning (CAL) in the UK and Computer Assisted instruction (CAI) 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. The modes used at SKI are:

- Tutorial mode
- Drill and practice mode
- Simulation mode

Three dimension (3D), multimedia soft package (e-learning package), reverse engineering and rapid prototyping are tools that play an important key role within engineering subject design, and technical knowledge that must be part of engineering and industrial design courses (Callaghan, Mccusker, Lopez, Harkin and Wilson 2009)). This study seeks to understand how the addition of a computer tool for Automotive, Manufacturing, Industrial Maintenance application in mechanical engineering subject area affect students in several dimensions e.g. their achievement, their attitudes, their interaction and action in the classroom (Bourne J., Brodersen A., and Daw J. 2000). Fry, Heather. Ketterdge, Steve. Marshall, Stephanie. 2003).

As technology has been introduced in classrooms over the last twenty years, research on the effects of technology (e-learning and blended learning) has also been necessary. Much of the research on the use of computers has been focused on the achievement of students (Bhavnani,

K. Suresh and John, E. Bonnie, 2000). K.L Kumar, (2006) 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 aligned to a structured pedagogical approach. Therefore, the e-learning and Blended Learning tool will be carefully designed so the instructional goals of the Automotive, Manufacturing and Industrial Maintenance modules are achieved.

Engineering drawing (CAD) and three dimensional (3D) tools represent a medium to link all Mechanical Engineering subjects so the lecturers should pay special attention to these (Roger Toogood, Jack Zeehe,. 2004). CAD 3D 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. K.L Kumar, (2006) shows several advantages of Computer aided Instruction (CAI) and Computer Aided Learning (CAL) packages: These are:

- Computer instructions (commands) are sent individually to each student
- 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 teaching and learning (T & L) in Mechanical Engineering subject (Gall, E. James, 2001, 2002). Use of multimedia with traditional drawing and use of updated technology of mechanical subjects (Automotive, Manufacturing, and Industrial Maintenance) need to be improved. The teaching methodologies for these subjects however remain unchanged (Bourne J., Brodersen A., Daw J. 2000). Guidelines for educational instruction software design have traditionally adopted a transmissive view of instruction derived from behaviourist and information-processing learning theories (Catalano et al. 1999). Software designed under an objectivist paradigm tends to view the learner as a passive recipient of instruction accordingly to (Kadiyala, M. and Crynes, B.L., 2000; Lonka, K and Ahola, K 1995; Liao, C, Y 1999). Interactive computer instruction based on instructive 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 K.L Kumar (2006) for the design of CAI and to develop different activities to transfer students from surface knowledge to deep knowledge and from passive to active:

- Needs analysis and identification of CAI
- 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-centred approach. The student centric approach is based on the empirically proved hypothesis (Clare, D, Backwell, J.L 2006). It proved 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 (Smith et al., 2010). 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 strongly required that the teaching of Automotive, Manufacturing, Industrial Maintenance with the use of computer technology be recommended in Mechanical engineering at higher education curriculum in Bahrain (Abdulrasool et al., 2007).

In this way the instructors are expected to modify their teaching methodology to make it more student-centred. With the advent of the National Curriculum, however, Mechanical Engineering subjects with computer technology are well and truly need to be immersed on the agenda in Bahrain's curriculum, both in the institute's 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 teaching/learning process of mechanical subject with integrating computer technology (Abdulrasool, S. Mishra, R. 2008). The Curriculum for Automotive, Manufacturing, Industrial Maintenance requires that pupils should be taught at higher level of thinking skills (HLTS), 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 (Roger Toogood, Jack Zeeher. 2004; Bourne J., et al., 2000).

The teachers will use the 3D and multimedia software (e-learning package) in their T & L process with the use of Auto Desk Inventor features and dynamic movements as standard program. The expectation from the program is move with the students from surface knowledge to deep knowledge and from passive to active. Furthermore, the expectation from Mechanical Engineering lecturers at SKI 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.

Traditional ways of teaching in engineering education situation show the existence of a step-by-step process of learning which begins with 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 (Abdulrasool, S. Mishra, R. 2008; Roger Toogood, Jack Zeeher, 2004). Hence, the explanation about these components should be included with demonstration or use suitable teaching aids (e-learning package) to make sure that the students can observe the relation between theory and reality (Abdulrasool, S. Mishra, R. 2008).

Furthermore, there is a need for a structured integration of traditional teaching methods with computing resources (blended learning). 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 classroom environment for optimum benefits (Graham, C. R. 2005).

2.2 Implementation and Evaluation of Blended Learning

The Collins Dictionary defines the meaning of 'blend' as 'to mix together to improve quality' (Conole, G. and M. Oliver2007). The Oxford English Dictionary defines 'blend' as to 'mix together so as to make a product of a desired quality' (Hughes 2007). In both of these, the underlying assumption is that something is going to be improved as a result of the blending action (Chen, N. S., Kinshuk, Ko H.C. and Lin, T. 2004). This is compatible with the aim of Blended Learning to improve quality and will therefore be taken on-board in this research for a definition of blended learning. Learning has to be perceived from the learners' perspective to reflect recent pedagogy developments (Chao, B. T., Shook, C. A. C. and Robert, G. K. L., 2006). This view positions the learner at the center of control of their learning in order to enable them to see what is best for them

The author started to use the phrase "magic is in the mix" when Blended Learning became popular as a term in the 1990s. The magic is the power of adding two or more learning elements. Learners have always known this. They have been blending learning for thousands of years. They add what is missing, they mix it with what they need, and they subtract what is not valuable. They socialize it. They find context, and they transform training and instruction into learning" (Conole, G. and M. Oliver2007).

This Spectrum of e-learning suggests that any definition of Blended Learning should take on board the level of technology used by the learner i.e. where between 0 and 100% electronic delivery the learning takes place. However, this by itself only tells part of the story; one also has to take on board the time the learner spends engaged with such technology. An attempt to bring together level of technology and the time of engagement with the technology is given in figure 2.3 Concept of Blended Learning adapted after (Heinze and Procter 2006).

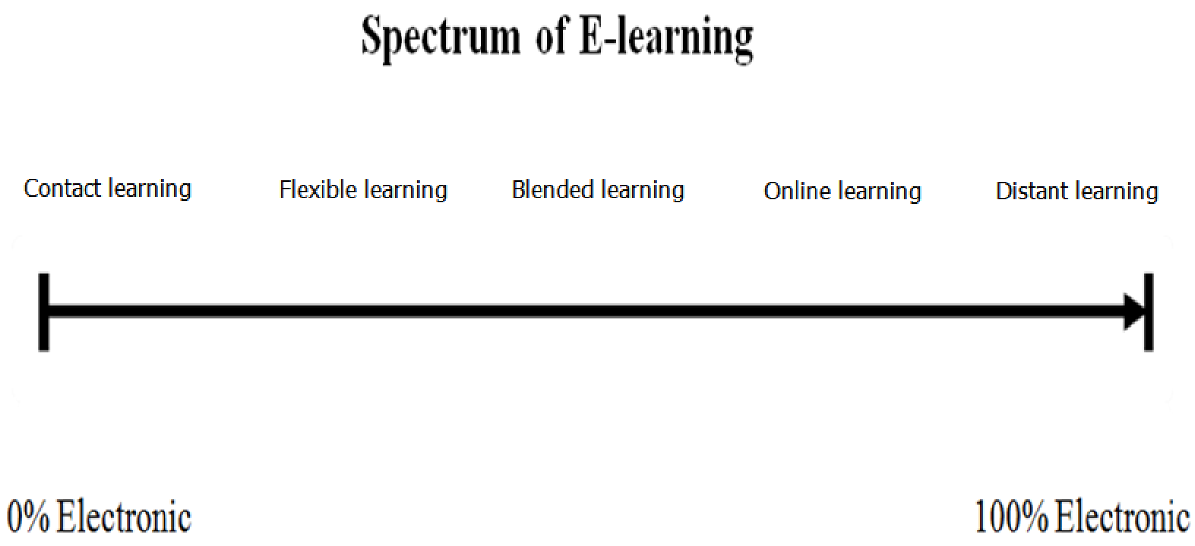


Figure 2.3 Spectrum of E-learning adapted after Procter (2006)

When considering different types of e-learning, it enables to identify where Blended Learning is situated. The perspective on Blended Learning is that it is positioned somewhere in between the face-to-face contact learning (0% electronic) and extreme cases of distance learning (100 % electronic) as depicted in figure 2.4; Spectrum of E-learning adapted after Procter (2006)

Any definition of Blended Learning should take on board the level of technology used by the learner i.e. between 0 and 100% of electronic delivery, the learning takes place. In figure 2.4, the rectangle on the far left (face-to-face) gives the technology/time space for face-to-face learning. What actually happens in any given face-to-face programme of learning could be represented anywhere within this space. The rectangle, representing the technology/time space for online learning has been on the far left. The Blended Learning technology/time rectangle can overlap with both online and face-to-face. This is expected because fully online course could have an annual face-to-face meeting, but this does not make the learning blended.

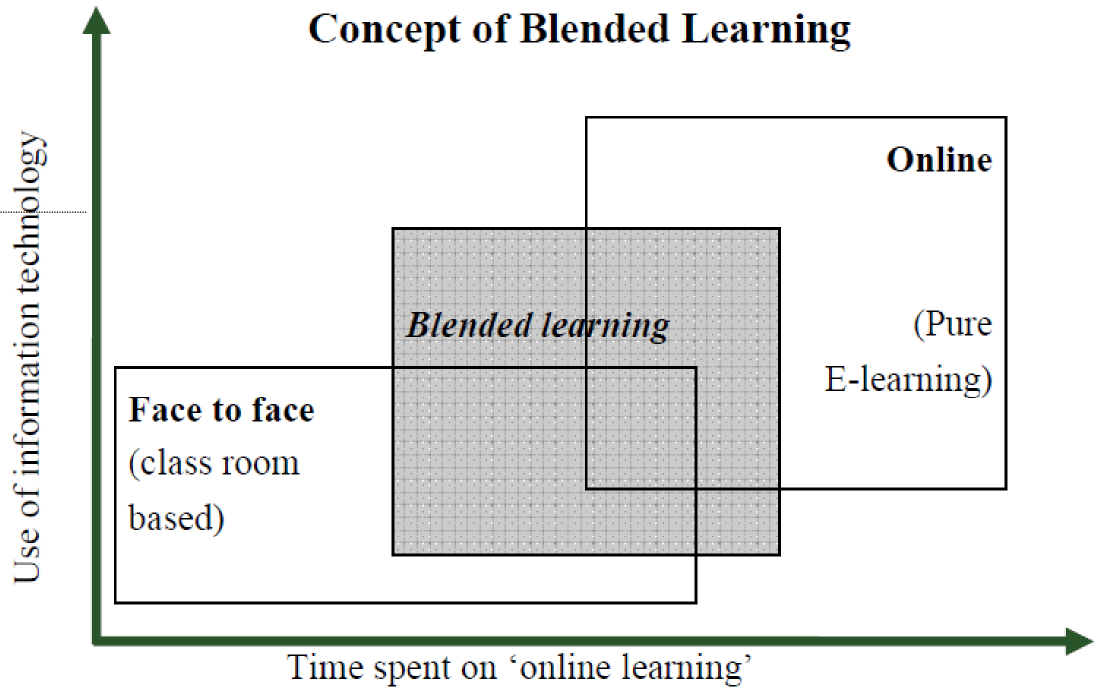


Figure 2.4 Concept of Blended Learning adapted after Heinze and Procter (2006)

The use of technology/time concept is most useful in attempting to arrive at a definition for Blended Learning which is centered on delivery. However, by itself the diagram cannot come to terms with how improved student learning takes place (Woodworth, P. and A. A. G. 2007). Nonetheless, knowing that improved student learning must be addressed, one can define Blended Learning as the delivery of teaching/learning through the combination of online and face-to-face interaction, resulting in improved student learning. e-learning is one of the most important components of Blended Learning and has been thoroughly defined in the next section.

2.2.1 Definition of e-learning Tools

e-learning is a broad definition of using Technology (Internet, Intranet, Wireless, Web-based Training, Web-based learning, Virtual Classrooms, computer-based learning, and digital collaboration, audio- and videotape, satellite broadcast, interactive TV and mobile learning) to deliver learning and training (Cot 2004).

The European Engineering Education has developed a new way of thinking skills of the educational process, as a cooperative process of the teachers and the students; a process in which all participants are creating something new and in which everybody participating became a challenging task to a lot of engineering education related people (BEST, 2006). Active learning methods appeared to be preferred from both engineering students and engineering teachers and their development and application increased in the last years in engineering education subject area at SKI. e-learning methods complete that new interactive and with no doubt more effective way of teaching (Gilbert, Wang and Sim 2005). Research clearly supports the widely accepted proposition that engineering students need to do more than just listening. Engineering students at SKI should be engaged in more activities than just listening during active learning style and apply what they listen effectively, debate, write, and problem solving, as well as higher-order thinking, e.g., analysis, synthesis, evaluation **(**Baldwin, L. & Sabry, K. 2010)**.**

Mechanical Engineering students at SKI, learning about engineering analysis and design, usually experience such complex or abstract aspects that they may not be able to fully understand without additional tutorial lessons or further explanations with visualizations. For example, when learning construction technology, students need to visualize materials and sequences of construction processes, i.e. how all components of a facility are assembled; such visualization cannot be achieved in a textbook and a traditional lecturing environment (Abdulrasool S. et al., 2006). Learning computer tutoring software, in which a new method of teaching, named 'learning with visualizations' is designed to assist students in deeply understanding and effectively mastering materials (Buzzetto-More, N. A. and Pinhey, K. 2006).

In electrical engineering, students can visually observe the performance of different types of modulators and demodulators; thus enabling them to deeply understand the characteristics of the communication components; in chemical engineering, intuitive understanding may be developed when students observe visual interactions among numerous atoms, and subject those simulated atoms to fundamental laws of nature such as conservation of energy, gravitational and electrostatic forces, conservation of momentum, etc.; and in computer science, interactive visualization has become a recognized branch of knowledge that studies how human-computer interaction create graphic illustrations of information efficiently (et al., 2006; Cohen, E. B. and Nycz, M. 2006).

Information and Communications Technologies (ICT) facilitate the development of novel teaching strategies for laboratory classes, including new approaches for illustration, simulation, demonstration, experimentation, operation, and communication. While the hands-on approach for laboratory experiments has enormous educational value, these traditional teaching methods are expensive and require complex logistics regarding space, staff, scheduling and safety (Haque, M., & Saherwala, M. 2004). Virtual laboratories (herein "virtual labs") may allow overcoming these limitations by allowing a computerized simulation of the laboratory experiments (Abdulrasool S., et al., 2007). Even though virtual labs cannot fully substitute the hands-on laboratory experiments in engineering curricula; they provide several advantages as a complementary educational tool, the most important being the possibility of performing them anytime at any place provided internet access is available (Hussein, S, 2005). Virtual labs have been considered as a support to physical laboratories and even remote laboratories may be used as a complement to lab sessions (Żywno S.M, 2002).

Excellence in engineering education comes from innovative teaching techniques and effective instructional materials. This would require one to change the traditional way of delivering engineering education (Biggs, J 1999). In the traditional teaching methods, lecturers offer course materials in a classroom where students listen, take notes, copy materials, execute homework and complete assignments. In many cases, lecturers fail to transfer knowledge to students effectively despite personally having sound technical knowledge in the subject area. This occurs because it is often hard for students to take notes and listen with good comprehension simultaneously. In fact better teaching techniques do exist but are often difficult and time consuming. The literature on active learning is replete with methods of engaging students to promote more effective learning than the traditional lecturing approach (UNESCO Report (2005). Some educationists stress the importance of cooperative learning, problem-based learning, and presenting information in various learning styles (MOE, Bahrain, 2010; UNESCO, 2005; Żywno S.M, 2002; Marcy J . et al., 2000; Carlile, O. and A. Jordan 2005; Fui T L, and Boon H Y 2009).

Virtual learning environments support teaching and learning of engineering educational context, offering the functionality to manage the presentation, administration and assessment of coursework. However the presentation layer of virtual learning environments are highly restrictive, offering limited opportunities to create highly engaging and immersive user experiences (MOE Bahrain 2010; Cooper, D. & Schindler, P 2008).

2.2.2 Information Quality Frameworks

Wang and Strong (1996) initiated the original work for setting standards for information quality frameworks. Their purpose was to critically evaluate user's viewpoints towards the content of a learning system and give priority to quality as an evaluation of excellence (Quality Assurance Manual, 2008). Figure 2.9 shows the information quality framework developed by Wang and Strong. There were 15 quality dimensions which were divided into four categories:

Intrinsic quality category measures the quality of the data which is independent from the users‟ point of view and consists of five dimensions:

- Believability: The e-learning system has updated and believable information
- Accuracy: The e-learning system provides scientific and accurate information
- Objectivity: The e-learning system has impartial learning information
- Reputation: The e-learning system is effective and could be used in benchmarking

Contextual quality category is subjective to the users' preferences and measures the quality of the data with respect to the point of view. It consists of six dimensions:

- Value added: The e-learning system adds value to the learning content
- Relevancy: The e-learning system contains relevant information
- Timeliness: The e-learning system contains up-to-date information
- Completeness: The e-learning system has information applicable to meeting the learning objectives and outcomes
- Amount of information: The learning materials contain an appropriate amount of information in a structured manner

Representational quality category measures the quality of how the data was represented in the e-learning system and consists of four dimensions:

- Interpretability: The learning content has clear and appropriate language, structure, and instructions
- Ease of understanding: The e-learning system arranges the information in a way that can be easily understood
- Representational consistency: The e-learning system is easy to use
- Concise representation: The available information in the learning content is concise

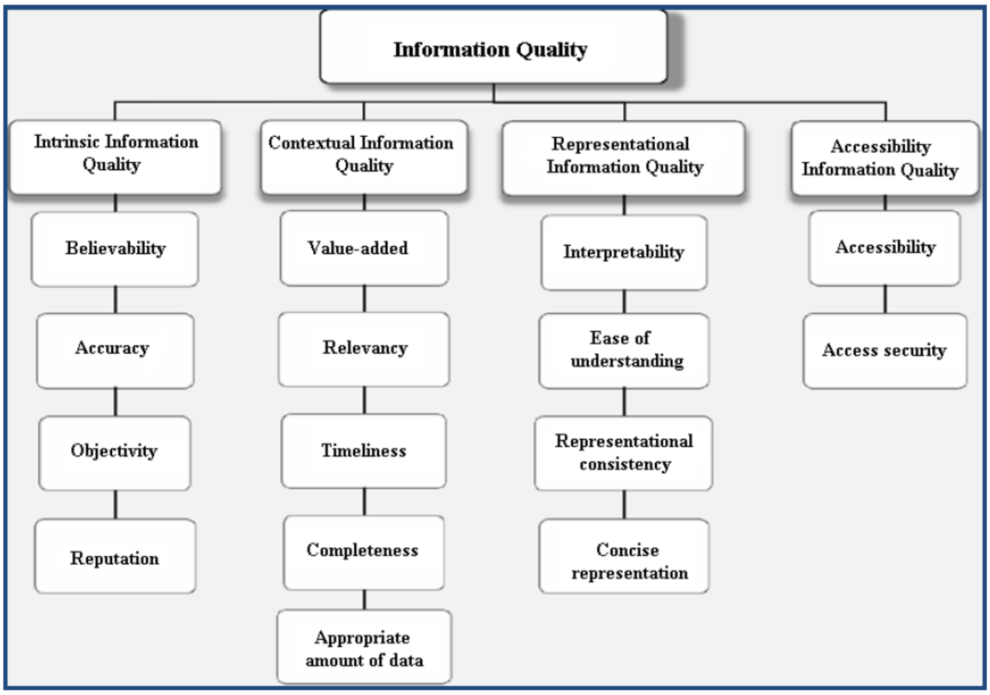


Figure 2.5 The original information quality framework (Wang and Strong; 1996)

Accessibility quality category measures the quality of accessing the information in the e-learning system and two quality dimensions:

- Accessibility: The e-learning system can be easily accessed online
- Access security: The access security features are enabled to protect the content of the e-learning system

2.2.3 Teaching/Learning Models

Hughes (2007) compared pre- and post-course test results for 6000 students from high-school and university physics courses, and found significantly more improvement in students in courses that used interactive-engagement methods (including classes over 100 students) than in those that did not. Koc, M. (2005) conducted a study on the undergraduate students in India where the students were asked questions about transformations between different frames. Both kinematical and dynamical issues were considered and student responses classified. It has been shown that the more prevalent alternative conceptions are also the ones which are held with greater conviction. The analysis has indicated that the students implicitly associate frames of reference with concrete objects, localised and bounded by the latter's extension; regard particular phenomena as belonging to particular frames; allow value judgement on real and apparentness of motion to co-exist with their learnt knowledge about relativity of motion; and equate physical description to anthropomorphic viewing.

Bullen and Janes (2007) carried out an investigation into the effects of instruction using microcomputer simulations and conceptual change strategies. The microcomputer program was designed in accord with a model of conceptual change to diagnose and remediate an alternative conception of velocity. Results show that, first, the microcomputer simulations are credible representations of reality, and second, that the remedial part of the program produced significant conceptual change in students holding the alternative conception. Hughes (2007) has studied the importance of when and how students apply their knowledge. Fourteen elementary and middle school teachers, in an in-service physics course, had been were asked to solve qualitatively a variety of series and parallel circuit problems and explicate their reasoning. These teachers were found to share a common core of strongly held propositions that formed a coherent, but incorrect and contradictory model of sequential current flow. Yet their predictions about the circuits were highly variable. Understanding the variations in not only what teachers knew, but also the differences in when and how they applied their knowledge complicated the task of designing instruction. However, it also made possible the design of more precise instruction in which the teachers were required to recognize, confront, and reconcile specific inconsistencies in their beliefs.

Bonk and Kim (2005) presents a model analysis, which applies qualitative research to establish a quantitative representation framework. With this method, students' alternative knowledge and the probabilities for students to use such knowledge in a range of equivalent contexts can be quantitatively assessed. It has been shown that model analysis is a way to integrate the qualitative knowledge gained from student interviews with the quantitative analysis of multiple-choice instruments. The results from model analysis provide more explicit information on improving instruction than score-based analysis. With the knowledge of students' model states and changes of such states with specific contextual features in different equivalent questions, instructors can see more directly the possible causes of the student difficulties and develop better instructional strategies to help students.

Hall, S., (2003) has carried out extensive statistical interpretation to the concepts of stimulus and response and by deriving quantitative laws that govern simple behaviour systems. Laws of the theory state probability relations between momentary changes in behavioural and environmental variables. From this point of view, simple relations between probability of response and several commonly used measures of learning have been derived, and mathematical expressions describing learning in both classical conditioning and instrumental learning situations under simplified conditions, have been developed.

The mathematical learning models proposed by Birbeck, D. (2009) predict student's knowledge as a function of the amount of instruction. The improvement of student's performance depends on the initial knowledge that is reflected by the pre-test score and on the type of instruction. Birbeck, D. (2009) presented four learning models: (i) pure memory model; (ii) simple connected model; (iii) connectedness model; (iv) tutoring model. All of these models include an equation that describes how the rate of unknown knowledge varies with the amount of instruction. The effectiveness of learning in each model is expressed by a parameter that expresses the probability that something taught sticks in the student's mind. The pure memory model is based on the so-called tabula rasa learning theory which suggests that the knowledge during learning is carved in the student's memory which is initially blank concerning the subject. The simple connected model assumes constructivism meaning that knowledge is constructed from associations between prior and new knowledge. Thus, according to this model, having prior knowledge is necessary for learning. The connectedness model interpolates between the pure memory model and the simple connect model. In reality, learning can involve both of the above types, and the connectedness model applies a connectedness parameter that describes what fraction of the learning is connected and what fraction is pure memory. The tutoring model considers one-on-one mentoring. The advantage of this type of learning is that the tutor does not need to spend time on what the student already knows as compared to a classroom instructor, enhanced by collaborative model.

The present thesis considers classroom learning; therefore, the first three models will be applied. A learning model will be presented in Chapter 3 that is based on those three learning models, but they are combined for several different learning domains. The learning domains are tested simultaneously after the learning period; however, each domain is related to the previous ones during learning. Therefore, the model that will be developed here relates the test results of any domain to the test results of the preceding domain. According to the model, learning in the first domain is independent of prior knowledge, i.e. it can be modelled by the pure memory model; learning in the last domain is based purely on association between prior and new knowledge, i.e. it can be modelled by the simple connected model; whereas learning in the other domains is a combination of both types, i.e. it is considered by the connectedness model. A further assumption of the model is that each of the learning domains has identical importance, but the connectedness parameter varies in the connectedness model for different learning domains. Learning models will be proposed for two types of learning: cognitive learning and development of psychomotor skills. The learning domains in cognitive learning are knowledge, comprehension, application, analysis, evaluation, and creating; whereas in the development of psychomotor skills the following learning domains can be distinguished: diagnose and explore, plan and design, action and implement, evaluate, improve, experiencing, and conclude.

2.3 Research Plan & Specific Research Objectives

From the literature review presented in the previous sections, the following research objectives have been identified:

1. Design of a Blended Learning System for Mechanical Engineering students

2. Development of the Blended Learning System for Mechanical Engineering students

3. Development of e-learning repository for Mechanical Engineering students

4. Implementation of the Blended Learning System for Mechanical Engineering students

5. Evaluation of the Blended Learning System for Mechanical Engineering students

6. Development of Novel Mathematical Models for the teaching/learning process in both Cognitive and Psychomotor Domains

CHAPTER 3
DESIGN AND DEVELOPMENT OF BLENDED LEARNING SYSTEM

3.1 Introduction

The literature review has shown that there is a need to design and develop a novel Blended Learning system that can impart higher level skills to the Mechanical Engineering students at SKI. In this chapter, Blended Learning system has been designed and developed for the Mechanical Engineering students at SKI, who have been reported to have Pedagogical and Technological constraints in learning of various modules. The pedagogical constraints have been attempted to be removed by using teacher's input in terms of quality enhancement of the taught modules, using questionnaires; while the technological constraints have been attempted to be removed by embedding the latest technology such as computers, internet etc. The following sections provide information regarding the development of pedagogical framework.

3.2 Rationale for e-blended, e-learning and computer instruction package

In investigating the effective and engaging ways to teach the Mechanical Engineering courses, literature review of pertinent research and the best practices reveal principles that support the use of blended learning, e-learning, and offer ways to optimize their use through co-constructed meaning and application. These principles have been used as guidelines for developing the proposed blended e-leaning-based teaching/learning framework. Advantages of using e-blended, e-learning and computer instruction package are:

1. The information computer technology (ICT) 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 e-blended and e-learning environment can scaffold the sequencing and presentation of the AIM tasks. For example, the package used in this study does allow the students to view the Power Point or video of a demonstration (the observation phase) during hands-on phases. Hence, they can change their responses after viewing the tutorial of the practical session slides and video recordings. The e-blended tutorial can also help the learner to save the their work practical responses into a database

3. The computer environment can support the use of the tutorial software and video medium to present the physical scenarios that are the focus of the AIM tasks

4. The inventor program and 3D, Power Point 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 i.e. operating, installation, configuration, running, testing, changing, achieving, performing etc). In this way the students become more aware that performing AIM tasks require a high degree of responsibility. The use of Toolbook clips and digital video gives Lecturers and students sophisticated tools to observe hands-on processes and physical phenomena in complex detail, the ability to repeat the procedures and replay exact replications of demonstrations

3.3 Design of Questionnaire

As already discussed, the teaching/learning process at SKI should be such that it meets the industrial requirements in Bahrain. In order to validate whether the teachers at SKI are teaching at higher levels of cognitive and psychomotor skills, a workshop was conducted for which questionnaires were specially designed. The workshop was aimed at understanding present level of knowledge amongst teachers with regard to pedagogical underpinning of the teaching and learning process being adopted. These questionnaires were distributed between three groups of Mechanical Engineering lecturers and instructors, both before and after the workshop. During the workshop the teachers were trained on use of Bloom's taxonomy of learning domains in developing course material. They were asked to answer the questions as mentioned in the questionnaires. The workshop conducted comprised of teacher's groups from the three specializations i.e.:

Group 1: Automotive Engineering

Group 2: Industrial Maintenance Engineering

Group 3: Engineering Manufacturing

Figure 3.1 shows the design of the questionnaire. The questionnaire was divided into two main categories i.e. lower and higher order of cognitive skills. Three questions have been included in each of these categories. Furthermore, the questionnaire contains 6 levels of the cognitive skills i.e. from A to F. For complete details of the questionnaire, please refer to Appendix 2. The same questionnaire was provided, to be filled in by the teachers, before and after the workshop. This technique enables analysis that how teachers thought of the lower and higher order cognitive skills in engineering education, before and after the conducted workshop, and whether they were teaching in lower or higher order of skills before the workshop (Croft and Wallis 2006). The results of the pre and post questionnaires enable one to quantify the effectiveness of the designed questionnaire. Hence, the results of the questionnaires have facilitated the author to develop the teaching and learning frameworks for SKI.

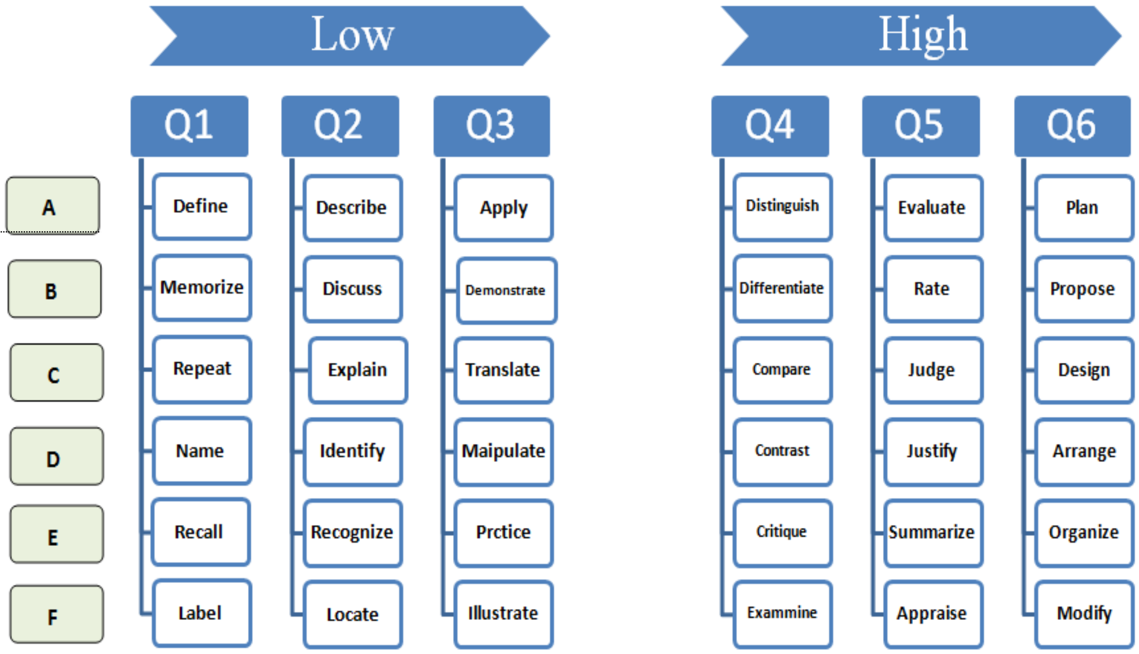


Figure 3.1 Design of the Questionnaire

- **Data Collection and Analysis**

The questionnaire was not provided to all of the teachers at SKI due to factors such as expenses, time and accessibility (Suresh K. Bhavnani and Bonnie E. John; 2000). This research employed the probability sample because it draws randomly from the wider population and allows the generalisation of questionnaire findings. The study has been carried out to explore problems during teaching and learning process in the subject area of Mechanical Engineering subjects. The questionnaires have been formulated to understand the mechanics of the learning process from teacher's perspective. Previous studies (Bhavnani, K. et al., 2000; Dye, R.C.F. 2003) suggest that a part of the problem in mechanical subject area is the use of inappropriate Learning Outcomes, which affects students' achievement and Teaching/Learning Style.

The teacher's questionnaires intend to ascertain how well the mechanical subject modules meet the stated learning outcomes and to identify the main strengths and weaknesses of various T & L methods at higher Order of Cognitive Skills (HOCS), and the possibility of integrating higher Order of Thinking Skills (HOTS) in the mechanical subjects. The analyses have been carried out by quantifying the frequency distributions and determining the most average response before and after (Pre & Post) the workshop, when the teacher fully comprehend the six levels of cognitive domain (Bloom, B. S, et al., 1956).

Teacher's answers were ranked according to the 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. Furthermore, the average positive responses were analysed in order to bring more depth in data analysis. For the purpose of this research, only final results have been presented.

- **Data Analysis**

Responses on the teachers' questionnaire provide evidence that substantial learning occurred during the teacher's workshop. In the pre-questionnaires, the participants have been asked if they used different levels of taxonomy during lesson preparation, students exam activities and students assignments. Over 85% of the participants indicated that they used most of the verbs (Table 3.1) in the low level of thinking and 15% were undecided or disagreed.

Table 3.1 Low level of skills

Remembering: can the student recall or remember the information?	define, duplicate, list, memorize, recall, repeat, reproduce state
Understanding: can the student explain ideas or concepts?	classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase
Applying: can the student use the information in a new way?	Choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write

The same questionnaires were distributed at post training session (end of teacher training) and about 83.5% of teachers indicated that they used most of the verbs in the low level of thinking, 13.5% were undecided and about 3% disagreed. The opposite results were found during data analysis for pre and post-questionnaires for higher level of thinking (Table 3.2). In pre-questionnaires, 43.5% of teachers indicated that they created the condition and encouraged their students to distinguish between different parts, justifying and creating new products. 31% of teachers were undecided and about 24.5% disagreed. These results indicate that the awareness of the participants about high level of thinking (Blooms Taxonomy) was low.

Table 3.2 High level of skills

Analysing: can the student distinguish between the different parts?	Appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, and test.
Evaluating: can the student justify a stand or decision?	appraise, argue, defend, judge, select, support, value, evaluate
Creating: can the student create new product or point of view?	assemble, construct, create, design, develop, formulate, write

In post-questionnaires, and after the participants got familiar with high level of thinking (Blooms Taxonomy), the results indicated the 49% disagreed that they were using high level of thinking and 36.5% agreed. 14.5% were undecided for 4^{th}, 5^{th} and 6^{th} level of high thinking. Prior to the discussion, their knowledge of the factors that contributed to high level of thinking (Blooms Taxonomy), was unacceptable and about 85.5% indicated that their awareness of the high level of thinking in Technical and Vocational Education was unacceptable. All of the objectives of the teachers' discussion in the institutes were in the unacceptable range prior to the discussion. In contrast, all participants indicated that their level of competence after the discussion was acceptable in all of the areas covered. In general, participants found the discussion useful and the way the discussion was facilitated interesting. Taken all together, the self-ratings, pertaining to the workshop objectives, indicate that teachers experienced major gains in competence as a result of their participation in this group discussion.

Figures 3.2 to 3.7 summarise the main scores for these teachers on each of the six levels of Bloom's taxonomy. Each of the charts contain several items from the survey that determine and describe whether the teaching methods used by the instructors' were driven by lower order thinking skills (associated with remembering, understanding and applying) or by higher order thinking skills (associated with analysing, evaluating and creating). It should be noted that the high level of thinking of taxonomy was not addressed for Hands-on (practical) work. Figure 3.2 summaries the response of survey items pertaining to the first level of Bloom's taxonomy i.e. knowledge. The high scores suggest that these instructors favoured imparting knowledge to their students. While teaching, they tended to allow their students to recall or remember the information (define, duplicate, list, memorize, recall, repeat, reproduce state).

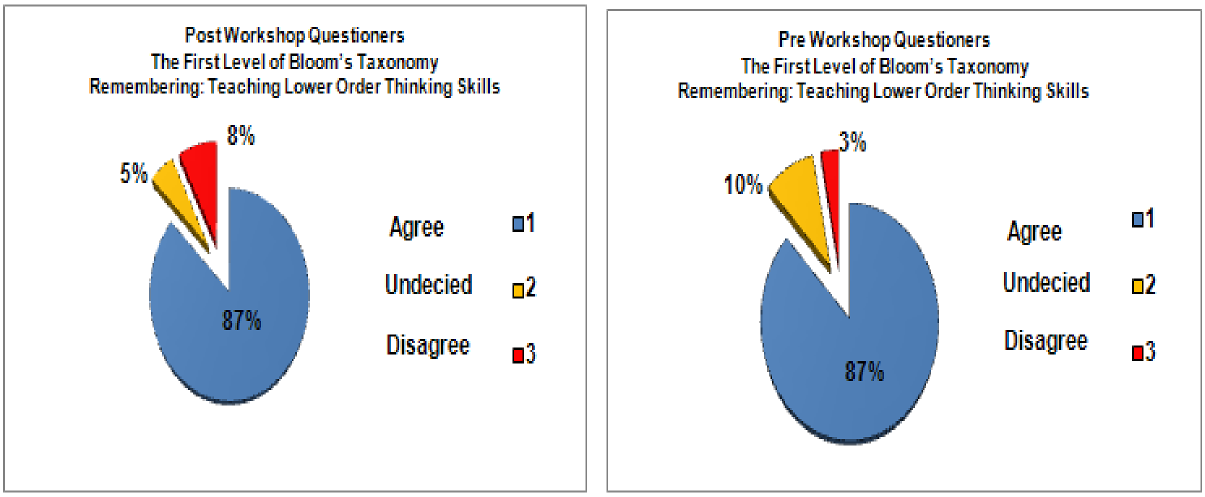


Figure 3.2 Pre and post teacher's response (Remembering)

Figure 3.3 summaries responses to the survey items pertaining to Bloom's taxonomy: Understanding. The high scores on the six variables indicate that these instructors supported understanding based learning activities. When teaching, these instructors helped students and explained ideas and concrete concepts in their classes (classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, and paraphrase).

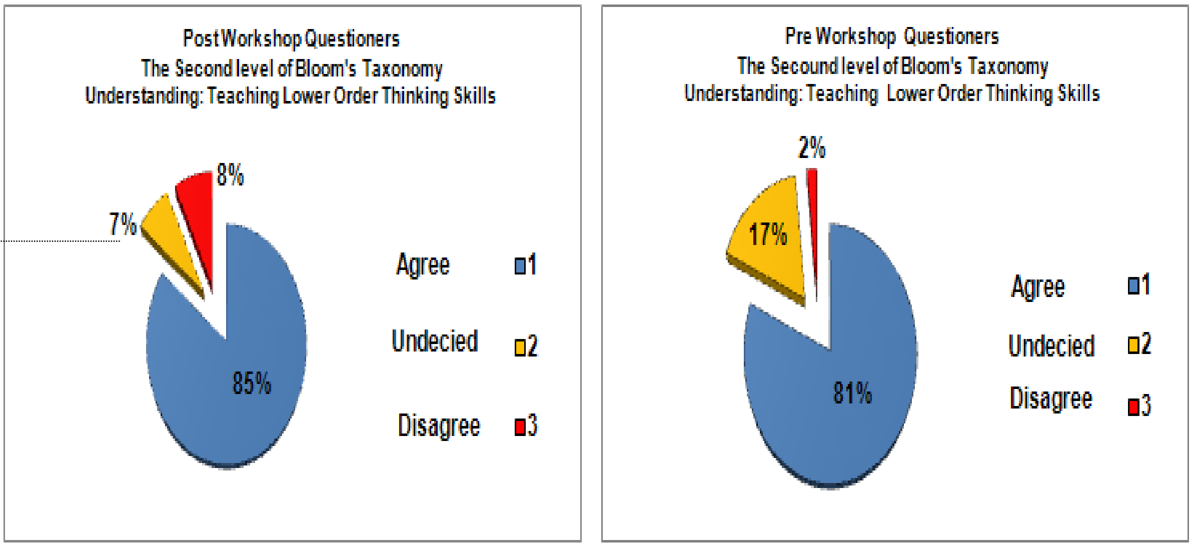


Figure 3.3 Pre and post teachers' response (Understanding)

Figure 3.4 summaries responses to the survey items pertaining to Bloom's taxonomy: Applying. The high scores reveal that these instructors helped students to use the information in a new way (choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write).

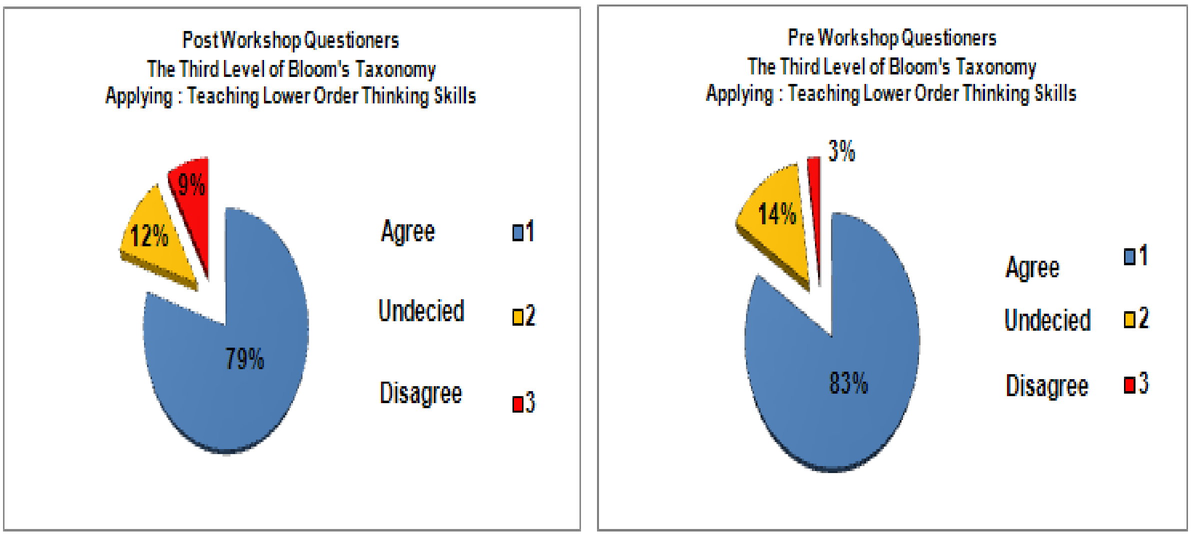


Figure 3.4 Pre and post teachers' response (Applying)

Figure 3.5 summaries responses to the survey items pertaining to Bloom's taxonomy: Analysing. These results suggest that these instructors did not let students distinguish between the different part (appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test) rules and principles in their classes. In other words, higher order thinking skills were not often taught in their classes, although critical tasks appear to have occurred regularly.

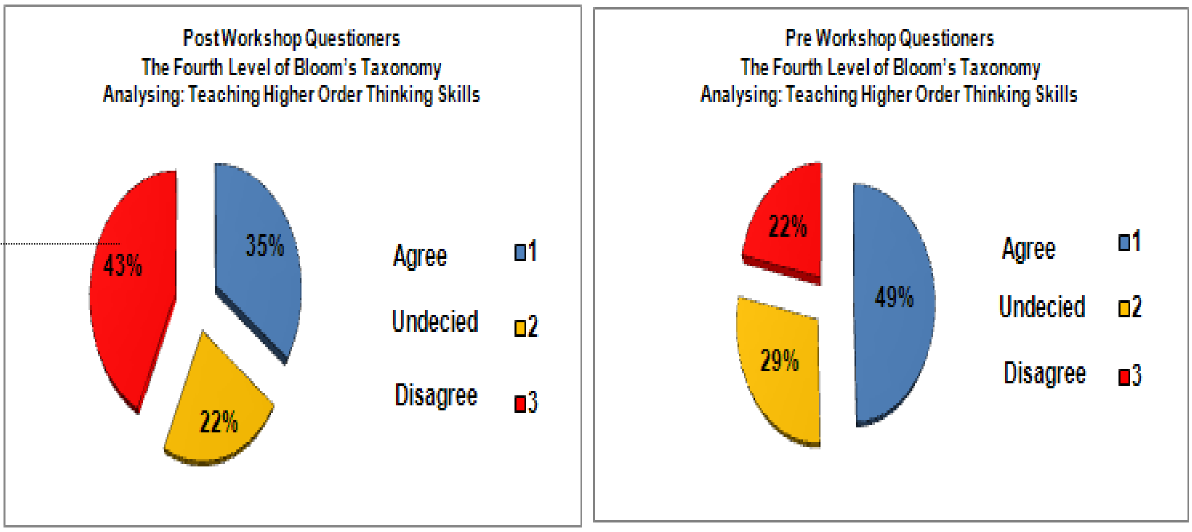


Figure 3.5 Pre and post teachers' response (Analysing)

Figure 3.6 summaries responses to the survey items pertaining to Bloom's taxonomy: Evaluating. The range of scores indicate that these instructors created conditions within their students, could sometimes practice some level six thinking skills like the "justify a stand or decision specifically "summarize, argue, defend, judge, select, support, value" and "appraise" their cognitive strategy. On the other hand, students seldom "evaluated" or "rated" their cognitive strategy (which seems somewhat inconsistent).

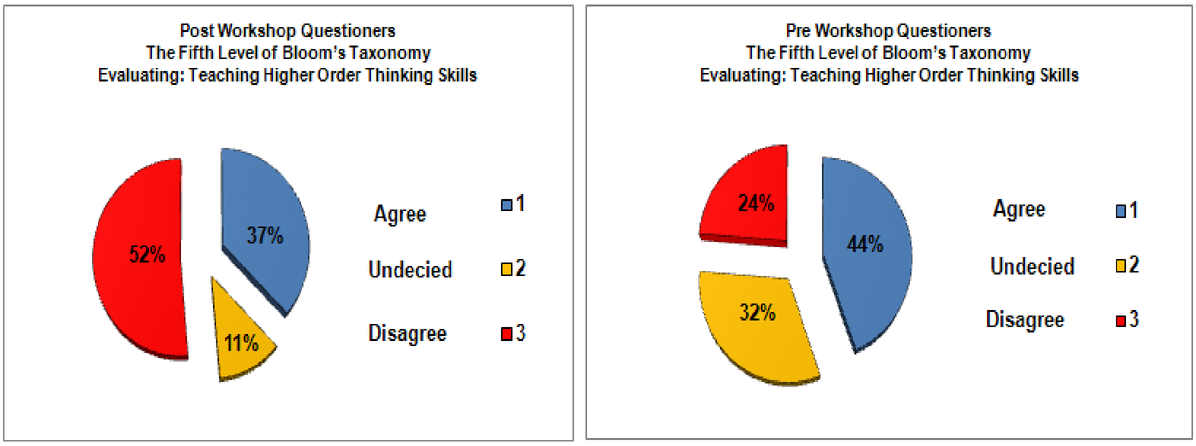


Figure 3.6 Pre and post teachers' response (Evaluating)

Figure 3.7 summaries responses to the survey items pertaining to Bloom's taxonomy 1956: Creating. The low scores in the six variables indicate that these instructors seldom gave their students opportunities to create new product (assemble, construct, create, design, develop, formulate, write) of the project and problem solving in their classes. Higher order thinking skills were not generally taught in their classes, although students seem to have had opportunities to modify problem solving.

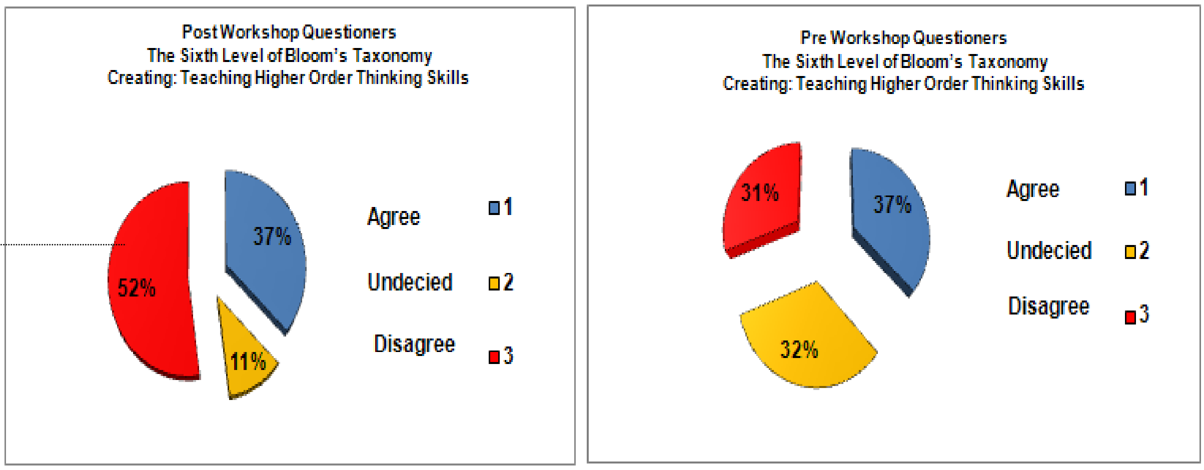


Figure 3.7 Pre and post teachers' response (Creating)

The detailed analysis of the workshop data revealed that the teachers at SKI were not teaching the course material at higher levels of cognitive and psychomotor skills. Most of the course material was designed at lower order of skills. Hence, there is need for the students to develop/apply the appropriate skills when dealing with complex problems from Mechanical Engineering area to satisfy the needs of Bahrain Labour Market.

3.4 Existing Pedagogical Framework

This section highlights the design of pedagogical framework required to design subject material, i.e. the pedagogical framework has been designed keeping in mind UNESCO's reports and Bahraini labour market's needs, as mentioned in Chapter 1 in detail. The pedagogical framework presented has taken into account the teaching and learning processes in both the cognitive and psychomotor domains such that it integrates both the classroom teaching/learning and laboratory/work-based learning (Conole, Dke, Oliver and Seal 2004). Based on the developed pedagogical framework, the process with which this framework has been implemented to develop course material for the three aforementioned common modules at SKI has been explained as well.

3.4.1 Basis of Teaching/Learning system in Cognitive Domain

Lorin Anderson, a former student of Bloom, revised the cognitive domain in the learning taxonomy and made some changes, with perhaps the two most prominent ones being (W, L Anderson, L and K, Krathwohl 2001; R, Paul. 1995):

- Changing the names in the six categories from nouns to verbs
- Rearranging these categories

Cognitive Skills i.e. mental skills of Bloom's Taxonomy has been extended from simply remembering to more complex cognitive structures, such as analyzing, evaluating, and creating new knowledge (Pickard, M., 2007) . Information Technology (IT) has also become more useful with the revised taxonomy. This new taxonomy reflects a more active form of thinking and is perhaps more accurate. Table 3.3 shows the various categories of this new taxonomy. The verbs used in each of the category have also been included to highlight the importance of this taxonomy.

Table 3.3 Cognitive Domain

Level	Category	Example and Key Words (verbs)
6	**Creating**: Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure	**Examples**: Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises and process to improve the outcome **Key Words**: categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes
5	**Evaluating**: Make judgments about the value of ideas or materials.	**Examples**: Select the most effective solution. Hire the most qualified candidate. Explain and justify a new budget. **Key Words**: appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports
4	**Analysing**: Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	**Examples**: Troubleshoot a piece of equipment by using logical deduction. Recognize logical fallacies in reasoning. Gathers information from a department and selects the required tasks for training. **Key Words**: analyses, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates
3	**Applying**: Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place.	**Examples**: Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test **Key Words**: applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses

2	**Understanding**: Comprehending the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words.	**Examples**: Rewrites the principles of test writing. Explain in one's own words the steps for performing a complex task. Translates an equation into a computer spread sheet **Key Words**: comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives an example, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates
1	**Remembering**: Recall previous learned information.	**Examples**: Recite a policy. Quote prices from memory to a customer. Knows the safety rules **Key Words**: defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states

3.4.2 Basis of Teaching and Learning system in Psychomotor Domain

Details of psychomotor skills have been suggested by Dave (1975). It fits with the model of developing skills, put forward by Ferris and Aziz (2005), and it also draws attention to the fundamental role of imitation in skill acquisition. The hierarchy is useful illustration of the manner in which the categories have been proposed as a hierarchy in which levels are normally progressive because each level involves a higher and more complex use of the capability developed in the levels below it.

Table 3.4 Psychomotor Domain

Level	Category	Example and Key Words (verbs)
5	**Naturalization** — Mastering a high level performance until it becomes second-nature or natural, without needing to think much about it.	**Examples**: Manoeuvre a car into a tight parallel parking spot. Operates a computer quickly and accurately. Displays competence while playing the piano. Michael Jordan playing basketball or Nancy Lopez hitting a golf ball **Key Words**: design, development

4	**Articulation** — Coordinating and adapting a series of actions to achieve harmony and internal consistency.	**Examples**: Combining a series of skills to produce a video that involves music, drama, colour, sound, etc. Combining a series of skills or activities to meet a novel requirement **Key Words**: adapt, constructs, creates, modifies
3	**Precision** — Refining, becoming more exact. Performing a skill within a high degree of precision	**Examples**: Working and reworking something, so it will be "just right." Perform a skill or task without assistance. Demonstrate a task to a beginner **Key Words**: calibrate, demonstrate, master, perfectionism
2	**Manipulation** — Being able to perform certain actions by memory or following instructions.	**Examples**: Being able to perform a skill on one's own after taking lessons or reading about it. Follows instructions to build a model **Key Words**: act, execute, perform
1	**Imitation** — Observing and patterning behaviour after someone else. Performance may be of low quality.	**Examples**: Copying a work of art. Performing a skill while observing a demonstrator **Key Words**: copy, follow, mimic, repeat, replicate, reproduce, trace

In Mechanical Engineering practical classes, students are required to dismantle, assemble, measure and arrange the machine and equipment. In these practical classes, the equipment, both the machine and the instrumentation, are unfamiliar to students. The author observed that student's competence in the laboratory is not correlated with performance in standard paper tests and assignment work, nor to any other obvious factor. The obvious question is "why is this so?" Why should students, who perform well in examinations, exhibit uncorrelated performance in laboratory skills? This issue may be a consequence of different emphasis of the education systems experienced by different groups in their 'Specialization' environments.

This issue coalesces leading to questioning of what laboratory work is expected of students and what the students should learn through the laboratory (Hands-on) work. Where one has a clear understanding of what should be learned through a particular teaching and learning activity, it becomes possible to design the activity in order to best target the learning of that particular outcome or combination of outcomes.

Bloom's taxonomy of educational objectives has been a popular tool for analyzing and thinking about the goals of particular educational activities and developing programs of educational activity provided for students. However, Bloom's taxonomy (Bloom 1956; W, L Anderson, L and K, Krathwohl 2001; R, Paul. 1995) has mainly addressed two domains, the cognitive and the affective, while the discussion regarding the psychomotor domain is severely limited. The issues that the author has noticed in teaching laboratory (hands-on) classes are closely linked to the psychomotor domain, and so this research is concerned with the development of a framework of objectives in a hierarchical form related to the psychomotor domain.

Ferris and Aziz (2005) discussed the issues and developed a reasonable psychomotor domain. The motives for development of this hierarchy have been described above. The proposed Psychomotor Domain hierarchy is shown below:

1. **Recognition of tools and materials**: Ability to recognize the tools of the trade and the machine, equipment, and materials

2. **Handling of tools and materials**: Ability to handled tools, materials, equipment and machine in certain ways

3. **Basic operation of tools**: Ability of the student to hold the tool appropriately for use, to set the tool in action and to perform elementary tasks that abstract tasks of work into their most basic, unitary form
4. **Competent operation of tools:** Ability to fluently use the tools for performing a range of tasks of the kind for which the tool was designed

5. **Expert operation of tools:** Ability to use tools with ease to rapidly, efficiently, effectively and safely perform work tasks on a regular basis

6. **Planning of work operations:** Ability to take a specification of a work output required and perform the necessary transformation of the description of the finished outcome into a sequence of tasks that need to be performed on the material in order to achieve the desired outcome and bring to fruition the finished product intended.

7. **Evaluation of outputs and planning means for improvement:** Ability to look at a finished output product and review that product for quality of manufacture, with the ability to identify particular deficiencies and the actions which could be taken to either correct the faults or to prevent the faults through appropriate planning of the manufacturing operations

3.4.3 The Proposed Skill's Model

From the collected data and theoretical foundation, along with best practices from literature, it is clear that there is need for students with high skill and knowledge level in order to satisfy industrial market needs, where specific skills are related to high level of psychomotor and high level of cognitive skills, and these skills should be critically sustained and justified (Allen and MOE, 2009).

Figure 3.10 depicts the proposed high level of psychomotor and high level cognitive skills model, which is based on pedagogical underpinnings and consist of cognitive skills for theoretical concepts in (classroom) and psychomotor skills for practical concepts (Hands-on) in the lab (work station). The model comprises of two categories, namely cognitive (W, L Anderson, L and K, Krathwohl 2001; Salah, Rakesh 2009) and psychomotor skills (Dave

1970; Simpson 1972; Harrow 1972; Ferris and Aziz 2005). Each category has several example and key words (verbs), shown in table 3.5, offering sophisticated information about the nature of the skills that should be gained by SKI students. The model provides an original contribution to the design process of engineering courses, relating to the learning levels of Bloom's domains. For example, in acquiring soft skills related to improving cognitive proficiencies, Bloom's cognitive learning levels should be employed sequentially in teaching the identified and specific skills effectively.

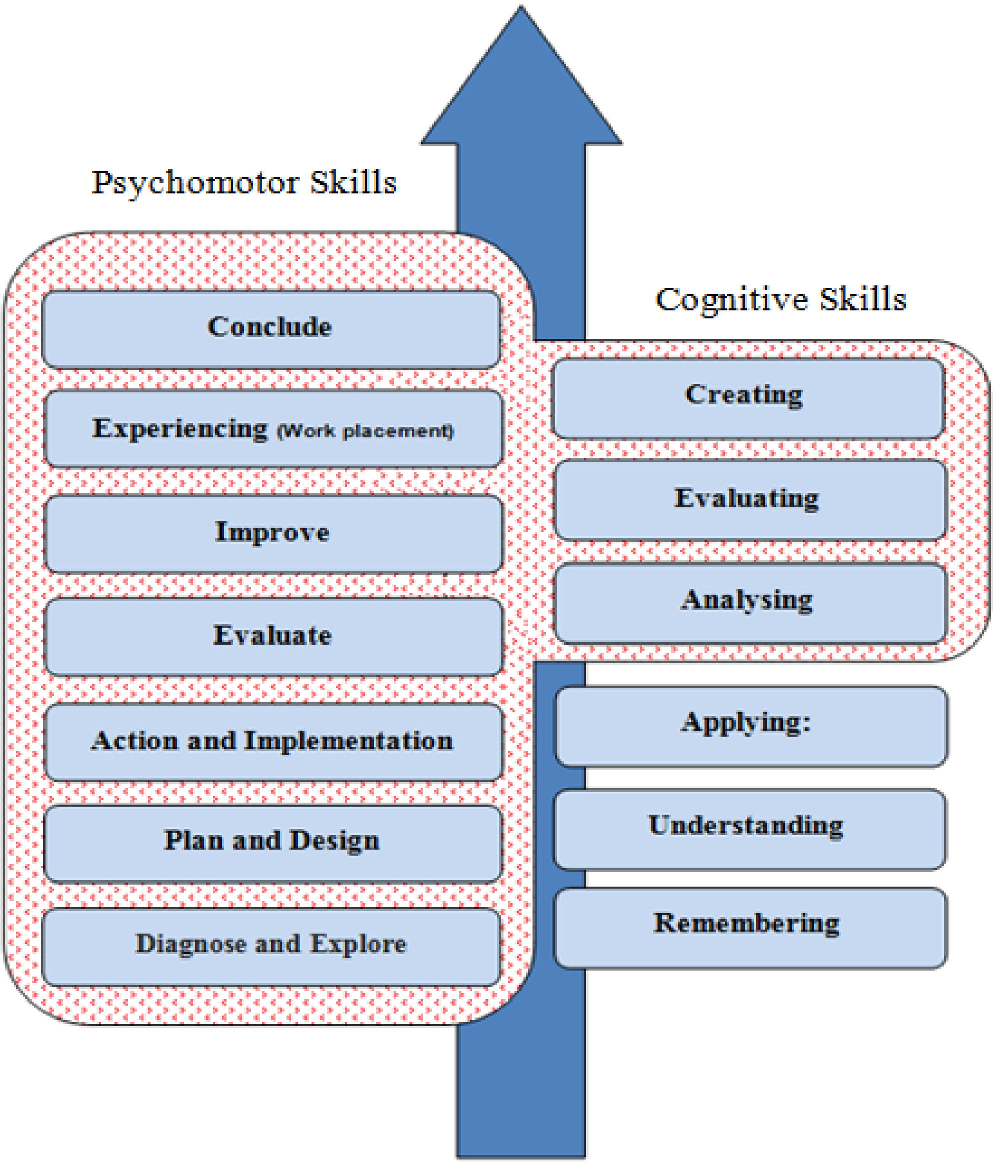


Figure 3.8 Proposed high level of psychomotor and cognitive skills

It should be noted that in figure 3.8, the lower order skills (remember, understand and apply) are the base of the learning hierarchy, and hence cannot be excluded or neglected from the proposed model (Birbeck 2009). Table 3.5 contains the diagram of the proposed relation between the proposed subject outcomes and the proposed higher level of psychomotor and cognitive skills hierarchy developed by the author based on pedagogical underpinnings. It contains a mixture of cognitive and psychomotor skills. The design of table gives the total frequency of corresponding outcomes, which is related to the Psychomotor and Cognitive skills, categorised by the author. The frequency of the proposed Psychomotor and Cognitive skills hierarchy is higher than the previous work.

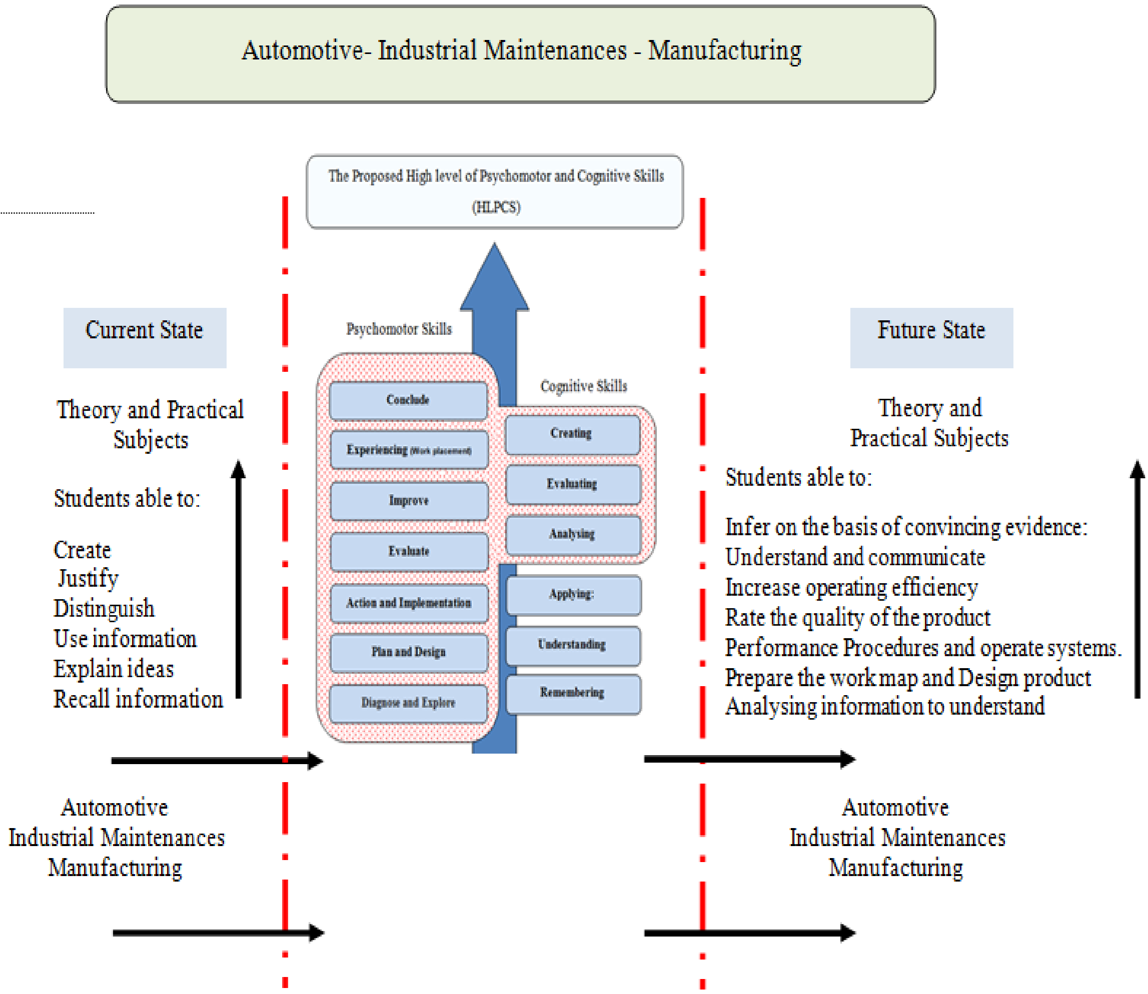
Table 3.5 Proposed Categories and Keywords (Verbs) of Psychomotor Skills

Level	Category	Example and Key Words (verbs)
1	**Diagnose and Explore** Analysing information to understand	**Example** analysing the accident report of the Car **Key Words:** Occurs, screening, conclude, functional, sequencing, routine, experimental, scale, selection, tests, existing variations, comparisons, reviewing, investing, characterizing, profile, implicate, specifying, measure, alignment, complete, collecting, express, constitute, contribute, directional
2	**Plan and Design** Prepare the work map and fabricate the mechanical product and assign the machine for manufacturing	**Example** Prepare the work map and develop the mechanical product and arrange the machine for manufacturing **Key Words:** Make a sketch or drawing, outline, pattern, or plans, structure, artistically, arrangement, plot, conceive, contrive, assign, structure, constructed features, creating by mental acts, arrange,, organise project, scheme, propose, invent, advise, tailor, draw up, fabricate, think up , facilitate
3	**Action and Implementation** Performance the best corrective actions Procedures and operate systems.	**Examples**: Carrying out the work – Dismantling, Repairing, adjusting, assembling and Manufacturing **Key Words**. Carrying out, execution, practice, preliminary thinking, order, operating, installation, configuration, running, testing, changes, achieve, perform, effect, carry through, complete, apply, perform, realise, fulfill, enforce , discharge, participate, Coaching, performance, recognizes, organise, manage, practical, activities , strategy, elements, tasks, Resource, allocation, funds , program

4	**Evaluate** Rate the quality of the product and estimate the cost.	**Examples**: Judge end product and rank the quality **Key Words**: Assess, rate, value, judge, estimate, rank, reckon, weigh, calculate, gauge, weigh up, appraise, size up, analyse, justify
5	**Improve** Increase operating efficiency and quality product.	**Examples**: Value organization services **Key Words**: useful, increase productivity or value, more desirable, more excellent, more quality, condition; make better, more desirable, valuable, or excellent state
6	**Experiencing (Work placement)** Understand and communicate across disciplines and work effectively in diverse teams.	**Examples**: Work in deferent environment, appreciate type of work and work in team **Key Words**: Endure, feel, have, know, pass, see, find, suffer, sustain, taste, undergo, witness, encounter, meet; accept, receive; assimilate, digest
7	**Conclude** arrive at (a logical conclusion or end) by the process of reasoning; infer on the basis of convincing evidence:	**Examples**: Give final report with right judgment **Key Words**: decide, judge, establish, suppose, determine, assume, gather, reckon (informal) , infer, deduce, surmise, end, close, finish, start, open, begin, extend, commence, bring to end, complete, terminate, round off, protract, effect, settle, bring about, fix, carry out, resolve, clinch, pull off, bring off

Details of the categories mentioned in table 3.5 are self-explanatory and this framework can be used effectively for the design of learning outcomes.

A new model for high level of psychomotor and cognitive skill is specifically proposed (figure 3.9) to satisfy both the SKI and labour market requirements. The proposed model could be used for structuring the content of engineering courses at SKI. The difference between this model and the one presented above is that this model describes the relationship between the current state of the skills and the future state of the skills at SKI.



Figurer 3.9 The proposed skills' model

3.4.4 Design of Mechanical Engineering Subjects Material at Higher Order of Cognitive and Psychomotor Skills

The Automotive, Industrial Maintenance and Manufacturing Engineering has been designed to provide learner with opportunity to develop knowledge and skills in any topics of Mechanical Engineering and equip them with the necessary confidence to perform tasks related to the topics (Dijk .Van et al., 2001). The main purpose of the topics is to provide students with an appreciation of what is involved in using these skills in industry. These topics are for any students who wish to develop practical skills in range of Mechanical Engineering disciplines (Caroline Baillie & Ivan Moore 2004).

Why are Automotive Engineering, Industrial Maintenance Engineering and Manufacturing Engineering important in the Engineering and Related Design programme? With the necessary knowledge and skills, students will be able to perform tasks and meet requirements set by the industries. These specializations enable students to be more self-reliant and marketable. The subject's outcomes allow progression to further qualifications and help students understand terms used in industrial, manufacturing and assembly (Dacre, L. & Sewell, P. 2007).

The link between the Automotive Engineering, Industrial Maintenance Engineering and Manufacturing Engineering is the Critical and Developmental Outcome. In Automotive Engineering, Industrial Maintenance Engineering and Manufacturing Engineering, students identify faults and solve problems related to their fields (Automotive, Maintenance and Manufacturing). Students have to work individually or in teams (Deignan, T 2009). These subject areas require complex skills to be learnt and these skills are then needed in the labour market in variety of jobs. Kills leant in these subject areas also include transferable skills that may be used in jobs that are not in these subject ares directly.

3.4.5 Details of the courses

A teaching and learning strategy with the pedagogical underpinning and delivered appropriately will enable meeting all the learning outcomes. Interested students benefit because it enables them to work with relevant knowledge and use of terminology required by labour market (MOE 2004). The details with regard to courses are as given below.

Time Duration: This is a one year instructional programme comprising 180 teaching and learning hours. The subject is offered on a full-time basis provided all of the assessment requirements are adhered to (Cochrane, T 2005).

Subject Level Focus: Carry out special study on Automotive Engineering, Industrial Maintenance Engineering and Manufacturing Engineering.

Range: Mechanical Engineering specialisations include:

- **Automotive and Industrial Maintenance:** Modules include Manual transmission (Gear and Clutch), fuel injection, coolant system, induction and exhaust systems, hydraulic systems, suspension systems, steering systems and differentials

- **Manufacturing:** Modules include Measuring Instruments, Marking out tools and Use of Machine tools (Centre Lathe, Milling and Pedestal Drilling)

The characteristics of specialized mechanical systems are identified and explained in terms of their properties and function. Common problems occurring within the systems are identified in terms of how they manifest. Solutions to the problems are identified and addressed according to manufacturer's specifications (Koper, E. J. R. 2001). Work is conducted in accordance with workplace safety requirements and current legislation. Table 3.6 shows the common subjects between the three Mechanical Engineering specializations, for which the course material has been design and developed.

Table 3.6 Mechanical Engineering Subjects

Foundation / HNC / HND: Mechanical Engineering Subjects

	Automotive	Industrial Maintenance	Manufacturing
HND Level 3& 4	• CAD and Design 2 • Manufacturing Process -2 • Applied Industrial Plant Maintenance • Project Management • Engineering Measurement • Engineering Systems Analysis • Electrical and Electronic Principles - 2 • Power and Transmissions System	• CAD and Design 2 • Manufacturing Process -2 • Applied Industrial Plant Maintenance • Project Management • Engineering Measurement • Pneumatics & Hydraulics • Single and Three Phase Induction Motors • Power and transmissions System	• CAD-CAM-CNC System - 2 • Manufacturing Process -2 • Applied Industrial Plant Maintenance • Project Management • Engineering Systems Analysis • Engineering Measurement • Business Awareness • Power and Transmissions System
HNC – Level 1& 2	• Information Technology- 2 • Engineering Communication Skills-2 • Mathematics for Engineering- 2 • Principles of Safe Engineering Systems-2 • CAD and Design - 1 • Manufacturing Process - 1 • Engineering Maintenance • Electrical and Electronic Principles - 1	• Information Technology- 2 • Engineering Communication Skills-2 • Mathematics for Engineering- 2 • Principles of Safe Engineering Systems-2 • CAD and Design - 1 • Manufacturing Process - 1 • Engineering Maintenance • Electrical and Electronic Principles 1	• Information Technology - 2 • Engineering Communication Skills - 2 • Mathematics for Engineering- 2 • Principles of Safe Engineering Systems - 2 • CAD-CAM-CNC System - 1 • Manufacturing Process - 1 • Engineering Maintenance • Machining Process - 2
Foundation	• Information Technology- 1 • Engineering Communication1-1 • Mathematics for Engineering -1 • Principles of Safe Engineering Systems - 1 • Basic Manufacturing Technology • Principal of Automotive	• Information Technology - 1 • Engineering Communication -1 • Mathematics for Engineering -1 • Principles of Safe Engineering Systems - 1 • Basic Manufacturing Technology • Engineering Maintenance	• Information Technology- 1 • Engineering Communication -1 • Mathematics for Engineering -1 • Principles of Safe Engineering Systems -1 • Basic Manufacturing Technology • Machining Process - 1

3.4.6 Teaching and Learning details for the pilot subjects

The educational standards, formulated by MOE for SKI engineering modules, list the subject outcomes of the various modules being taught. For the purpose of this research study, as already discussed above, the subject/module outcomes of the common subjects have been shown in table 3.7.

Table 3.7 Pilot Subject Outcomes

No	Subjects	Subject Outcomes
1	Power and Transmissions System	Diagnose, Dismantling and Repair Manual Transmissions
2	Engineering Measurement	Use of Measuring Instruments and Marking out Tools
3	Manufacturing Process – 2	Use of Machine Tools Centre Lathe Milling and Pedestal Drilling

The subject outcome:

- Contains various learning activities enabling the development of students' cognitive and psychomotor skills
- Provides comprehensive online theoretical information
- Contains various practical applications which allow the students to use their knowledge for the development of relevant technical skills
- Focuses on student-centred learning and Interactive learning through team working and problem solving activities
- Uses technology (animations, simulations, videos) to present the industrial Complex learning materials
- Provides discussion boards and forums where students can ask questions and clarify points of view in their own time
- Provides online practical work guidelines
- Contains various modes of delivery (teachers' direct instructions, online material) appropriate for various learning styles
- Comprises of practical, online and written assessments (Appendix 1)

3.4.7 Internal Assessment

<u>Theoretical Component</u>

The theoretical component forms 40% of the internal assessment. Theory is integrated with the practical component.

<u>Practical Component</u>

The practical component forms 60% of the internal assessment marks. Practical components include applications and exercises. All practical components must be indicated in an Evidence File (EF). Internal assessment of the practical component in Automotive Engineering, Industrial Maintenance Engineering and Manufacturing Engineering Level 4-5 takes the form of assignments, practical exercises, case studies and practical examinations in a workshop environment. Students may complete practical exercises daily. Assignments and case studies can be completed at the end of a topic. Practical examinations can form part of internal practical assessment. Some examples of practical assessment include:

- Presentations (lectures, demonstrations, group discussions and activities, practical work, observations, role play, independent activity, synthesis and evaluation)
- Exhibition by students
- Visits undertaken by students based on a structured assignment task

- Task performance in a structured environment

- **Definition of Structured Environment**

Structured environment, for the purposes of assessment, refers to an actual or simulated workplace, or workshop environment (Lindorff, M. 2011). Evidence of this practical component must be provided in the form of evidence file with a clear listing of the competencies to be assessed. The following information must be contained:

- Date of activity
- Task description
- Starting time
- Completion time
- Student's signatures
- Supervisor's signatures

For the evidence file (EF) to be regarded as valid evidence, it must be signed-off by an officially assigned supervisor and Quality Assurance Officer (Quality Assurance Manual, 2008).

- **Evidence in Practical Assessments**

All evidence pertaining to evaluation of practical work must be reflected in the student's EF. The tools and instruments used for the purpose of conducting such assessments must be part of the evidence contained in the EF (Quality Assurance Manual, 2008).

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- **Processing of Internal Assessment Mark for the year**

A year mark, out of 100, is calculated by adding the marks of the theoretical component and the practical component of the internal continuous assessment (Quality Assurance Manual, 2008).

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- **Moderation of Internal Assessment Mark**

Internal assessment is subject to internal and external moderation procedures as set out in the National Examinations Policy for Further Education and Institute Programmes (Quality Assurance Manual, 2008).

3.4.8 External Assessment

A national examination is conducted annually in May or June by means of a paper (s) set and moderated externally. External assessment details are set out in the Assessment Guidelines for Automotive, Industrial Maintenance and Manufacturing (Level 4 & 5) as shown in table below.

- **Calculation of Final Marks**

Continuous Assessment	Student's mark/100 x 50/1 = mark out of 50 (a)
Theoretical Examination Marks	Student's mark/100 x 50/1= mark out of 50 (b)
Final Marks	(a) + (b) = mark out of 100

All marks are systematically processed and accurately recorded to be available as hard copy evidence for the purpose of moderation and verification, as well as purposes of reporting. Note that the principle topics are customized modules approved for BTEC qualifications.

3.4.9 Resource used for Teaching/Learning

The following resources have been developed and prepared for teaching/learning and assessing methods:

Practicing Room:

- A simulated workshop environment, equipped with the basic tools and workshop equipment
- Necessary electronic equipment, e.g. training models, television with video or DVD to play filing cabinet, computers, printers and smart boards have been provided
- The latest visual aid equipment are available at SKI. The computers have been provided and connected with internet connection to enable the facilitator to demonstrate website browsing for research purposes

Theory Room:

- Computers and data projector or latest technology to electronically project data for students, is available for facilitator
- Flash disk for facilitator to store information

- Presentation program on computer were used by facilitator to provide students with visual information on Learning Outcomes
- White board and pull down screens
- Desks for students; big enough to work on. Students can use many resources e.g. laptops, documents etc. to work from

Lecturer / Facilitator:

- Applicable subject related qualification
- It is an advantage for facilitators/lecturers if they declare competence as assessors and/or moderators
- Full time technology and research center managers (with knowledge of computers, website browsing, research and reference books)

Other Resources

- Text books
- Answer books, with examples which students must complete for practical assignments
- Calculator for each student
- File for each student to serve as Evidence file
- Lever arch file for Practical Assessment Portfolio

3.4.10 Use of Visual Tools in T & L process

At different stages in the students' learning, different types of visual tools are considered. For example, at the instructional stage, simulations can be more structured in order to check for student's understanding throughout the module. When students progress to the analysis and application stage, they welcome more unstructured environments where they can script their own engineering experiments and control their own learning (Uran, Jezernik, 2008; Dyke, M., G. Conole, A. Ravenscroft 2007).

Video research in education: Video-based AIM laboratories have been reported positively in the engineering education literature (Abdulrasool et al, 2007; Zywno, 2003). In these learning sessions, interactive tutorial based video clip presentations are used to help students assess, rate, value, judge, estimate, rank, operate and install their tasks. Learning takes place in a social constructivist environment with integrated technology. In this study, interactive tutorial with video presentations are used to help students to make experiments, scale, assess, rate, value, judge, estimate, rank, operate, install, configure, test, change, achieve, perform, complete and apply. However, the program used in this study incorporates a qualitative use of digital video. Students make comparison of measurements data of tasks in the tutorial with the help of video clips but are required to discuss and compare the recorded data of their tasks and detailed observations and use these as feedback and conclusion as part of the mechanical report sequences. The emphasis is on the articulation of rich, detailed, qualitative responses, important to learning in a social constructivist environment with integrated technology (Zywno, 2003; Richard E Mayer 2011).

Power Point Slides and Digital Video: The Power Point slides and digital video demonstrations need to contain interesting and relevant material and where appropriate, creative outcomes suitable for inclusion in AIM tasks. The outcomes have to be clearly visible and preferably rely on student's direct observation skills rather than second hand observations using measurement instruments, machine, equipment, and mechanical tools (Richard E Mayer 2011; Zywno, 2003). The demonstrations have to be suitably challenging for students in an introductory maintenance and production course but not too challenging to avoid students guessing and encourage personal reasoning. Commercial sources of CAL slides needed copyright permission.

3.5 Various components of Blended Learning System

This section highlights the design process of Blended Learning and e-learning system to satisfy teaching and learning provision requirements at SKI. e-Blended and Computer Instruction Tutorial Framework has been proposed to organise the structure of the tutorial package. The reasons, aims, rational, and influence of tutorial and computer instructions were discussed. Furthermore a website has been developed for teaching/learning activities integrating all the above.

3.5.1 The Proposed Blended Learning and Computer Instruction Tutorial Framework

From the extensive literature review presented in Chapter 2, and from the frameworks developed in the previous sections, it has been found out that the following six components are the ones that primarily form the tutoring framework:

- **Visual input**: text, picture, video, animation, the selected visuals were inspected prior to implementation by professional educationalist from visual aids department, (Ruiz M.E. 2006)

- **Learner control**: Module outcomes, outcomes material, outcomes, assessment, tasks and time

- **e-Learning**: Tutorial software (e-learning materials) and computer instruction were used with help of website, iPhone and youtube for short video clips

- **Teaching strategies and learning style**: Teacher-centred approach, student-centred approach and interactive

- **Psychomotor and Cognitive Engagement:** where students engage at higher level of skills, according to the new seven domains of psychomotor skills i.e. diagnose, design, implement, evaluate, experience and improve, and cognitive skills i.e. analyse, evaluate and create

- **Teaching and learning**: Three methods of teaching and learning, and three group of students were selected for the purpose of this study to find out the effectiveness of the teaching/learning process at SKI when the teachers teach at higher level of psychomotor and high level of cognitive skills for both theory classes and practical sessions (Hands-on)

The proposed tutoring framework, shown in figure 3.10, was implemented into a computer platform through aforementioned six steps. The learning materials for Automotive, Industrial Maintenance and Manufacturing Engineering, were prepared. After subject outcomes, questions were developed at both lower and higher level of psychomotor and cognitive skills to test ability of engineering students when they perform diagnosis, design, implementation, evaluation, gain experience and improve it in the real world environment (Appendix 1). Tasks were developed at high level of cognitive skills to find out the level of the students skills in analyzing, evaluating and creating the knowledge.

The user interface for the proposed tutoring tool was designed such that the student will be able to interact with the learning tools through illustrative visualisations (interactive learning) and dialogues rather than just reading or watching. The students are asked to answer questions in the shape of quiz in order to test the effectiveness of student’s learning. If the students are incapable of achieving passing grades in laboratory work he/she will be recommended to undergo the chapter material again. Finally, the proposed tutoring framework and the user interface are implemented into a computer platform to obtain a visualization based on the tutoring tool, named blended learning (e- learning Package). Tool book, video clips and photoshop software are adopted for the implementation of combined chapters, since it offers the broadest range of creative tools to design interactive dialogues and visualizations using advanced graphics, text, animation, video and audio tools (Abdulrasool, S. Mishra, R. 2008).

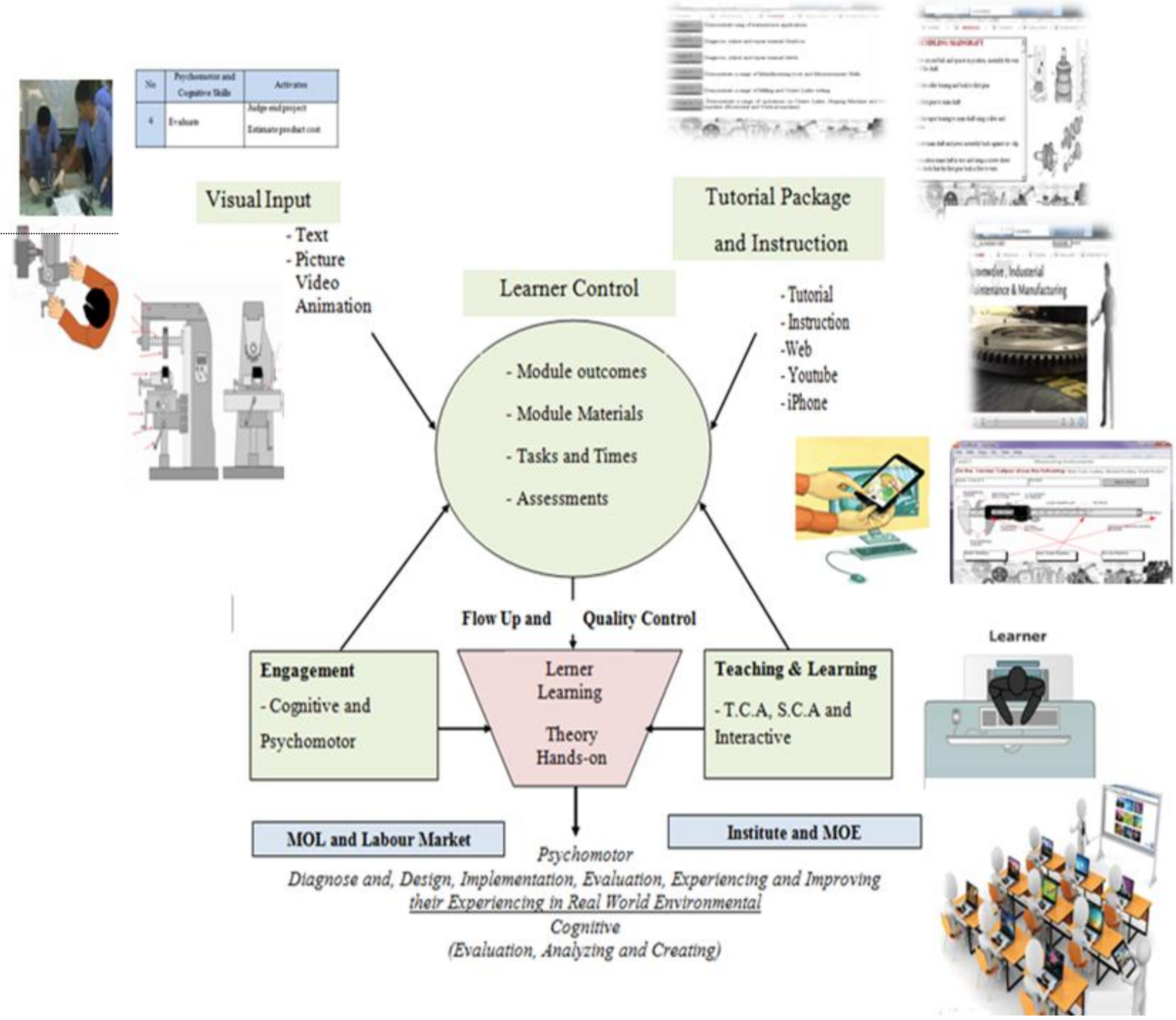


Figure 3.10 Blended Tutorial Framework

3.5.2 Description of Computer Instruction Tutorial

The final e-blended e-learning and computer instruction tutorial is developed using the Toolbox, Power Point, digital video, animation software. It makes use of 80 shots of the inventor and 45 minutes video film as tutorial exercise for Automotive, Industrial maintenance and Manufacturing (AIM) students. Furthermore, 120 Power Point slides and digital film of appropriate AIM demonstrations have been included. The tutorial, Power Point and video demonstrations depict scenarios that represent real mechanical components, equipment and tools to the students. These include tools to acquire diagnosis, design, Implementation, evaluation, experience skills and high level of cognitive skills i.e. analysis, evaluation, creation tasks. These are designed to act as instructional views in the automotive, industrial maintenance and manufacturing module (Shephard, K. 2008).

The package has been 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 teaching method (TCA). Whole class demonstrations provide a suitable scaffold for mechanical learning strategy (SCL) and supports the use of the digital video medium to present complex features (Salah, et al., 2009). Like other instruments designed to elicit students' views (e.g., experimental, scale, , fabricate, calculate, gauge, assess, rate, value, judge, estimate, rank, reckon, weigh, operating, installation, configuration, running, testing, changes, achieve, perform, effect, carry through, complete, apply, perform, realise), the package also offers the students an opportunity to learn and understand many techniques used in advance processes. This represents a new development in the use of the AIM strategy in mechanical engineering education (Salah, et al., 2009; Shephard, K. 2008).

Each task in mechanical engineering education requires students to use their plan, design and high level skills for achievement of learning outcomes and to be able to evaluate any discrepancies between their end product and its 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 AIM sequence, the students collaborate in small groups at their computers to make detailed qualitative observations of the tutorial shot and video-based demonstrations (Abdulrasool et al, 2007; Zywno, 2003). These observations provide the intrinsic feedback on their earlier production.

In the laboratory (workstation) environment, the students perform the AI tasks and manufacture work pieces using a checklist format. Then they compare the characteristics of work piece with the initial diagnostic and analyses (Tomei, L 2008).

3.5.3 Example of Teaching/Learning Resources

Learning: First, students go through the dialogues and visualisations to enhance their knowledge and understanding. Links between relevant documents are provided within the materials. These links allow students to review the materials of interest themselves, thus resulting in better memory of what has been learned (Tang, and Hung 2009).

The students were asked to implement the theoretical concept of mechanical engineering subject after diagnosis and analysis. They have to adjust, dismantle, assemble, repair and evaluate by testing, producing and enhancing the end of the product for good conclusions. These were the subject outcomes for automotive, industrial maintenance and manufacturing. The example shown in figure 3.11 depicts the student’s response during practicing sessions. Students in the lab should cover 6 tasks with the use of e-blended e-learning in the following area (Appendix 1):

Task 1: Demonstrate range of transmission applications for example: Gearbox and Clutch.

Task 2 Diagnose, adjust and repair manual Gearbox

Task 3 Diagnose, adjust and repair manual clutch

Task 4: Demonstrate range of Manufacturing tools and Measurements Skills for example

Task 5: Demonstrate range of Milling and Centre Lathe setting for example

Task 6: Demonstrate range of operations on Centre Lathe, Shaping Machine and Milling machine (Horizontal and Vertical machine) for example

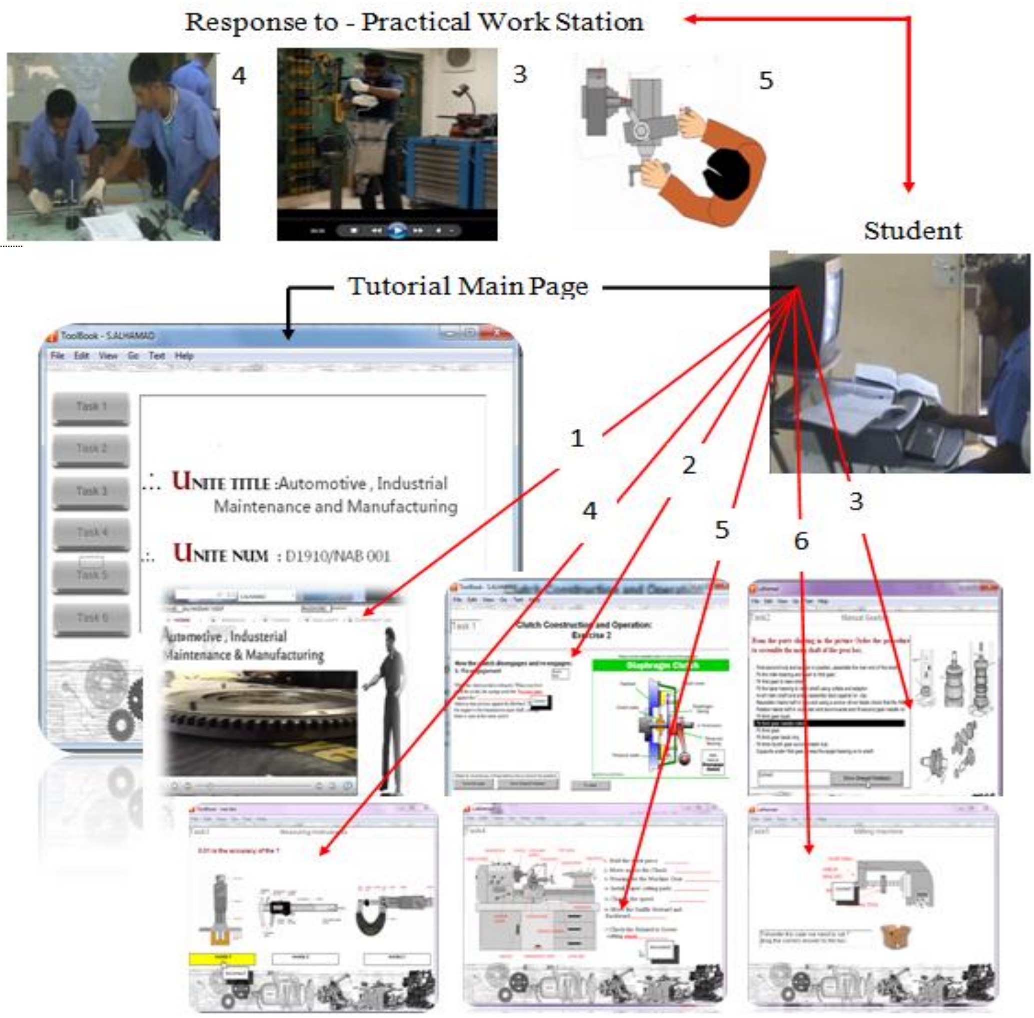


Figure 3.11 Proposed tutorial package

Practicing: Students are prompted to solve practical problems using the acquired knowledge, and apply what was learned to unfamiliar problems. Six tasks were selected from the main module by the curriculum specialist. The continent of the tasks focused on high levels of psychomotor and cognitive skills (high thinking skills), (Shephard, K. 2008; Tiffany Ho and Eric Lee 2004). The tutorial provides verbal and written guidance to them. The learning tutorials contain the specified guidelines to interlink (step-by-step) between workstation and text to finish required task. Hence, 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 as interact with it (e.g. hear, see, and do). The computer tutorial provides an excellent mean 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 (Appendix 1).

3.6 Evaluation criteria for Blended Learning System

This section highlights the steps followed in order to develop the course material of the three common modules. The elicitation of student's instructional automotive, industrial maintenance and manufacturing (AIM) views is a key strategy in any teaching approach informed by constructivism (Zywno, 2003). The e-blended and computer instruction package developed in this research is designed to use the proposed high level of psychomotor skills i.e. diagnose, design, implement, evaluate, experience, and the well-known high level of cognitive skills i.e. analyse, evaluate and create. Furthermore, e-blended and computer instruction package offers the students opportunities for learning and practicing what they have learned to develop more in-depth understanding (Zywno, 2003) It has the potential to help the students to explore and justify the final decision (conclusion) of their individual ideas, especially in the production and reasoning stages. Several elements / areas which are generally used for quality assessment, Mayes (2007) have been taken into consideration in the e-blended, e-learning and computer instruction 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 Diagnosing stage to the analyses and implementation of production
- **Security:** extent to which access to information is restricted appropriately to maintain its security
- Contains various learning activities enabling the development of students' cognitive, and psychomotor skills at High level of thinking skills
- Provides comprehensive online theoretical and practical information
- Appropriate for various learning styles
- Comprises of practical, online and written assessments
- **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
- Contains various practical applications which allow the students to use their knowledge for the development of relevant technical skills
- Focuses on interactive and student-centred learning approach through individual, team working and problem solving activities
- Use technology (animations, simulations, videos) to present the industrial subject materials in interactive way and motivate students
- Provide discussion boards and forums where students can ask questions and clarify points of view in their own time
- Give opportunity to dialog by using mobility system (iPhone) software and youtube

- **Concise:** extent to which information of the e-blended, e-learning and computer instruction is compactly represented in proper way
- **Reliability and Accessibility:** it gives flexibility to the students using the e-blended, e-learning and computer instruction without Lecturer instruction easily and quickly (students centre
- **Availability:** extent to which information is available and accessible to all AIM students and Lecturers during the laboratory work (Workstation)
- **Relevancy:** the standard of the e-blended, e-learning and computer instruction was designed to meet the AIM students' requirements of higher thinking skills the study plan
- **Usability:** extent to which e-blended, e-learning and computer instruction is designed clearly and easily to use at high standard of psychomotor and high level of cognitive skills
- **Understand Ability:** extent to which e-blended, e-learning and computer instruction are clear without ambiguity and easily prepared for complex work like evaluation and improving
- **Believability:** extent to which information is believable to the learner
- **Navigation:** extent to which data are easily used and linked the classroom work Plain and design with the laboratory work implementation and experiencing
- **Usefulness:** extent to which information of the computer aided instruction is designed overcomes the problems within the mechanical engineering subject area
- Provide online practical work guidelines
- Contains various modes of delivery (teachers' direct instructions, online material)
- **Efficiency:** how students can design and manufacturing the project using computer aided instruction tools without errors
- **Value-Added:** extent to which e-blended, e-learning and computer instruction is beneficial, provides advantages from its use

The e-blended, e-learning and computer instruction package is designed by the author to be used by students in an interactive way to enable them to acquire skills at High level of Psychomotor and Cognitive skills. This is a significant change from the use of other methods of 'investigation of understanding'. For example, student's interviews, questionnaires, tests, assignment, concept project and student journals are usually completed individually (E, R Mayer, 1999; Mayer, 2001; Zywno, 2003). By using this computer investigation in an interactive way or in group work the interactive learning can take place., 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 details 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, the students are asked to dismantle, adjust, repair and produce individual parts and then to combine them in assemblies, which are evaluated by the lecturers. The collaborative uses of e-blended, e-learning and computer instruction 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 (Mayes 2007; Mayer, 1999; Zywno, 2003).

3.7 Writing Learning Outcomes in Cognitive and Psychomotor domains

The main features of the research plan are the development of Blended Learning system to improve the ways of delivering teaching/learning materials at SKI. All modules and programmes at Higher National Diploma (HND) level throughout the Bahrain Higher Education area should be re-written in terms of learning outcomes at higher level of psychomotor and cognitive skills (MOE in Bahrain and SQA, 2009). Learning outcomes are used to express what learners are expected to achieve and how they are expected to demonstrate and practice that achievement with critical thinking.

In 2007, SKI representatives, the Ministers of Education Curriculum specialist and other experts from SQA, BTEC and UNESCO convinced the MOE (MOE), Centre of Excellence (CDE), Bahrain to formulate SKI, aimed at establishing new Course Subjects for SKI Higher Education area. The SKI process spells out a number of action lines in which learning outcomes should play an important role (MOE in Bahrain and SQA, 2009). One of the logical consequences is that, by 2009, all programmes and significant constituent elements of programmes at HND level of SKI should be based on the concept of learning outcomes at higher level of psychomotor and cognitive skills (HLPCS), and that curriculum should be redesigned to reflect this.

At the follow-up meeting in Bahrain in 2010, the author, through Ministers for Education, Bahrain issued a communiqué regarding the state of implementation of the SKI process. They emphasised the creation of a common model for Higher Education at SKI, and encouraged National Higher Diploma students and education systems for Engineering Education (Mechanical) to ensure, through the development of programme frameworks, that degrees (HNC and HND) would also be described in terms of learning outcomes, rather than simply by number of credits and number of hours of study.

It is worth noting that defining courses in terms of learning outcomes is not unique to SKI, Bahrain. Gosling and Moon 2001 have indicated that the outcomes-based approach to teaching/learning (T & L) is becoming increasingly popular at an international level. The learning outcomes at higher level of psychomotor and cognitive skills-based approach has been increasingly adopted within credit frameworks and by national quality and qualifications authorities such as the QAA (Quality Assurance Agency for Higher Education) in the UK, the Australian, New Zealand and South African Qualification Authorities. (Gosling and Moon, 2001);.

This research draws on the work of the HND involved at SKI association Teaching and Learning – during 2010/11, and of academic staff from different faculties at SKI, Bahrain who re-wrote all or part of their courses in terms of learning outcomes during 2010/11.

3.7.1 Details of the Learning Outcomes in the Cognitive and Psychomotor domains

In previous section of this chapter, the author has discussed about the work of different researchers like Dave (1970), Simpson (1972, Harrow (1972), Ferris and Aziz (2005). The work was related to various skills of mechanical engineering graduates which can be used as a benchmark against the proposed High level of Psychomotor and Cognitive domain skills (HLPCS). The extensive review has indicated that the available skill's models could be used to benchmark the performance of students.

The teaching/learning methodology with current outcomes was not matched with the skills categorised into low level of cognitive and psychomotor skills. It is clear that they were generic and not focused on engineering students in Bahrain (Declan Kennedy, Áine Hyland, Norma Ryan 2005). Also, they did not meet the modern skills requirements by the industry.

A new model for High level of Psychomotor and Cognitive Skills (HLPCS) is proposed, to focus on the HNC and HND level of higher education students of SKI to equip them with the skills required by Bahrain labour market. (Ellen and MOE 2009) reports show the skills required for engineering graduate should be focused on High level of critical thinking. The novel Psychomotor and Cognitive skills (HLPCS) model would give more strength to the existing outcomes and will be embedded within the proposed outcomes. The main process that was used to develop the teaching material at f High level of Psychomotor and Cognitive Skills (HLPCS) are:

1. Literature review of Cognitive, Affective and Psychomotor skills
2. Literature review of Mechanical Engineering objectives, subject outcomes and Learning outcomes
3. Teaching strategies and learning style
4. Higher level of Thinking skills and critical Thinking
5. Current state of SKI (Teachers, Teaching/learning Resources, Students level and assessments)
6. Technology used
7. Curriculum

Table 3.8 contains the diagram of the proposed relationship between the proposed subject outcomes and the proposed higher level of Psychomotor and cognitive skills hierarchy developed by the author based on pedagogical underpinnings. It contains a mixture of cognitive and psychomotor skills. The design of table gives the total frequency of corresponding outcomes, which is related to the Psychomotor and Cognitive skills, categorised by the author. The frequency of the proposed Psychomotor and Cognitive skills hierarchy is higher than the previous work.

Table 3.8 The relationship between proposed outcomes and proposed high level of psychomotor and cognitive skills

Psychomotor Domain (1970-2005) | High Level of Psychomotor and High Level of Cognitive Skills — Research area

Learning Outcomes			Dave (1970)					Simpson (1972)							Harrow (1972)				Ferris and Aziz (2005)							Proposed Psychomotor skills							High level of Cognitive Skills		
			Imitation	Manipulation	Precision	Articulation	Naturalization	Perception	Set - Mental	Guided Response	Mechanism	Complex Overt Response	Adaptation	Origination	. Observing	Imitating	Practicing	Adapting	Recognition of tools and materials	Handling of tools and materials	Basic operation of tools	Competent operation of tools	Expert operation of tools	Planning of work operations	Evaluation for improvement	Diagnose and Explore	Plan and Design	Action and Implement	Evaluate	Improve	Experiencing (Work placement)	Conclude	Analysing	Evaluating	Creating
Automotive and Maintenance	1	Test, diagnose, and rectify faults of Vehicles		√																√		√			√	√			√		√		√	√	√
	2	Analyse faults readings, using a laptop and conect electronic control unit.	√	√	√					√		√								√		√			√	√			√		√	√	√	√	√
	3	Researching faults, using manufacturers' circuit diagrams and specification manuals																							√	√			√		√	√	√	√	√

Automotive and Industrial Maintenance	4	Checking and testing wiring and parts in older vehicles sing portable instrument.																							√	√			√		√	√	√	√	√
	5	Working out the estimated time and cost.																							√		√		√		√				
	6	Use of Measuring and Marking out tools		√	√					√															√			√	√		√				
	7	Dismantling and repair faults in exhaust systems.			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	8	Dismantle and repair hydraulic brake systems.			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	9	Dismantle and repair cooling systems.			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	10	Dismantle and repair manual transmissions.			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	11	Dismantle and repair suspension systems.			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	12	Dismantle and repair steering systems.			√				√	√											√	√	√		√	√	√	√	√	√	√	√			
	13	Dismantle and repair vehicle differentials			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	14	Carrying out repairs and replacing parts			√			√	√	√	√										√	√	√		√	√	√	√	√	√	√	√			
	15	Fitting and servicing accessories			√				√	√											√	√	√		√	√	√	√	√	√	√	√			
	16	Carrying out standard servicing and checks.																			√ √	√ √	√ √					√	√	√	√	√			
	17	Carrying out the road testing.			√						√														√	√		√	√	√	√	√			
	18	Use precise measuring tools and make accurate setups on machine			√				√											√					√	√		√	√	√	√	√	√	√	√
	19	Customer Care																							√	√	√	√	√	√	√	√	√	√	√

Industrial Maintenance and Manufacturing	1	Develop Engineering CAD/ and Generate CAM Operation,																							√	√	√	√	√	√	√	√	√	√	√
	2	Prepare and set the cutting tool machine and Manufacture the product			√			√	√	√	√											√	√	√		√	√	√	√	√	√	√				
	3	Set Up the machine with precise measuring tools to ensure accurate Results						√	√		√											√	√	√		√	√		√	√	√	√				
	4	Select the proper measuring instruments			√			√			√											√	√			√	√		√	√	√	√		√	√	√
	5	Feed the accurate procedure and perform each machine (manual lathes, Horizontal, Vertical milling machines, Shaping Machine, surface grinders and Drilling			√				√	√												√	√	√		√	√	√	√	√	√	√	√	√	√	√
	6	Load the computer Software to perform computer numerical controlled (CNC)		√	√			√		√	√											√	√			√	√	√	√	√	√	√	√	√	√	√
	7	Performing routine maintenance on equipment and determining when and what kind of maintenance is			√			√			√											√	√	√		√	√	√	√	√	√	√	√	√	√	√
	8	Controlling operations of equipment or systems.		√																						√	√	√	√	√	√	√	√	√	√	√
	9	Repairing machines or systems using the needed tools.		√	√			√		√	√											√	√			√	√	√	√	√	√	√	√			
	10	Conducting tests and inspections of products, services, or processes to evaluate quality or performance.		√						√	√											√	√	√		√	√	√	√	√	√	√	√	√	√	√

Industrial Maintenance and Manufacturing	11	Identifying complex problems and reviewing related information to develop and evaluate options and implement		√	√			√		√	√										√	√			√	√	√	√	√	√	√	√			
	12	Determining causes of operating errors and deciding what to do about it.		√	√			√		√	√										√	√			√	√	√	√	√	√	√	√	√	√	√
	13	Managing one's own time and the time of others.																									√		√		√	√	√	√	√
	14	Communicating effectively in writing as appropriate for the needs of the audience.		√	√			√		√	√										√	√								√	√	√	√	√	√
	15	Teaching others how to do something.			√			√		√										√	√	√			√		√	√	√	√	√	√	√	√	√
	16	Determining the kind of tools and equipment needed to do a job.		√		√			√	√	√	√										√	√	√	√			√	√	√	√	√	√	√	√
	17	Determining how a system should work and how changes in conditions, operations, and the environment will affect		√		√			√	√	√	√										√	√	√	√			√	√	√		√	√	√	√
	18	Evaluation measures or indicators of system performance and the actions needed to improve or correct performance.		√		√			√	√	√	√										√	√	√	√		√	√	√	√	√	√	√	√	√
	19	Solve problems scientific operation		√		√			√		√	√										√	√	√	√	√	√	√	√	√	√	√	√	√	√
	20	Analyzing and Improve product equirements to create a design		√							√	√													√	√	√	√	√	√	√	√	√	√	√
Frequency			1	15	23	4	0	17	17	22	22	6	0	0	0	0	0	0	0	4	23	29	20	4	37	30	26	32	38	32	37	31	21	21	21

More attention was given to support every staff member, how and when best to use the learning outcomes at higher order of cognitive skills in their practice so that the student experience can be improved significantly by encouraging creativity and reflection (characteristics of lifelong learners)

3.8 Development of Course Material

Main objective: This section has been designed to give students knowledge and understanding of the operation, maintenance and manufacturing requirements of mechanical engineering subject area (Automotive Engineering, Industrial Maintenance Engineering and Manufacturing Engineering). The students will also be provided with the opportunity to diagnose, explore, plane, design implement (action) of dismantling, inspect, repair, assemble (engine and car parts) and manufacture. Furthermore, the students can evaluate and give feedback, and experience the work in good work placement environment. In the following some examples of development of course materials have been presented, which are based on previously developed integrated cognitive and psychomotor models.

Range: Mechanical Engineering subjects.

No	Subjects	Subject Outcomes
1	Power and Transmissions System	Diagnose, Dismantling and Repair Manual Transmissions
2	Engineering Measurement	Use of Measuring Instruments and Marking out Tools
3	Manufacturing Process – 2	Use of Machine Tools Centre Lathe Milling and Pedestal Drilling

Subject # 1: Power and Transmissions System

Subject Outcomes: Diagnose, Dismantling and Repair Manual Transmissions

Learning Outcomes:

a- Cognitive Skills

No	Learning Outcomes
1	Explain Front and Rear Gear Drive Applications

2	State Front Rear Gear Drive Troubleshooting
3	Identify Clutch Applications
4	State Clutch Troubleshooting Procedure
5	Analyse Gearbox Faults
6	Write Gearbox - Removal Steps
7	Name Gearbox Parts and State Repair Steps
8	Evaluating Procedure of Gearbox Installation
9	Analysing of Clutch Faults
10	Evaluating Removal Steps of Clutch
11	Name Clutch Parts and State Repair Procedure
12	Right application of Clutch Installation

b- Psychomotor Skills

No	Learning outcomes
1	Demonstrate Front and Rear Gear Drive Applications
2	Demonstrate Front Rear Gear Drive Troubleshooting
3	Demonstrate Clutch Applications
4	Demonstrate Clutch Troubleshooting

5	Diagnose and analyse Gearbox Faults
6	Gearbox - Removal
7	Gearbox Parts Inspection and Repair
8	Gearbox Installation and Testing
9	Diagnose and analyse Clutch Faults
10	Clutch - Removal
11	Clutch Parts Inspection and Repair
12	Clutch Installation and Testing

Subject # 2: Engineering Measurement

Subject Outcomes: Use of Measuring Instruments and Marking Out Tools

Learning Outcomes:

a- Cognitive Skills

No	Learning outcomes
1	Demonstrate a range of Centre lathe and milling Feed Dial
2	Demonstrate Application of Vernier and Micrometer

3	Evaluate a range of Vernier Caliper Demonstration
4	Evaluate a range of Micrometers Demonstration

b- Psychomotor Skills

No	**Learning outcomes**
1	Use a range of Centre lathe and milling Feed Dial
2	Demonstrate Vernier and Micrometer Applications
3	Demonstrate a range Vernier Caliper
4	Demonstrate a range Micrometer

Subject # 3: Engineering Measurement

Subject Outcomes: Use of Machine Tools Centre Lathe, Milling and Pedestal Drilling

Learning Outcomes:

a- Cognitive

No	**Learning outcomes**
1	Demonstrate Steps of Setting Procedure of work Holding on Milling
2	State Setting Procedure of work Holding on Center Lathe and Shaping

3	Demonstrate Milling Machine Application of cutting Speed and feed
4	Calculate Center Lathe and Shaping Machine cutting Speed and feed
5	Demonstrate Machining Steps of (Flat surface) on Milling and Shaping .M
6	Calculate Gear Cutting on Milling .M
7	Demonstrate Parallel and Taper Turning Procedure on Center Lathe
8	Demonstrate Screw Cutting Steps (V & Square Shape) on Center Lathe

b- Psychomotor Skills

No	Learning outcomes
1	Demonstrate Set of Milling Machine for work and Cutter Holding
2	Set Center Lathe Machine for work and Tools Holding
3	Set Milling Machine for cutting Speed and feed with suitable Direction
4	Set Center Lathe Machine for cutting Speed and feed with suitable Direction
5	Generate Flat surface on Milling and Shaping Machine
6	Demonstrate Gear Cutting on Milling machine
7	Demonstrate Parallel and Taper Turning on Center Lathe

8	Generate Screw Cutting (Vee form & Square Shape) on Center Lathe

3.8.1 Development of Purposeful T & L Materials and e-Resources

The Engineering Automotive, Engineering Maintenance and Manufacturing Engineering HND courses at SKI in the Kingdom of Bahrain is one year course of 2 terms. There are 15 weeks for teaching in each term, with two lectures and four hours laboratory every week (Felder. N, et al, 2002; Abdulrasool, S. et al., S 2005). In the traditional teaching mode, most of the lecture time is dedicated to introducing students to the theory and practice. It is proposed to investigate various modes of teaching and learning methods later. Based on the authors experience the following three methods are proposed to be used for delivery.

Table 3.9 shows the developed schedule for the implementation of the proposed model. It can be seen that the three groups, discussed above, have been provided with various tasks in various weeks. The table also shows the amount of time to be spent on a specific task by the students, on both theory and practical sessions. Tasks are devoted to demonstrate range of transmission applications, diagnose, adjust and repair manual gearbox, clutch operations, demonstrate a range of manufacturing tools and measurements operations, and demonstrate a range of Milling and Centre Lathe setting operations. The following is the teaching plan for the material developed in this research.

Table 3.9 1st Semester and 2nd Semester Plan

Task	**Week**	**Time /Module Hours**				**Outcomes tasks and activities**	**Groups**
		Theory		**Practical**			
		Classroom	**Technology Base**	**Hands-on**	**Technology Base**		
T1	1,2,3	**1**	1	**3**	1	Demonstrate rang of transmission applications	G1-T.C.A
T2	4,7,5,8,6,9	**2**	2	**6**	2	Diagnose, adjust and repair manual Gearbox	G2-S.C.A
T3	10,13,11,14,12,15	**2**	2	**5**	3	Diagnose, adjust and repair manual clutch	G3-Interactive
T4	16,17,18	**1**	1	**2**	2	Demonstrate a range of manufacturing tools and measurements	

						Skills	
T5	19,22,20,23, 21,24	**2**	2	**5**	3	Demonstrate a range of Milling and Centre Lathe setting	
T6	25,28,26.,29,27,30	**2**	2	**5**	3	Demonstrate a range of operations on Centre Lathe, Shaping Machine and Milling Machine (Horizontal and Vertical Machine)	
	30 weeks	**10**	10	**36**	14		

3.8.2 Examples of the Tasks

In the following task-wise details of the material developed is presented.

Subject Outcomes # 1: Diagnose, Dismantling and Repair Manual Transmissions

Task (T1): Demonstrate rang of transmission applications

Task (T2): Diagnose, adjust and repair manual Gearbox

Task (T3): Diagnose, adjust and repair manual clutch

Subject Outcomes # 2: Use of Measuring Instruments and Marking Out Tools

Task (T4): Demonstrate a range of Measurements Skills

Subject Outcomes # 3: Use of Machine Tools Centre Lathe, Milling and Pedestal Drilling

Task (T5): Demonstrate a range of Milling and Centre Lathe setting

Task (T6): Demonstrate a range of operations on Centre Lathe Machine and Milling machine (Horizontal and Vertical machine)

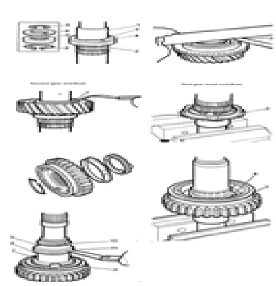
Table 3.10 to 3.15 shows the examples of the tasks undertaken by the students at SKI. These tasks have been directly derived from the subject outcomes shown above. These tasks have been designed to assist students in understanding and effectively mastering materials at high level of cognitive skills (HLGS) in classroom and High level of psychomotor skills (HLPS) in laboratory work. The recourses have been developed for mechanical engineering subjects which are aimed to help raise the standard of skills and knowledge of the student to satisfy labour market requirements in Bahrain (Allen and Moe 2009).

- **Task 1: Demonstrate the range of transmission applications**

The proposed resources have been selected from course module to cover the main activities at higher level of psychomotor and cognitive skills. In this stage, the students demonstrate the range of translation application with action and verbs Dave (1970):

Screening, conclude, functional, sequencing, routine, experimental, scale, arrange, organise configuration, running, testing, changes, achieve, perform, organise, manage, calculate, gauge, analyse and justify.

Table 3.10 Course resource of task 1

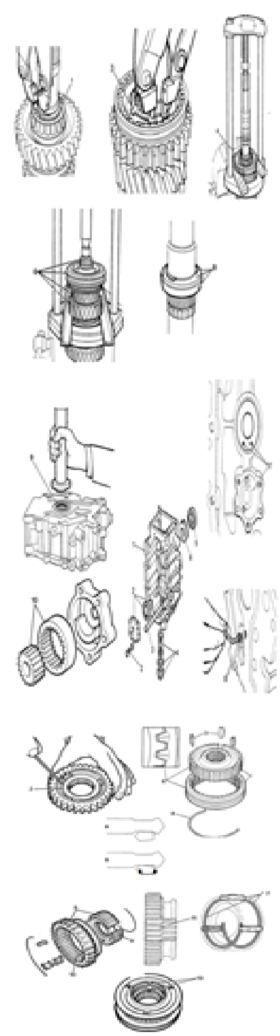
No	Psychomotor and Cognitive Skills	Activities	Proposed Resources
7	Conclude	Judge final application of transmission application	  
6	Experiencing (Work placement)	How you meet the required experience	
5	Improve	Value of improving application	
4	Evaluate	Assess transmission system. Rank, condition of transmission	
3	Action and Implement Inspector Check List	1-Carry out the demonstration and the application of transmission. 2-Install the transmission application 3-Achieve management system of transmission	
2	Design and Plan	1-structure work plan. 2-Assign design sheet	
1	Diagnose and Explore	1-Analysing the accident report of the Car.	

- **Task 2: Diagnose, adjust and repair manual Gearbox**

In diagnose, adjust and repair manual gearbox, the selected resources cover most gear parts. Students will be able to achieve the proposed activities at Higher level of Psychomotor and cognitive skills (HLPCS) given below:

Arrangement, experimental, scale, , fabricate, calculate, gauge, assess, rate, value, judge, estimate, rank, reckon, weigh, operating, installation, configuration, running, testing, changes, achieve, perform, effect, carry through, complete, apply, perform, realise, , end, close, finish, start, open, begin, extend, profile, implicate, specifying, m Make a sketch or drawing, outline (Dave 1970 ; Simpson 1972)

Table 3.11 Course resource of task 2

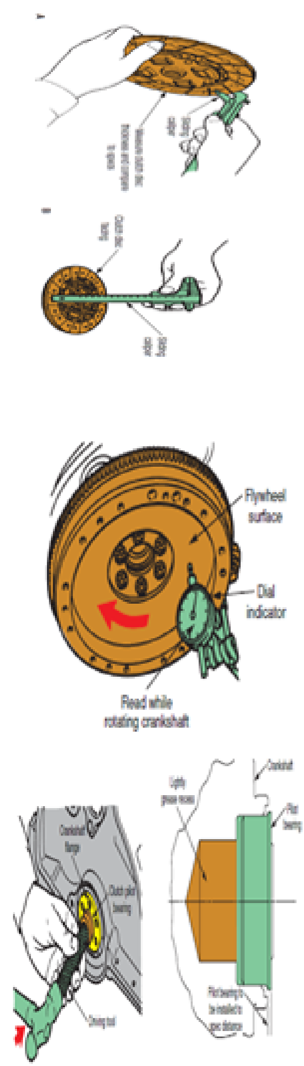
No	Psychomotor and Cognitive Skills	Activities	Proposed Resources
7	Conclude	Establish, your weekly report	
6	Experiencing (Work placement)	Submit your evidence file and explain about your experience.	
5	Improve	Chuck the quality of the Gears. What type of gears materials give long life.	
4	Evaluate	Calculate gear speed Ratio. Measure diameter of inner holes. Asses the gear movement Give your final judgment about the gear condition	
3	Action and Implement Inspector Check List	Discharge the Gear oil system. Dismantle Gear Parts Adjust the gear link Road and Gear set. Reaper the Shaft mechanism. Install the gears 1,2,3,4. Perform the gearbox.	
2	Design and Plan	Plan your work and give the maximumno of working hours.	
1	Diagnose and Explore	Chuck the Gear system. Test the gear box Gears set and gears fork. Test the Gearbox road	

- **Task 3: Diagnose, adjust and repair manual clutch**

The Higher level of Psychomotor and cognitive skills (HLPCS) activities and verbs used for diagnose, adjust and repair manual clutch are:

Arrangement, experimental, scale, , fabricate, calculate, gauge, assess, rate, value, judge, estimate, rank, reckon, weigh, operating, installation, configuration, running, testing, changes, achieve, perform, effect, carry through, complete, apply, perform, realise, , end, close, finish, start, open, begin, extend, profile, implicate, specifying, m Make a sketch or drawing, outline (Dave 1970 ; Simpson 1972).

Table 3.12 Course resource of task 3

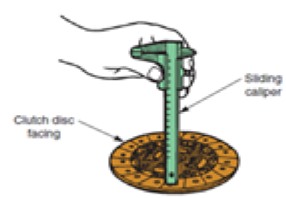
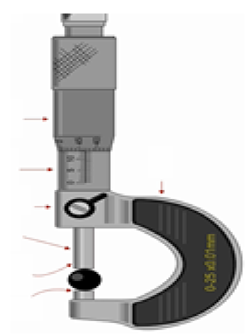
No	Psychomotor and Cognitive Skills	Activities	Proposed Resources
7	Conclude	Gather information for end report	
6	Experiencing (Work placement)	Talk about experience feeling.	
5	Improve	Can we increase the life of the clutch release bearing?	
4	Evaluate	Compare the pressure clutch with manual standard. Rank the condition of the clutch.	
3	Action and Implement Inspector Check List	Perform the complete overhaul of the clutch (Dismantling, reappearing and installing).	
2	Design and Plan	Give the total no of hours for clutch adjusting	
1	Diagnose and Explore	Diagnosis the clutch system	

- **Task 4: Demonstrate a range of Manufacturing tools and Measurements Skills**

The selected resources and action verbs of higher level of Psychomotor and Cognitive skills (HLPCS) for demonstrating a range of Manufacturing tools and Measurements Skills cover most of machining process and the procedure during practicing. The following action verbs have been discussed for accuracy purposes:

Assess, rate, value, judge, estimate, rank, calculate, gauge, appraise, size up, analyse, justify. useful, increase productivity or value, more desirable, more excellent, more quality, condition; make better, more desirable, valuable, or excellent state. Endure, artistically surmise, end, close, finish, start, open, begin, extend, commence, bring to end, complete, terminate, round off, protract, effect, settle, bring about, fix, carry out, resolve, clinch, pull off, bring off.

Table 3.13 Course resource of task 4

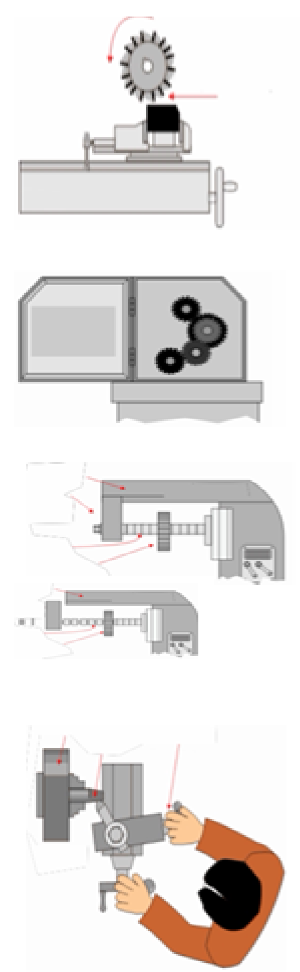
No	Psychomotor and Cognitive Skills	Activities	Proposed Resources
7	Conclude	Submit weekly report	
6	Experiencing (Work placement)	Give example of the work condition of the industry work shop.	
5	Improve	How you check the Excellency of the work.	
4	Evaluate	Rank the measuring reading with manual standard size Adjust fault of the Micrometer.	
3	Action and Implement Inspector Check List	Carry out the marking out of the product Change the reading of inside measurement	
2	Design and Plan	Plane the work and arrange marking out tools.	
1	Diagnose and Explore	Test the function of: Micrometer Dial Testing Indicator (DTI) And Vernier caliper	

- **Task 5: Demonstrate a range of Milling and Centre Lathe setting**

To demonstrate a range of Milling and Centre Lathe setting, the action and verbs should reach Higher Level of Psychomotor and Cognitive skills (HLPCS), which gives worker most of machining process and the procedure to demonstrate the practical work with high accuracy. The following action verbs has been used for accuracy purposes:

Assess, rate, value, judge, estimate, rank, calculate, gauge, appraise, size up, analyse, justify. useful, increase productivity or value, more desirable, more excellent, more quality, condition; make better, more desirable, valuable, or excellent state. Endure, artistically surmise, end, close, finish, start, open, begin, extend, commence, bring to end, complete, terminate, round off, protract, effect, settle, bring about, fix, carry out, resolve, clinch, pull off, bring off.

Table 3.14 Course resource of task 5

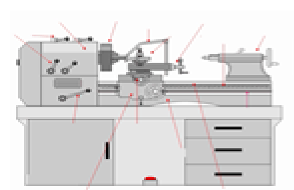
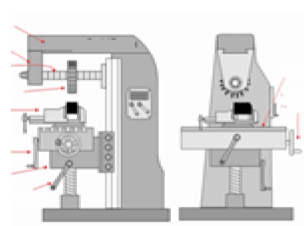
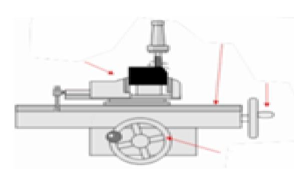
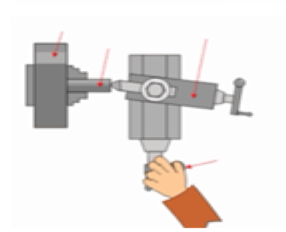
No	Psychomotor and Cognitive Skills	Activities	Proposed Resources
7	Conclude	Gather for final report	
6	Experiencing (Work placement)	Rat your experience during work placement.	
5	Improve	Check The quality of the machine setting and determine the equipment used.	
4	Evaluate	calculate the taper ratio on the center lathe Calculate pitch and diameter for 26 teeth of gear indexing on the milling machine. Estimate manufacturing product cost.	
3	Action and Implement Inspector Check List	Install all the Machine software and the machine parts. Practice setting of the Milling machine gears. Complete taper setting on the center lathe.	
2	Design and Plan	Propos the design of the product Plan the procedure of the machine setting.	
1	Diagnose and Explore	Analyses the working condition of all the machine	

- **Task 6: Demonstrate a Range of Operations on Centre Lathe, Shaping Machine and Milling Machine (Horizontal and Vertical machine)**

In production line of mechanical engineering, the Higher Level of Psychomotor and Cognitive skills (HLPCS) are essential to help management team to work toward the excellent product. Action and verbs need careful selection for purpose of excellent production.

Occurs, screening, conclude, functional, sequencing, routine, experimental, scale, selection, tests, existing variations, comparisons, reviewing, investing, characterizing, profile, implicate, specifying, Make a sketch or drawing, outline, pattern, or plans, structure, artistically, arrangement, plot, conceive, contrive, assign, structure, Assess, rate, value, judge, estimate, rank, calculate, gauge, appraise, size up, analyse, justify. useful, increase productivity or value, more desirable, more excellent, more quality, condition; make better, more desirable, valuable, or excellent state. Endure, artistically surmise, end, close, finish, start, open, begin, extend, commence, bring to end, complete, terminate, round off, protract, effect, settle, bring about, fix, carry out, resolve, clinch, pull off, bring off.

Table 3.15 Course resource of task 6

No	Psychomotor and Cognitive Skills	Activities	Proposed Resources
7	Conclude	Analyses information in team and submit the final report With PowerPoint (presentation)	
6	Experiencing (Work placement)	What is your feeling about work placement at this stage.	
5	Improve	Quality products	
4	Evaluate	Judge end project Estimate product cost	
3	Action and Implement Inspector Check List	Install the cutting tools for all manufacturing machine. Achieve all the operation of manufacturing machine. Coach the project working team Perform the milling machine and centre lathe operation.	
2	Design and Plan	Plane the work on different machine and arrange the Measuring and marking out tools.	
1	Diagnose and Explore	Explore the machine results of early stage of machining	

Automotive and industrial maintenance technology, "How" Engineering students diagnose, dismantle, adjust, demonstrate and repair manual Gearbox/Clutch, and how all components of a facility (tools, equipment's and sequences) can be achieved at practical session and workplace. Manufacturing technology, "How" Engineering Students demonstrate and operate Measuring Instruments, Marking out tools and Use of Machine tools (Centre Lathe, Milling, Shaping and Pedestal Drilling) can be achieved at practical session and workplace. In engineering disciplines, students learn about engineering analysis and design. Students typically experience such complex or abstract aspects that they usually need additional tutorials with illustrative animations, simulations, or further explanations with visualizations (Anderson & Krathohl; 2001).

3.9 Proposed Website

The proposed website, shown in figure 3.12, provides computer assisted instructions which stimulate students towards the subject matter. The power of integrating the new media technologies into the education process is demonstrated. Evidence shows that the students are better motivated, and their achievement is superior to that previously obtained, when more traditional methods of instruction are used for the same course content (Abdulrasool, S. et al., 2007;. S, M Zywno, 2003; Richard E Mayer 2011) (Appendix 1).

Figure 3.12 Proposed Website

In order to show how the proposed website has been integrated into the teaching and learning process at SKI, figures 3.13, 3.14 and 3.15 have been included here that depict the pages from the tutorial package. The pages are included on the proposed website. This information pops-up once a student clicks on a specific task. Figure 7.2 shows the details of dismantling and repairing of an Automotive Clutch. Figure 7.3 depicts various steps included in the dismantling of a Gearbox. Furthermore, figure 7.4 depicts the settings that are used for the operation of a Centre Lathe machine.

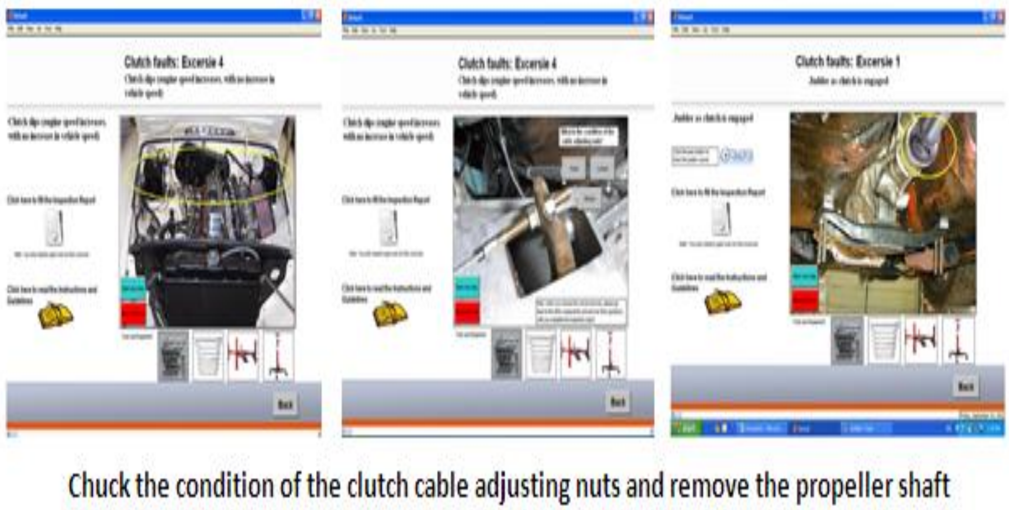
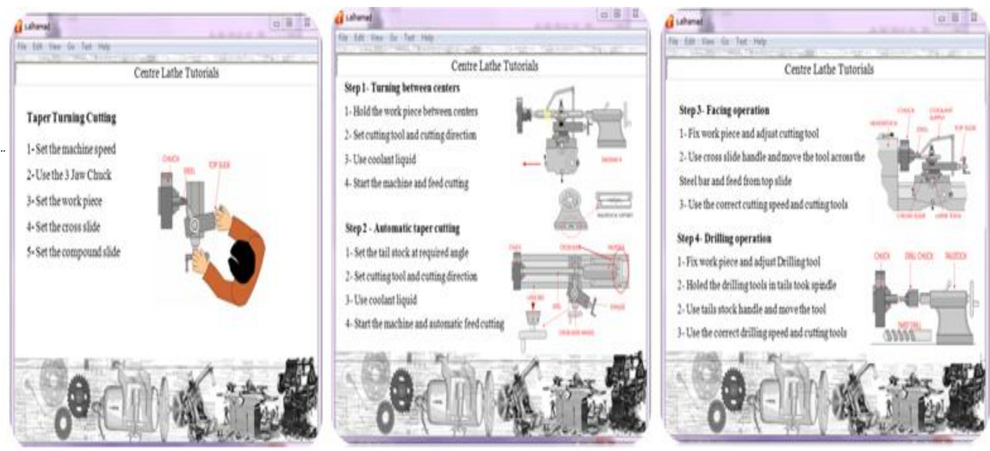


Figure 3.13 Tutorial (video clips, images and animation) and instruction for adjusting nuts and propeller shaft

Figure 3.14 Tutorial (video clips, images and animation) and instruction for gearbox and clutch components



Demonstrate Centre Lathe setting and practicing range of operations

Evaluate and improve manufacturing product practically in the lab

Figure 3.15 Tutorial (video clips, 3D images and animation) and instruction for Centre Lathe

In Automotive, Industrial Maintenance and Manufacturing Engineering, effective teaching (theory and practical) is not possible if only traditional methodologies and tools, like blackboard or slides, are used during the course. However, in AIM where one needs to understand the functions and principles of various machines and processes, which are three dimensional in nature, it is a good practice to show the real world rotations/motion etc. to the students in 3D rather than 2D. This helps students understand the complex phenomena much more easily. Hence, 3D animations/visualisations have been included in the website, as shown in figure 3.15 (Bhavnani, K. et al., 2000). Furthermore, working with programs not only helps to illustrate problems, but also increases student's motivation. Providing students with programs enable them to do their exercises, deepen their understanding of the problems and build up their own settings of diagnose and, design, implementation, evaluation, experiencing and improving their experiencing in real world environmental (evaluation, analyzing and creating) level. In this way learning can be greatly improved. Website was developed with six main pages (Appendix 1).

3.9.1 Structure of the Website

The structure of the proposed website has been described below:

- **Home page**: For username, password and browse name (module, tasks, gallery and contact us) and video snapshot for mechanical engineering
- **Module**: Contents of six tutorial help the students update their understanding before arriving final test (tasks)

- **Tasks**: Six tasks were developed to assess students after they complete required work. It gives opportunity to the student in case they fail to pass the task first time. At the end, the evidence records were printed

- **Gallery**: Store all the photos or snapshots for both teacher and students

- **Contact us**: Author's details

3.9.2 Use of the website

Figure 3.16 depicts the use of the proposed website from the teaching and learning prospective. It can be seen that the teacher/instructor gives commands within the website, at both lower and higher order of cognitive and psychomotor skills. These instructions are then processed to the students at the user-end. After processing this information, the student applies it for practical purposes (Cot, A 2004)

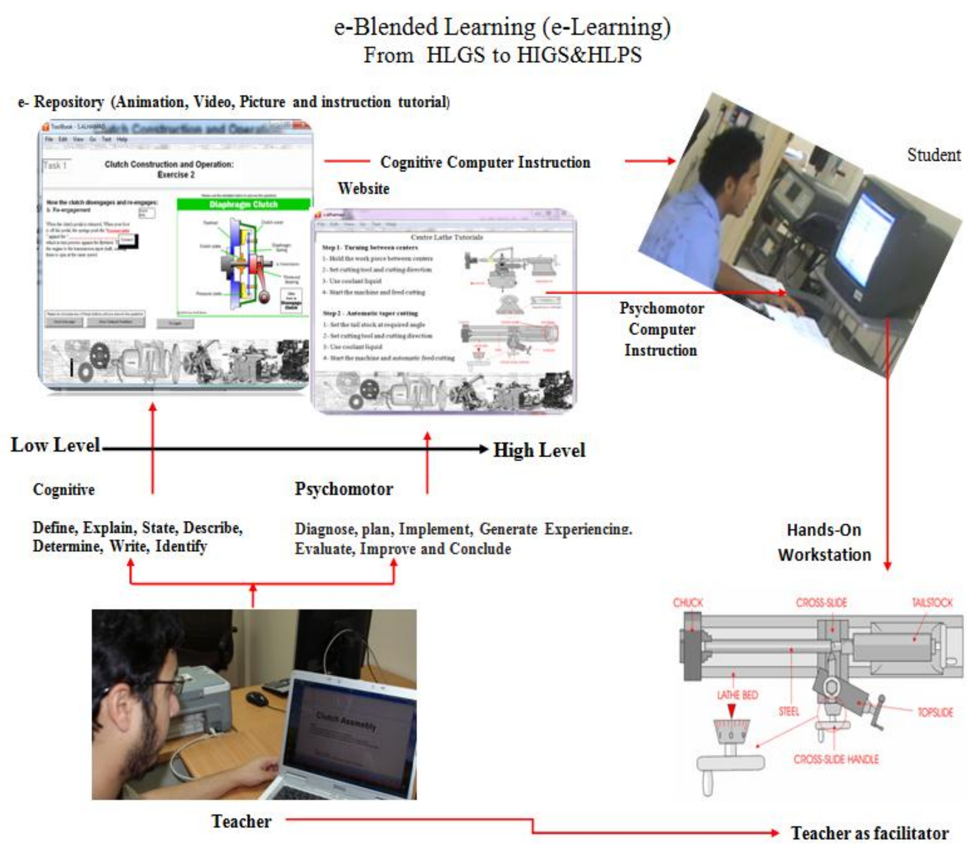
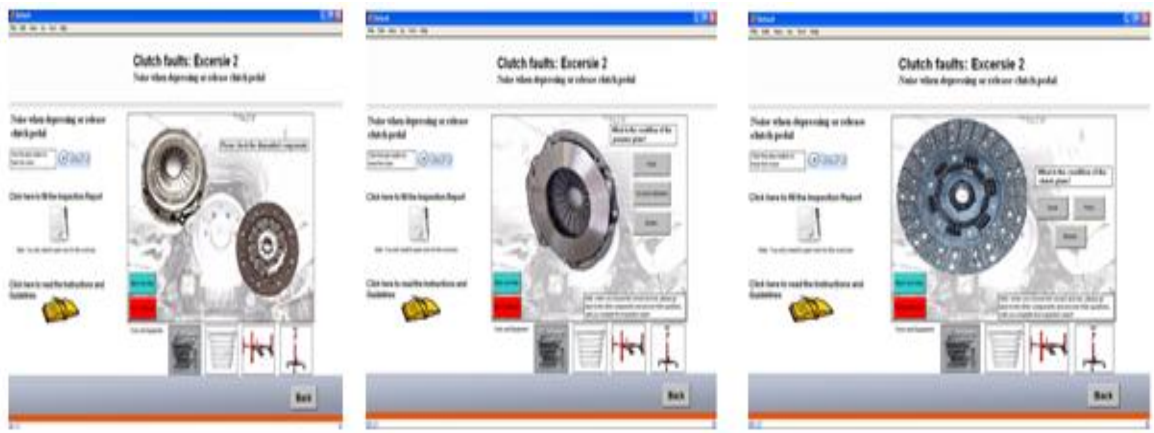


Figure 3.16 e-blended and e-learning from Lower to Higher level of Cognitive and Psychomotor Skills

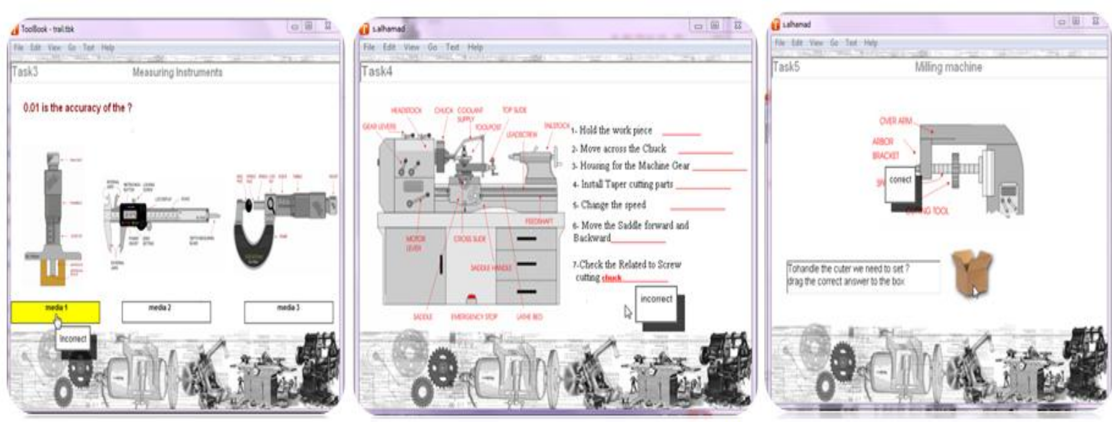
3.9.3 Student's assessment using the website

After going through the learning material for a particular subject (e.g. pressure plate, cultch plate, centre lathe and milling machine operation), students are prompted to answer questions that tests their ability. These tests are scored to make sure students understand the material before going further in the subsequent tasks. Figure 3.17 is an example of the tests for clutch, and figure 3.18 for centre lathe and milling machine.



Check the condition of the dismantled components (Pressure plate and clutch plate) and replace

Figure 3.17 Students assessment and the results (clutch components)



Tests in Measuring instruments, Centre lathe Operation and Milling operating procedure

Figure 3.18 Students assessment and the results (Measuring Instrument, Centre Lathe and Milling Machine)

These tests are scored to make sure students understand the materials before going further in the subsequent tasks. The tests scores and assessment results are reported to provide students with recommendations on what materials should be reviewed for deeper understanding. Figure 3.19 shows a typical assessment report (Appendix 1 and 4)

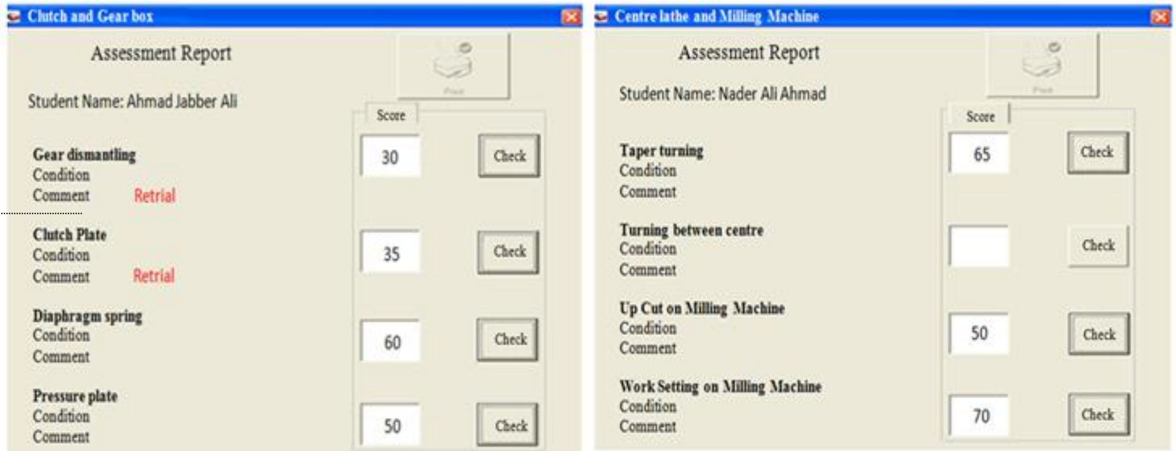


Figure 3.19 Student assessment reports (Gear box, Clutch, Centre Lathe and Milling Machine)

3.9.4 Expert Evaluation of the Prototype e-blended Tutorial

The expert evaluation has been carried out by informal discussions between the information computer technology experts (Cot, A 2004). The following aspects were targeted accordingly to Nielsen heuristics (Richard E. Mayer, 2011; Abdulrasool et al, 2010):

1. **Visibility of system status:** the user knows what is going on through appropriate feedback

2. **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

3. **User control and freedom:** the package support undo, redo and has "emergency exits"

4. **Error prevention:** the package checks for error-prone conditions and present users with a confirmation option before they commit to the action

5. **Flexibility and efficiency of use:** the product can cater to both inexperienced and experienced users

6. **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

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

d. The background colour for the tutorial was changed to white for ease of reading

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

f. Website instruction was made clear and username/password was offered

g. Easy to assess the student's knowledge

h. Tutorial material was clear and easy to use

The developed tutorial package was tested on students and lecturers presenting the topics and their opinions were expressed by answering questionnaires. The quantitative and qualitative analysis of the results is presented in Chapter 5.

3.10 Summary

The design and development of the teaching/learning material at high level of thinking skills has been presented in this chapter. High level of Psychomotor domain model has been proposed besides high level of Cognitive domain (analyze evaluate and create), for the practical sessions. The main aim of this proposed module was to ensure that SKI students receive the necessary training required by labour market. The chapter described design of subject outcomes and learning outcomes with the learning material and tasks.

The chapter described the stages of the design for e-blended and e-learning tutorial incorporated in the proposed domains of psychomotor and cognitive skills module: tutorial package, structure and representation, knowledge and communication analysis, interface and navigation design. Furthermore, the chapter discusses the design of proposed website and how it can be linked with the classroom and lab work. The chapter contains the explanations of the six tasks which have been included in the proposed tutorial module. The design of learning activities and modes of delivery took into consideration the teaching and learning styles and the development of students' cognitive and psychomotor skills have been discussed. The proposed outcomes of e-blended module are expected to make a major contribution to the improvement of SKI system because it challenges the students and teachers to fit for the purpose. The next chapter presents the expert evaluation, the teaching/learning methodology, experimental group's, data collection, data analyses and user evaluation of the proposed module.

CHAPTER 4
IMPLEMENTATION AND USER EVALUATION

4.1 Introduction

This chapter describes the process for implementation and evaluation of teaching/learning methods. The effectiveness of teaching methods are determined by questionnaires (data collection methods) completed by lecturers and students. Their answers have been analysed from quantitative and qualitative points of view. The implemented teaching/learning method was operational in year 2011. The main theme of these teaching learning methods is the pedagogical underpinning in a novel Blended Learning system, as highlighted in the Chapter 3. This theme is influenced by general questions of this research and the following questions in particular: How is pedagogy affected by using e- learning (blended learning) at high level of thinking skill in programme delivery?

The students learned various skills through study of mechanical engineering modules and approached the learning tasks differently. In the theoretical subject (classroom-based), focus was on the cognitive domain (recall information, comprehend information, apply information, analyse, evaluate and create). The last three elements were used as higher level of cognitive skills (Billett, S. 2008). In the practical tasks, the author used psychomotor domain skills for the purpose of this research (diagnose, plan, implement, evaluate, improve experience and conclude). These two domains have been used to plan, deliver and assess teaching/learning effectiveness for different groups of students exposed to different T & L methods (Abdulrasool, S, Mishra, R, Khalaf, H 2010).

4.2 Selection of the Three Experimental groups of Students and Lecturers

Table 4.1 shows that 45 students and 30 teachers were selected from the three mechanical engineering specialisations i.e. Automotive, Industrial Maintenance and Manufacturing Engineering. The students and the teachers have then been divided into three separate groups. Each group consists of 15 students and 10 teachers, where the students have almost similar abilities.

Table 4.1 Characteristics of the three groups of students

	Group 1	Group 2	Group 3	Teachers
Automotive	5	5	5	10
Industrial maintenance	5	5	5	10
Manufacturing	5	5	5	10
Total	15	15	15	30

The three groups of students that were formed were taught using different teaching methods. The details of these methods are:

- **First Method**

Group 1: Demonstration under the watchful eyes of the instructor (Teacher Centred, Interactive Dependent)

Teachers in this group serve as the centre of knowledge in both theory and practical sessions, and are primarily responsible for directing the learning process. During assessment phase (student's participation and demonstrations), teachers were focused almost exclusively on what had the students learned. Students were viewed as empty vessels, whereas the teacher imparts learning into these vessels within a given time period. Furthermore, learning was viewed as additive process (Mei-Y L, et al., 2008).

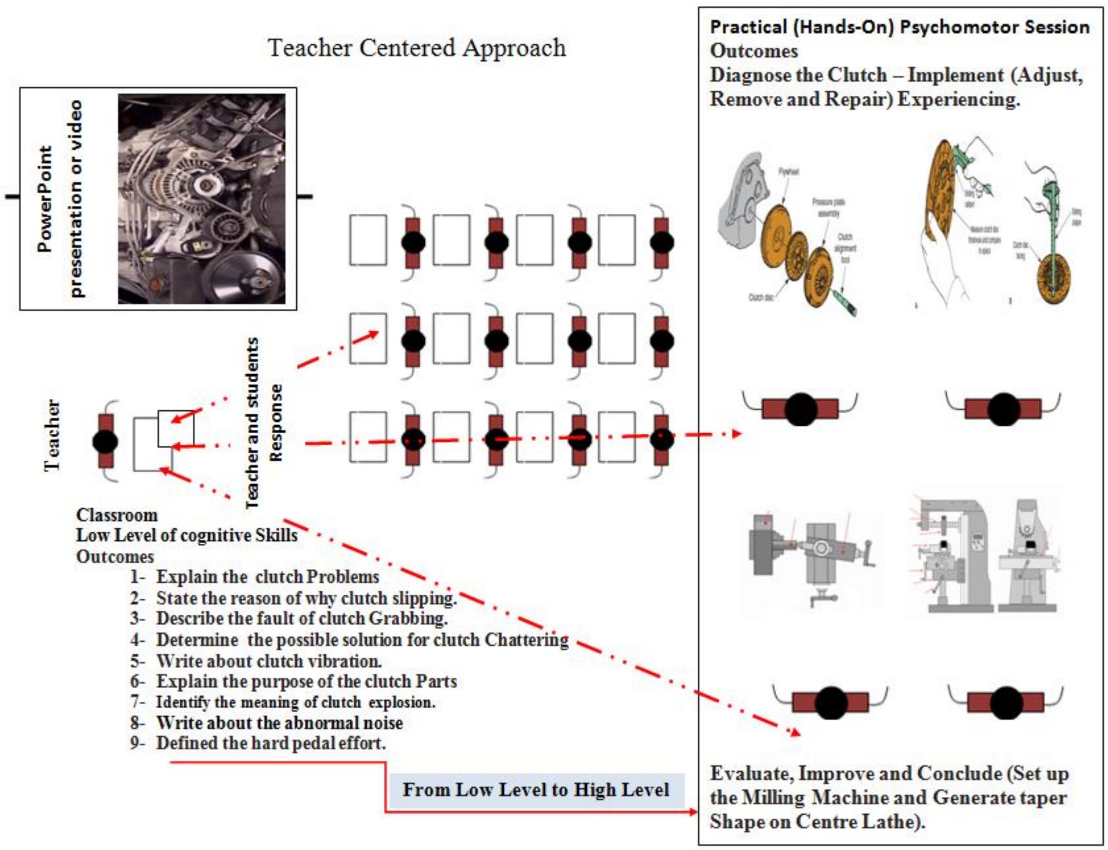


Figure 4.1 Teacher-Centered Approach

In figure 4.1, the lecturer explains various tasks that require low level cognitive skills of factual information on routine procedures, which include definition of engine parts, dismantling procedure and detailed description of manufacturing process. The lecturer then shows students, how the skills learned in the classroom can be used in practice by practical demonstrations of the procedures on an actual car engine (Clutch, Gearbox and manufacturing machines) with power point presentation and video clips. Then students are encouraged to repeat these procedures in their own time without any support (Roger and Jack, 2004; Bourne, Brodersen, Daw, 2000; Emory).

The lecturer uses a projector in order to give theoretical background of the Automotive, Industrial Maintenance and Manufacturing Engineering subjects. The lecturer also explains the standards and describes other relevant activities. The resources available to students to practice what they had learned in theory classes are manuals, exercise books, access to video clips, power point presentations of lecturer and workstations (labs) equipped with all the tools and machinery (Teo, Chang, et al., 2006). The lecturer supervises students continuously during these lecturer-centred sessions in the classroom and workshop (hands-on), assuming that each student is progressing to high level of thinking skills at the same rate.

Anderson & Krathohl; 2001 and Razzqaly 2008 mentioned that in teacher-centered approach, teachers focused on the students with average abilities, and each student is forced to progress at the same rate. Assessments are carried out in form of traditional exams.

- **Second Method**

Group 2: Students learn using computers and the teacher facilitates the process (Student Centred, Interactive Independent).

In this method, students were considered as knowledgeable and they can bring about engagement and personal responsibility in learning (Felder. N, et al 2002). This supports the idea of knowledge construction by learners through their use of prior knowledge and experience, which assists them to shape meaning and acquire new knowledge. The mechanical engineering teachers, during their preparation, observed that in constructive learning students participated in class and they may have a wide range of previous learning experiences, which enable teachers to select teaching/learning methods at higher level of skills for optimal learning (Watters, D. J and J. Watters 2007).

Mehmet (2010) and Oates (2006) further stated that effective learning occurs when learners can create meaning by linking new information to what they already know. Lecturers explored student's learning ability by involving them in tutorial package with support from other softwares (wikipedia 2009, Toolbook, animation multimedia and video clips) like intranet and websites to describe Automotive, Industrial Maintenance and Manufacturing applications. The students can follow the suggested procedures in order to demonstrate and practice most of the mechanical maintenance and the production procedures at high level of thinking skills with the help of updated computer technology (see figure 4.2).

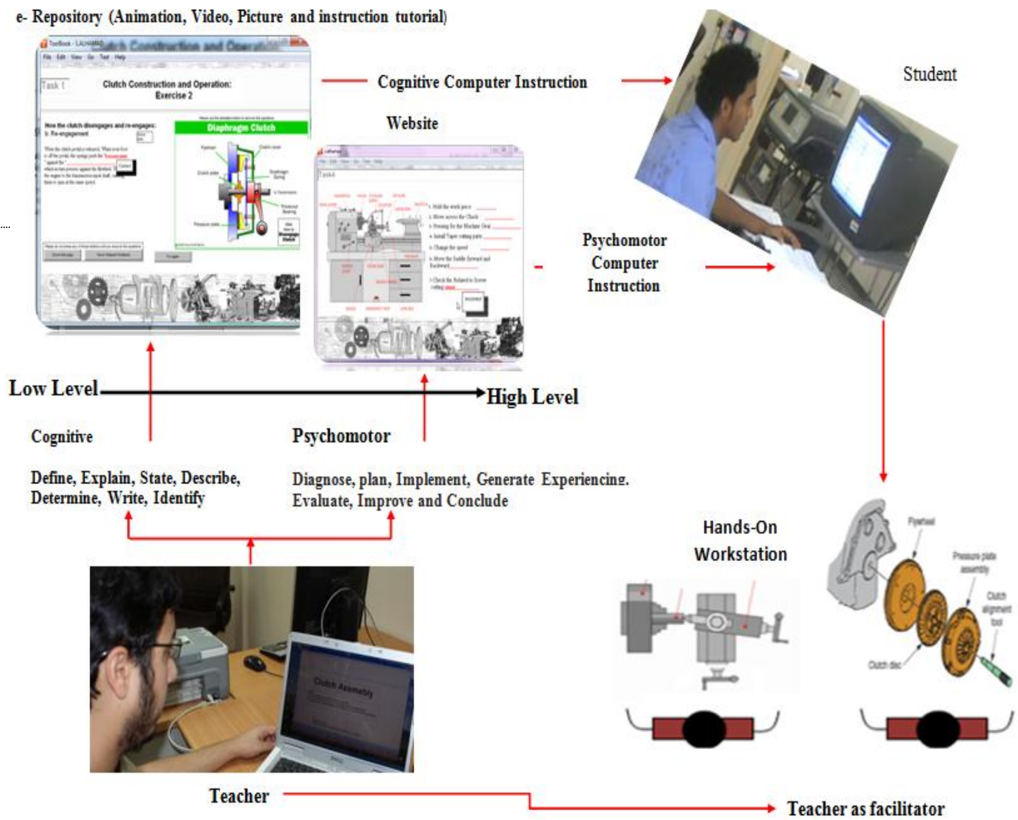


Figure 4.2 Student-Centered Approach

The lecturer delivers the lecture with the use of computer instruction materials, with help of SKI interface, which was linked with workstation computers as institute's network (intranet). It is different from teacher-centered approach in the sense that it is not face-to-face learning process. The students are given computer instructions, embedded with tutorial software, in case they need to practice (Watters, D. J and J. Watters 2007). The computer software describes the procedures step by step and in a dynamic manner to preform required skills at high level of thinking skills, in both classroom and the lab (workstation). Various activities and tasks are included to explain, for example, the clutch problems, state the reason of why clutch slips, describe the fault of clutch grabbing, determine the possible solution for clutch chattering, write about clutch vibrations, explain the purpose of the clutch parts, identify the meaning of clutch explosion, write about the abnormal noise and define the hard pedal effort at low level of cognitive skills. It also covers diagnosing the clutch: implement (adjust, remove and repair) experience, evaluate, improve and conclude (set up the Milling Machine and generate taper shape on Centre Lathe) etc.

A software package has been used to adapt mechanical engineering subject's content and convert it into tutorial package. Each computer used by students is connected to institute's network (Richard E, 2011). Therefore, the students use the lab facilities offered, to gain required experience and demonstrate all the practical procedures applied to real machines, tools, measurements instruments and mechanical equipment.

Furthermore, the students are provided with computer user name and password so that they can use subject e-Repository any time and simulate models of these procedures, which can be used whenever they want (Toogood and Zeeher, 2004; Abdulrasool et al, 2005).

- **Third Method**

Group 3: Project Base Group, work with and without supervision (Interactive)

In this collaborative-interactive approach, as shown in figure 4.3, the lecturer provides computer tutorials including videos and animations, which show the students how to use tutorial instructions in order to warm-up to the lecture with the use of tutorial tasks and questions (Mumcu, F.K. & Usluel, Y.K. 2010; Richard E, 2011). The lecturer intends to use two ways of communication between the teacher and the students, combined with active learning to increases understanding. The method was established in cooperative environment where students work together. It allows learning to continue after the class session. Students teach each other. The most effective way to learn is to actually teach, because this requires the highest degree of mental processing (high level of thinking skills) and greatly increases the likelihood that long-term memories will be produced. The tutorial was provided with motivational animations to stimulate team work, and it has a greater likelihood of being incorporated into long-term memory (Mumcu, F.K. & Usluel, Y.K. 2010; Richard E, 2011).

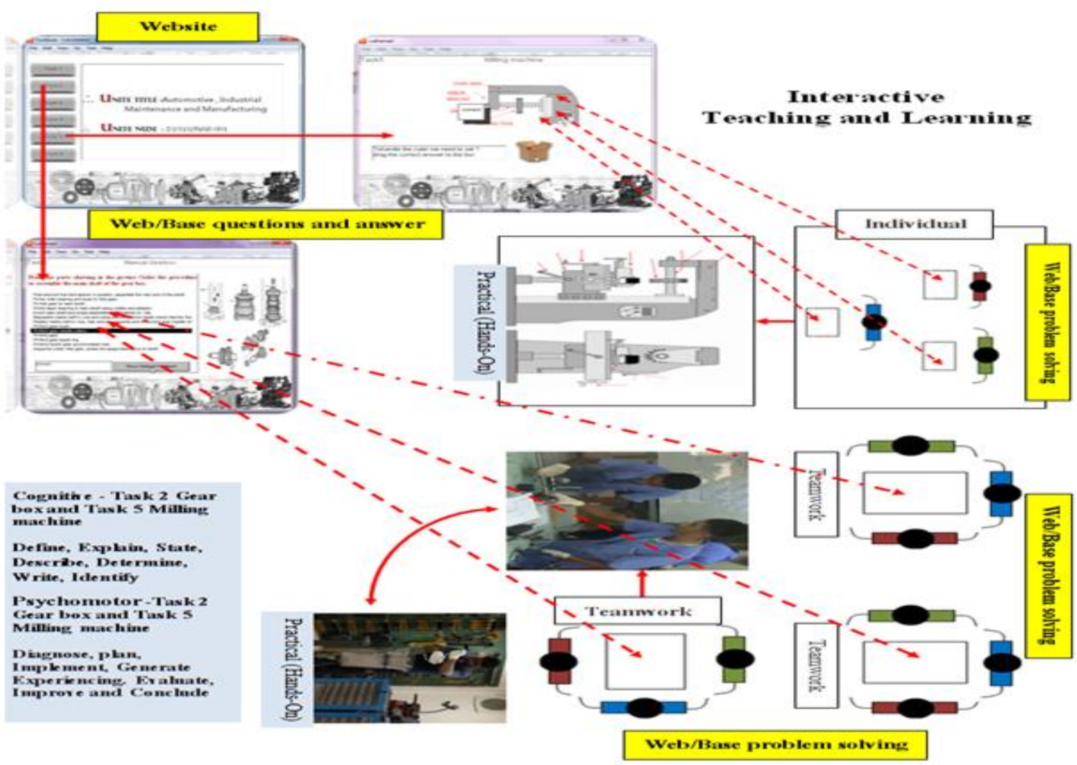


Figure 4.3 Interactive teaching and learning

The tutorial was provided with animations regarding explanation of the clutch problems, clutch slipping, fault of clutch grabbing, possible solution for clutch chattering, clutch vibrations, clutch explosion, abnormal noise and hard pedal effort (Watters, D. J and J. Watters 2007). The tasks were given at low level of cognitive skills. The tutorials covered high level of thinking skills in the same way for diagnosing the Clutch: Implement (Adjust, Remove and Repair) Experience, Evaluate, Improve and Conclude (Set up the Milling Machine and Generate taper Shape on Centre Lathe).

At the end of session, students were asked to study in their own time (unsupervised study), and they have to solve exercises which were assessed by the lecturers on the basis of a checklist (Appendix 4). Students have the opportunity to switch between all the tasks by using website pages, tutorial package and other multimedia offered through website gallery and other programme (Mumcu, F.K. & Usluel, Y.K. 2010). Students discuss the subject matter with each other. Collaborative learning taking place was the aim of the lecturer. The students are given supervised demonstrations of application of mechanical engineering subjects (AIM) so that the regulations for health and safety are fulfilled (Abdulrasool et al, 2005).

4.3 The Learning Environment

The important role that educationalists can create effective teaching and learning provisions is by providing favourable learning environment. Mumcu, F.K. & Usluel, Y.K. (2010) illustrate the roles and functions that educationalists adopt within teaching/learning, often facing quite different circumstances and examines how these roles support teachers in their work. Retaining and developing effective learning is a priority in all teaching/learning systems (Watters, D. J and J. Watters 2007). The three teaching/learning methods were examined for their usefulness in teaching/learning methodology. Table 4.2 shows teaching/learning environment for three methods of teaching and learning implemented at SKI.

Table 4.2 Learning Environment

No	Items	Teacher Centred Approach	Student Centre Approach	Interactive Teaching and learning	References
1	Encouragement	Discipline-specific oral information as the main focus of the teaching-learning encounters. Lower order thinking skills -summative assessment based Memorisation of	Interdisciplinary knowledge Encourage students at higher order thinking and information skills, e.g. problem-solving, and communication of knowledge	Lower order thinking skills (summative assessment based) with little attention to the higher level of thinking skills	Hussein, S 2005

		abstract and isolated facts, figures and formulas			
2	Teaching strategies	Group-paced, designed for the 'average' student Information organised and presented primarily by teacher	Student is given direct access to multiple sources of information (e.g. books, online tutorial) and helped to solve a problem/task by making principled and informed use of these resources	Supervise un supervise in the lab Individual and group work Established cooperation group Students teach each other	Hussein, S 2005
3	The teacher	Organises and presents information to groups of students Acts as gatekeeper of knowledge, controlling students' access to information Directs learning	Acts as facilitator, helps students access and process information	Acts as facilitator; helps student's access and process information. Controlling student's access	Hughes, G. 2007
4	The student	Passive recipient of information? Simply reconstructs knowledge and information, without necessarily understanding it	Tasks responsibility for learning Is an active knowledge seeker	Tasks responsibility for learning Is an active knowledge seeker Teach others Leading group	Hughes, G. 2007
5	Learning environment	Students sit in rows. Information is presented via lectures, books and films and, increasingly, via media like Power Point (which often encourages a bullet-point, superficial approach to learning)	Students work at stations with access to multiple e- resources Students work individually at times but often also need to collaborate in small groups	Students work individually and collaborate in small groups, and large group under the teacher's supervision. in the workshop	Howard, J 2007

4.4 Assessment Delivery Procedure

The assessment procedure shown in figure 4.4 depicts the strategy used to evaluate student's performance in different teaching/learning methods applied. It is essential that a variety of approaches are used throughout the year. Each learning activity was assessed in a different way, and it is part of the teacher's role to identify the most appropriate and helpful method for assessment. This procedure was guideline for the lecturers (MOE in Bahrain and SQA, 2009).

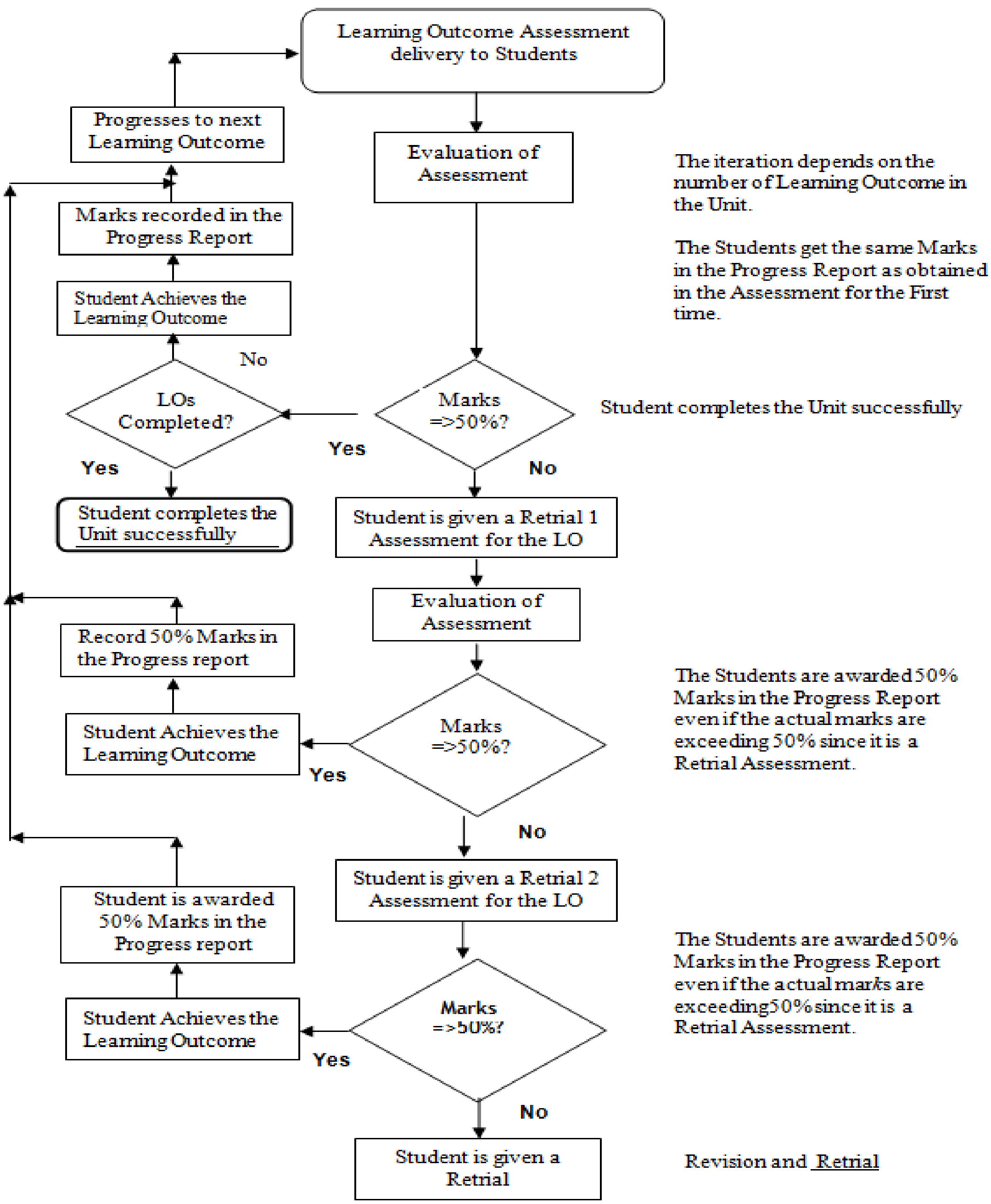


Figure 4.4 Assessment delivery procedures

Several assessments were used for teaching/learning to determine the students' performance level in both Cognitive and Psychomotor skills, in each outcome and task, as following:

- **Regular Practical Work:** Computer simulations, exercises, laboratory works, problems solving and reflective learning statements

Value

- Keeps students on task
- Encourages students early rather than later
- Formative in nature as there are opportunities for students and teachers to make adjustments
- Can encourage application, translation and interpretation of concepts learnt

- **Final Exams**

Value

Assurance that students have attained the appropriate knowledge, skills and dispositions

- **Essays and assignments**

Value

- Opportunity to develop an extended argument
- Can achieve depth rather than breadth of learning
- Opportunity to develop capacity to interpret, translate, apply critique and evaluate.
- Opportunity to problem pose and conduct inquiry
- Opportunity to explore the boundaries of what is known

- **Field reports**

Value

- Develops observation and recording skills
- Requires organization skill

- **Group Work**

Value
• Communication of ideas • Encourages independence • Collaboration and co-operation • Opportunity for authentic skill development

- **Portfolios (Evidence File):**Collection of student work with inclusions carefully selected and justified

Value
• Can be used to demonstrate progress towards, and achievement of, topic or course objectives • understanding of complexity of professional roles • synthesis of what students have learnt in a number of topics • capacity to use new understandings in novel ways in unpredictable work contexts • Valid and authentic assessment as they can include real world tasks • Focus on higher order thinking • Students have to accept a high degree of responsibility so it

- **Projects**

Value
• Final project and Real world tasks (Work placement)

4.5 Validity

In order to facilitate analysis, at all stages, data collection was conducted using invited participants. Video recordings of groups have been made for 15 sessions (one term). The camera focused on individual students to record interactions and activities as well as finer elements, such as reactions. The same have been repeated for practical tasks (hands-on) in the lab (workstation). The video camera did not focus on the computer screens, but faced the students and monitored the lecturer’s physical movements and inter-groups dynamics. The 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 (Tang H, and Hung K 2009). These video recordings were automatically stored in text files. This helps in modifying the tutorial package.

Risks were minimized by informing the participants about the detail of the study, and giving them an opportunity to ask questions in relation to the study; asking them to sign consent form and assuring them that the data would not be disclosed outside the group. All information collected during the study was stored at SKI, and access was limited to the author, principal and associate investigators. All participants were informed that they were free to withdraw from the study at any time. However, no one withdrew. The effectiveness of the three T & L methods is evaluated by questionnaires which have been completed by lecturers and students. The data collection methods, questionnaire design, implementation and result's analysis are presented in the following sections.

4.6 Questionnaires

For the purpose of evaluation of the three groups with different T & L methodologies applied, questionnaires have been design and developed that can help in evaluating the effectiveness of these methodologies. On the basis of the results of the questionnaires, one can identify which teaching and learning methodology is best suited for SKI. Chen and Manion (2000) stated the classification of the enquiries in terms of their purpose and research strategy. The purpose of classification is to distinguish between the principles and techniques necessary to gain data analysis. It covers the main issues of the preparation of the work, providing information to clarify the main objective and purpose of the enquiry.

The following research questions were considered when designing the questionnaires:

1. What is the teaching/learning methodology from lecturer's and student's point of view?

2. What are the student's views about teaching and learning methods of mechanical engineering subject?

3. What are the student's opinions about teaching of mechanical engineering subject?

4. What are the student's attitudes towards teaching/learning methodology of mechanical engineering subject?

5. What are the lecturer's views about classroom management and organisation?

6. What are the lecturer's views about assessment?

7. What are the lecturer's attitudes towards mechanical subject?

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; Litoselliti 2003).
- 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 lecturers' questionnaires were designed to find out lecturers' opinions about the following aspects of educational process (Appendix 2 and 3):

a) Planning and organising the teaching session

b) Presentation of the instructional material

c) Management of students within the classroom

d) Assessment of students' performance

e) Lecturers' perception of T & L methods

The students' questionnaires intend to ascertain how well the mechanical engineering subject tasks meet the stated learning outcomes, and to identify the main strengths and weaknesses of various T & L methods. Furthermore, it is intended to improve students' learning experience by increasing the student involvement in education process. Hence, the questions referred to the following topics:

- Student's attitudes towards learning mechanical engineering subjects
- Student's opinions about their lecturers' approaches to teaching process
- Student's opinions and views about various aspects of T & L mechanical engineering subject such as planning and organising, presentation of course material, classroom management, assessment of student's performance and feedback strategy, students' interaction and enjoyment

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 mechanical engineering subjects in the previous years

The present study was not carried out for the whole population of mechanical engineering students at SKI 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.

4.6.1 Lecturer's Questionnaires

The objective is to find out the lecturer's awareness of the teaching experience, while teaching mechanical topics, and the effectiveness of the three T & L methods. Previous studies (Bhavnani, K. et al., 2000; Dye, R.C.F. 2003), suggest that part of the problem in mechanical engineering subject is use of unsuitable teaching methods which affect student's achievement. With the aid of this questionnaire, an attempt has been made to understand lecturer's experience of the T & L process.

Many lecturers involved in this program were engineering lecturers from Mechanical

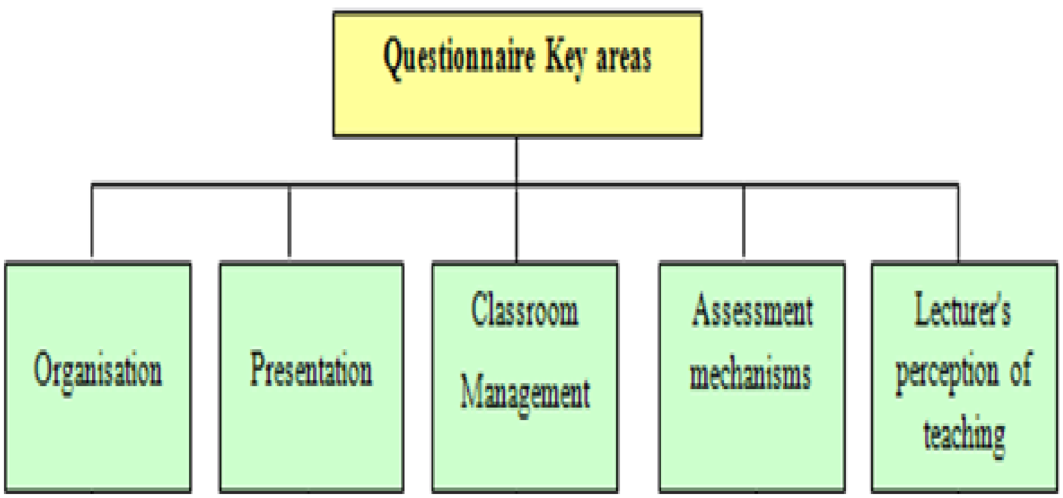


Figure 4.5 Key areas for Lectures' questionnaire

Engineering with background of Information Communication Technology (ICT) and had a background of lecturing experience with learning technologies. Some lecturers have taught using websites to communicate information, and have supported students via email and other technologies. Although the majority of lecturing staff had been lecturing for several years, there was still a wide diversity of experience, from junior colleagues who joined in the last five years to others who were nearing retirement. Overall, 30 members of lecturing staff participated in the questionnaires. The questions were divided into five categories (figure 4.5) (Appendix 2 and 3).

4.6.2 Student's Questionnaires

The aim is to find out the learning experience of students in the mechanical 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 mechanical engineering. The questionnaires have been devised to understand the mechanics of the learning process from student's perspective. Previous studies (Bhavnani, K. Suresh And John, E. Bonnie, 2000; Dye, R.C.F. 2003) suggests that a part of the problem in mechanical engineering subject area is the use of inappropriate T & L methods which affects students' achievement. Through this student's questionnaire, it will be attempted to obtain student's views and opinions about teaching and learning process. A number of categories will be 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. Various categories used in the questionnaire have been shown in the figure 4.6 (Appendix 2 and 3)

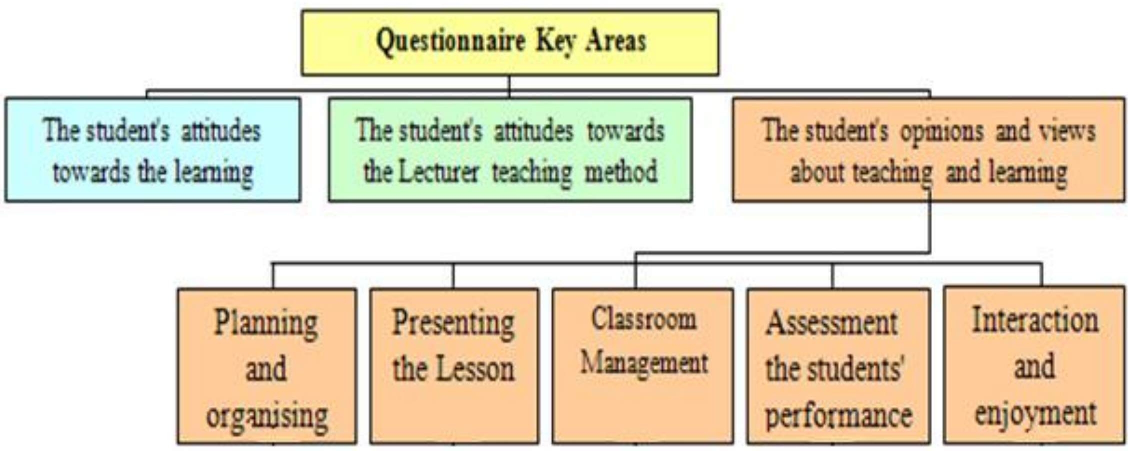


Figure 4.6 Key areas for students' questionnaire

This descriptive method of collecting data (Litoselliti 2003), facilitated the exploration of teaching/learning practices in engineering classrooms and labs. Survey questionnaires were administered to both teachers and learners, following the classroom and lab observations; they required approximately thirty minutes to complete. The piloting of survey questionnaires in three mechanical areas at SKI assisted in effecting modifications. It was used in order to elicit the required information (M, R Felder. R.M. A, B. Soloman.2001). The survey questionnaires revealed patterns of teachers' and learners' perceptions about classroom and lab practices. Two survey questionnaires were designed; one for teachers and one for students, to survey participants about their responses to the research questions (Appendix 2).

The questionnaires intend to examine the effectiveness of the three T & L methods versus the learning objectives for AIM subjects outcomes and tasks. The changes carried out in the T & L strategy (methods 2 and 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). Methods 2 and 3 are based on shifting the emphasis from lecturer-centered to interactive student-centered learning, by including computer tutorials and websites that encourage learning through problem solving, discovery, teamwork and enquiry. Hence, the student-centered learning approach, with interactive learning and teaching enables the development of cognitive and psychomotor skills (such as learning how to learn, understand, evaluate and use knowledge, and continuous improvement of diagnosis, planning, implementation, evaluation, improved experience and conclusions). This aspect was considered when formulating the questions, addressed to lecturers and students.

4.7 Data Considerations

4.7.1 Data Type

Research presented in this section is qualitative in nature. The reasonable roots of action research imply the use of participant observation as at least one of the data sources. However, observation can be of different types: it can be non-numeric, for example, providing descriptions of human behavior; or numeric for example, providing the number of occurrences of certain events. This leads to the basic differentiation between qualitative and quantitative data. The latter is primarily concerned with numbers and the former with words (Miles and Huberman 1994).

A more elaborate differentiation between qualitative and quantitative data can be made in relation to their utilization in a research method (Felder and Soloman 2001). This has been done in the form of a table which compares qualitative and quantitative data in the context of research characteristics and relates this to the imperatives of the current research (table 4.2). Data type considerations for the given research have been adapted after (Siegel and Dray 2003). Additions are italicized. As summarised in the table, there are a number of characteristics that are associated with the data types. Overall, it appears that the characteristics of qualitative data align more with the current research. Consequently, while numeric data is thought useful for descriptive goal, such as the number of students on the course and the number of interviews held, it is not perceived as being as important as is, for example, the comments of individuals.

Table 4.3 Data type considerations for the given research adapted after Siegel and Dray (2003)

Quantitative versus Qualitative			
	Quantitative	Qualitative	This research
Method, design	Predetermined	Ad hoc, opportunistic	Ad hoc, opportunistic with limited level of predomination

Sampling	Large, representative, Random	Small, strategic	Small only one program over two years is examined
Data analysis	Standardized measures allow efficient data reduction Facilitates combining and comparing across cases	Volume of raw data overwhelming, often of unclear pertinence Data reduction not straightforward Data not standardized across cases	Interpretive data analysis, drawing on participants' Beliefs.
Evaluation of quality	Standards of quality exist, looks objective, degree of support for inferences open to scrutiny	Inferences can seem to come from "invisible" intuitions, hard to assess quality	Quality is based on participants' interpretation and related academic publications
Focus	Questions should be specified in advance based on theory Must be narrowed, sometimes ridiculously, to isolate variables, or it takes "black box" approach	Open to possibility you don't know the right questions to ask in advance Broad, holistic, explanatory, tries to grasp complex interactions of Factors	Exploratory with some emphasis on actions being investigated in particular research cycle.
Aimed at	Understanding "What?" Numerical Abstractions Characterizing the population	Understanding "How and why?" Realistic representations Characterizing the "Design Space"	Research questions are focusing on understanding of "How?"
Values	Statistical validity	Practical implications	Pragmatist emphasis on theory supported by practice

4.7.2 Data Analysis

Quantitative data analysis for student's responses has been divided into three key areas that are:

- Student's attitudes towards learning mechanical subjects

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

The author analysed 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 facts (Prince and Felder 2006). The students' and lecturers' answers were ranked according to the following likert 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), the negative responses (disagree) and the third category i.e. undecided.

4.7.3 Observations

When collecting data in action research, participant observation is essential. In action research, the emphasis is more on what practitioners do than on what they say they do (Avison, Lau et al. 1999). Action research has an explicit need for participant observation (Baskerville and Myers 2004), and a number of different data sources can be used to capture this. There are generally two types of observations; 'covert' and 'overt' (Oates 2006). In the former, the people being observed are not aware that this is happening; in the latter, they know that the researcher is watching what they do. Observations, whether covert or overt, are based on a researcher's impression of the situation drawing on their senses such as hearing and seeing.

The previous discussions of bias in action research extend their applicability to the bias in the observations. The two distinct sources of bias are 1) the effects of the researcher on the case and b) the effects of the case on the researcher (Mayes, T. 2007). It is acknowledged that field study researchers are less likely to be in danger of the earlier bias i.e. 1), since they spend enough time to blend in with the research setting. However, this increases the possibilities of bias in 2), where the research settings can absorb the researcher and make him/her less likely to question the taken-for-granted issues (Ibid). There are number of ways in which these biases can be managed and one of these is the triangulation. The essence of triangulation is that the researcher relies on independent measures to evaluate one situation (Miles and Huberman 1994). Triangulation can be on several levels, including one where different data sources are used (Anfara, Brown et al. 2002). Therefore in addition to the observations, which are essential in action research, the current work draws on focus groups, interviews and other documentary sources. In this way, significant help is obtained for better learning.

4.8 Evaluation of Lecturer's Questionnaires

The aim is to find out the lecturer's perception of the teaching experience while teaching mechanical topics, and the effectiveness of the three T & L methods. Previous studies (Bhavnani, Suresh, Bonnie.2000***;*** Dye, 2003; Gall, and James 2002; Borg, and (Peter 2004), suggests that a part of the problem in mechanical 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 (table 4.4) (Appendix 2 and 3).

Table 4.4 Evaluation of lectures' questionnaire

Lecturers Questionnaires		
No.	Key areas	Statements
1	Organisation	1, 3, 7, 14, 18
2	Presentation	4, 5, 6, 8, 9, 10, 11, 16, 21, 28, 29, 52, 53, 63
3	Classroom Management	12, 13, 15, 19, 22, 30, 33, 34, 35, 36, 37, 38, 61, 62, 64, 65
4	Assessment mechanisms	17, 20, 24, 26, 27, 39, 40, 41, 42, 43, 44, 45, 46, 47, 59
5	Lecturer's perception of teaching	2, 23, 25, 31, 32, 51, 54, 55, 56, 57, 58, 60, 66

- **Planning and organising the teaching session**

Only 20% of the lecturers, teaching group 3, had their own techniques to prepare their lessons. Hence, the rest were 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 teacher centred approach) were using lecturer's guide because this method does not require the developed tutorial in teaching; they also found power point and white board adequate. It is difficult to explain various tasks involved in psychomotor skills with mechanical 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 will use examples to explain lessons.

- **Delivering the instructional material**

90% of the lecturers for group 2 and group 3 used tutorial package, visual aids and websites for assessment as a normal part of their repertoire; whereas only 50% of the lecturers for group 1 did this. The lecturers were asked earlier in the current research if they had adequate teaching aids at institute like TV, video, computer and handouts. 90% 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 complex parts of the machine during diagnosis level because the traditional T & L method is not the most suitable one for teaching at high level of cognitive and psychomotor skills. However, 40% of lecturers for group 2 and 30% of lecturers for group 3 had fewer difficulties in presenting the subject because the computer technology helped them to explain the selected tasks for this research with ease. 80% of lecturers for group 1 agreed that the students find it difficult to see the relevance of what they learn in mechanical modules because it is difficult to make the connection between theory and practical applications with traditional T & L approach (teacher centred). Only 50% of lecturers for group 2 and 30% of lecturers for group 3 had the same problem i.e. combining the teaching with simulations.

- **Management of students within the classroom**

40% of lecturers for group 1 agreed that group learning is an effective method but students have limited access in choosing activities in the teacher-centred approach. 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 communication between students and give them opportunity to work in a team. 100% of lecturers for group 1 found it difficult to encourage the students in order 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 tutorial package, animation and computer assisted interaction. 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 tutorial and 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.

- **Assessment of students' performance**

100% of lecturers for group 1 reinforced the transmitted knowledge by asking relevant questions at the end of sessions with the use of traditional power point. 100% of lecturers for group 2 and 90% of lecturers for group 3 were doing the same thing because the extensive use of computer tutorials was helping student-centered approach and group interaction (team work) to understand and solve various exercises. Only 60% of lecturers for group 1 encouraged the students to express their opinions and judge their practical skills (hands-on) at high level of thinking skills for their usefulness. 80% of lecturers for group 2 and 90% of lecturers for group 3 were 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 found it easy to rate the students' knowledge, understanding (low level of thinking skills) and abilities because the traditional T & L approach 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 found it easy to assess the students' work by using developed tutorial and computers assisted instruction with help of website. Lecturers for group 1 did not believe that the traditional teacher-centered approach increases the students' performance while 70% of lecturers for group 2 (students-centered approach) and 80% of lecturers for group 3 (interactive T & L) thought that the use of CAI and websites in educational process increases students' performance.

- **Lecturers' attitudes towards various T & L methods**

60% of lecturers for group 1 and 70% of lecturers for group 3 had friendly relationships with students, so that the students did not find it difficult to ask the lecturers for more explanations as required during the lesson time. However, 90% of lecturers for group 2 communicated in a friendly manner with students because lecturers' attitudes became friendlier while 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. 70% of lecturers for group 1 found it difficult to apply knowledge received in the theory class when they work practically in the lab because of the traditional T & L approach with face-to-face lectures and lectures' explanations of mechanical tasks.

80% of lecturers for group 2 and group 3 mentioned that computer tutorial and animations of the mechanical parts, with computer assisted instruction, encouraged the students to think logically at high level of cognitive skills (applying, analysing, evaluating and creating) and psychomotor skills (diagnose, design, implement, evaluate, improve, experience and conclude). Lessons were built rationally according to the students' needs. All lecturers for group 1 disagreed with this statement because in the teacher-centred approach the students follow lecturers' logic rather than thinking for themselves, and lecturers' main concern is to finish their lesson rather than giving students time to think (Appendix 2 and 3).

4.9 Evaluation of Student's Questionnaires

The aim is to find out the learning experience of students in the mechanical engineering module, and effectiveness of the three T & L methods, with and without computer Technology. The study has been carried out to explore problems during teaching and learning process in the subject area of mechanical engineering. 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; M, R Felder. R.M. A, B. Soloman.2001) suggested that a part of the problem in mechanical engineering 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 table 4.5 (Appendix 2 and 3).

Table 4.5 Evaluation of student's questionnaire

Questionnaires		
No.	Key areas	Statements
1	The student's attitudes towards the learning	1, 2, 3, 4, 8, 9, 10.11,13
2	The student's attitudes towards the Lecturer teaching method	5, 6, 7, 12, 14, 15
3	The student's opinions and views about teaching and learning	
3.1	Planning and organising	19, 35
3.2	Presenting the Lesson	17, 20, 23, 27, 33, 34, 37
3.3	Classroom Management	18, 21, 24, 28, 29
3.4	Assessment the students' performance	16, 31, 32
3.5	Interaction and enjoyment	22, 25, 26, 30, 26

- **Student's attitudes towards learning mechanical engineering subjects**

93.3% of the teacher-centered approach students in group 1 did not like the way of teacher's teaching Automotive, Industrial Maintenance and Manufacturing as a subject. The entire groups 2 & 3, teaching with the support of computer technology (tutorial, video, animations and websites), said they liked T & L with computer package CAI subject. This could be because of the necessity of learning mechanical engineering subject with learning package (tutorial) that enables them to work with high level of skills correctly. 87% to 93% of the students agreed that learning with the help of computer technology helps to develop their learning abilities in AIM. Most of the students in groups 2 & 3 agreed that learning with embedding technology enabling them to work with high level of thinking skill which gives opportunities to improve their engineering skills of Mechanical Engineering subject area. The students value the subject matter taught but they had problems with the way it was taught. In teacher-centered teaching group, 67% students said they had difficulties in improving their skills because there wasn't enough time for interaction with subject activities. Most of the students in the student-centered and interactive methods agreed that the knowledge of the subject content with the help of e-Recourses and tutorial instruction helped them to improve their practical skills. This reduced their mistakes when they were practicing their tasks.

The students explained one of the reasons why they had negative attitudes towards teaching of mechanical subjects using traditional teaching method (teacher-centered approach). 80% of group 1 students found it difficult to understand the material in the mechanical model book. The material itself sometimes did not suit the students' ability or their capability. Author's experience indicates that there are a few lessons in the mechanical student's book which are higher than their level of understanding. The author believes that the complexity of automotive and manufacturing materials could cause negative attitudes towards learning. At the same time, 58% to 70% of group 2 and 3 said they did not had any difficulty in understanding the automotive and manufacturing material in the book because the computer technology facilitated learning of even complex tasks for the students with all levels of abilities.

- **Student's opinions about their Lecturers' approach towards teaching process**

All of the students in the group 1 (teacher-centered approach) did not like to have more AIM lessons. This indicates how much the students dislike engineering Automotive, Industrial Maintenance and Manufacturing lessons because they do not understand the subject and they find difficulties in application of subject outcomes (complex tasks), and they consider it as a waste of time. 73% to 93% of the students in e-learning (tutorial base) and computer assisted instruction methods liked to have more Automotive, Industrial Maintenance and Manufacturing lessons because the computer technology facilitated easy learning at high level of thinking skills (complex) and they can communicate with each other.

- **Student's opinions and views about various aspects of T & L**

Mechanical subject area requires a careful integration of theoretical knowledge and laboratory work. In teacher-centered approach, it is difficult to manage teaching in a satisfactory manner. 93% of the students in group 1 felt that theory and practical work were not linked properly. Whereas, 80% to 87% of the students in groups 2 and 3 mentioned that their lecturers linked theoretical knowledge with practical work. For example, the lecturer showed the students how to dismantle and assemble Automotive and Industrial Maintenance parts and equipment in theory by giving examples, and then asked the students to carry out the same practice in laboratory, and then found how they linked information. Lecturers teaching group 2 and 3 had enough time to try and make a real connection between theoretical knowledge of Automotive and Manufacturing operations (implementing and experiencing) with textural package.

- **Session Planning and Organising**

80% to 100% of the students in group 2 and 3 agreed that the lecturer kept motivating the students and attracted them toward the subject matter because of the tutorial package and CAI. The students felt that the atmosphere was friendly when they worked with support of computer technology (website based), and this keeps students motivated. 93% of teacher-centered approach students mentioned that their lecturers always followed the same method when they taught mechanical subject and relied on the manual book and over-head projector, and sometimes power point, which was creating difficulties for learners to visualise movements of engines and manufacturing machine tasks. 47% to 53% of group 2 and 3 students said that the lecturers brought educational aids and variety of teaching patterns and educational software to keep students interested. 67% to 73% students of all groups said that their lecturers had adequate knowledge about engineering Automotive, Industrial Maintenance and Manufacturing. Lecturers need to be confident and should know the system and methodology of teaching engineering subjectsm delivery of course material, classroom management, assessment and feedback strategy and students' interaction.

- **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 agreed that the lecturers had good control of their classes because the students from group 2 and group 3 worked with the help of computer tutorial and CAI package. Hence, the computer tutorial and computer assisted instructions (CAI) gave support to the students in order to understand the subject, and they were occupied for the whole session. 73% of students from group 1 (teacher centered approach) said it was difficult for the lecturer to control the class because students need to discuss with each other during the lectures and laboratory classes. The result shows 60% to 80% of group 2 & 3 mentioned that the mechanical lecturer, with technological background, works with less effort than other lecturers. The lecturers were busy explaining the mechanical lessons and worked hard to enable the students to understand. This is not perceived by 20% of students, who believe that the mechanical subject lecturer was working with less effort than the other lecturers.

73% of the traditional students also mentioned that their lecturers did not explain the target of their lesson and did not deal with them according to their ability. 67% of the students with animation instruction method mentioned that the tutorial package dealt with individual differences when the lecturer divided his students into groups, and gave them different activities to test their abilities. 80% of the teacher-centered approach mentioned that their lecturers did not follow up their work by providing them with feedback, which is important. 53% to 73% of the students in group 2 and 3 mentioned that their lecturers followed up their work and checked it.

- **Assessment and feedback strategy**

It has been shown that 73% to 80% of group 2 & 3 students mentioned that mechanical engineering lecturer corrected their mistakes during the lesson. All other surrounding circumstances of the teaching process indicate that the lecturers do not have time to do corrections effectively. The lecturers corrected the student's work while they were busy with their practical work using computer tutorial software and computer assisted instruction, with help of verification checklist rather than afterwards. All students' of teacher-centered approached said they knew that the lecturer of the engineering subjects is always busy and overloaded with students, and this makes it difficult for lecturers to pay the kind of attention they need.

80% of the teacher-centered approach students believed there is no justice, in terms of correcting their work. Such a view suggests that the lecturers discriminated between their students, sometimes 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 good or at least passing marks. If the lecturer ignores that effort, the students lose their opportunity to pass. In such cases, the students feel unfairness. This develops negative attitude amongst students, towards subject lecturers. 73% of the students in both groups 1 & 2 said that their lecturers were fair when they marked 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 practicing lesson.

73% to 80% of the students in groups 2 and 3 mentioned that their lecturers used different ways of assessing their performance during evaluation stage. These include hearing students talk, marking work, testing them in lessons, submitting their assignments and examining them formally. Lecturers concentrated more on assignment and exam, specifically, on the questions which measure the students' application and analysis. In teacher-centered approach group, it was demonstrated from the answers of the students that it is not easy to evaluate student's work and assess their performance. The lecturers did not always correct student's mistakes as a part of their task of helping to improve the students' skills in mechanical subjects.

- **Delivery of course material and students' interaction**

60% of students from group 2 and 67% of students from group 3 recognised that learning with tutorial and CAI was interesting to them. All students from group 1 were either unconvinced or did not believe that the teacher-centered T & L method is interesting. All students from group 3 and 93% of students from group 2 perceived that the lecturers encouraged them to learn. Only 53% of students from group 1 (teacher-centered approach) mentioned that the lecturers tried to encourage them during their mechanical 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 found it difficult to encourage their students during their lessons.

The result reveal that 73% of the students in groups 2 & 3 mentioned that their lecturers respect them. This answer is consistent with the lecturer's answer when they were asked if they had friendly relationships with their students. But it is worth mentioning here that not all the lecturers believed in friendly communication with their students; there were some lecturers who remain formal with their students. All of the students, in teacher-centered approach, mentioned that their lecturers did not encourage them to work with computer support. It seems that it is not a popular method in teaching mechanical for some lecturers. Such a work situation might be because of lack of training in using this method. At the same time, 67% to 87% of students in groups 2 and 3 mentioned that lecturers in their groups were aware that teaching with the tutorial software package and availability of web based tutorials can be very effective and successful if carried out properly (Appendix 2 and 3).

4.10 Summary

This chapter focused on the implementation and user evaluation of the Blended Learning system designed and developed in the previous chapter. The students were asked to study individually the mechanical subject’s tutorial, and the lecturer presented the tutorial for high level of cognitive skills in the classroom, and psychomotor skills for maintenance and production operations (hands-on) to the students in the laboratory environment (supervised learning). The prototype of tutorial package was evaluated by experts (heuristic evaluation) and the product was changed in accordance with their comments. The tutorial package was tested on students and lecturers teaching the modules. This chapter described the structure of mechanical engineering 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 aimed to find out lecturers’ opinions about the various aspects of educational process i.e. 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 etc.

The students’ questionnaires intended to ascertain how well the mechanical engineering modules meet the stated learning outcomes, and to identify the main strengths and weaknesses of various T & L methods. It is intended to improve students’ learning experiences by increasing the student involvement in education process. Hence, the questions referred to the following topics: student’s attitudes towards learning mechanical engineering subjects, student’s opinions about their lecturers' approaches to teaching process etc. Furthermore, 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 etc.

Next chapter discusses about the assessment of the education environment for mechanical engineering modules and shows qualitative analyses.

CHAPTER 5
ASSESSMENT OF THE BLENDED LEARNING SYSTEM

5.1 Introduction

This chapter discusses the evaluation techniques of Pedagogical Package used for three groups of Mechanical Engineering students from different specialisation (Automotive, Industrial Maintenance and Manufacturing) at SKI. The mechanical module tasks are:

- Demonstrate range of transmission applications
- Diagnose, adjust and repair manual Gearbox
- Diagnose, adjust and repair manual clutch
- Demonstrate a range of Manufacturing tools and Measurements skills
- Demonstrate a range of Milling and Centre Lathe setting
- Demonstrate a range of manufacturing operations on Centre Lathe, Shaping Machine and Milling machine

Rate the quality of the service, product and estimated time, which was to perform procedures and operate systems, prepare the work map and design the product, analysing information to understand, the techniques of teaching strategies and learning style will be experimented during user analyses with three teaching/learning methods:

- Group 1 (G1) Traditional teacher centre approach with technology support (TCA)
- Group 2 (G2) Students centre approach with technology support (SCA)
- Group 3 (G3) Interactive learning with technology support (Interactive)

Two evaluation methods of Bloom's framework were used to assess learning effectiveness of different student groups exposed to three T & L methods.

- **First Evaluation:** Using developed model of cognitive level skills related to the knowledge (recall data), comprehension (understand information), application (applying knowledge to the new situation), analysis (separating information into part of butter understanding), evaluating (justify a stand or decision by appraising, arguing, defending, judging, selecting, supporting, valuing and evaluating) and creating (create new product or point of view by assembling, constructing, creating, designing, developing and formulating idea) (Anderson L, and Krathwohl K 2001)
- **Second Evaluation:** Using the proposed psychomotor skills model concluded from the previous module

Table 5.1 Action verbs for Dave; Simpson ; Harrowc; Ferris and Aziz

No	Author	Action verbs
1	Dave (1970)	Adapt, adjust, administer, alter, arrange, assemble, balance, bend, build, calibrate, combine, construct, copy, design, deliver, detect, demonstrate, differentiate (by touch), dismantle, display, dissect, drive, estimate, examine, execute, fix, grasp, grind, handle, heat, manipulate, identify, measure, mend, mime, mimic, mix, operate, organise, perform (skillfully), present, record, refine, sketch, react, use
2	Simpson (1972)	Observed, guide, action, practice, confidence, Responses, problem solving, creativity
3	Harrow (1972)	flexion, extension, stretch, postural adjustments, walking, running, pushing, twisting, gripping, grasping, manipulating, Visual, auditory, kinaesthetic, coordinated movements such as jumping rope, punting, catching, recreation, and dance, body postures, gestures,
4	Ferris and Aziz (2005)	Recognize, handled, hold, perform, use efficiently, effectively and safely, specify, describe, identify, action
(Dave 1970; Simpson 1972; Harrowc 1972; Ferris and Aziz 2005)		

The skills model are diagnosis and exploration (analysing information to understand), plan and design (prepare the work map and fabricate the mechanical product and assign the machine for manufacturing), action and implementation (performance the best corrective actions procedures and operate systems), evaluate (rate the quality of the product and estimate the cost), improve (increase operating efficiency and quality product), experiencing and work placement (understand and communicate across disciplines and work effectively in diverse teams), conclude (arrive at a logical conclusion by the process of reasoning; infer on the basis of convincing evidence).

The following sections will discuss about activities and results of students learning in both theory (classroom) and practical (lab) sessions. The analysis has been carried out on student's results for assignments and exams, and time has been quantified for their quantitative and qualitative results in both cognitive and psychomotor skills.

5.2 Cognitive Skills Evaluation Techniques

The students are tested for their abilities in the mechanical subject area by asking them to perform practical work on milling machine, centre lathe, clutch and gear box. The verbs used at lower level and higher level were recall data, apply knowledge and construct and develop experiencing (see figure 5.1). The author links the levels of cognition from Blooms' taxonomy with the activities which should be completed by students (Appendix 4, 5, and 7).

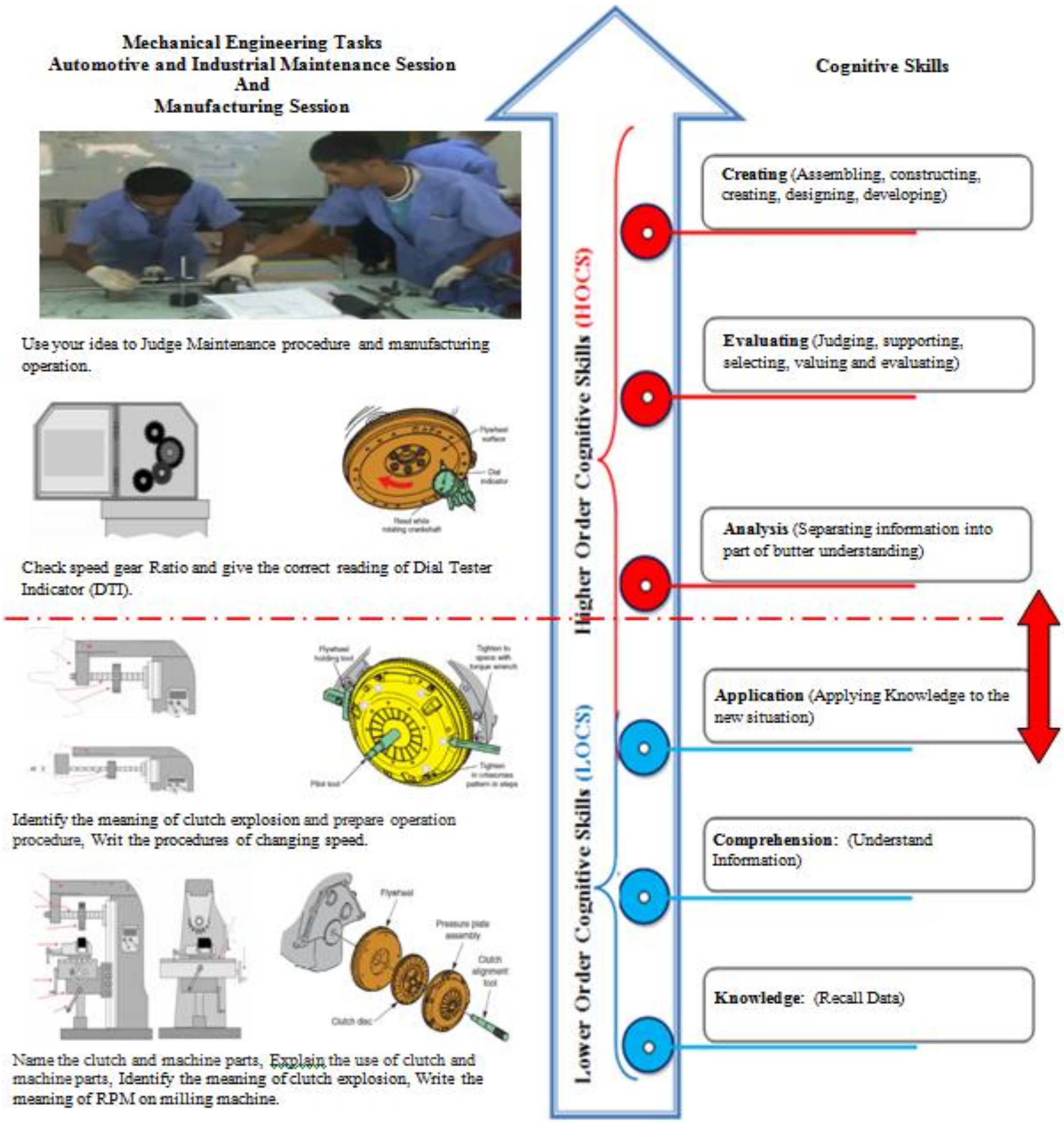


Figure 5.1 Lower and Higher Level of Cognitive skills and student's tasks

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 mechanical engineering modules, various levels have been identified as per the developed model of cognitive level skills related to the knowledge (recall data), comprehension (understand information), application (applying knowledge to the new situation), analysis (separating information into part of better understanding), evaluating (justify a stand or decision by appraising, arguing, defending, judging, selecting, supporting, valuing and evaluating) and creating (create new product or point of view by assembling, constructing, creating, designing, developing and formulating idea) (Anderson L, and Krathwohl K 2001). 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 (Appendix 1, 4, 5, 7)

Lecturer marked the students during maintenance and production of six tasks in Automotive, Industrial Maintenance and Manufacturing. 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.

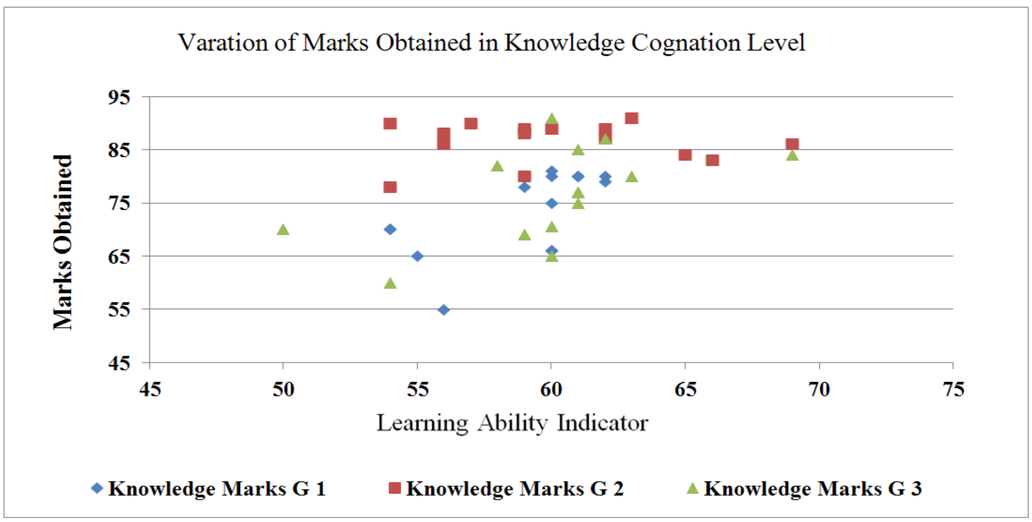


Figure 5.2 Comparison between teaching methods in knowledge cognition level

Figure 5.2 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. Most groups show considerable improvement in knowledge but final marks for group 2 students are uniformly distributed between 80% and 95%. This indicates that student-centred approach has increased the level of achievement of learning outcomes for this heterogeneous group of students. The final marks for group 3 are spread between 65% and 85%. Hence, the interactive T & L methods have produced a slight increase in the final marks but not too much like group 2.

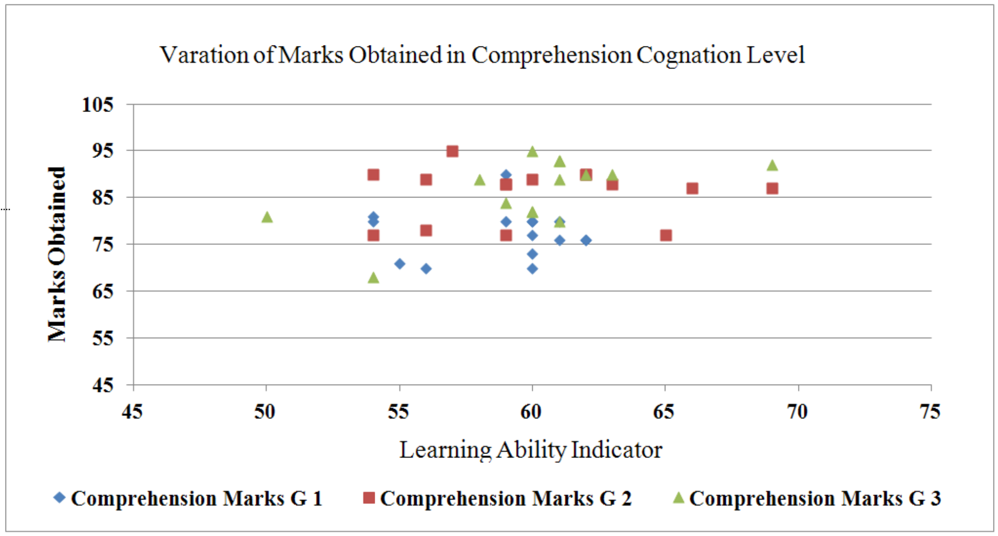


Figure 5.3 Comparison between teaching methods in comprehension cognition level

Figure 5.3 shows variations in marks obtained in comprehension cognition level where students were required to understand the information like machining operation, tools, equipment, measuring instruments, selecting and locating cutting parameters, setting the tools and the work piece. The figure indicates that the overall trends are similar to the one seen in knowledge cognition level, although the scatter in the marks has increased for the three groups. Here, once again method 2 (student-centered approach) has produced the highest increase in students' marks.

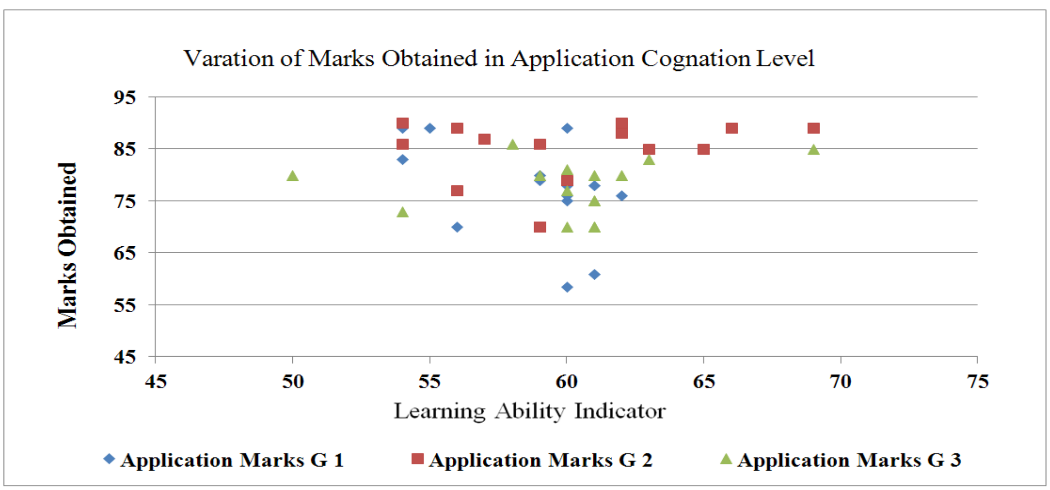


Figure 5.4 Comparison between teaching methods in application cognition level

Figure 5.4 shows the variations in marks in application cognition level where students are evaluated for their ability to apply information of measuring, marking out, machine and experiment of the manufacturing machine as well application of gears and clutch, model, assemble the parts as well as perform and verify manufacturing operations. The final marks for group 2 are concentrated more in the interval 75% to 95%. Hence, their level of achievement is slightly lower than for the previous cases (knowledge, comprehension).

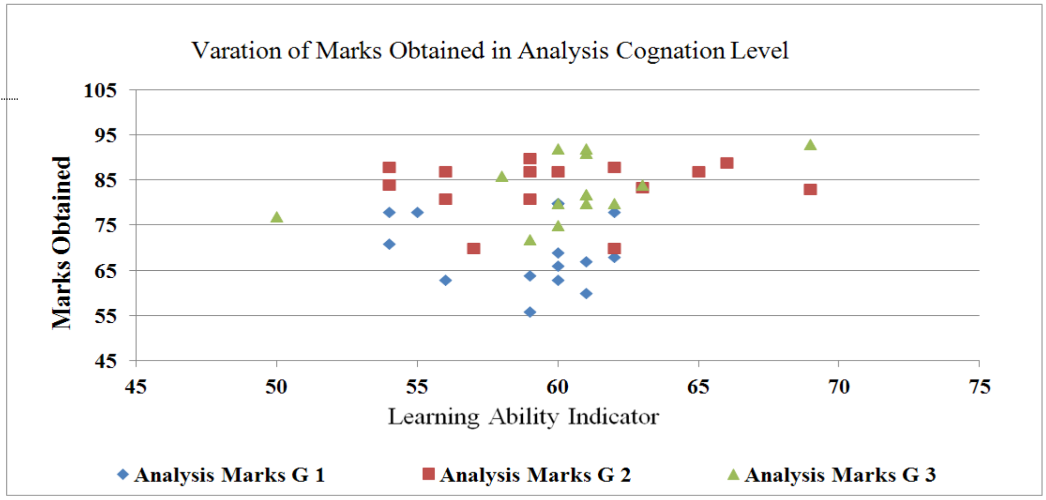


Figure 5.5 Comparison between teaching methods in analysis cognition level

Figure 5.5 presents the variation of students' marks in analysis cognition level. The final marks for group 2 are concentrated in the interval 75% to 95% so their level of achievement is the same as in previous cases (knowledge, comprehension, application). Furthermore, the students' final marks from group 1 are in the interval 55% to 80%. Hence, the teacher-centred approach does not increase the marks significantly at analysis cognition level.

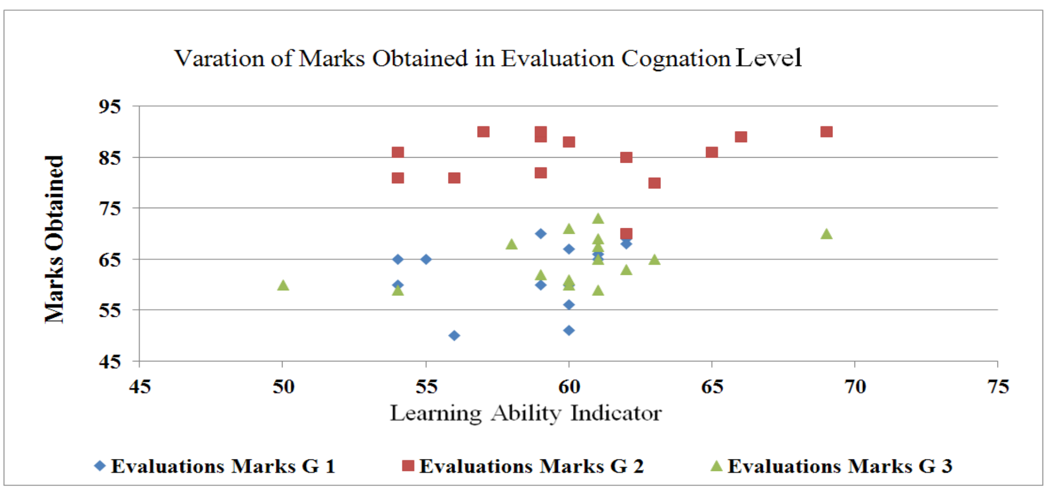


Figure 5.6 Comparison between teaching methods in Evaluation cognition level

Figure 5.6 presents the variation of students' marks in evaluation cognition level. The students were evaluated for their abilities in analyzing and evaluating the machining operation and procedure and selecting, preparing tools and equipments and using measuring instruments facilities to calculate missing dimensions of engineering application. This also requires students to be capable of 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 and engineering maintenance preparation of parts an tools. The students' final marks from group 1 are clustered around the interval 55% to 65%. The teacher-centered approach does not enable the development of appropriate students' skills for evaluation cognitive level. Furthermore, students from group 1 obtained the lowest marks in comparison to those from group 2. Group 3 show less marks than the previous cases (knowledge, comprehension, application and analyses). This shows that the combination students-centred approached is far more useful in delivering learning outcomes at higher level of developed cognition skills.

Figure 5.7 presents the variations in students' marks in creating cognition level. This cognition level tests student's ability to create by assembling, constructing, creating, designing, developing and formulating ideas (Anderson, L. and Krathwohl) with regard to final product's fitness, shape, movements and quality.

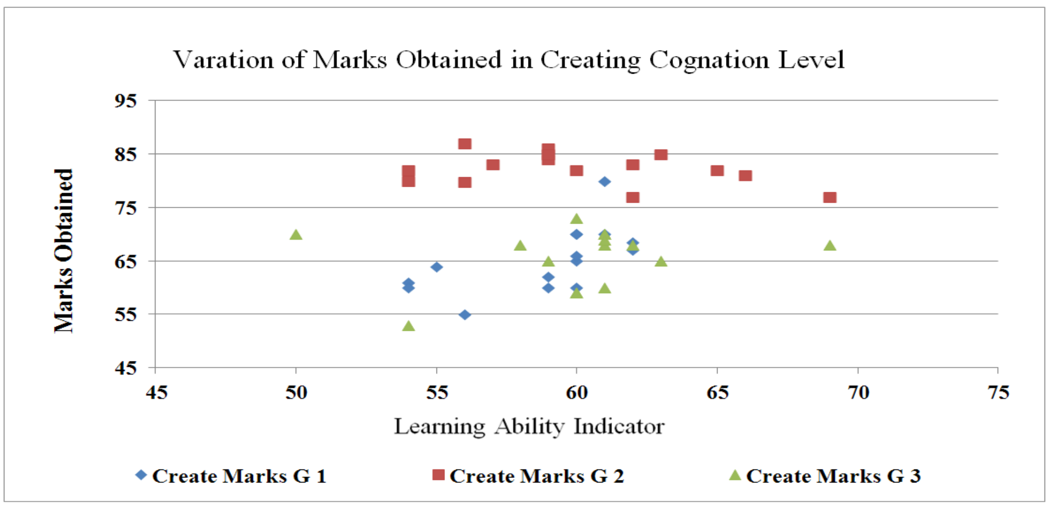


Figure 5.7 Comparison between teaching methods in creating cognition level

Students from group 2 have the highest marks, and those from group 3 obtained higher marks than for the previous cognition level (evaluation). Hence, introducing students-centred approach, with pedagogical package, has helped the students, with various learning abilities, to achieve learning outcomes at high level. The differences between lowest and highest marks within each group are small.

5.3 Psychomotor Skills Evaluation Techniques

The students are tested for their abilities in mechanical subject area by asking them to perform practical work on milling machine, centre lathe, clutch and gear box. The verbs used at lower level and higher level were diagnose, perform, experience, apply knowledge and construct and develop experience (see figure 5.8). The author links the levels of psychomotor skills with the activities and tasks which should be completed by students (See Appendix 1, 4, 6, and 7).

The skills model used includes diagnosis and exploration skills (analysing information to understand), planning and design skills (prepare the work map and fabricate the mechanical product and assign the machine for manufacturing), action and implementation skills (performance the best corrective actions procedures and operate systems), evaluation skills (rate the quality of the product and estimate the cost), improve (increase operating efficiency and quality product), experience and work placement (understand and communicate across disciplines and work effectively in diverse teams) and conclude (arrive at a logical conclusion by the process of reasoning; infer on the basis of convincing evidence)

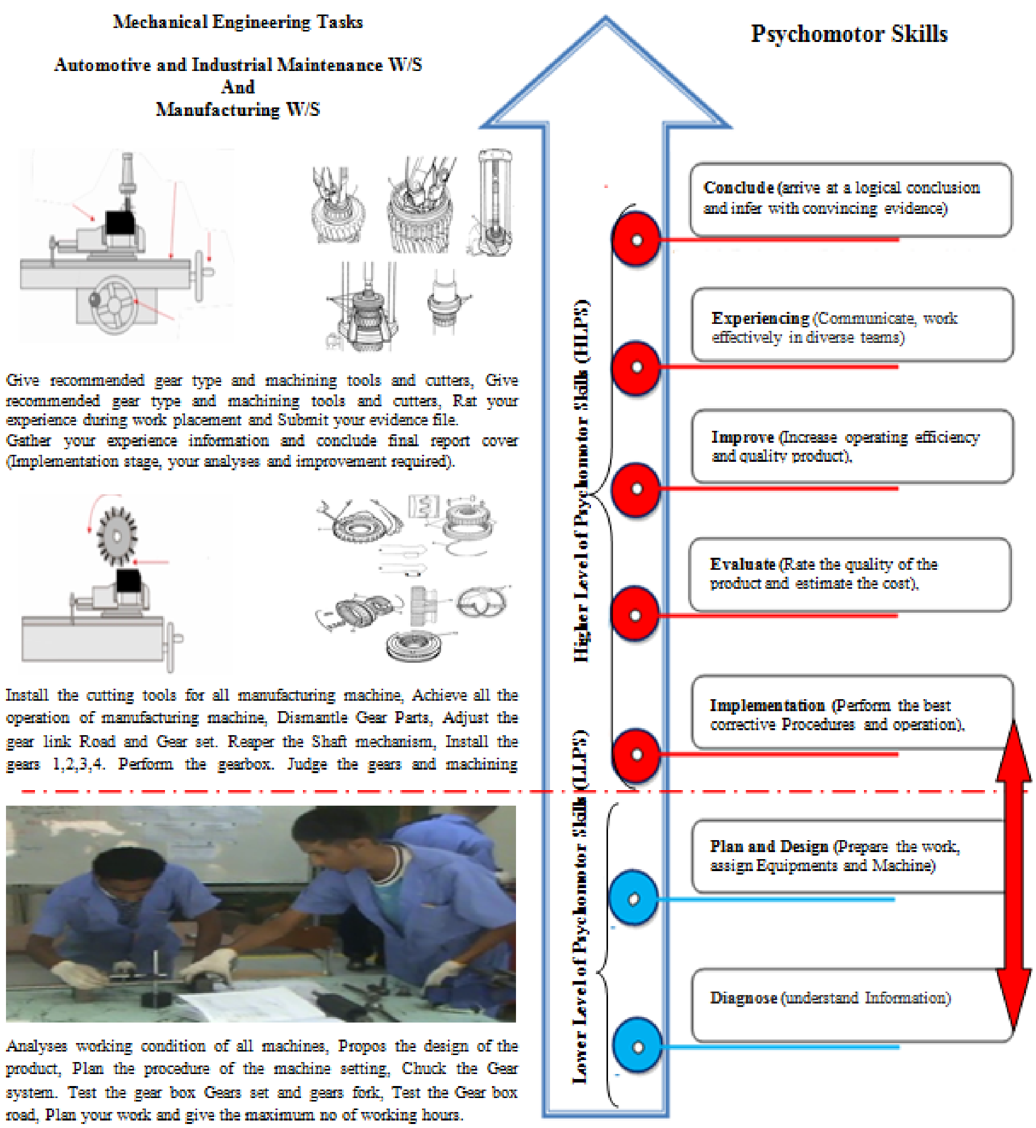


Figure 5.8 Lower and Higher Level of Psychomotor skills and student's tasks

Lecturer marked the students during maintenance and production of six tasks in Automotive, Industrial Maintenance and Manufacturing. The quality of students' results for each activity is determined by comparing their products with the checklist and awarding a mark for each student and task. The marks obtained show how well the student has performed a certain task by comparing students' application results with the checklist.

Figure 5.9 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 diagnosis of psychomotor skills . Most groups show considerable improvement in diagnosis, but final marks for group 2 students are uniformly distributed between 80% and 90%. This indicates that student-centered approach has increased the level of achievement of learning outcomes for this heterogeneous group of students. The final marks for group 3 are spread between 55% and 85%. Hence, the interactive T & L methods have produced a slight increase in the final marks but too much like the combination between traditional methods (teacher-centred approach).

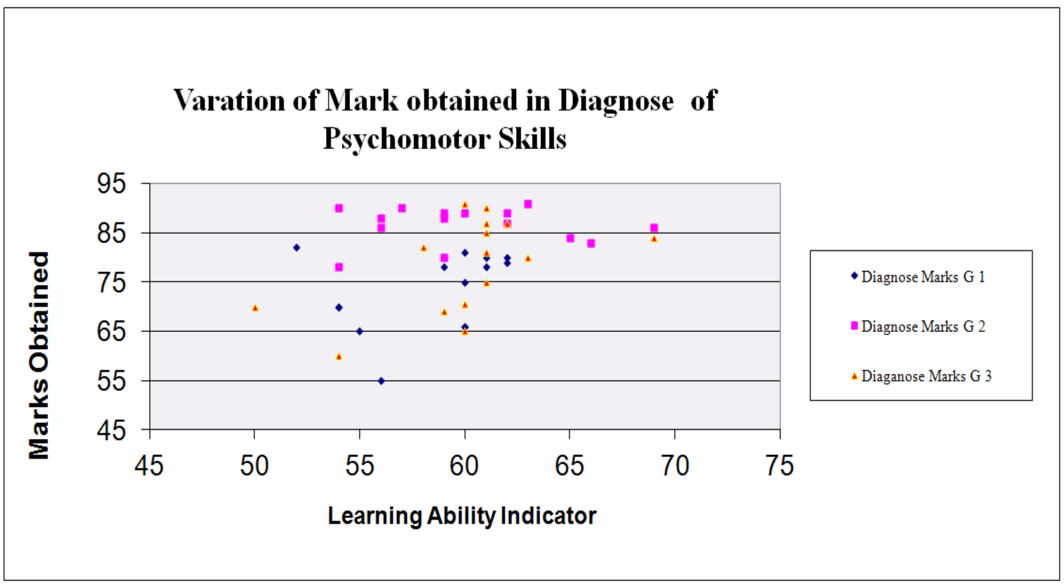


Figure 5.9 Comparison between teaching methods in Diagnose of Psychomotor Skills

Figure 5.10 shows variations in marks obtained in plan and design of psychomotor skills. Students were required to prepare the machine for manufacturing and machining operation, tools, equipment, measuring instruments, selecting and locating cutting parameters, setting the tools and the work piece and papering engine and maintenance new parts. The figure indicates that the overall trends are similar, although the scatter in the marks has increased for the three groups. Hence, once again, method 2 (student-centered approach) has produced the highest increase in students' marks.

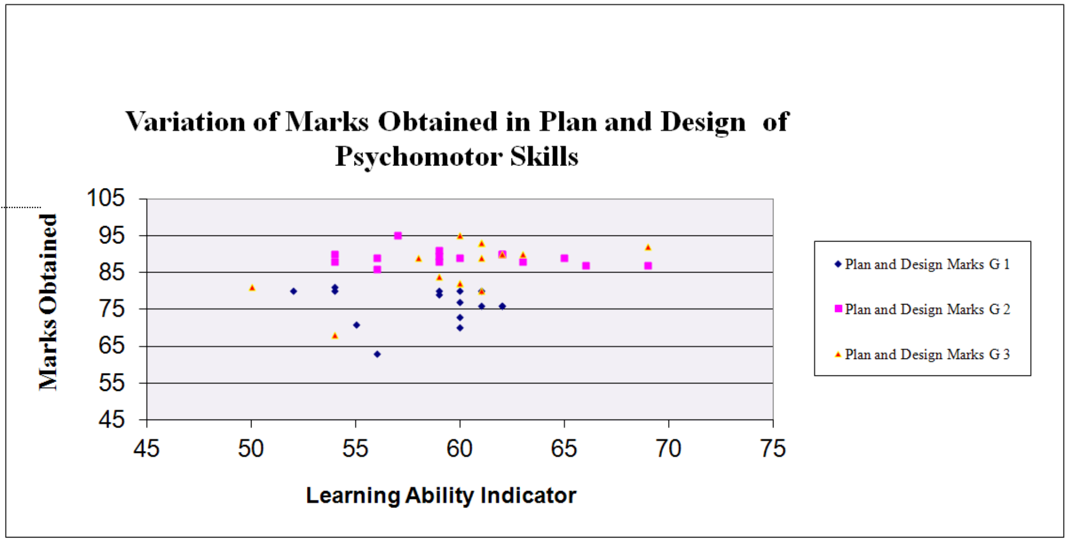


Figure 5.10 Comparison between teaching methods in plan and design of Psychomotor Skills

Figure 5.11 presents the variations in students' marks in action and implementation. The final marks for group 2 are concentrated in the interval 75% to 95%. Hence, their level of achievement is the same. Furthermore, the students' final marks from group 1 are just behind group 3 i.e. 75% to 89%. Hence, the teacher-centred approach does not generate significant increase in marks at action and implementation of psychomotor skills.

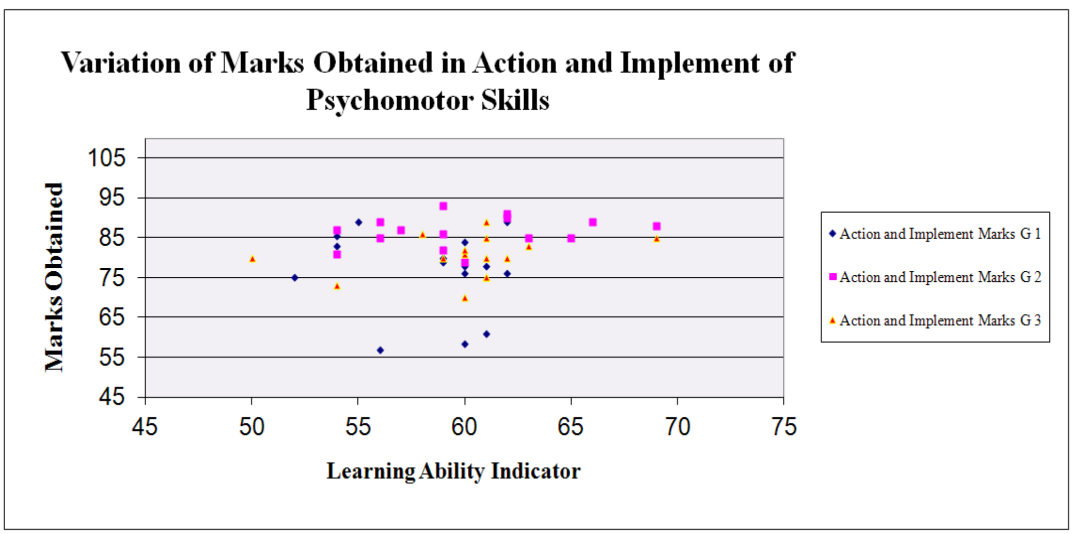


Figure 5.11 Comparison between teaching methods in action and implementation of Psychomotor Skills

Figure 5.12 shows the variations in marks in evaluation of psychomotor skills, where students are evaluated for their ability to decide the quality of the product and estimate the cost of marking out, machining and experimentation of the manufacturing machines, as well as application of dismantling and repairing gears and clutch, modelling, assembling the parts, as well as performing and verifying manufacturing operations at high level of psychomotor skills. The final marks for group 2 are concentrated more in the interval 80% to 90%. Hence, their level of achievement is 5% lower than the previous case i.e. action and implementation.

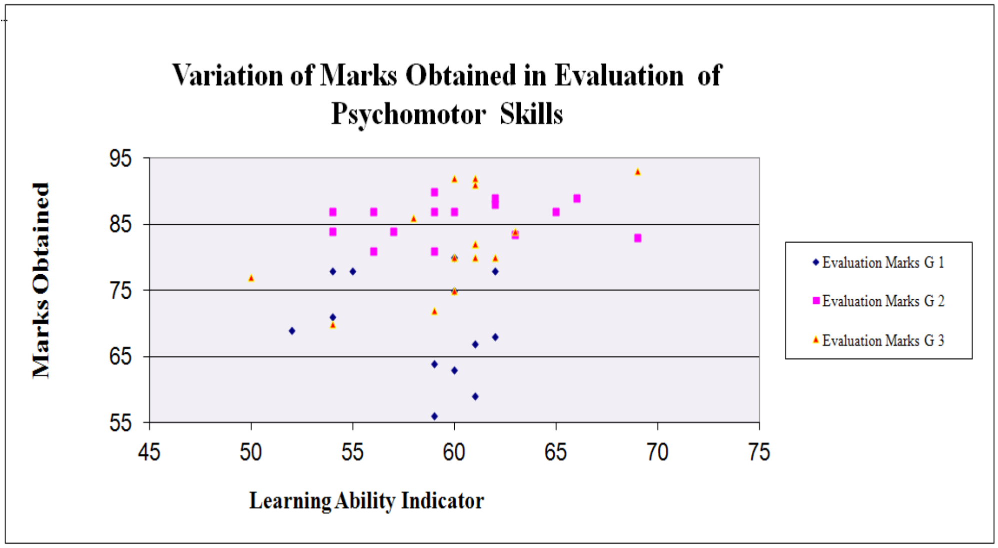


Figure 5.12 Comparison between teaching methods in Evaluation of Psychomotor Skills

Figure 5.13 presents the variations in students' marks in improvement. The final marks for group 2 are concentrated in the interval 75% to 90%. Hence, their level of achievement is nearly the same as observed in the previous cases (evaluation, action and implementation). Furthermore, the students' final marks from group 1 are grouped around the interval 50% to 70% which means that they remains the same as previous results. Hence, teacher-centred approach does not generate a high increase of marks at analysis cognition level.

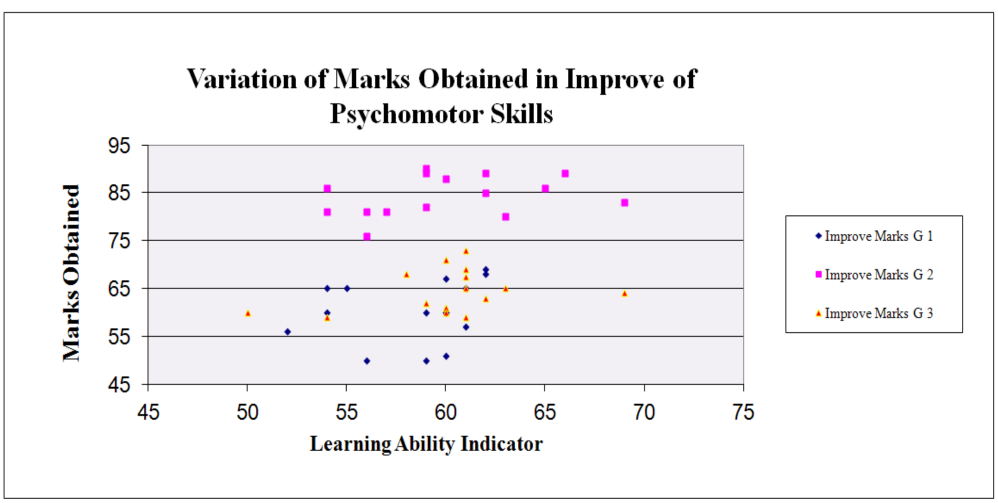


Figure 5.13 Comparison between teaching methods in Improve of Psychomotor Skills

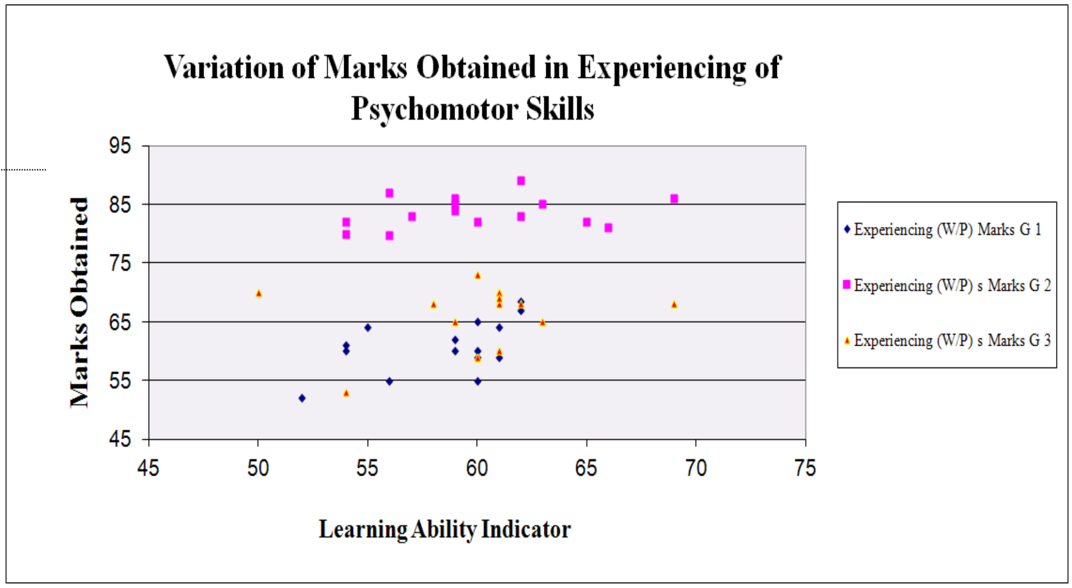


Figure 5.14 Comparison between teaching methods in experiencing (work placement) of Psychomotor Skills

Figure 5.14 presents the variations in students' marks in experiencing (work placement) skills of psychomotor. The students were evaluated for their abilities in experience (understand and communicate across disciplines and work effectively in diverse teams) of machining operation and procedures, and selecting/preparing tools and equipments, and using measuring instruments facilities to calculate missing dimensions of engineering applications. This also requires students to be skilled enough (experienced) in 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 and engineering maintenance preparation of parts an tools, dismantling, adjusting, repairing and installing new parts of the engine. The students' final marks from group 1 are clustered around the interval 55% to 65%. Hence, the teacher-centered approach does not enable the development of appropriate students' skills at experiencing level. Furthermore, students from group 1 obtained the lowest marks in comparison with those from group 2. Group 3 show similar marks as previously (improving). This shows that the combination students-centred approach is far more useful in delivering learning outcomes at higher level of developed psychomotor skills.

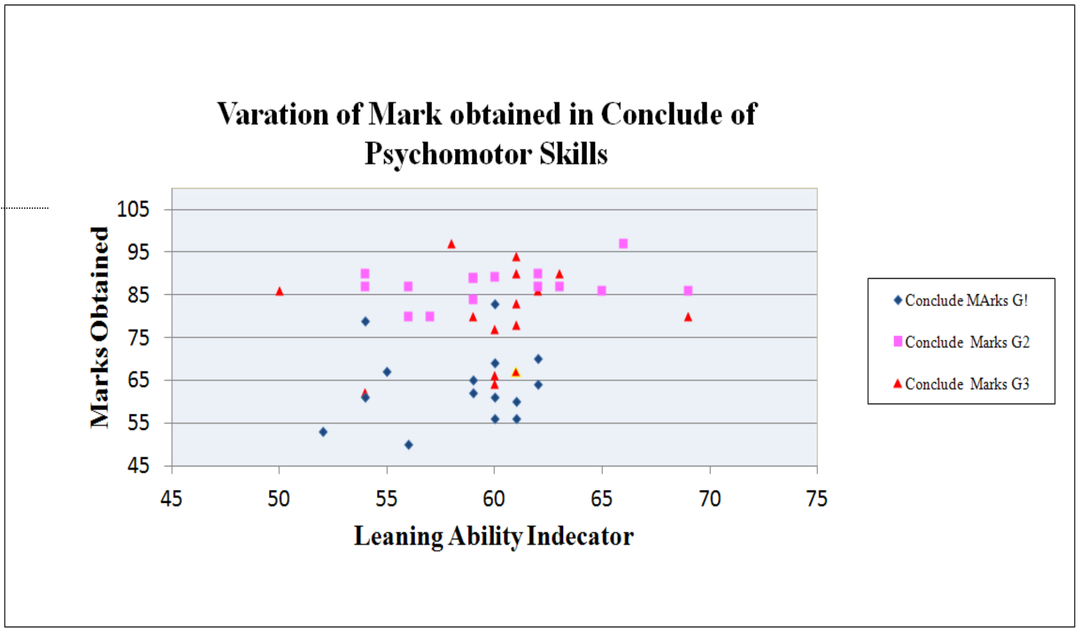


Figure 5.15 Comparison between teaching methods in conclude of Psychomotor Skills

Figure 5.15 presents the variations in students' marks in conclusion of psychomotor skills. This psychomotor skill tests student's ability to conclude (arrive at a logical conclusion) by the process of reasoning and infer on the basis of convincing evidence, with regards to final products fitness, shape, movements and quality with evidence records. Students from group 2 have the highest marks, and those from group 3 obtained higher marks than the for the previous psychomotor (experiencing). Hence, introducing students-centred approach with pedagogical package has helped the students with various learning abilities to achieve learning outcomes at high level of psychomotor skills, and the differences between lowest marks and highest marks within each group are small.

The above study has clearly indicated that a Blended Learning system that includes face to face teaching which is supported by flexible software support provides best learning opportunity to students. It has been seen that skills acquired in both cognitive and psychomotor domains are in-depth when a Blended Learning system has been used.

5.4 Evaluation Techniques Used for Three T & L Methods in Hands-On Lab (Psychomotor) Skills Using Students' Pre-Test Ability and Post-Teaching Assessment

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

a) Demonstrate range of transmission applications

b) Diagnose, adjust and repair manual Gearbox

c) Diagnose, adjust and repair manual clutch

d) Demonstrate a range of Manufacturing tools and Measurements Skills

e) Demonstrate a range of Milling and Centre Lathe setting

f) Demonstrate a range of manufacturing operations on Centre Lathe, Shaping Machine and Milling machine

These outcomes represent main engineering skills that are needed to be learnt from these modules. These are included here to test the effectiveness of Blended Learning systems on imparting engineering skills to students. In the previous sections these skills were separated into cognitive and psychomotor skills where as in this section these skills are represented in integrated form.

The subject of T & L process was measuring instruments, marking out tools and use of machine tools (Centre Lathe, Milling and Pedestal Drilling) for manufacturing module. Manual transmission (Gear and Clutch) diagnosis, adjustment, dismantling, repair and installation for Automotive and Industrial Maintenance module consists of several parts(see figure 5.16). To evaluate the effectiveness of different teaching methods against various learning outcomes, marks obtained by students for each outcome have been plotted against marks obtained by students in the preparation module from previous academic year (pre-learning indicator) (See Appendix 4).

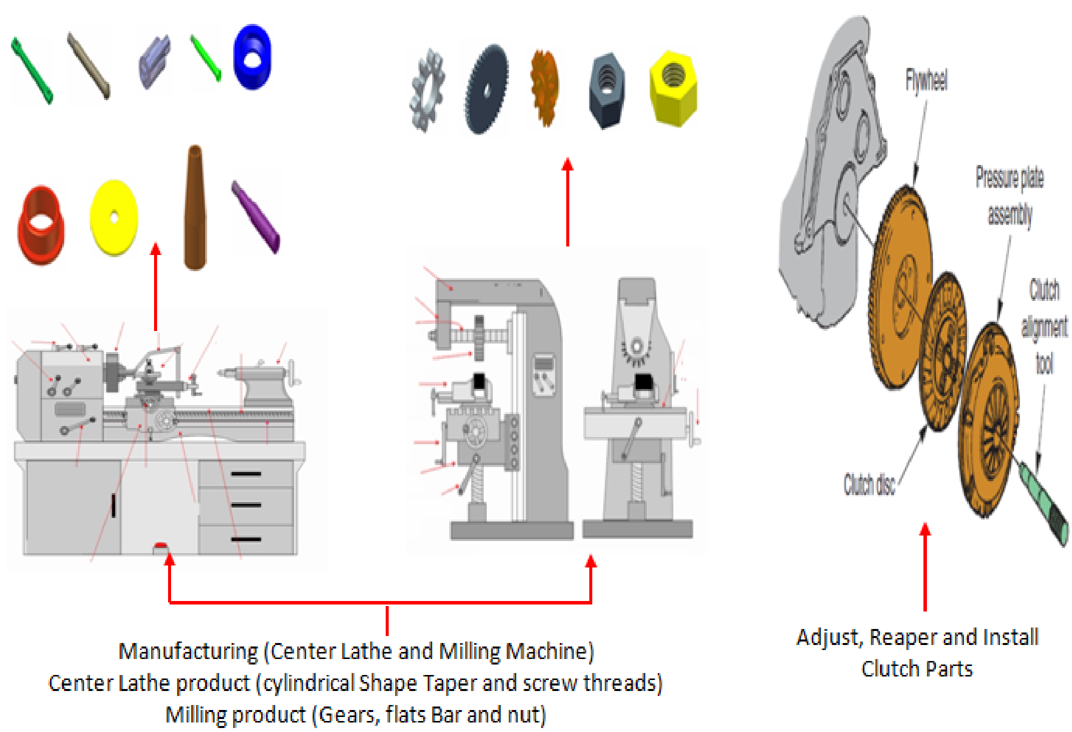


Figure 5.16 Machine and tools for Psychomotor Skills

Figure 5.17 shows that the students from group 1 (blue colour) did not register significant improvement in final marks (post-teaching assessment), after performing the activities related to learning outcome 1. The students from group 2 scored the highest marks and have a uniform distribution of marks, typical of a heterogeneous group. Furthermore, it is obvious that half of the students from group 3 have reduction in capabilities, and the other half are more able to obtain good results.

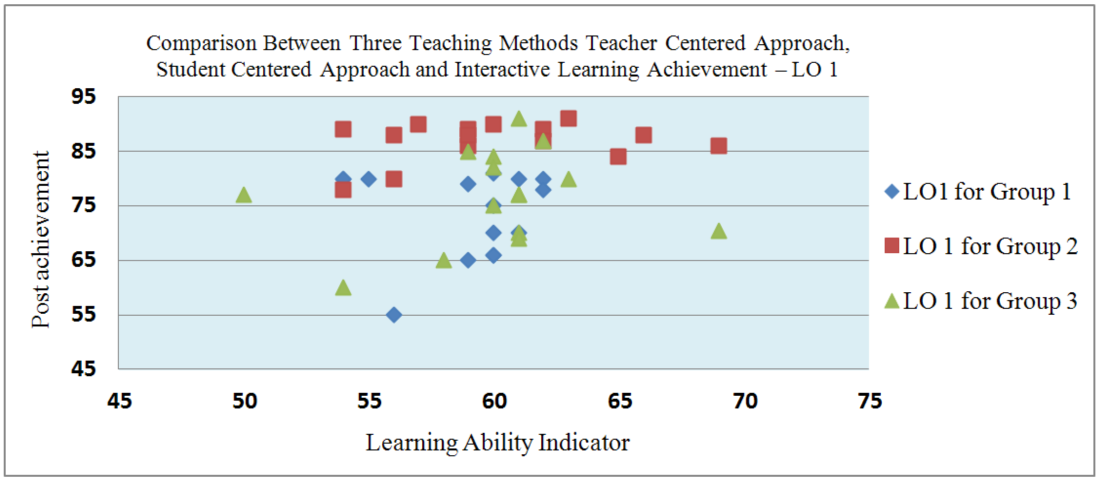


Figure 5.17 Achievement of Learning Outcome 1

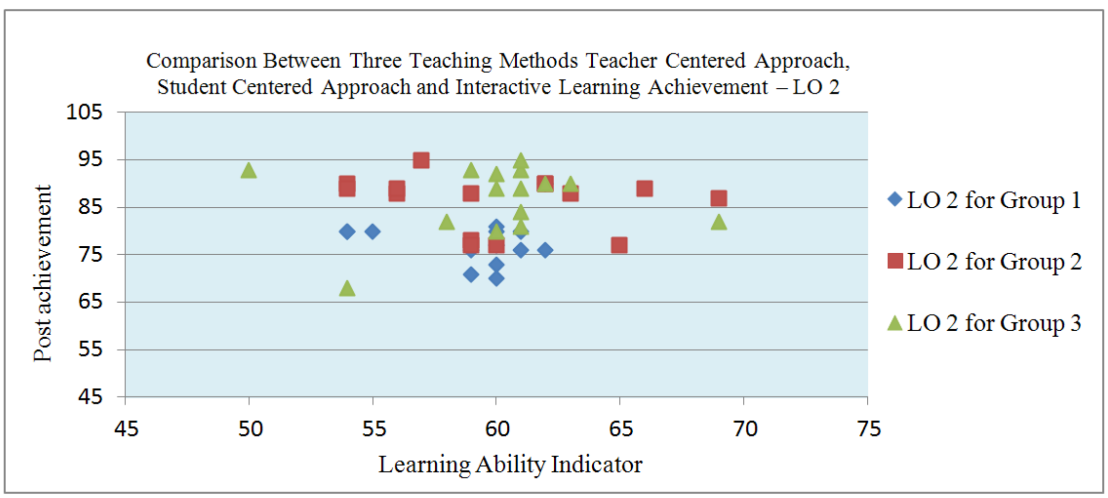


Figure 5.18 Achievement of Learning Outcome 2

Figure 5.18 shows that the students from group 1 obtained lowest marks (clustered around 70% to 80%), which are similar to those corresponding to learning outcome 1. This could be due to the fact that the students the training on how to use, adjust and dismantle, repair the gear box and clutch, that students received proper instructions. Students received support during practicing and experiencing (performing). Figure 5.19 show that the distribution of final marks for the students from group 1 is lowest 55% to 90%. Hence, the students who were struggling to score high marks for learning outcome 1 and 2, have more difficulties to reach learning outcome 3. The students from group 2 obtained highest marks, and the students from group 3 still find it difficult to score high marks. Hence, their ability to apply the knowledge received in the classroom during the lab work was difficult because of teacher-centred approach. All T & L methods should be improved to enable students to perform better.

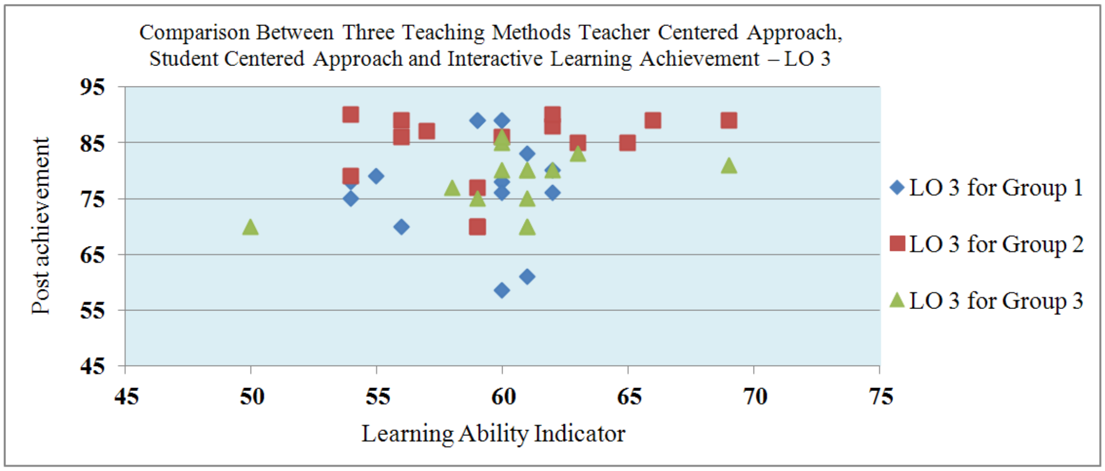


Figure 5.19 Achievement of Learning Outcome 3

Figure 5.20 shows that the marks for students from group 1 have improved (grouped around 60% to 75%). Hence, it seems that they have practiced at lower skill. Furthermore, after obtaining lower marks for the previous learning outcome, they were capable to manufacture the final product using the milling machine tool. This conclusion is applicable for all groups because all marks have increased in comparison to those corresponding to the previous learning outcomes.

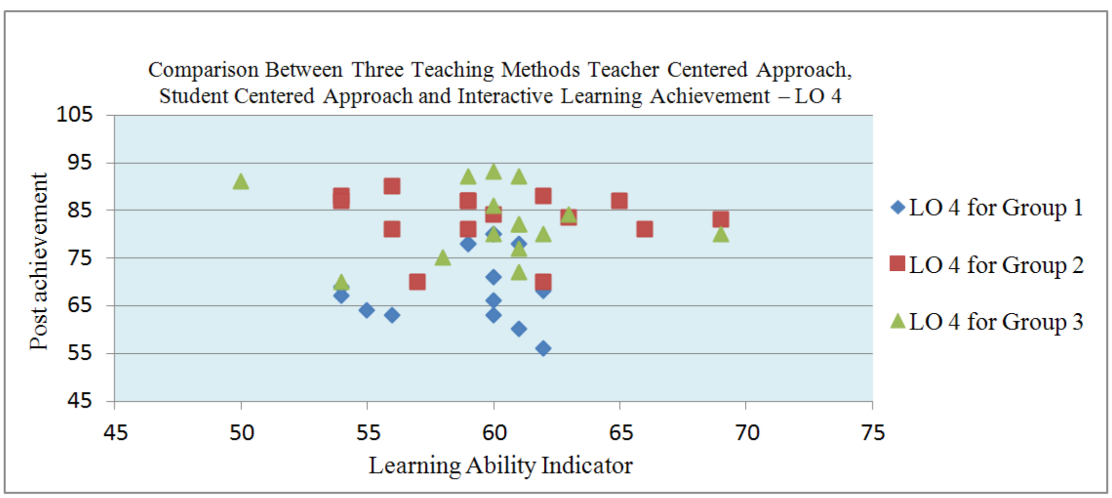


Figure 5.20 Achievement of Learning Outcome 4

Figure 5.21 shows that the students from group 1 obtained lowest marks in comparison with group 2 and 3 students. The marks for group 1 are clustered around 50% to 70%. This could be due to the fact that the students got the training at high level (adjust and dismantle, repair the gear box and clutch). Students need another teaching style to perform.

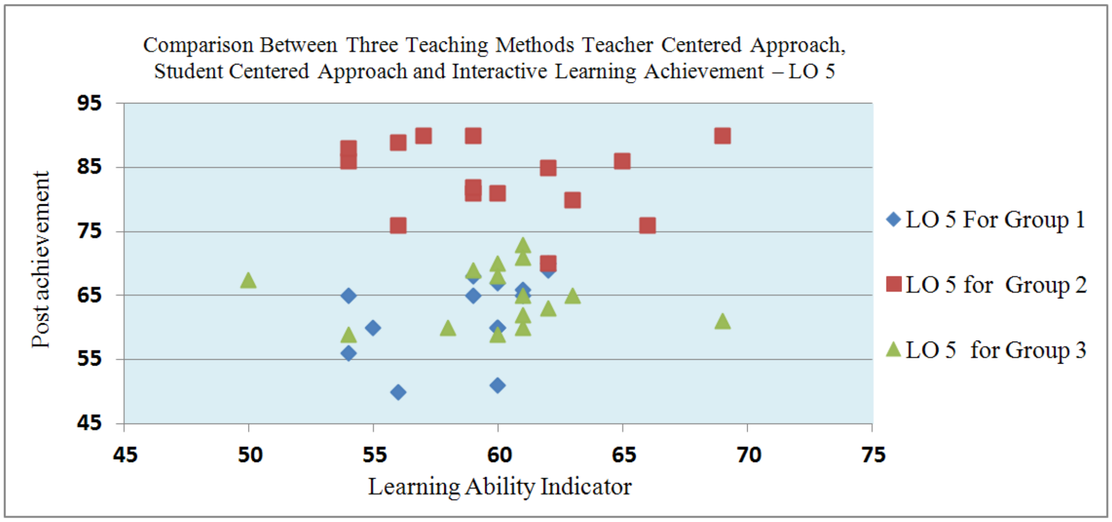


Figure 5.21 Achievement of Learning Outcome 5

Figure 5.22 shows that the students from group 2 have the highest marks at higher level of thinking skill (centre lathe and milling machine operation and procedure). Teaching/learning style used with group 2 can be used for other students as well.

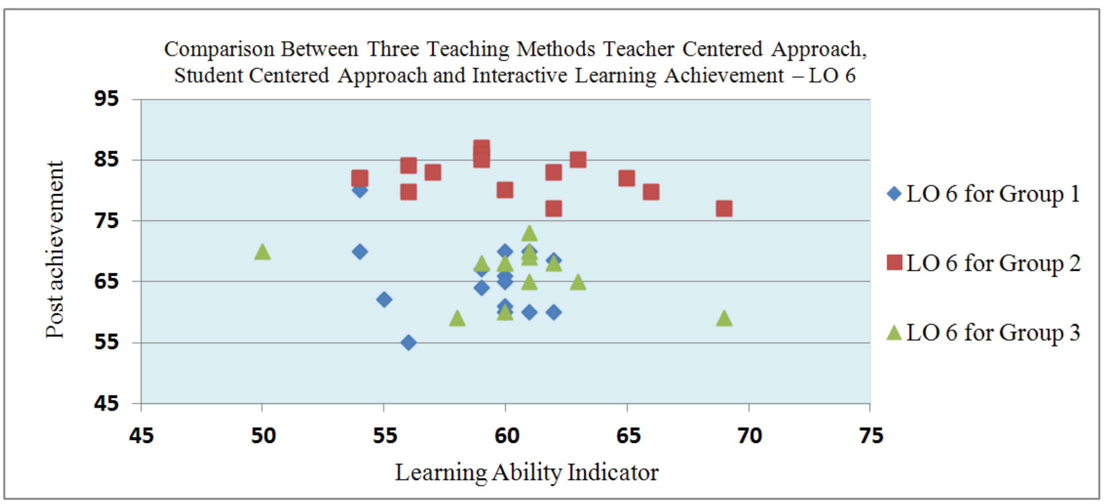


Figure 5.22 Achievement of Learning Outcome 6

It is concluded here that the use of Blended Learning system increases the effectiveness of T & L process (figure 5.23).

It is obvious that Blended Learning system helps all students in achieving the learning outcomes with a good success rate, whereas teacher-centred approach is an interactive learning method that does not enable students, who have difficulties in understanding, to obtain good marks. Furthermore, the teacher-centred approach increases the difference in levels of achievement for low and high ability students, whereas pedagogical package reduces this gap.

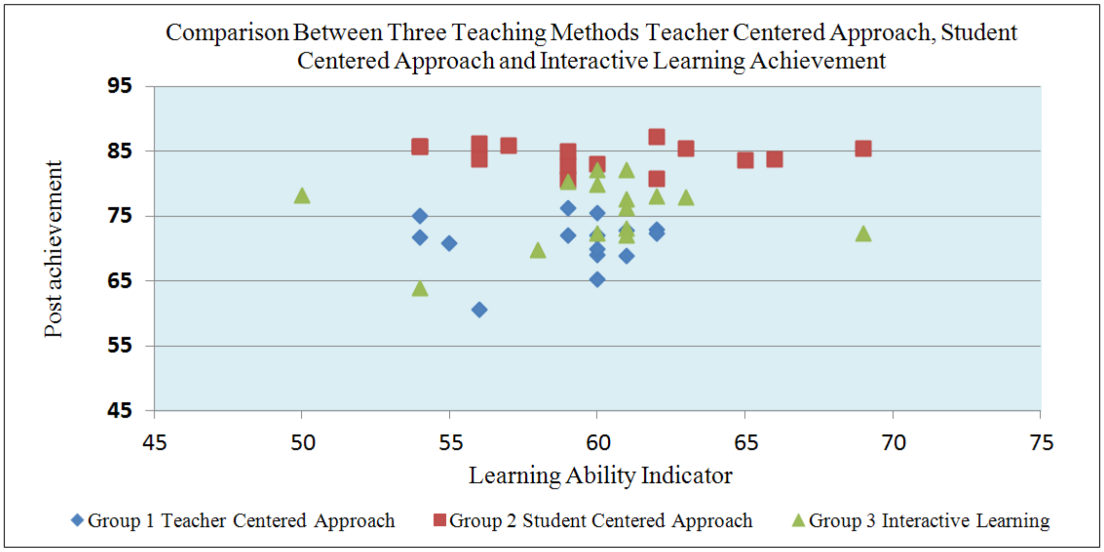


Figure 5.23 Comparisons between Three Teaching Methods

5.5 Time Management Analysis

The previous sections presented the analysis of T & L effectiveness based on cognitive, psychomotor and subject outcomes (specific learning outcomes). Table 5.2 presents the correlation of these results, plus the link between the achievement levels, time and number of the trials required to complete the tasks successfully. The achievement level of 100% means that all students from the specified groups completed 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. Furthermore, the students from group 2 required less time to complete all the tasks; between 84% and 87% of the allocated time. Therefore, the introduction of pedagogical package into the T & L approach makes the students more efficient and effective as they gain the appropriate knowledge and understanding in less time.

The achievement levels of students from group 2 were higher than for group 1 and group 3 in achieving the higher levels of cognitive skills (analysis, evaluate and create) and psychomotor skills (diagnose, plan and design, implement evaluate, improve, experience and conclude). Hence, the students are more capable to perform the following tasks in comparison with their colleagues:

1. Analysing and comparing during generation of tool path for different layers (cut complex gear in milling machine; perform taper cutting on the centre lathe and installing clutch parts)

2. Combine existing elements in order to create something original, or improve original, and modify the product or machine parts, after evaluating and judging the product. In some cases, errors are present

3. Judge the product using a standard, like when verifying the manufacturing production or gear box assembly, or to install new parts to the engine, the students judged and agreed according to the standard criteria using manufacturing and manual checklist.

Table 5.2 Students' achievement, average time and no of trail for students in each group

Proposed Cognitive Skills	Students achievement																	
	T1			T2			T3			T4			T5			T6		
	Demonstrate rang of transmission applications.			Diagnose, adjust and repair manual Gearbox.			Diagnose, adjust and repair manual clutch.			Demonstrate a range of Manufacturing tools and Measurements Skills.			Demonstrate a range of Milling and Centre Lathe setting.			Demonstrate a range of operations on Machine tools		
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
Knowledge	12	14	12	14	15	14	11	12	10	10	13	13	12	15	9	11	12	10
Comprehension	10	15	13	13	13	12	12	12	12	12	13	13	9	13	9	11	10	10
Application	11	12	12	12	11	12	13	13	10	11	13	13	9	13	9	11	11	9
Analysis	11	12	11	13	13	13	12	12	12	12	12	13	9	12	9	8	10	5
Evaluation	12	13	11	11	11	14	11	13	12	10	13	12	9	12	10	8	14	10
Creating	12	11	11	11	13	15	12	14	13	10	12	12	6	10	9	10	14	15
Proposed Psychomotor-Skills	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
Diagnose	10	15	12	10	15	12	12	13	12	10	13	12	12	12	9	12	15	15
Plan and Design	11	15	12	11	15	11	12	12	11	10	13	12	12	13	11	13	13	15
Implement	9	15	13	11	14	12	12	12	13	10	13	12	9	14	12	11	10	7
Improve	11	12	11	11	11	12	11	12	12	10	12	12	10	13	10	9	11	12
Experiencing	11	12	11	11	13	13	12	13	12	10	13	13	9	13	9	8	12	5
Evaluation	12	13	11	11	11	14	11	13	12	10	12	11	9	12	9	6	14	2
Conclude	12	11	11	11	13	15	11	13	12	10	12	11	6	11	12	9	14	14
Achievement % / group	74%	87%	77%	77%	86%	87%	78%	84%	78%	69%	84%	82%	62%	84%	65%	65%	82%	66%
Average time	23%	16%	19%	19%	16%	18%	24%	20%	22%	27%	20%	23%	20%	16%	19%	19%	15%	17%
Average number of trial	6%	2%	4%	5%	2%	4%	4%	2%	3%	5%	2%	4%	5%	2%	4%	5%	2%	3%

The other indicator for student's performance is the number of trials used by groups in completing the given tasks (figure 5.24). It is advisable in mechanical engineering (Automotive, Industrial Maintenance and Manufacturing) applications to have a reduced number of trials to build the correct production and maintenance model, and to 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.

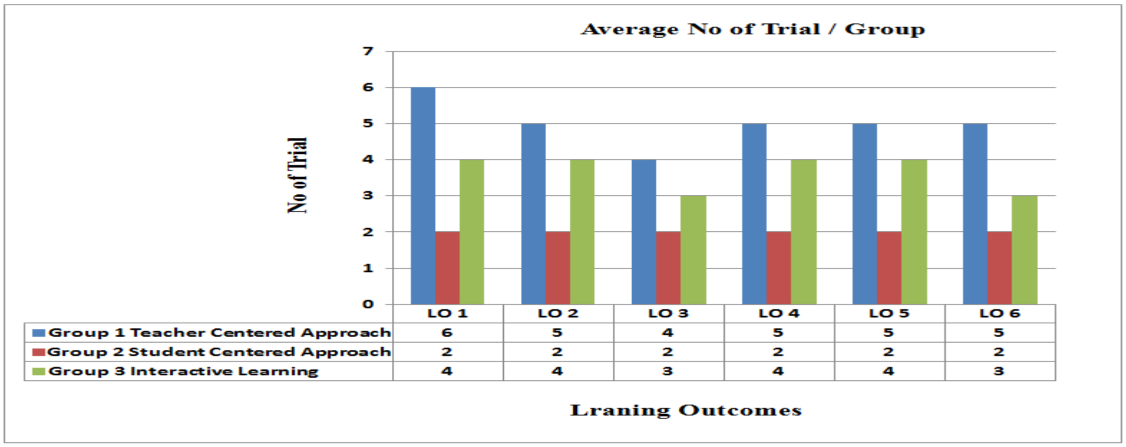


Figure 5.24 Number of trials used by groups in achieving learning outcomes

Figure 5.24 shows the comparison 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. Hence, they have used less material and time to achieve all six learning outcomes.

In mechanical engineering applications, it is necessary to build the correct product model, and use the correct procedures for the maintenance and manufacturing operations within the given time. The period of time taken by student's groups in order to achieve the learning objectives indicate the level of acquired skills and student's performance for various T & L methods.

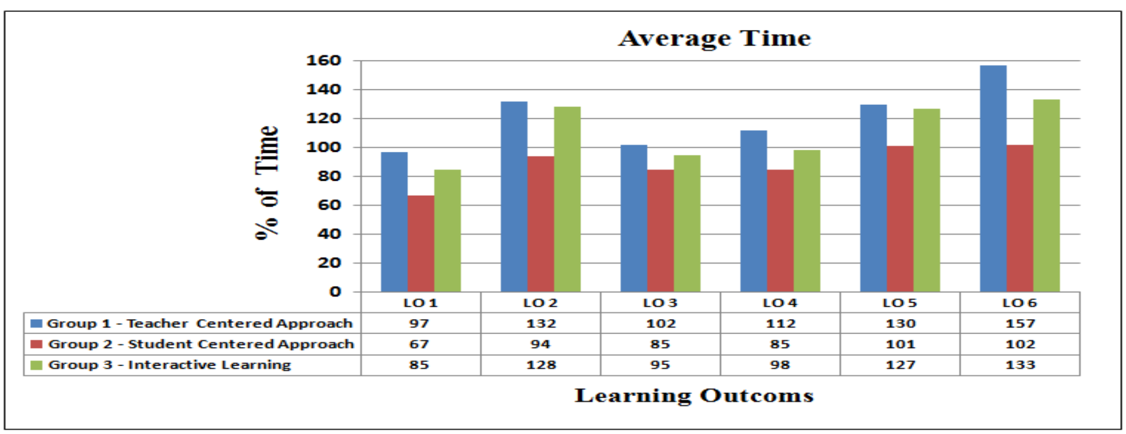


Figure 5.25 Average Time used by groups in achieving learning outcomes

Figure 5.25 shows the average time used by the student groups in achieving various learning objectives. It can be seen that students from group 2 spent 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 mechanical engineering module, using developed pedagogical package. They were then taught in the lab for practicing so that they could acquire the skills related to independent critical learners, and their efficiency increased afterwards.

5.6 Summary

This chapter has clearly demonstrated the effectiveness of developed Blended Learning system in a heterogeneous group learning activity. It has been observed that the group with combined teacher-centred approach performed much better than the group with traditional teacher-centred approach. Furthermore, combined teacher-centred approach helped students with widely differing pre-learning abilities to satisfy various learning outcomes in mechanical subject area.

It has indicated that the teacher, as facilitator, in teaching and learning, has significant effect on the performance of students. It has also been observed that in teaching methods, used in classroom and practical sessions, for group 2 and 3, the students felt more confident, and the learning achievement rates significantly increased as compared to group 1 students. The last section of this chapter, time management, shows that students in group 1 (teacher-centred approach) had good opportunity to demonstrate better than group 1 and 3 because of more number of trials.

The next chapter shows the quantitative and qualitative evaluation used for teaching and learning with help of Technological Techniques

CHAPTER 6
MATHEMATICAL LEARNING MODELS

6.1 Introduction

In the previous section it has been seen that use of Blended Learning system in a structured manner results in achieving higher order skills both in cognitive as well as psychomotor domains. There is a need to quantify skills improvements as the students go through lower level skills to higher level skills. To ascertain this progression it is necessary to develop a mathematical model of learning which can indicate the effectiveness of teaching and learning methods on skills improvement. In this chapter mathematical learning models have been developed, which predict the students' knowledge, depending on the amount of instruction they receive. It is hoped that these models will enable development of direct correlation between teaching and learning methods and the skills level attained by the students. The models are based on those proposed by Pritchard et al. (2008), and they are applied for different categories of learning. Parameters in the models are determined after least square fitting has been applied on observed student learning data.

6.2 Description of Learning Models

Four different models have been constructed by Pritchard et al. (2008), depending on the theory of learning. All of these models determine students' knowledge K_T as a function of the amount of teaching or instruction *t*. Thus, K_T represents the fraction of the material that is known by the student, and another parameter, U_T, represents what is unknown. Consequently:

$$U_T(t) = 1 - K_T(t) \tag{1}$$

The parameter that expresses the probability that something taught sticks in the student's mind is the sticking coefficient α. The models involve a differential equation for $\mathrm{d}U_T / \mathrm{d}t$, i.e. for the rate of change of unknown knowledge. The equations are based on U_T, because given instructions are generally related to what students do not know. However, once the solution for U_T is found, K_T can easily be obtained.

Students' knowledge, during the teaching period, depends on their initial knowledge K_{T0} which can be obtained by pre-instruction test scores, and can be used as input in the models. The improvement from pre-instruction to post-instruction scores can be described by the normalized gain as follows:

$$g(K_{T0}) = \frac{K_T(t_{ins}) - K_{T0}}{1 - K_{T0}} \tag{2}$$

where t_{ins} is the total amount of instruction received until the end of teaching period considered.

6.2.1 Pure Memory Model

The pure memory model assumes that students learn by memorization, and that learning is independent of prior knowledge. This model is particularly applicable of lowest skills in cognitive and psychomotor domains. If the sticking coefficient in this model is denoted by α_{mem}, then the equation for the rate of change of unknown knowledge can be written as follows:

$$\frac{\mathrm{d}U_T(t)}{\mathrm{d}t} = -\alpha_{mem} U_T(t) \tag{3}$$

This equation gives the solution:

$$U_T(t) = U_T(0)\exp(-\alpha_{mem} t) \tag{4}$$

or, for the known knowledge, using equation (1):

$$K_T(t) = 1 - (1 - K_{T0})\exp(-\alpha_{mem} t) \tag{5}$$

Then, the application of equation (2) provides solution for $g(K_{T0})$.

6.2.2 Simple Connected Model

The simple connected model is based on the assumption that students learn new knowledge by constructing an association between new and some prior knowledge. This knowledge is more suited for higher levels of cognitive and psychomotor domains. In this case, the learning rate is also proportional to the knowledge already known; thus, the governing differential equation takes the form:

$$\frac{\mathrm{d}U_T(t)}{\mathrm{d}t} = -\alpha_{con} U_T(t)(1 - U_T(t)) \tag{6}$$

Here, α_{con} is the sticking coefficient for this model. The solution for the known knowledge is obtained as follows:

$$K_T(t) = \frac{1}{1 + \frac{(1 - K_{T0})\exp(-\alpha_{con} t)}{K_{T0}}} \tag{7}$$

6.2.3 Connectedness Model

Real learning usually involves some learning of both types, mentioned in sections 6.2.1 and 6.2.2. Therefore, a further model is also introduced, which interpolates between, and even beyond, those two models. The model is called connectedness model, and the parameter that establishes the relationship between the pure models is called the connectedness parameter, denoted by β. This model can be effectively used for all the skill levels of cognitive and psychomotor domain skills. The model is equivalent to the pure memory model for β=0, and it is equivalent to the simple connect model for β=1. The governing differential equation takes the following form:

$$\frac{\mathrm{d}U_T(t)}{\mathrm{d}t} = -U_T(t)\left(\alpha_{con}\beta\left(1-U_T(t)\right)+\alpha_{mem}(1-\beta)\right) \quad (8)$$

and the solution for the known knowledge is written as follows:

$$K_T(t) = 1-\frac{(1-K_{T0})\left(\alpha_{mem}(1-\beta)+\alpha_{con}\beta\right)}{(1-K_{T0})\alpha_{con}\beta+\left(\alpha_{mem}(1-\beta)+K_{T0}\alpha_{con}\beta\right)\exp\left(\alpha_{mem}(1-\beta)t+\alpha_{con}\beta t\right)} \quad (10)$$

6.2.4 Tutoring Model

The key difference between the previous models and the tutoring model is that the classroom instructor needs to spend some time on reinstructing what some students already know, whereas the tutor need not. The tutoring model assumes that the tutor can impart knowledge at the student's maximum assimilation rate k_a; thus, the learning rate is independent of K_T and U_T, and the model is characterized by a uniform learning rate:

$$\frac{\mathrm{d}U_T(t)}{\mathrm{d}t} = -k_a \quad (11)$$

The solution of this equation for the known knowledge is the following:

$$K_T(t) = k_a(t-t_0) \quad (12)$$

6.3 Development of an Integrated Connectedness Model (ICM) for different learning domains

Two types of learning are studied here: cognitive learning and development of psychomotor skills. The following learning domains are distinguished in cognitive learning: knowledge, comprehension, application, analysis, synthesis, and evaluation. All of them are tested simultaneously after the learning period; however, each domain is based on the previous ones during learning. Therefore, the proposed model relates the test results of any domain to the test results of the preceding domain. Furthermore, the model assumes identical importance to each of these domains, i.e. the total knowledge that may be gained in each domain takes 1/6 of the total knowledge in the subject that students learn. The initial knowledge for the knowledge test is assumed to be $K_{T0,kn} = 0$, i.e. students do not know anything about the subject that they are about to learn. The knowledge gained in the knowledge domain is 1/6 of the total knowledge in the subject, and it is essential for gaining knowledge in the comprehension domain. Therefore, the initial knowledge for the comprehension test is $K_{T0,co} = 1/6K_{T,kn}(t_{ins})$, where $K_{T,kn}(t_{ins})$ is the known knowledge in the knowledge domain at the end of learning period. The initial knowledge can be determined similarly for all the other domains, ending with the initial knowledge for evaluation, which is $K_{T0,ev} = 5/6K_{T,sy}(t_{ins})$ with $K_{T,sy}(t_{ins})$ standing for the known knowledge in the synthesis domain at the end of learning period.

The model also assumes that learning in knowledge domain is independent of prior knowledge, learning in the evaluation domain is based purely on association between prior and new knowledge, whereas learning in the other domains is a combination of both types.

First, an appropriate model has to be chosen, then the sticking coefficients α_{mem} and α_{con} as well as the connectedness parameter β have to be determined. In practice, since the sticking coefficients always appear in the products αt in the models, the products $\alpha_{mem}t$ and $\alpha_{con}t$ are determined and used in further calculations. These parameters are determined by fitting the solution in the chosen model on test data.

Consequently, the combined model is constructed as follows (see figure 6.1). Learning in the knowledge domain is modelled by the pure memory model, and the product $\alpha_{mem}t$ is determined. Learning in the evaluation domain is modelled by the simple connect model, and the product $\alpha_{con}t$ is determined. Then, the same sticking coefficients α_{mem} and α_{con} in the connectedness model are used to simulate learning in the remaining four domains, and the connectedness parameter β is determined for each of the four domains.

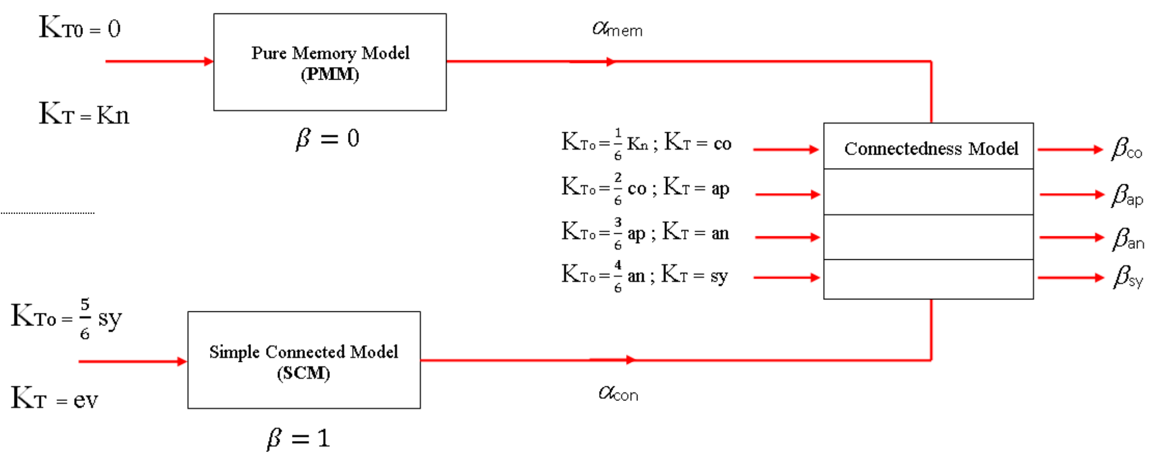


Figure 6.1 Flowchart of combined model for cognitive learning

The learning domains in the development of psychomotor skills are diagnose and explore, plan and design, action and implement, evaluate, improve, experiencing, and conclude. Similar assumptions are made as for cognitive learning, and consequently, model construction involves the same steps as those explained in the previous paragraphs. The only difference is that there are seven domains in psychomotor skills; thus, each domain takes 1/7 of the total knowledge in the subject that students learn, and the constants in determining initial knowledge will be 0 for diagnose and explore, 1/7 for plan and design, and so on, ending with 6/7 for conclude.

The above assumptions enable application of the mathematical learning model for evaluating skills learnt at each step of cognitive and psychomotor domains. Through this model it can be clearly seen that whether teaching and learning effectiveness of the blende learning system is consistent across all the sub-domains.

6.4 Validation of ICM

Appropriateness of various models presented above, for the prediction of the effectiveness of teaching/learning process, has been presented in this section. For this purpose, the data available in the literature has been used to quantify the usefulness of the teaching and learning process (Salah 2009). It is hoped that this analysis will enable judging the suitability of an appropriate mathematical model.

Three groups exposed to different teaching and learning methods provide us enough information on how these models could predict the teaching and learning mechanics. The three models, namely Pure Memory Model (PMM), Simple Connected Model (SCM) and Connectedness Model (CM), have been analysed for their appropriateness in simulating various teachings/learning methods used in this study. In evaluating cognitive and psychomotor skills at the lowest level, it is necessary to use pure memory model as skill development at that level takes place purely by memory recall. In the intermediate skills level, the skill development takes place through memory recall as well as connecting various knowledge information obtained. As such, the simple connected model best represents the skills' level development for intermediate skills. The highest level skill is the evaluation /creation, and at this level connectedness model represents skills' development best as at this level students need to integrate all the skills learned earlier, and they do not need to take recourse to memory recall. Table 6.1 clearly shows the sticking coefficient α_{mem}, or more precisely the product $\alpha_{mem}t$, as determined for each of these groups from the pure memory model only, using the test results obtained for the knowledge domain and assuming no initial knowledge. Then, the product $\alpha_{con}t$ was calculated from the simple connect model using the test results obtained for the evaluation domain and using test results obtained for the synthesis domain as input. Results are collected in table 6.1. The dependence of post-instruction knowledge on initial knowledge in the evaluation domain is shown in figure 6.2 together with the test data used for fitting. The same function for the knowledge domain cannot be shown, since the initial knowledge of each student was assumed to be zero.

Table 6.1 Sticking coefficients for cognitive learning

	Group 1	Group 2	Group 3
$\alpha_{mem}t$	1.48	3.01	1.69
$\alpha_{con}t$	0.39	0.93	0.5

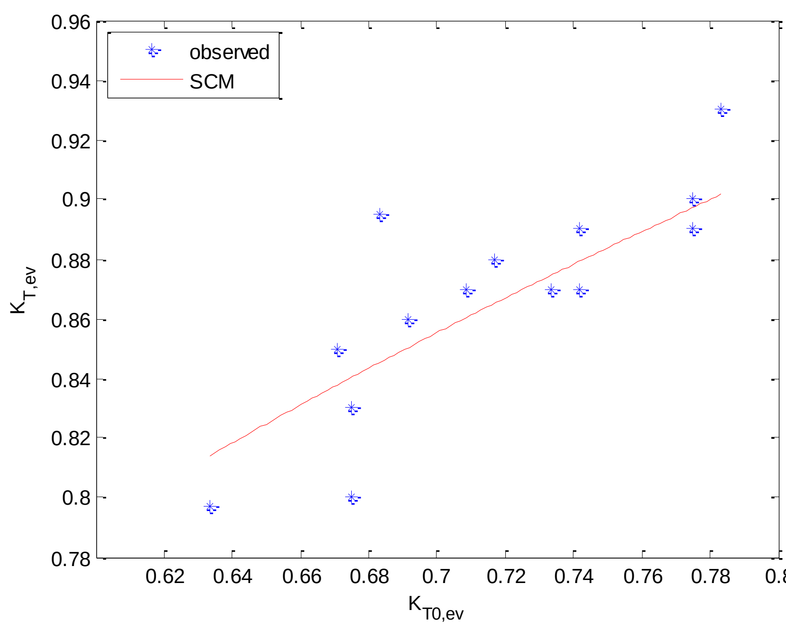


Figure 6.2 Curve fitting on data for evaluation domain (simple connected model – SCM) for Group 2

Furthermore, table 6.1 clearly shows the effectiveness of teaching and learning methodology used with Group 2. It can be clearly seen that not only it is more effective at lower level skills such as memorisation but it is also effective at evaluation which is a very high order cognitive skill.

Furthermore, assuming the same sticking coefficients for all of the learning domains, the connectedness parameter was also determined for each learning domain. This parameter was assumed to be zero and one for the knowledge domain and for the evaluation domain, respectively, and it was obtained from least squares fitting on test data for the remaining four domains. Results are listed in table 6.2. The connectedness parameter increases for the different domains from knowledge to evaluation, because the more advanced the students' learning in the subject, the more association they can construct between new and prior knowledge. The only value that did not follow this trend is the connectedness parameter for the comprehension domain for Group 3. This value is negative, which means that the normalized gain slightly decreases with increasing pre-instruction test scores. This can happen when students with higher pre-instruction scores exert less effort, whereas students with lower pre-instruction scores make more effort to improve their results (Pritchard et al., 2008). Furthermore, this grouped was exposed to not a very structured learning environment as instructor's input was least with this group. This might have caused skills development that cannot be explained form the model that has been used. The post-instruction knowledge as a function of initial knowledge is shown in figure 6.3. The blue and the red curves represent results that could have been obtained assuming pure memory model and simple connect model, respectively. The green curves show the result that actually obtained by the connectedness model. Corresponding to the increasing connectedness parameter, the green curve is closer and closer to the red one as learning advances from the comprehension to the synthesis domain. Since the observed data are closest to the green curve, figure 6.3 also demonstrates that the connectedness model is the most appropriate for modelling the learning processes where the skills are not at the lowest or at the highest level as it is the case for learning domains from the comprehension to the synthesis domain, in this example.

Table 6.2 Connectedness parameters for all the learning domains in cognitive learning

	Group 1	Group 2	Group 3
Knowledge	0	0	0
Comprehension	0.05	0.22	–0.12
Application	0.14	0.46	0.32
Analysis	0.70	0.64	0.34
Synthesis	0.91	0.85	1.04
Evaluation	1	1	1

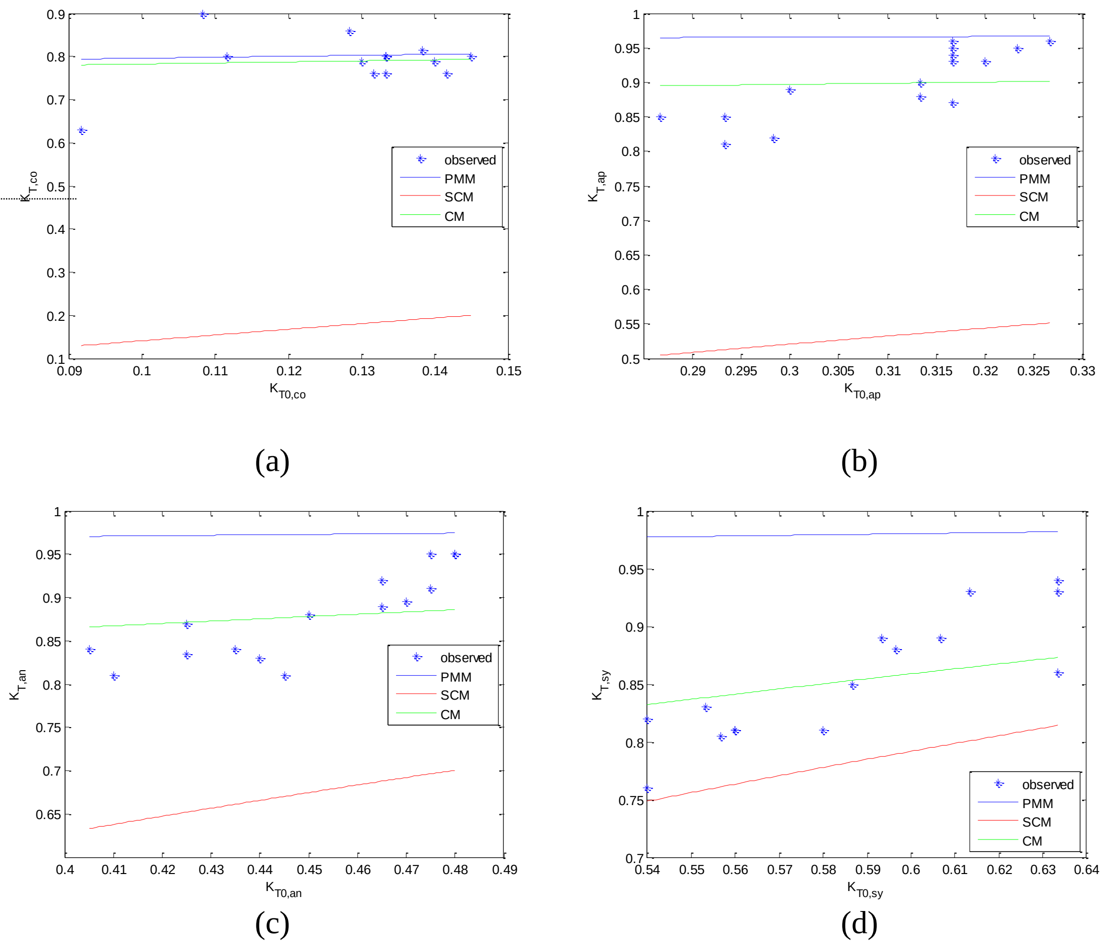


Figure 6.3 Curve fitting on data for Group 2 (connectedness model – CM), (a) comprehension, (b) application, (c) analysis and (d) synthesis domains; PMM – pure memory model, SCM – simple connect model

The normalized gains for all the six domains are shown in Figure 6.4. The normalized gains for the knowledge and for the evaluation domains are represented by the blue and red curves, respectively. They are shown in each figure, because they would be the same for all the other domains if pure memory model or simple connect model were applied in those domains. The normalized gain is constant for the knowledge domain, because the applied pure memory model assumes that the normalized gained knowledge is independent of initial knowledge. However, there is a significant increase in the gained knowledge with the initial knowledge for the evaluation domain, because the key assumption of the simple connect model is that students learn by constructing associations between prior and new knowledge. The normalized gains for the remaining four learning domains are represented by the green curves. Similarly to the function of gained knowledge shown in Figure 6.3, the normalized gain is also closer and closer to that obtained by the simple connect model as learning advances from the comprehension to the synthesis domain.

The above discussion clearly indicates that the novel learning model developed in this study is appropriate to be used in investigating effectiveness of teaching and learning methods used in this study.

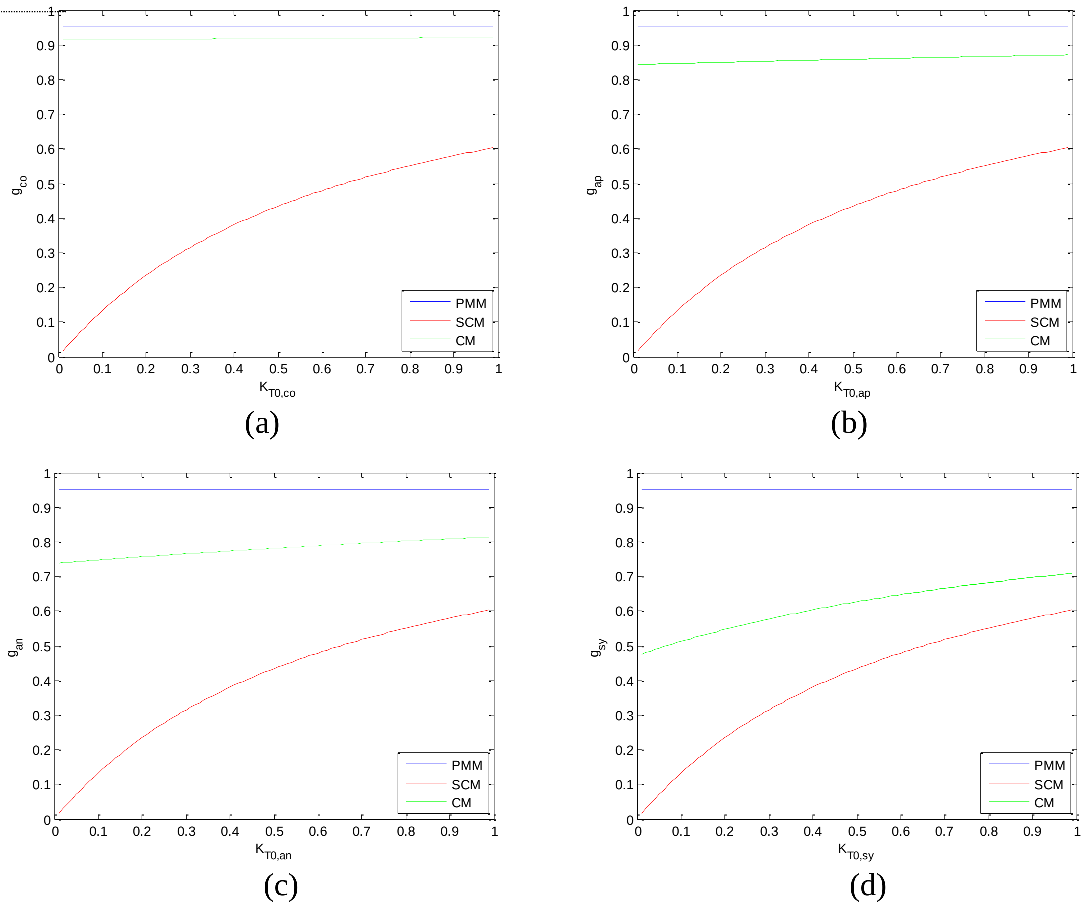


Figure 6.4 Normalized gain for Group 2 for knowledge domain (pure memory model – PMM, blue), evaluation domain (simple connect model – SCM, red), (a) comprehension, (b) application, (c) analysis and (d) synthesis domains (connectedness model – CM, green)

6.5 Microscopic Evaluation of Teaching/Learning methods used in this study through ICM

As mentioned previously, the three teaching and learning methods used with the three different groups yielded different results. As shown in Chapter 5, teaching/learning methods used with Group 2 provided best student's overall results. However, it is not clear how students' progress from lower level of skills to the higher level of skills. To develop a benchmark for this skills progression, mathematical model developed in the previous section has been used to quantify learning process in terms of few parameters. From the previous section, it can be seen that these parameters are α_{mem}, α_{con} and β. In the following sections, these parameters have been evaluated for different teaching and learning processes.

6.5.1 Cognitive Learning

The combined model is applied here for the case of imparting cognitive learning skills through Blended Learning system used in the present study. The same procedure described earlier in this chapter is followed for different learning domains. The learning domains for this case are the following: knowledge, comprehension, application, analysis, evaluation and creating. The test data collected in this study for the three groups, where different teaching methods have been used, for obtaining learning parameters (Table A8.2 in Appendix 8). The product $\alpha_{mem}t$ for the knowledge domain as well as the product $\alpha_{con}t$ for the creating domain were determined for each of the groups, and results are provided in Table 6.3. The dependence of post-instruction knowledge on initial knowledge in the creating domain is shown in figure 6.5 together with the test data used for fitting.

Table 6.3 Sticking coefficients for revised cognitive learning

	Group 1	Group 2	Group 3
$\alpha_{mem}t$	1.33	2.01	1.45
$\alpha_{con}t$	0.57	0.71	0.49

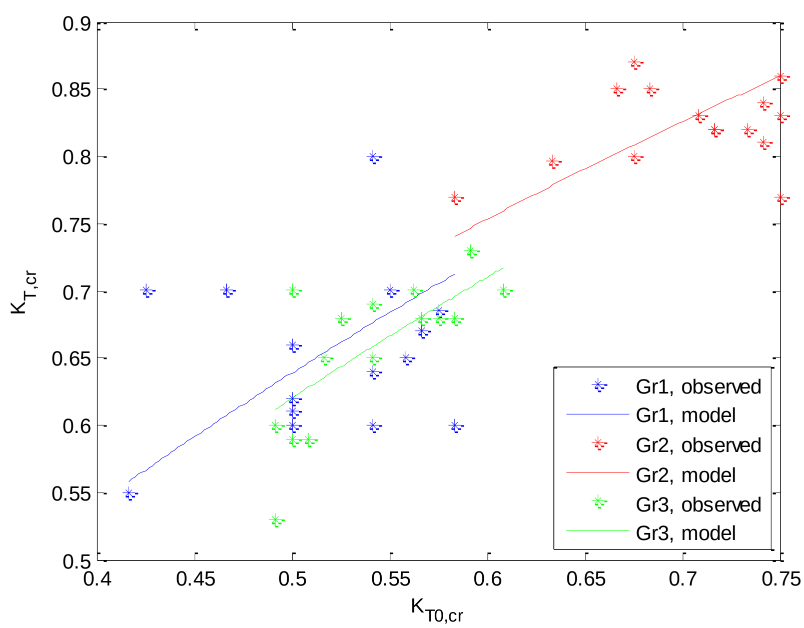


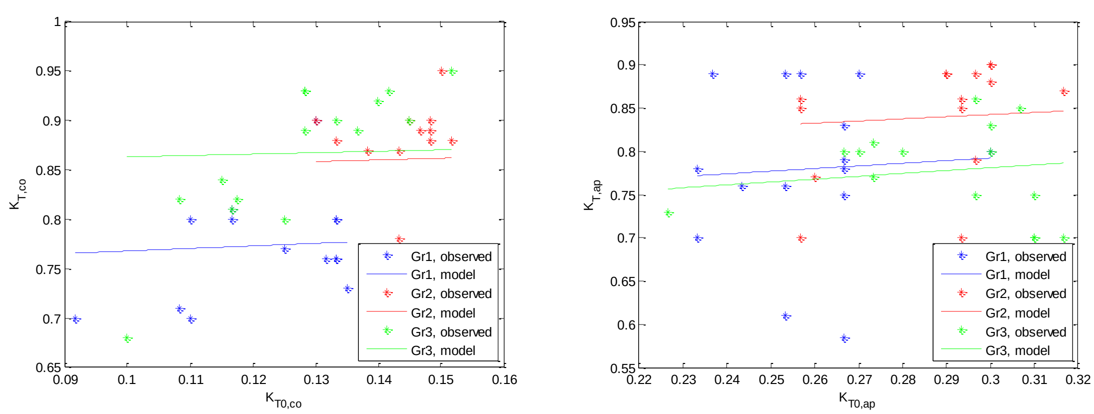
Figure 6.5 Curve fitting on data for creating domain (simple connect model)

Once the sticking coefficients are known, the connectedness parameter was also determined for each learning domain, and results are given in Table 6.4. Similarly to the previous example, the connectedness parameter increases for the different domains from knowledge to creating.

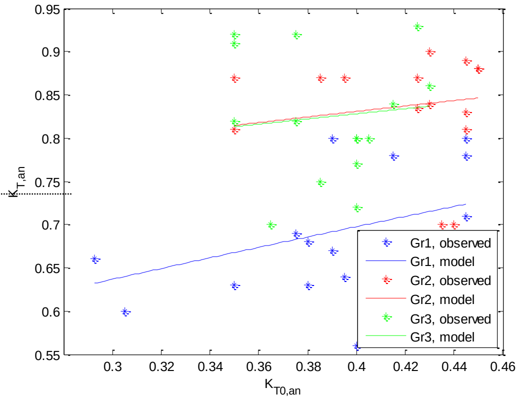
Table 6.4 Connectedness parameters for all the learning domains in cognitive learning

	Group 1	Group 2	Group 3
Knowledge	0	0	0
Comprehension	–0.02	0.12	–0.37
Application	0.12	0.33	0.25
Analysis	0.64	0.48	0.18
Evaluation	0.94	0.66	1.03
Creating	1	1	1

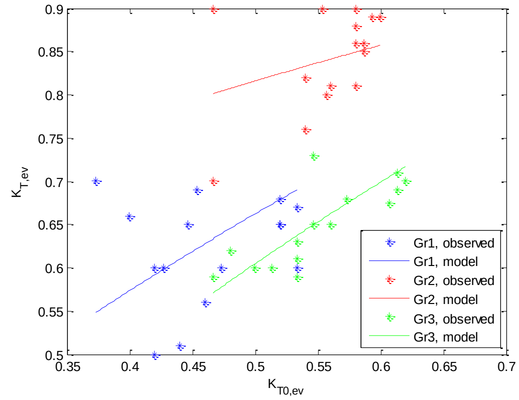
The post-instruction knowledge as a function of initial knowledge is shown in figure 6.6. The normalized gains for the knowledge domain and for the creating domain are obtained from the pure memory model and the simple connected model, respectively, and they are shown in figure 6.7. The normalized gains are calculated for the remaining four learning domains by using the connectedness model, and they are presented in figure 6.8. It can be seen that the knowledge as well as the normalized gain is always highest for Group 2. The knowledge and the normalised gain are lowest for Group 1 in the knowledge, comprehension and analysis domains, whereas these are lowest for Group 3 for the application, evaluation and creating domains. Thus, the teaching method applied for Group 3 is more effective at lower level skills, but the method applied for Group 1 is more effective at higher level skills. However, the most effective teaching method in all the cases is the one that has been applied with Group 2.



(a) (b)

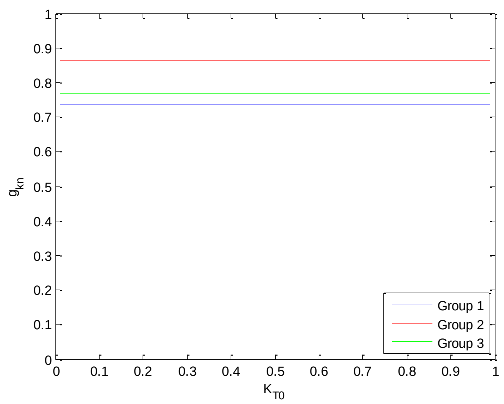


(c)

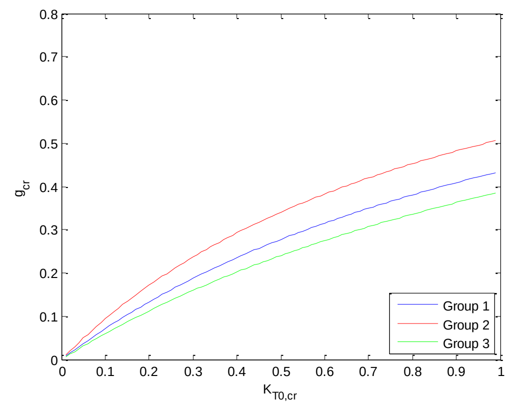


(d)

Figure 6.6 Curve fitting on data (connectedness model), (a) comprehension, (b) application, (c) analysis and (d) evaluation domains

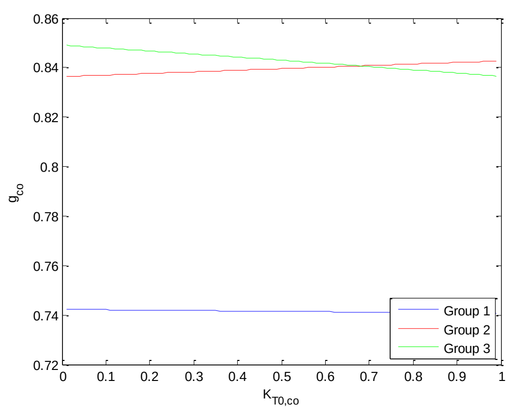


(a)

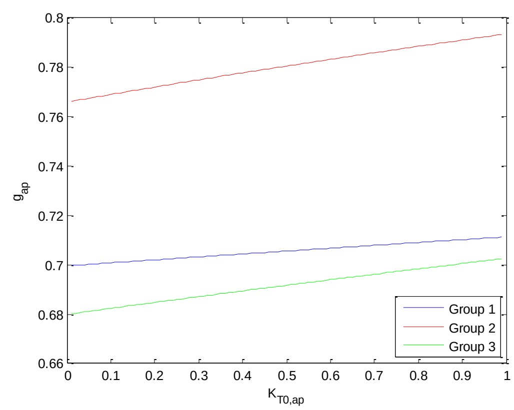


(b)

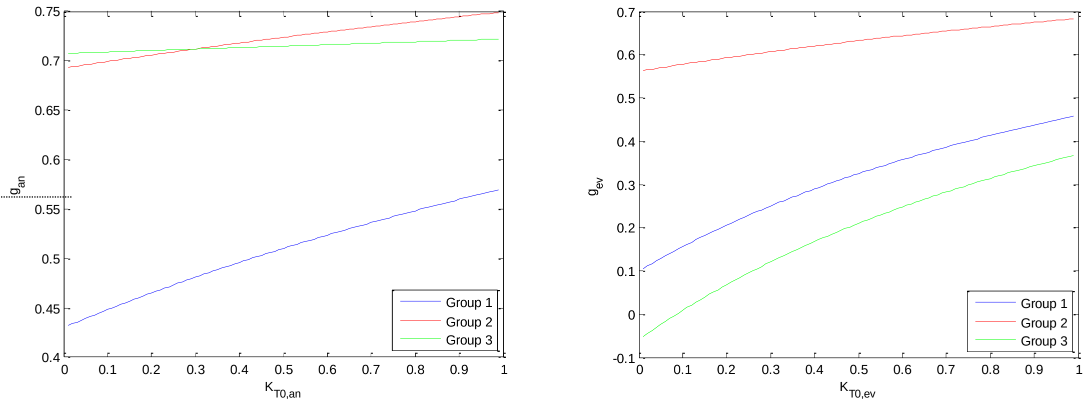
Figure 6.7 Normalized gain (a) for knowledge domain (pure memory model), (b) creating domain (simple connect model)



(a)



(b)



(c) (d)

Figure 6.8 Normalized gain for (a) comprehension, (b) application, (c) analysis and (d) evaluation domains (connectedness model)

6.5.2 Psychomotor Skills

The combined model is applied in this section for the development of psychomotor skills. The same procedure described in section 6.4 is followed for different learning domains. Test data are available again for three groups where different teaching methods were applied (Table A8.3 in Appendix 8). The product $\alpha_{mem}t$ for the diagnose and explore domain as well as the product $\alpha_{con}t$ for the conclude domain were determined for each of the groups, and results are provided in table 6.5. The dependence of post-instruction knowledge on initial knowledge in the conclude domain is shown in figure 6.9 together with the test data used for fitting.

Table 6.5 Sticking coefficients for development of psychomotor skills

	Group 1	Group 2	Group 3
$\alpha_{mem}t$	1.33	2.01	1.53
$\alpha_{con}t$	0.49	1.00	1.15

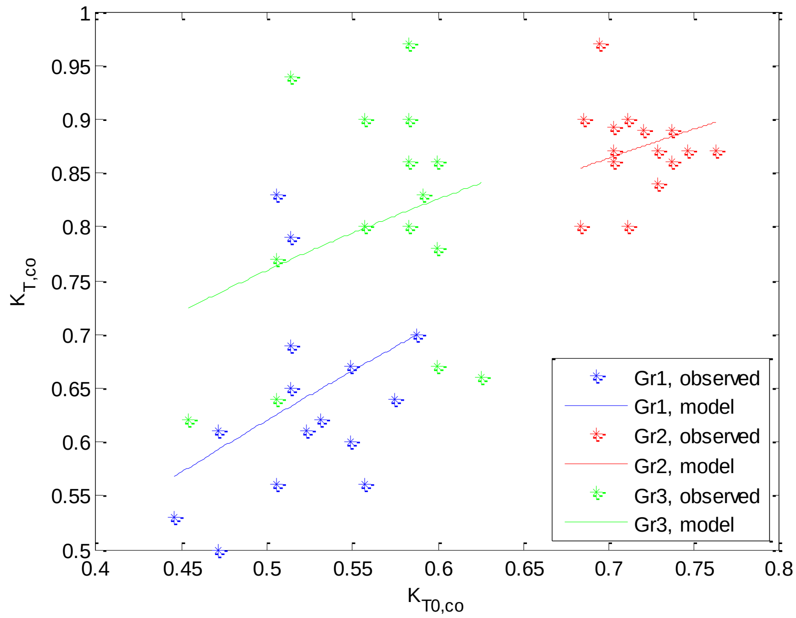


Figure 6.9 Curve fitting on data for conclude domain (simple connect model)

Once the sticking coefficients are known, the connectedness parameter was also determined for each learning domain, and results are given in table 6.6. Similar tendency can be observed as for the cognitive learning in section 6.5.1. The connectedness parameter increases for the different domains from diagnose and explore to conclude.

Table 6.6 Connectedness parameters for all the learning domains in development of psychomotor skills

	Group 1	Group 2	Group 3
Diagnose and explore	0	0	0
Plan and design	0.01	-0.06	-0.43
Action and implement	0.12	0.22	0.23
Evaluate	0.58	0.38	0.27
Improve	0.83	0.63	1.25
Experiencing	0.89	0.87	1.21
Conclude	1	1	1

The post-instruction knowledge as a function of initial knowledge is shown in figure 6.10. The normalized gains are presented in figures 6.11 and 6.12. The normalized gains for the diagnose and explore domain and for the conclude domain are obtained from the pure memory model and the simple connected model, respectively (Figure 6.11); whereas they are calculated for the remaining five learning domains by using the connectedness model (Figure 6.12). It can be observed in Figures 6.10-6.12 that the knowledge as well as the normalized gain is always highest for Group 2 and lowest for Group 1. Thus, the most effective teaching method is applied for Group 2.

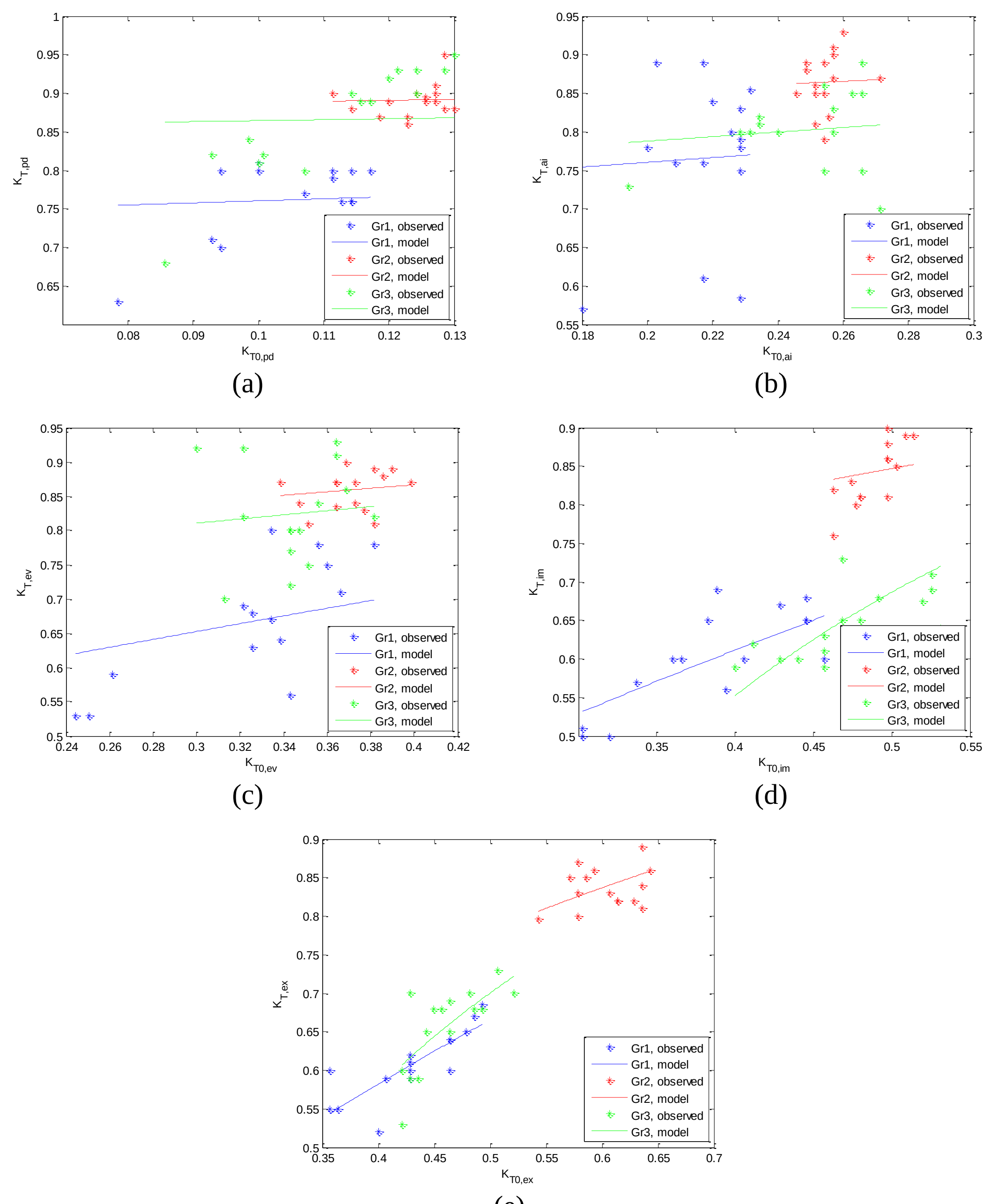
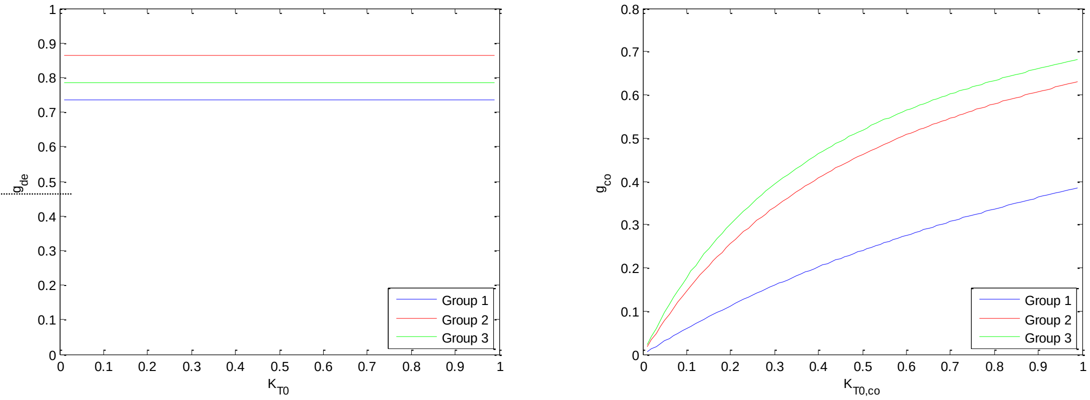
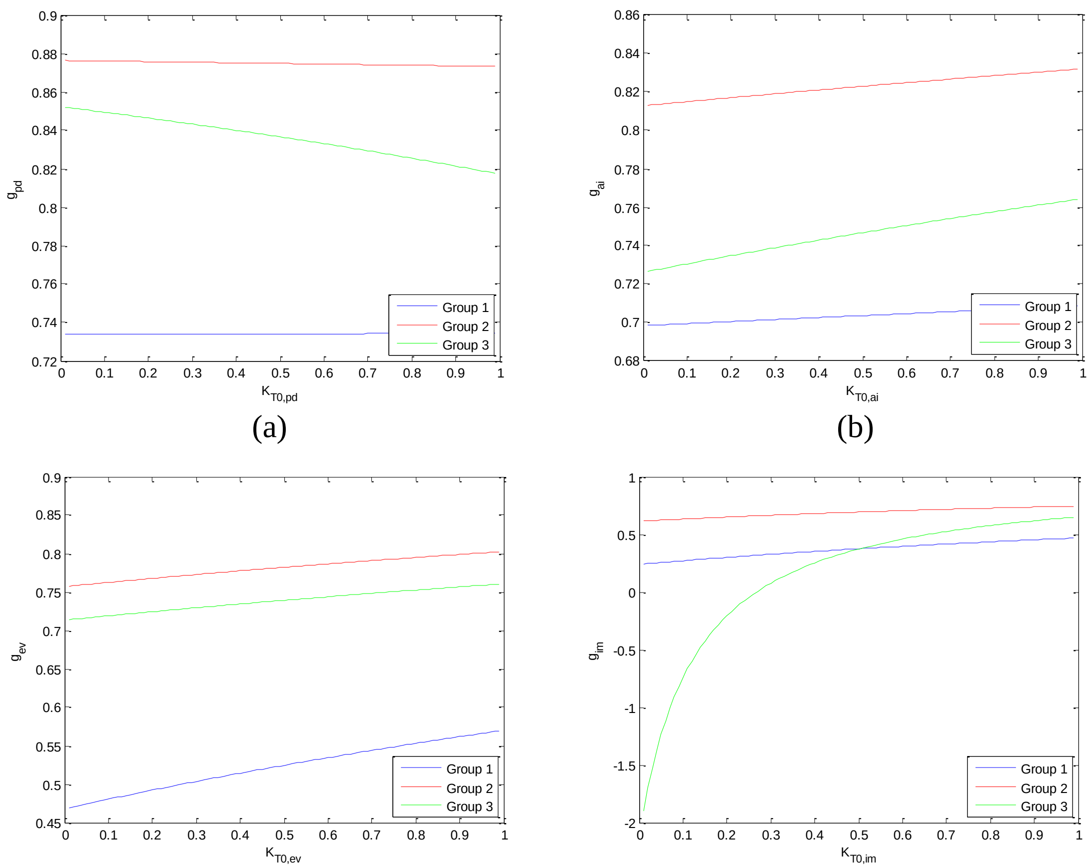


Figure 6.10 Curve fitting on data (connectedness model), (a) plan and design, (b) action and implement, (c) evaluate, (d) improve, and (e) experiencing domains



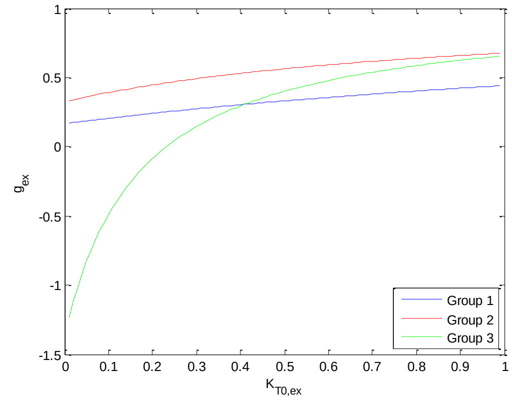
(a) (b)

Figure 6.11 Normalized gain (a) for diagnose and explore domain (pure memory model), (b) conclude domain (simple connect model)



(a) (b)

(c) (d)



(e)

Figure 6.12 Normalized gain for (a) plan and design, (b) action and implement, (c) evaluate, (d) improve, and (e) experiencing domains (connectedness model)

The above study has clearly indicated that integrated connectedness model (ICM) represents skills development in cognitive and psychomotor skills domains fairly well. ICM can be used to monitor effectiveness of the teaching and learning strategies through well-developed assessment strategies. It can also dictate development of teaching and learning materials by providing important feedback on the effectiveness.

CHAPTER 7
CONCLUSIONS AND FURTHER WORK

7.1 Research Synopsis

The quality of the teaching and learning provisions at SKI was reviewed at regular intervals each academic year (MOE in Bahrain and SQA, 2009; Quality Assurance Manual, 2008). The reviewed report indicates that there is a gap that exists between modern industrial requirements and the work skills of the graduating students. More specifically, the factors that result in this gap have been identified as the need for state of the art engineering courses that impart necessary skills at Higher level of Thinking Skills, need for modern teaching and learning processes blended with state of the art computer technology to help develop teaching strategies and learning styles at High Level of Thinking Skills (HLTS).

The main aim of this research is to bring about a step change in the SKI's (SKI) quality of teaching and learning provisions including both the Cognitive and Psychomotor at HLTS, in order to equip Bahraini labour market with high level of hands-on skills in mechanical engineering, by bridging the gap between the entry skills (skills at pass-out from HND), and the exit skills (required by labour market), by a well-constructed curriculum, delivery and assessment. This will minimize the following constraints present in the teaching and learning system.

- The amount of information, and the time allowed for delivering the existing engineering courses in Cognitive and Psychomotor, limits students' abilities and does not consider labour market needs
- The existing engineering courses are based on teacher- centred learning, and focus on theoretical learning in ordinary classrooms, and little attention is being paid to the practical applications
- The existing mechanical engineering courses have limited ability to link theoretical content and practical applications
- The existing engineering courses focus on low level of cognitive skills. The transition need to be at high level of cognitive and psychomotor skills, and at higher level of thinking skills

Several research activities have been conducted at the pilot site of higher education, at SKI (SKI), to get first-hand information from the stakeholders. This enabled the author to understand problems currently being faced at SKI Bahrain. Mechanical Engineering subject area has been authors primary interest hence detailed literature review has been carried out on main aspects of teaching and learning provisions at SKI Bahrain in mechanical engineering subject area. Most of the information collected from the stakeholder's were reports (MOE, labour market, awarding body, EDB, Allen skills gab study, SKI teacher's and student's results) that investigated teaching and learning systems at SKI Bahrain. (See chapter 1).

Literature from different references, and some readily available reports, gave information on how the Government of Bahrain, MOE, SKI and other educational organizations are supporting the integration of computer technology in the higher education, and other educational institutions, for better quality of education and improved access to teaching/learning materials. The design and development of a Blended Learning system was carried out in the year 2011. The Blended Learning system focuses on integrating pedagogical and technological features into teaching and learning system.

A new model for High level of Psychomotor and Cognitive skills (HLPS & HLCS) was developed in an integrated form, which focused on HND level of higher education students at SKI, to equip the students with the skills required by Bahraini labour market. The proposed methodology could be used for restructuring the content of engineering courses in higher education (institutes, college and universities) system to include High level of Cognitive and Psychomotor skills. The author designed and developed mechanical engineering (Automotive, Industrial Maintenance and Manufacturing Engineering) subjects' material at Higher Order of Cognitive and Psychomotor skills, to equip engineering students with the necessary skills so that they could be confident in performing tasks related to hands-on work of mechanical engineering disciplines.

Development of the -Blended Learning system involved the integration of the pedagogical underpinnings with technical subject matter that is delivered through a variety of ways. The approach required chunking down of bulky learning materials into small objectives, each with a learning objective. The model permits for user involvement in all the phases, and continuous assessments of all the phases until all the requirements are satisfied. It also permits for any alteration whenever is required. The analysis phase is the basic and necessary step in order to guarantee production of quality learning materials. The subject's contents were obtained from developed teaching/learning materials from SKI. The design of the proposed subject layout has been accomplished with the help of the mechanical syllabus and approved by Higher Education and MOE in Bahrain.

The relation between the existing approaches of teaching and learning, practiced in higher education environment with SKI students, teaching/learning styles were examined using teacher's and student's questionnaires. The aim of the teacher's questioners is to find out the lecturers perception of the teaching experience, while teaching mechanical topics, and the effectiveness of the three T & L methods (teacher-centred approach, student-centred approach and interactive learning) with and without Computer Tutorial Package (CTP) and Computer Assisted Instruction (CAI). Through this questionnaires, an attempt has been made to understand lecturer's experience of the T & L process. The questions were divided into five categories i.e. Organisation, Presentation, Classroom Management, Assessment Mechanisms and Lecturer's perception of teaching.

The aim of the students questioner's is to find out the learning experience of students in the mechanical engineering module, and effectiveness of the three T & L methods (teacher-centred approach, student-centred approach and interactive learning) with and without Computer Tutorial Package (CTP) and Computer Assisted Instruction (CAI). The study has been carried out to explore problems during teaching and learning process in the subject area of mechanical engineering. The questionnaires have been formulated to understand the mechanics of the learning process from student's perspective. Through this, student's questionnaires have 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. Furthermore, various categories used in the questionnaire are student's attitudes towards learning mechanical subjects, student's opinions about their lecturers' approaches to teaching process, student's opinions and views about various aspects of T & L the mechanical subjects such as session planning and organising, delivery of course material, classroom management, assessment and feedback strategy and students' interaction.

After implementing the Blended Learning with the help of three different teaching and learning systems, the performance of the students was tracked throughout the year. This was carried out to enable best possible way of blending e-learning systems with traditional teaching mode. This enabled a close monitoring of teaching and learning provisions. To monitor the teaching and learning systems at, microscopic level, a mathematical model based approach was followed. This allowed determination of effectiveness as skills level both in cognitive and psychomotor learning domains and various skills level starting from lower levels to higher levels.

7.2 Thesis Conclusions

A comprehensive study has been carried out to support the existing literature regarding the design, development, implementation and evaluation of a novel Blended Learning system for Mechanical Engineering courses in Bahrain. The major conclusions from each facet of this research study are summarized as follows:

1. Design and Development of a Blended Learning System for Mechanical Engineering students

A novel Blended Learning system has been developed through integration of pedagogical concepts with traditional teaching material in mechanical engineering subject area in order to improve the teaching and learning process at SKI. Its effectiveness has been determined by questionnaires (data collection methods) completed by lecturers and students. The answers have been analysed from quantitative and qualitative points of view. The questionnaires have been designed by taking into consideration the issues of reliability, validity and bias and concentrating on specific research questions. The lecturers' questionnaires aims to find out lecturers' opinions about the various aspects of educational process i.e. 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 etc.

Based on the Blended Learning system, learning outcomes of various Mechanical Engineering modules have been developed in both cognitive and psychomotor domains. Furthermore, assessment criteria have also been developed for these modules. The effect of using technology in teaching/learning process, and the design of the website to incorporate e-learning method into teaching has been investigated in detail.

2. Development of e-repository for Mechanical Engineering students

The author has designed and developed Mechanical Engineering subjects' course material (for Automotive, Industrial Maintenance and Manufacturing Engineering specializations) at higher level of both Cognitive and Psychomotor skills, in order to equip engineering students with the necessary skills to meet Bahraini labour market's needs. The developed subject materials have been integrated into an e- repository, which has been designed to give students knowledge and understanding of the operation, maintenance and manufacturing requirements of mechanical engineering subject area. This integration has been implemented through the design of a website that contains the course material for various mechanical engineering modules. The students can evaluate and give feedback through the use of this website. They experience the work in good work placement environment using the latest technology, which is required by Bahrain labour market.

3. Implementation of the Blended Learning System for Mechanical Engineering students

In order to implement the Blended Learning system at SKI, three different teaching methodologies have been adopted. These methodologies correspond to the conventional face-to-face teaching (teacher-centered), teaching through the use of technology with supervision from the teacher (student-centered), and teaching through an interactive method in which students use the technology for learning purposes as per their convenience. The effectiveness of teaching methods has been determined by user evaluation method of questionnaires i.e. data collection method, completed by both the lecturers and the students. The questions that have been considered for the design of these questionnaires include the teacher's and student's point of views about the teaching/learning methodology. Their answers have been analysed from both quantitative and qualitative points of views.

4. Evaluation of the Blended Learning System for Mechanical Engineering students

Three groups of students and three groups of mechanical engineering teachers have been selected for the evaluation of the Blended Learning system developed for Mechanical Engineering students at SKI. The aforementioned T & L methods have been implemented with each group. Group 1 was taught under the watchful eyes of the instructor (teacher-centered), Group 2 was taught under the watchful eyes of the instructor with the use of technology (student-centered), and Group 3 learned through interactive learning method. The effectiveness of developed Blended Learning system has been clearly mentioned in a heterogeneous group learning activity. It has indicated that the teacher, as facilitator, in teaching and learning, has significant effect on the performance of students. It has also been observed that in teaching methods, used in classroom and practical sessions, for group 2 and 3, the students felt more confident, and the learning achievement rates significantly increased as compared to group 1 students. The last section of this chapter, time management, shows that students in group 1 (teacher-centred approach) had good opportunity to demonstrate better than group 1 and 3 because of more number of trials

5. Development of a Novel Mathematical Model of teaching/learning process in both Cognitive and Psychomotor Domains

Microscopic evaluation of the proposed teaching/learning method through the use of novel mathematical learning models has been carried out that takes into account the results presented in this study. These models have been implemented on the three groups of students for three different teaching methods (teacher-centered approach, student-centered approach and interactive learning). The developed mathematical models have been validated using the data available from literature and used in the current study to quantify the improvement in skills in both the cognitive and psychomotor domains.

7.3 Thesis Contributions

In respect to this thesis, the following contributions to the knowledge are found to be new to the Higher education at SKI.

a) Design and Development of a Novel Blended Learning System

A novel Blended Learning system has been developed in the present study that has been designed in accordance with the labour market's requirements in Bahrain. The Blended Learning system has been developed using high level of cognitive and psychomotor skills for Mechanical Engineering students at SKI. This model has been shown to significantly improve the teaching and learning process. The developed system is unique in the sense that such systems are not available for mechanical engineering subjects, which need higher level of cognitive and psychomotor skills in advanced modules. The developed system satisfies these requirements very closely as the subject matter developed is linked to individual cognitive and psychomotor skills needed by the industry.

b) Implementation of the Blended Learning System

The implementation of the Blended Learning system is a novel contribution of this study, where both conventional and technology based teaching methods have been implemented and compared against each other. Various groups of teachers and students have experienced these models, and their reviews about these models have helped in understanding the dynamics of the developed model. Implementation of Blended Learning system needs a careful balance between teacher-led teaching and flexible learning through e-learning systems that is student-led.

c) Evaluation of the Blended Learning System

Macroscopic evaluation of the effectiveness of different teaching and learning methods is a novel contribution of this study. Author is not aware of any study where these two methods have been blended in different proportions for the teaching and learning of the modules presented in this study. It has been clearly shown that the teaching through the use of technology with supervision from the teacher (student-centered approach) is best suited for Mechanical Engineering subjects.

d) Development of Novel Mathematical Models

Novel mathematical models have been developed in the present study that quantifies the learning process at microscopic level within cognitive and psychomotor skills domain. In contrast to the macroscopic (conventional) evaluation methods used throughout the world, these models provides a much clearer picture of the teaching/learning taking place at different skills' levels enabling a better control over the quality of teaching and learning process. These models can be further modified in order to apply them to other fields of education.

7.4 Recommendation for Future Work

The instructional design methodology for the pedagogical and technological content development involves five main phases which are analysis, design, development, implementation and evaluation. As far the licentiate research is concerned, the analysis phase is nearly completed. The design phase and evaluation phase are covered incorporate with modifications for better results. The Development, Implementation and Evaluation phases for the pedagogical and technological contents are to be carried out in the near future for the completion of the PhD work.

A summary of the recommendations of future work can be made on the basis of this study to improve the quality of the teaching Mechanical Engineering subjects in Sh. Khalifa Institute from Bahrain as given below:

1. Development of the Mechanical Engineering subjects contents will involve the use of Computer Tutorial Packages (CTP), Computer Assisted Instruction (CAI) and web based technologies (WBT). A through literature review and practice of pedagogical and technological content packages for the determination of Teacher Centered Approach and Interactive Learning will be carried out at this stage. The aim is to use Computer Tutorial Packages, Computer Assisted Instruction and Web Based Technologies Packages for teaching/learning in mechanical engineering subject area at SKI. Software license fee may also be considered for application like Micromedia Flash, Dreamweaver etc. depending on the availability and compatibility with the system to be developed. Web based packages must also be taken into consideration for the use Computer Tutorial Packages, Computer Assisted Instruction environment. Micromedia Flash, Dreamweaver etc. technologies have been widely used in the content creation and management. This will be studied for further implementation of content development

2. The learning objects developed will be gathered and stored in the developed content repository and e-repository. The implementation phases will involve continues testing of the Computer Tutorial Packages (CTP), Computer Assisted Instruction (CAI) and web based technologies (WBT) system at the pilot site. The subject of mechanical engineering will be the first subject to be tested. Teacher Centered Approach and Interactive Learning with e- blended and e-learning delivery method will be used. The contents will be accessed using the Internet (online) and using CD-ROMs (for off line delivery)

3. The new models of high level of psychomotor skills and high level of cognitive skills can be used to develop the content of other engineering courses in the higher education level (Institute, College and University) system in order to include learning activities for developing student's skills which are required by Bahrain labour market

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

5. 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

6. More attention should be given to support every staff member how best to use Computer Tutorial Packages (CTP), Computer Assisted Instruction (CAI) and web based technologies (WBT) in their practice so the student experience is substantially improved by encouraging creativity and reflection (characteristics of lifelong learners)

7. Video and computer footages of real life contexts should be seriously considered in mechanical engineering 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, and simulations) will facilitate small group learning and give students the control over their learning and increase their motivation, knowledge, understanding and performance

8. Student at high Order of thinking skills (critical thinking skills) should be fostered through problem-based learning opportunities and innovative approaches to student-centered instruction. The developed Computer Tutorial Packages (CTP), Computer Assisted Instruction (CAI) and web based technologies (WBT) needs some refining and afterwards could be used to achieve the above mentioned goals in Mechanical Engineering education

9. 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 SKI will become a leading education institution in Bahrain in terms of using efficiently e-blended and e-learning in modern education environment

10. Virtual learning environments (VLE) should be seriously considered as basic components of contemporary distance learning using internet, and in house learning using intranet but can also be integrated with cognitive and psychomotor skills (physical learning environment) which is referred to as blended learning.

11. Empower teachers and instructors to improve their teaching and learning practices, with the use of new emerging e-pedagogical models and integrative technology to enhance the KIS learning experience in line with the Bahrain 2030 strategic educational plan and relevant to the Career & Personal development subject through project oriented approach of Continuing Professional Development (CPD), with special attention to specialized mechanical engineering. And also to enrich the technology and enhance employability and career development programmes, preparing students for success.

The research results presented in this thesis could be used to develop an innovative strategy for identifying modern labour market skills requirements, planning and developing up-to-date learning resources content using modern technology, implementing the new learning content at higher level of psychomotor and cognitive skill, and assessing it by using the evaluation framework.

A new academic approach for performance improvement in the SKI system in Bahrain could be developed and used as a benchmark for other (institutes, colleges and universities) systems internally from Bahrain and externally from Arab region who have same system with similar cultures.

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APPENDICES

APPENDIX ONE: Technological Package

a. Computer Tutorial Package (CTP)
b. Computer Assisted Instructions (CAI)

APPENDIX TWO: Thesis Questionnaire

a. Lecturer's Workshop Questionnaire Lower and Higher level of Cognitive Skills (Pre-Post)
b. Lecturer's Questionnaire
c. Student's Questionnaire

APPENDIX THREE: Data Analysis

a. Lecturers Questionnaire's Data Analysis
b. Students Questionnaire's Data Analysis

APPENDIX FOUR: Students Checklist

a. Student's Results – Cognitive Skills (Outcomes 1 - 6)
b. Student's Results – Psychomotor Skills (Outcomes 1 - 6)

APPENDIX FIVE: Cognitive Skills Worksheet (Group 1, 2 and 3)

APPENDIX SIX: Psychomotor Skills Worksheet (Group 1, 2 and 3)

APPENDIX SEVEN: Time Management Analysis

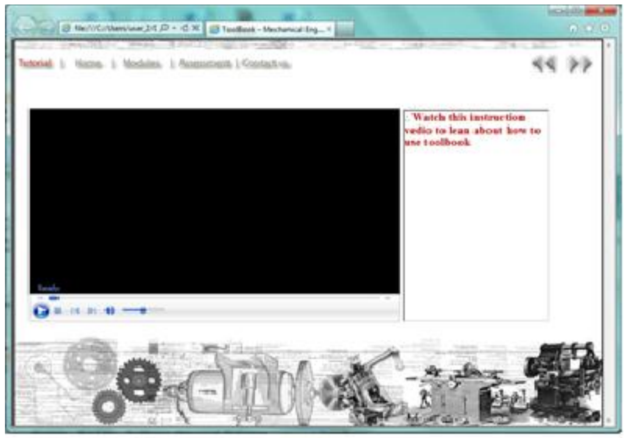
APPENDIX EIGHT: Mathematical Learning Models Data Analysis

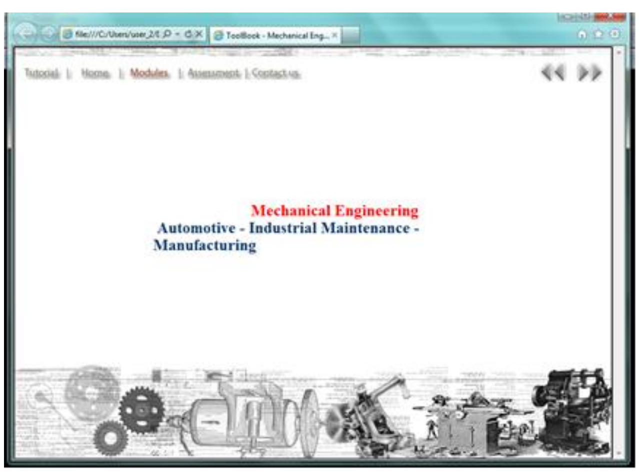
APPENDIX EIGHT: Mathematical Learning Models Data Analysis

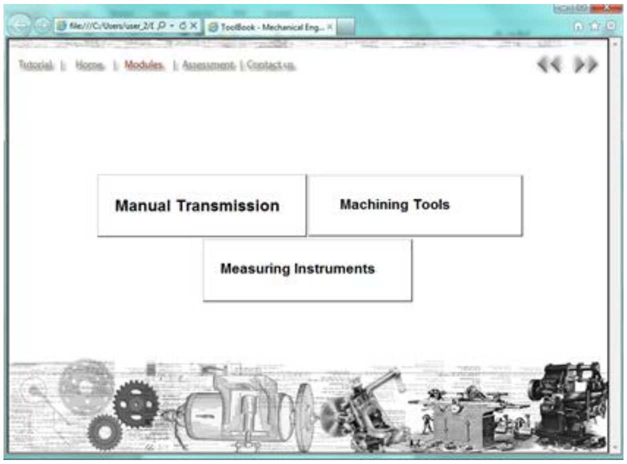
a. Students' results data for cognitive learning (MPhil Data)
b. Students' results data cognitive learning
c. Students' results data for psychomotor learning
d. Student's Results – Learning Data Analysis

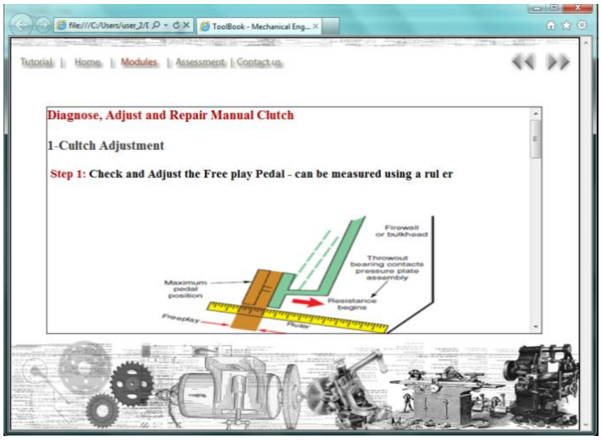
APPENDIX ONE
Technological Package

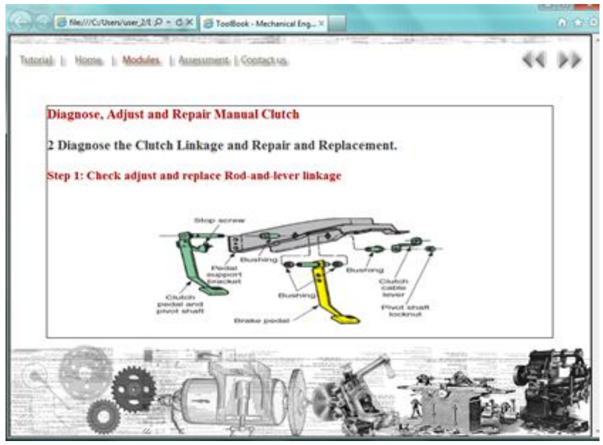
a- Computer Tutorial Package (CTP)

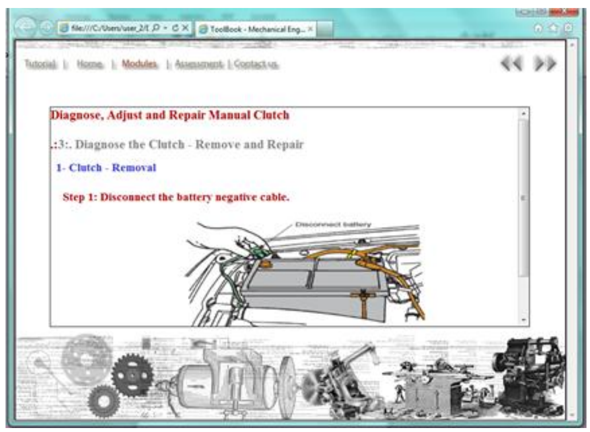


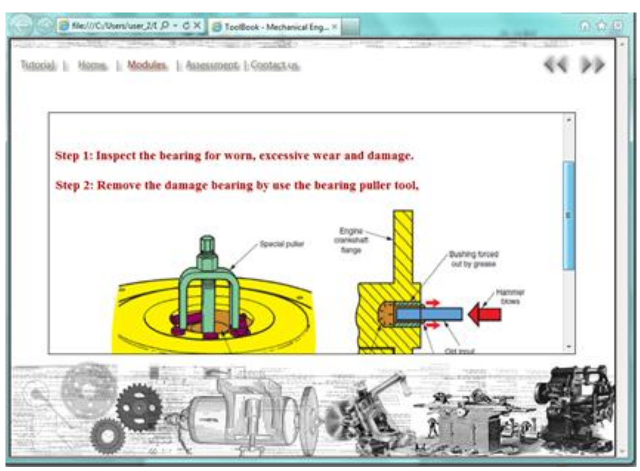


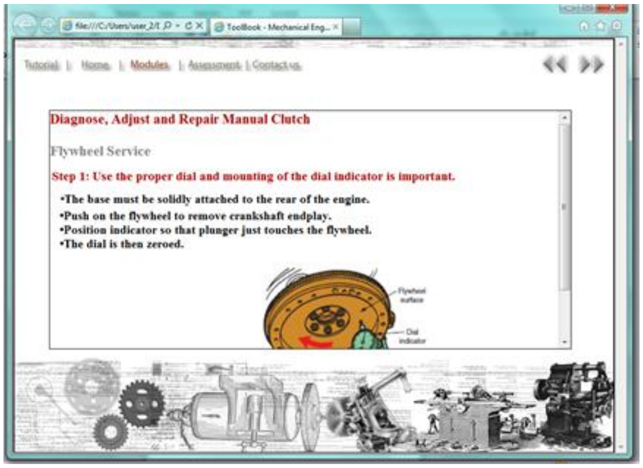

Tutorial | Home | Modules | Assessment | Contact us
Manual Transmission
Machining Tools
Measuring Instruments

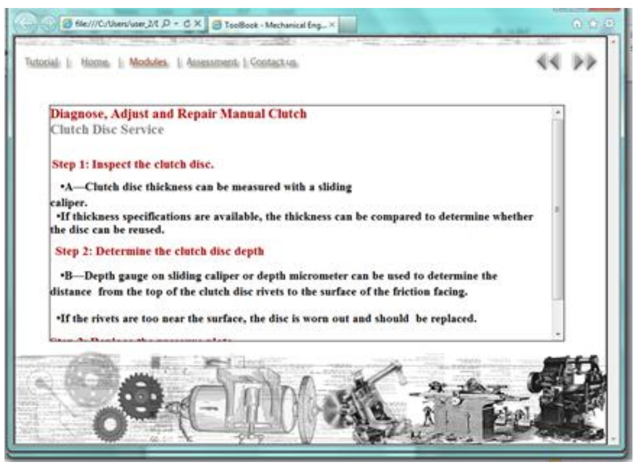

Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Clutch
1-Cultch Adjustment
Step 1: Check and Adjust the Free play Pedal - can be measured using a rul er
Firewall or bulkhead
Throwout bearing contacts pressure plate assembly
Maximum pedal position
Resistance begins
Freeplay
Ruler

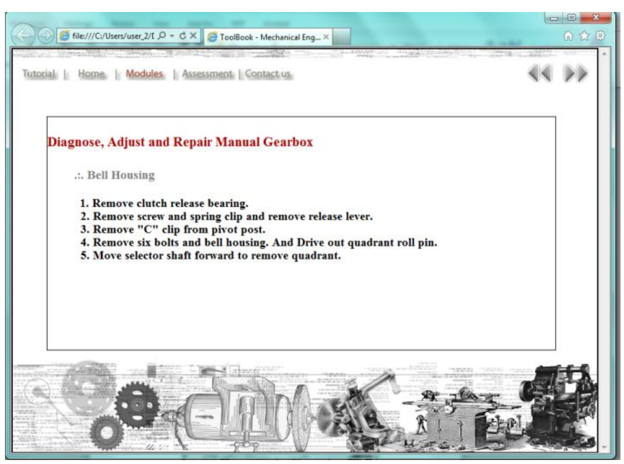

Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Clutch
2 Diagnose the Clutch Linkage and Repair and Replacement.
Step 1: Check adjust and replace Rod-and-lever linkage
Stop screw
Bushing
Pedal support bracket
Bushing
Clutch cable lever
Clutch pedal and pivot shaft
Bushing
Pivot shaft locknut
Brake pedal


Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Clutch
.:3:. Diagnose the Clutch - Remove and Repair
1- Clutch - Removal
Step 1: Disconnect the battery negative cable.
Disconnect battery

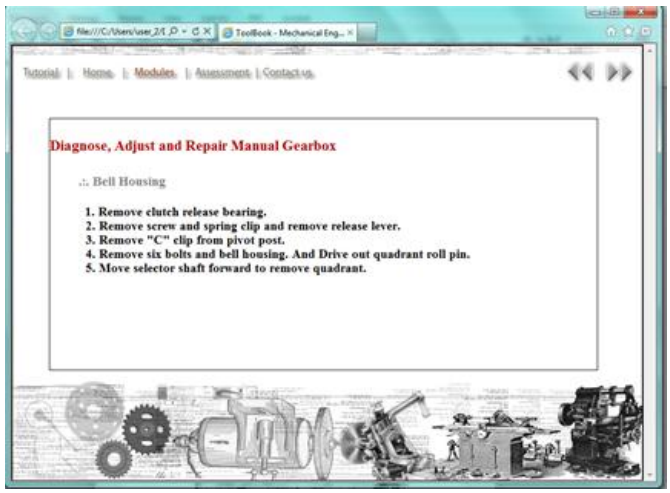

Tutorial | Home | Modules | Assessment | Contact us
Step 1: Inspect the bearing for worn, excessive wear and damage.
Step 2: Remove the damage bearing by use the bearing puller tool,
Special puller
Engine crankshaft flange
Bushing forced out by grease
Hammer blows

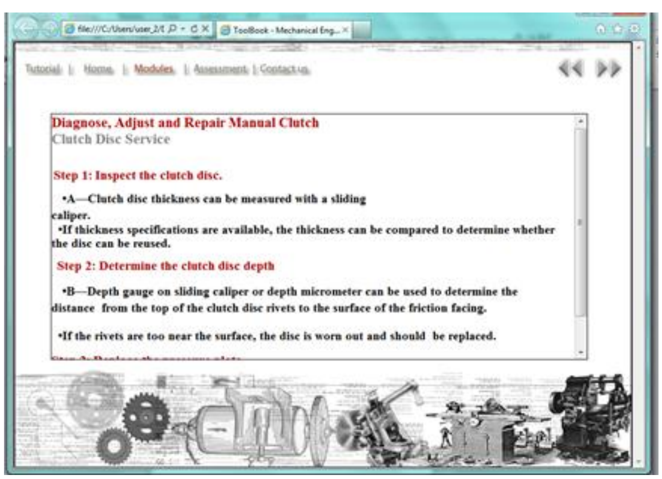

Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Clutch
Flywheel Service
Step 1: Use the proper dial and mounting of the dial indicator is important.
•The base must be solidly attached to the rear of the engine.
•Push on the flywheel to remove crankshaft endplay.
•Position indicator so that plunger just touches the flywheel.
•The dial is then zeroed.
Flywheel surface
Dial indicator

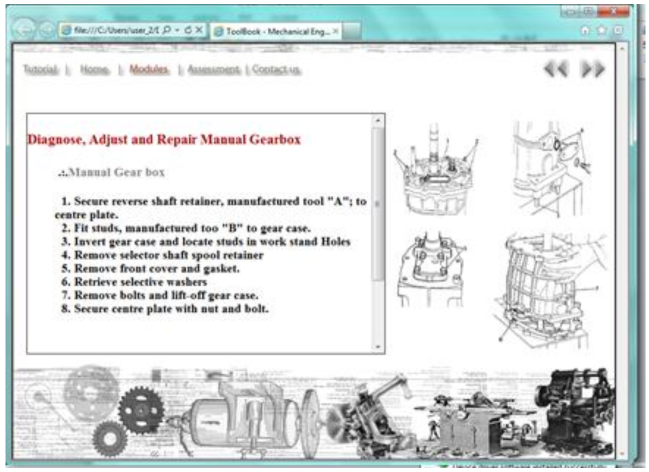

Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Clutch
Clutch Disc Service
Step 1: Inspect the clutch disc.
•A—Clutch disc thickness can be measured with a sliding caliper.
•If thickness specifications are available, the thickness can be compared to determine whether the disc can be reused.
Step 2: Determine the clutch disc depth
•B—Depth gauge on sliding caliper or depth micrometer can be used to determine the distance from the top of the clutch disc rivets to the surface of the friction facing.
•If the rivets are too near the surface, the disc is worn out and should be replaced.

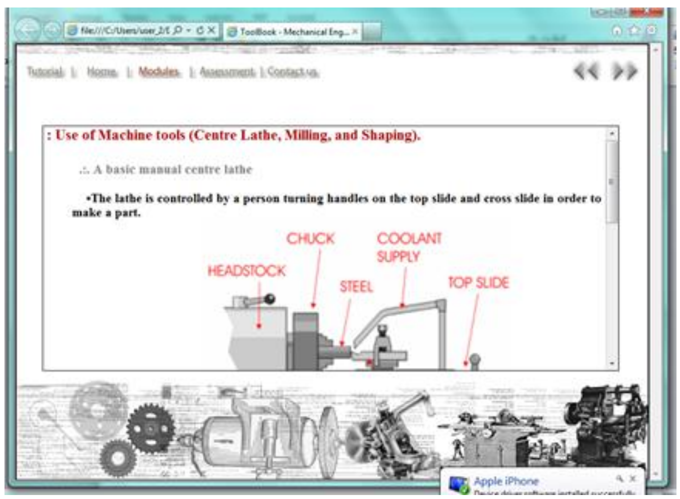

Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Gearbox
.:. Bell Housing
1. Remove clutch release bearing.
2. Remove screw and spring clip and remove release lever.
3. Remove "C" clip from pivot post.
4. Remove six bolts and bell housing. And Drive out quadrant roll pin.
5. Move selector shaft forward to remove quadrant.


ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Gearbox
.:.Gear Selector Housing
1. Remove four bolts and remove main gearbox selector housing.
2. Remove transfer box housing.
3. Remove remaining bolts and remove remote housing


ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Gearbox
.:. Bell Housing
1. Remove clutch release bearing.
2. Remove screw and spring clip and remove release lever.
3. Remove "C" clip from pivot post.
4. Remove six bolts and bell housing. And Drive out quadrant roll pin.
5. Move selector shaft forward to remove quadrant.

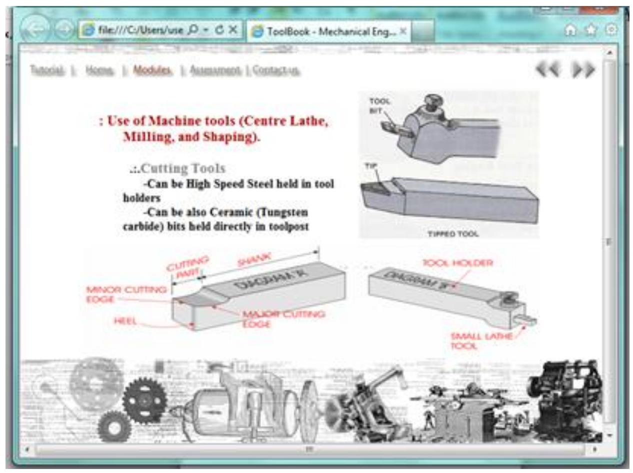

ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Clutch
Clutch Disc Service
Step 1: Inspect the clutch disc.
•A—Clutch disc thickness can be measured with a sliding caliper.
•If thickness specifications are available, the thickness can be compared to determine whether the disc can be reused.
Step 2: Determine the clutch disc depth
•B—Depth gauge on sliding caliper or depth micrometer can be used to determine the distance from the top of the clutch disc rivets to the surface of the friction facing.
•If the rivets are too near the surface, the disc is worn out and should be replaced.


Tutorial | Home | Modules | Assessment | Contact us
Diagnose, Adjust and Repair Manual Gearbox
.:.Manual Gear box
1. Secure reverse shaft retainer, manufactured tool "A"; to centre plate.
2. Fit studs, manufactured too "B" to gear case.
3. Invert gear case and locate studs in work stand Holes
4. Remove selector shaft spool retainer
5. Remove front cover and gasket.
6. Retrieve selective washers
7. Remove bolts and lift-off gear case.
8. Secure centre plate with nut and bolt.


Tutorial | Home | Modules | Assessment | Contact us
: Use of Machine tools (Centre Lathe, Milling, and Shaping).
.:. A basic manual centre lathe
•The lathe is controlled by a person turning handles on the top slide and cross slide in order to make a part.
CHUCK
COOLANT SUPPLY
HEADSTOCK
STEEL
TOP SLIDE
Apple iPhone


Tutorial | Home | Modules | Assessment | Contact us
: Use of Machine tools (Centre Lathe, Milling, and Shaping).
.:. Lathe parts
..Tailstock
-Can be moved along slideways
-Can be clamped in any location
-Inside tapered to hold drill chuck
CHUCK
DRILL CHUCK
TAILSTOCK

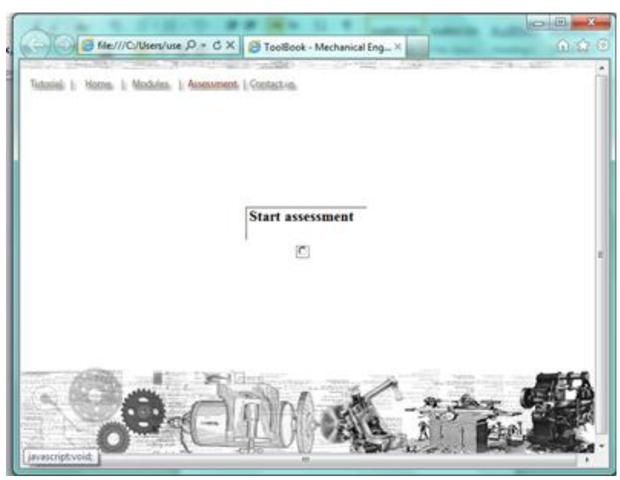

Tutorial | Home | Modules | Assessment | Contact us
Use of Machine tools (Centre Lathe, Milling, and Shaping).
.:.Turret Lathe
Tailstock replaced by "turret" that holds up to six tools
•Tools rapidly brought into action by indexing the turret
•Tool post replaced by four-sided turret to index four tools
• Applications: high production work that requires a sequence of cuts on the parts

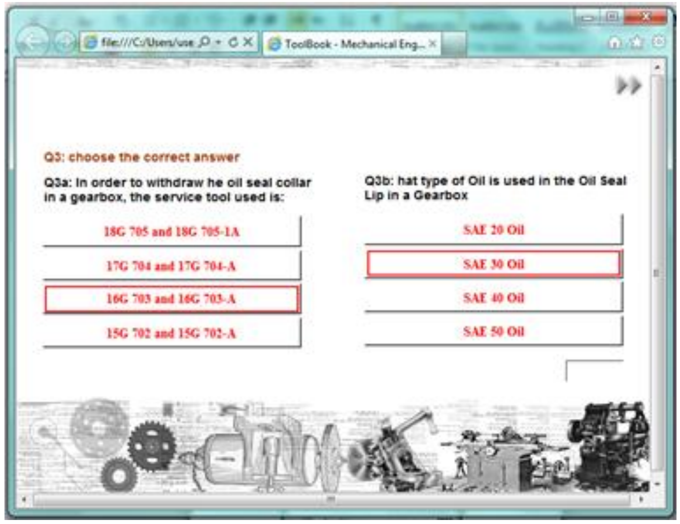

Tutorial | Home | Modules | Assessment | Contact us
: Use of Machine tools (Centre Lathe, Milling, and Shaping).
.:.Cutting Tools
-Can be High Speed Steel held in tool holders
-Can be also Ceramic (Tungsten carbide) bits held directly in toolpost
TIPPED TOOL
CUTTING PART
SHANK
MINOR CUTTING EDGE
HEEL
MAJOR CUTTING EDGE
TOOL HOLDER
SMALL LATHE TOOL

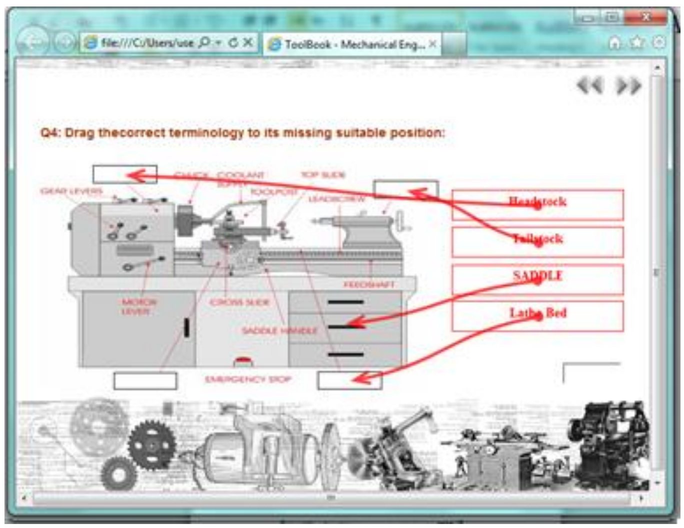

Tutorial | Home | Modules | Assessment | Contact us
Milling Accessories
ADAPTERS
ARBOR
SLEEVES
COLLET
ADAPTER

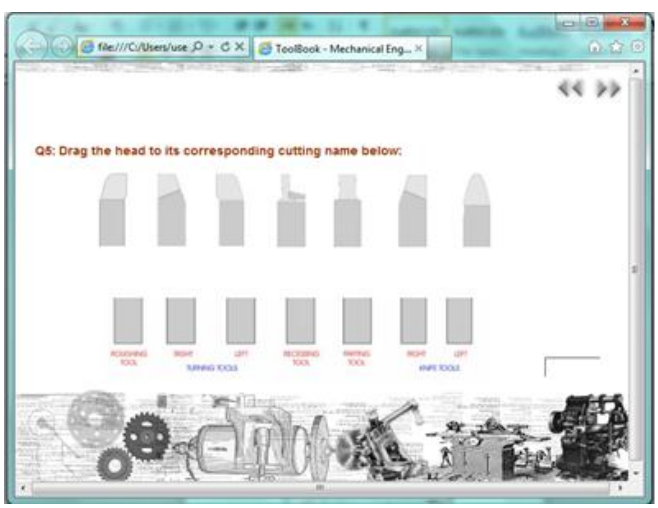

Tutorial | Home | Modules | Assessment | Contact us
Shaping Machine
Shaping Machine Operations
Speed
Ram
Toolhead
Feed
Column
Workpart
Crossrail
Worktable
Base
1- A straight, flat surface is created in both operations
2- Interrupted cutting Subjects tool to impact loading when entering work
3- Low cutting speeds due to start-and-stop motion
4- Usual tooling: single point high speed steel tools

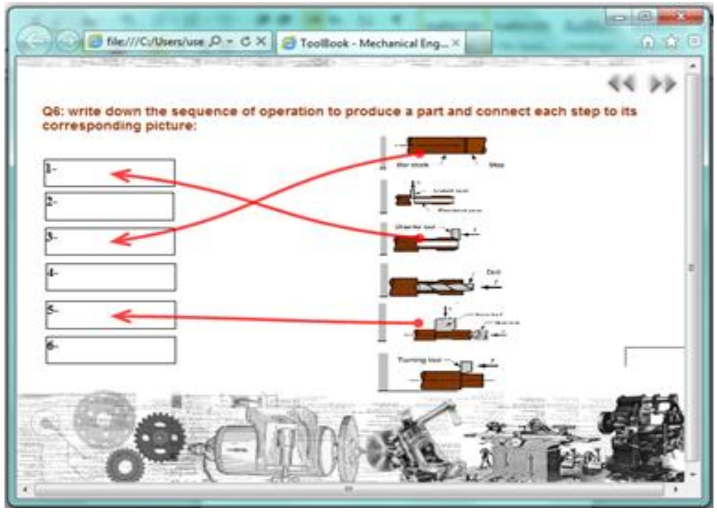

Tutorial | Home | Modules | Assessment | Contact us
Measuring tools:
Micrometer Caliper-barrel
1- A micrometer caliper is read just like an ruler.
2- Start by determining the smallest whole unit, and then determine the values of each sub division.
3- The smallest whole unit is determined by the frame size.

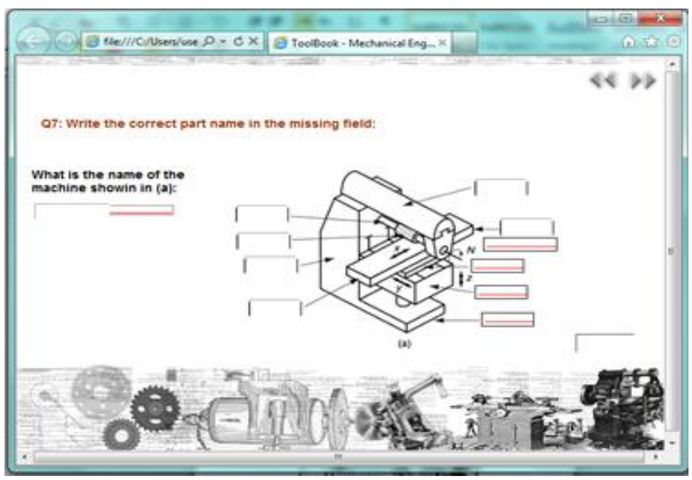

Tutorial | Home | Modules | Assessment | Contact us
Start assessment

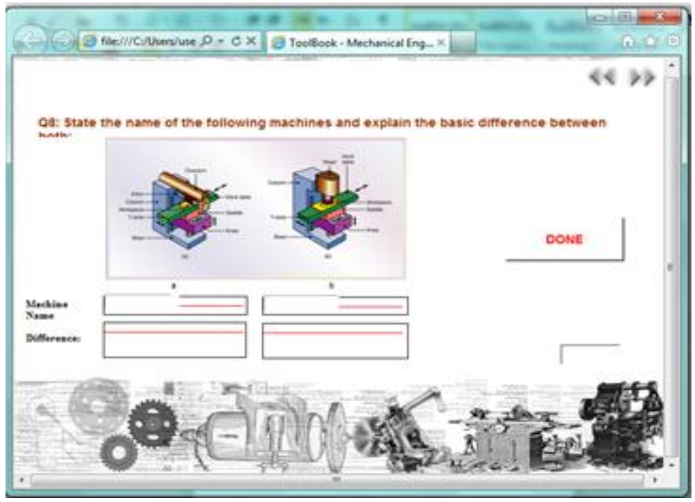

Q3: choose the correct answer
Q3a: In order to withdraw he oil seal collar in a gearbox, the service tool used is:
18G 705 and 18G 705-1A
17G 704 and 17G 704-A
16G 703 and 16G 703-A
15G 702 and 15G 702-A
Q3b: hat type of Oil is used in the Oil Seal Lip in a Gearbox
SAE 20 Oil
SAE 30 Oil
SAE 40 Oil
SAE 50 Oil

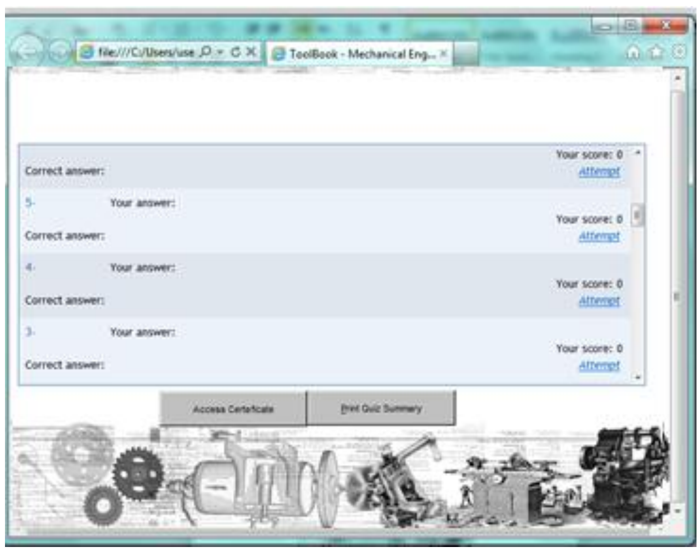

Q4: Drag thecorrect terminology to its missing suitable position:
Headstock
Tailstock
SADDLE
Lathe Bed

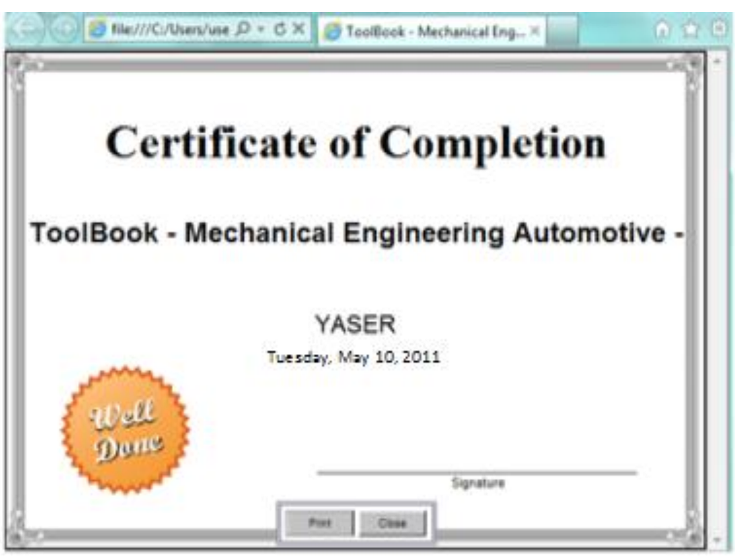

Q5: Drag the head to its corresponding cutting name below:


file:///C:/Users/use
ToolBook - Mechanical Eng...
Q6: write down the sequence of operation to produce a part and connect each step to its corresponding picture:
1-
2-
3-
4-
5-
6-
Drill
Turning tool


file:///C:/Users/use
ToolBook - Mechanical Eng...
Q7: Write the correct part name in the missing field:
What is the name of the machine showin in (a):
(a)

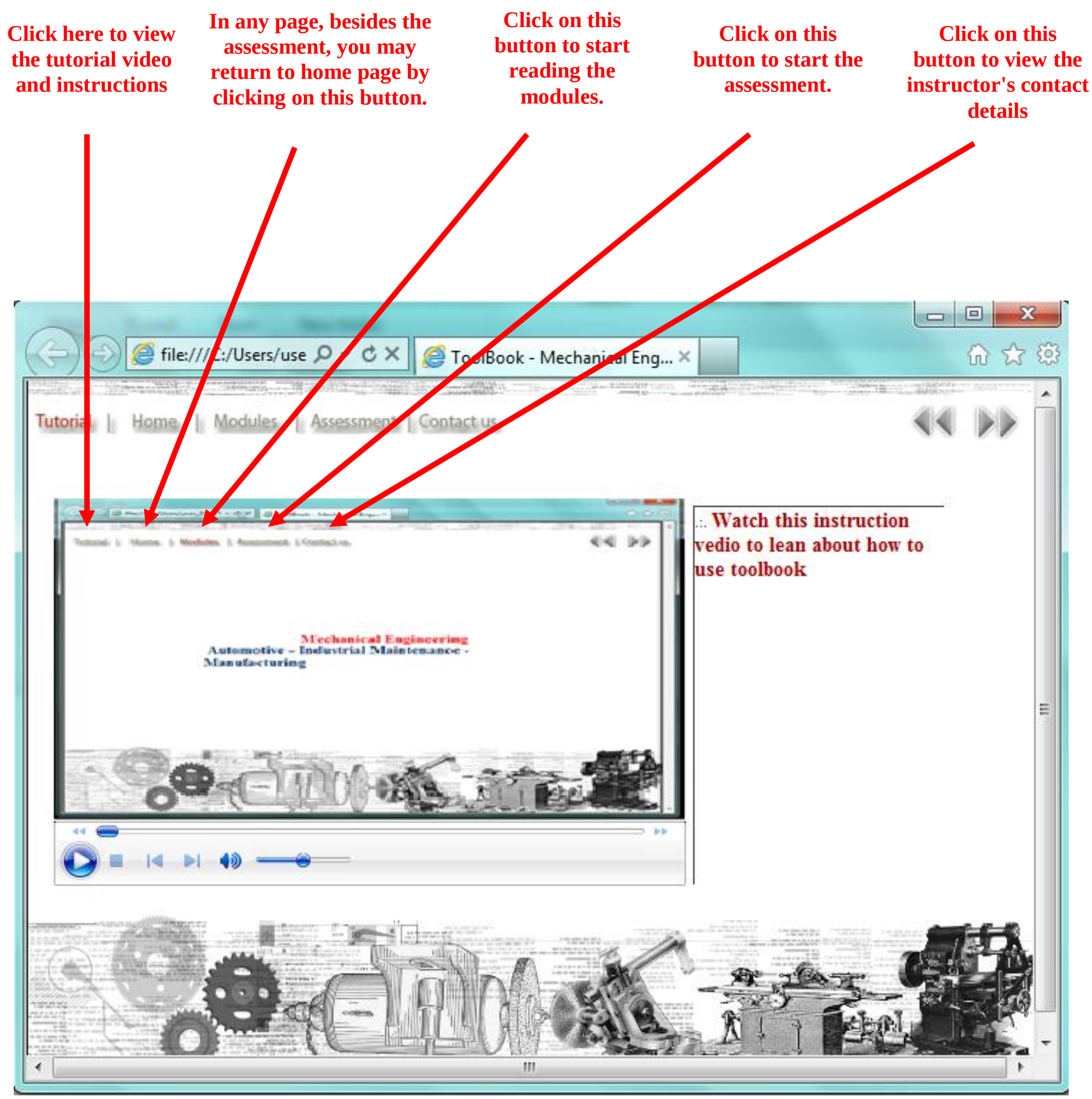

file:///C:/Users/use
ToolBook - Mechanical Eng...
Q8: State the name of the following machines and explain the basic difference between both:
DONE
Machine Name
Difference:


file:///C:/Users/use
ToolBook - Mechanical Eng...
Your score: 0
Attempt
Correct answer:
5-
Your answer:
Your score: 0
Attempt
Correct answer:
4-
Your answer:
Your score: 0
Attempt
Correct answer:
3-
Your answer:
Your score: 0
Attempt
Correct answer:
Access Certificate
Print Quiz Summary

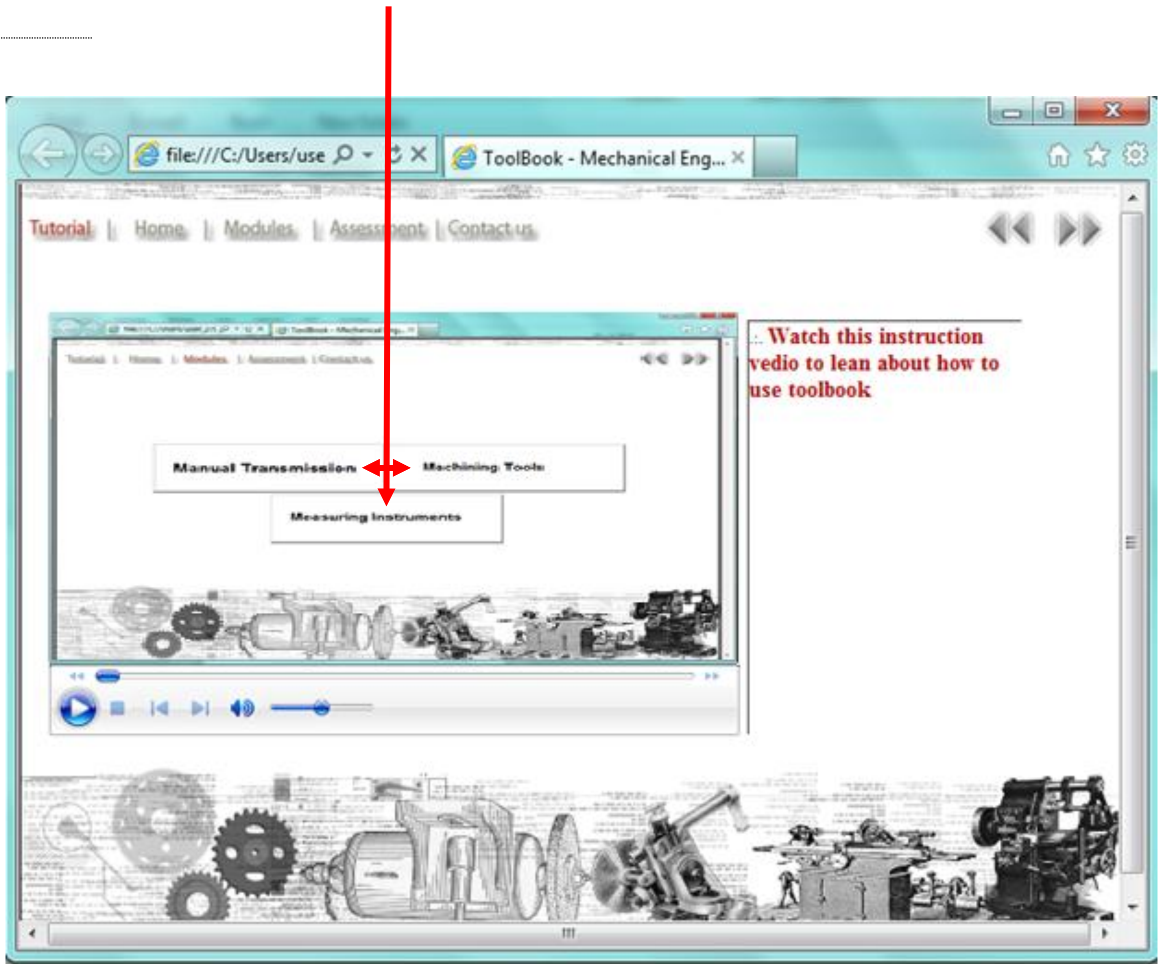

file:///C:/Users/use
ToolBook - Mechanical Eng...
Certificate of Completion
ToolBook - Mechanical Engineering Automotive -
YASER
Tuesday, May 10, 2011
Well Done
Signature
Print
Close

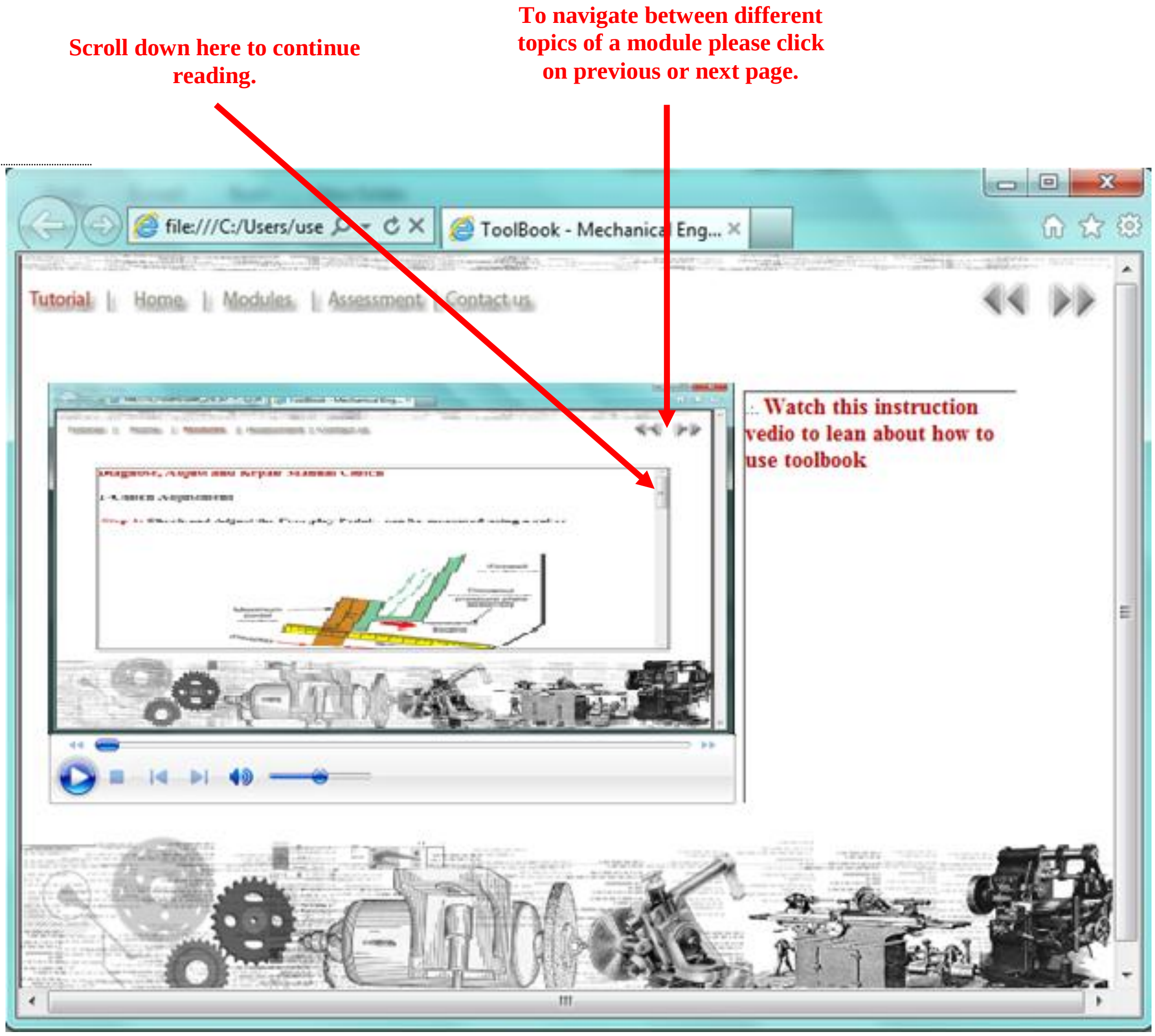
b- Computer Assisted Instructions (CAI)

The following captures are taken from the tutorial video created to instruct the students upon the steps to follow in order to start the computer assisted instruction (Blended Learning -E-learning package), hence a brief explanation is shown on the function of each button designed in the package. The set of captures samurizes all steps students are required to follow in each different section o the package. The video is accessable through the E-learning package.

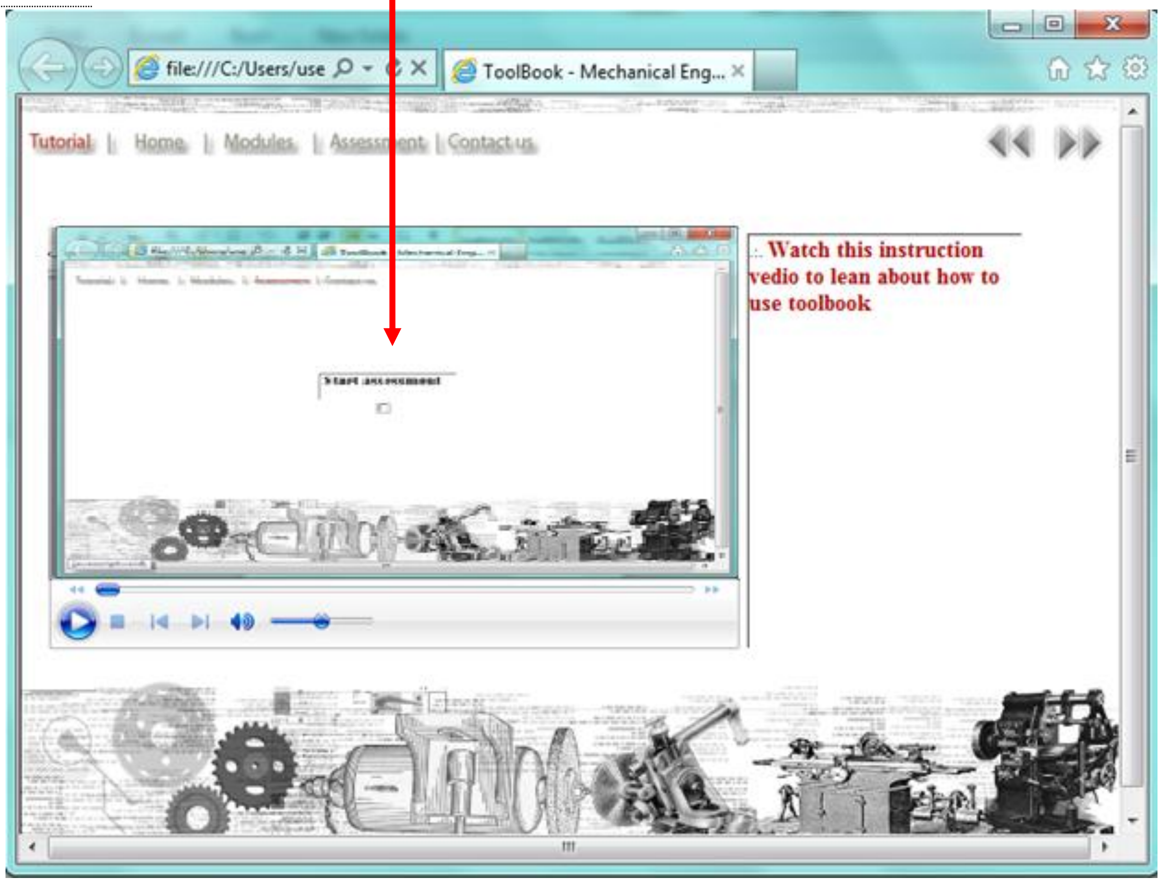


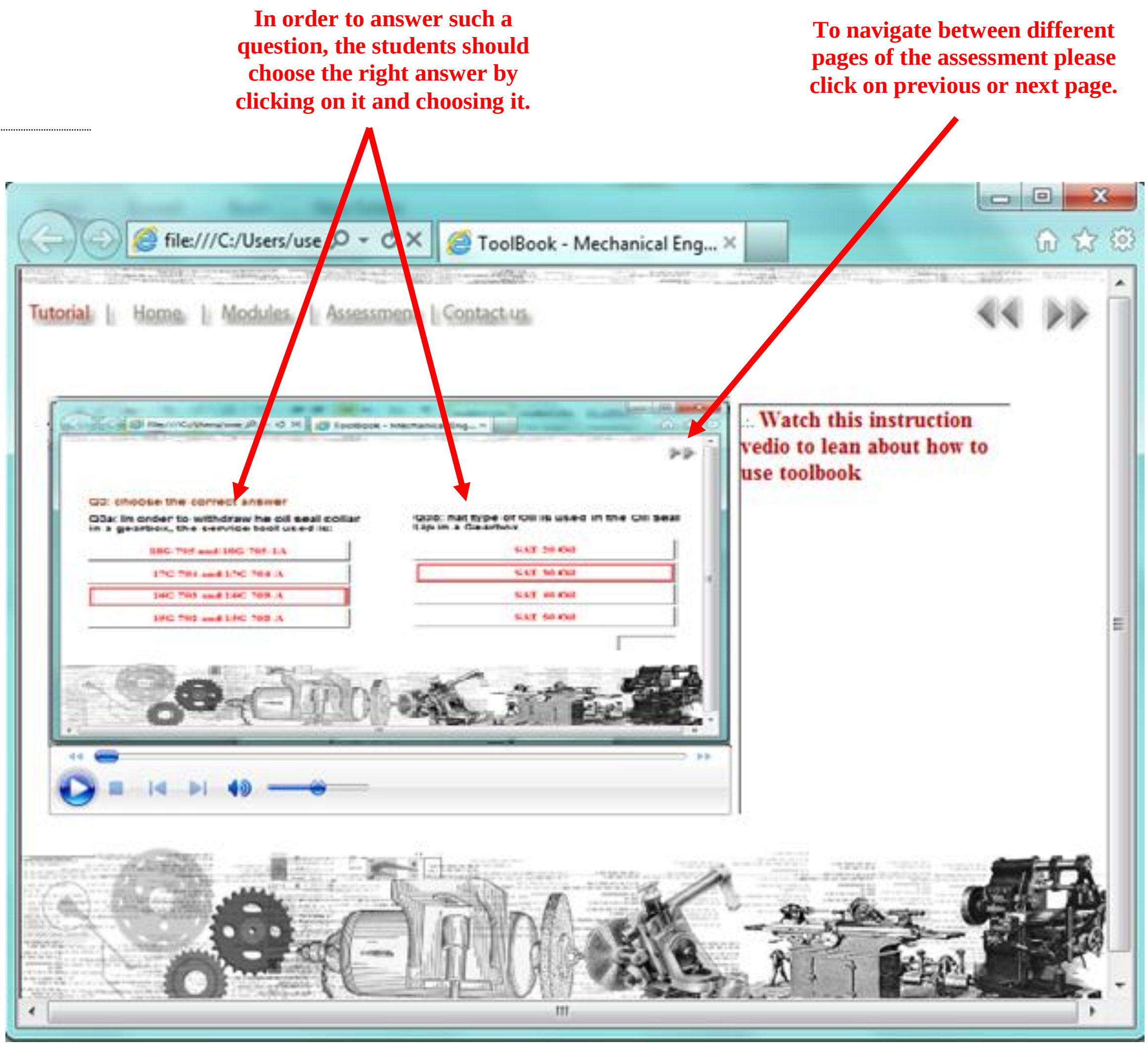
To start reading the modules, choose the one of the topics by clicking on its name.



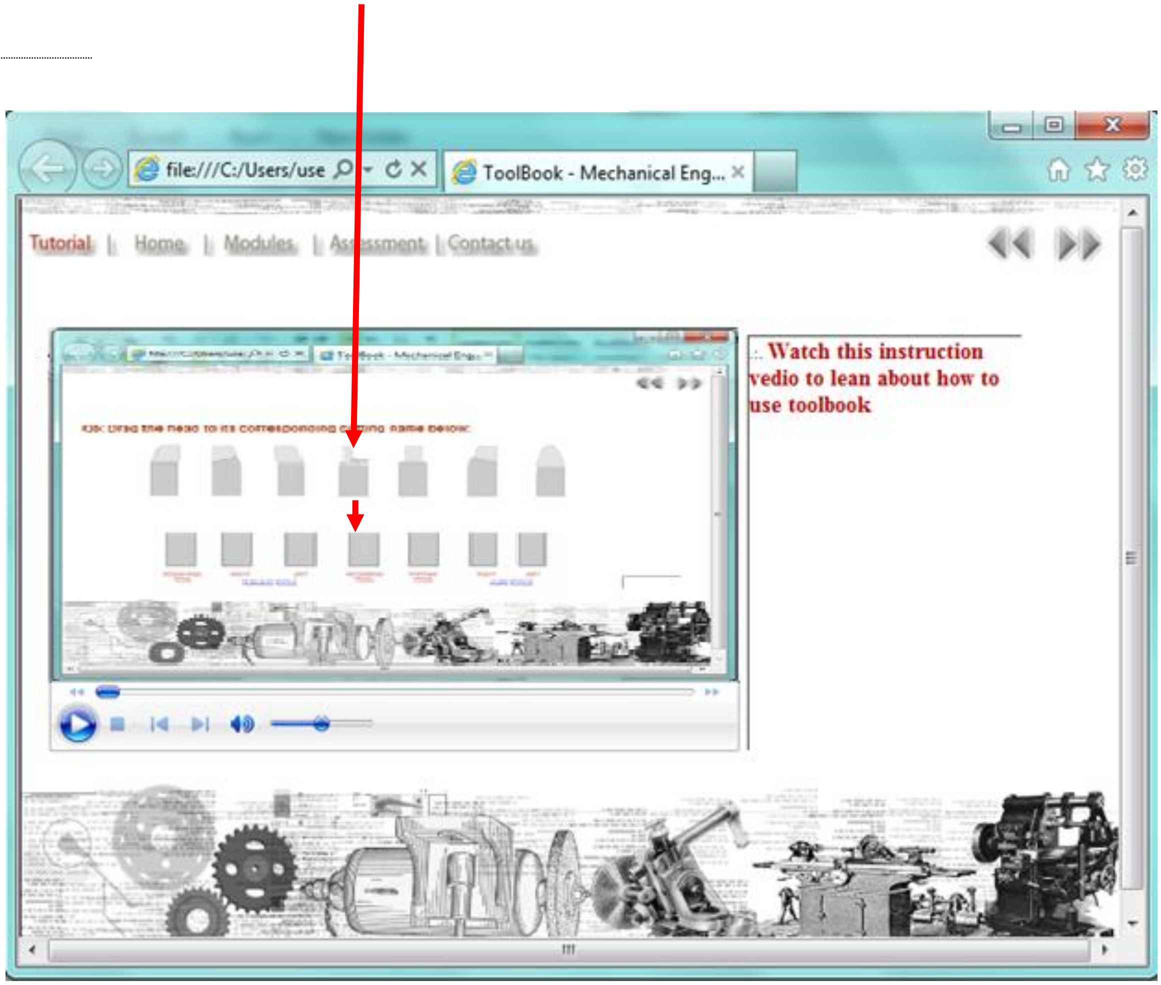

Scroll down here to continue reading.
To navigate between different topics of a module please click on previous or next page.
file:///C:/Users/use
ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Watch this instruction vedio to lean about how to use toolbook

After reading the modules, the student should start the assessment if ready by clicking on this button.

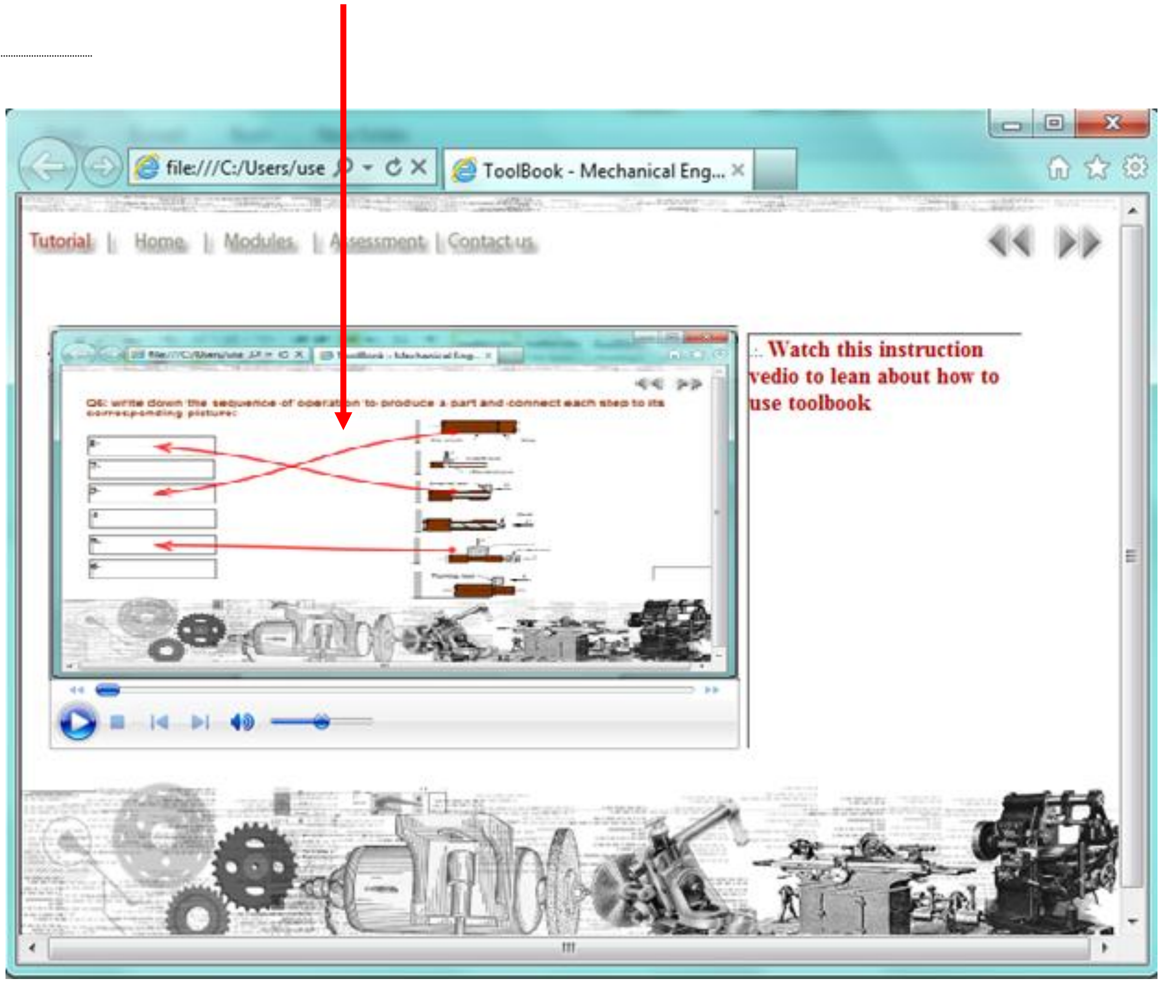


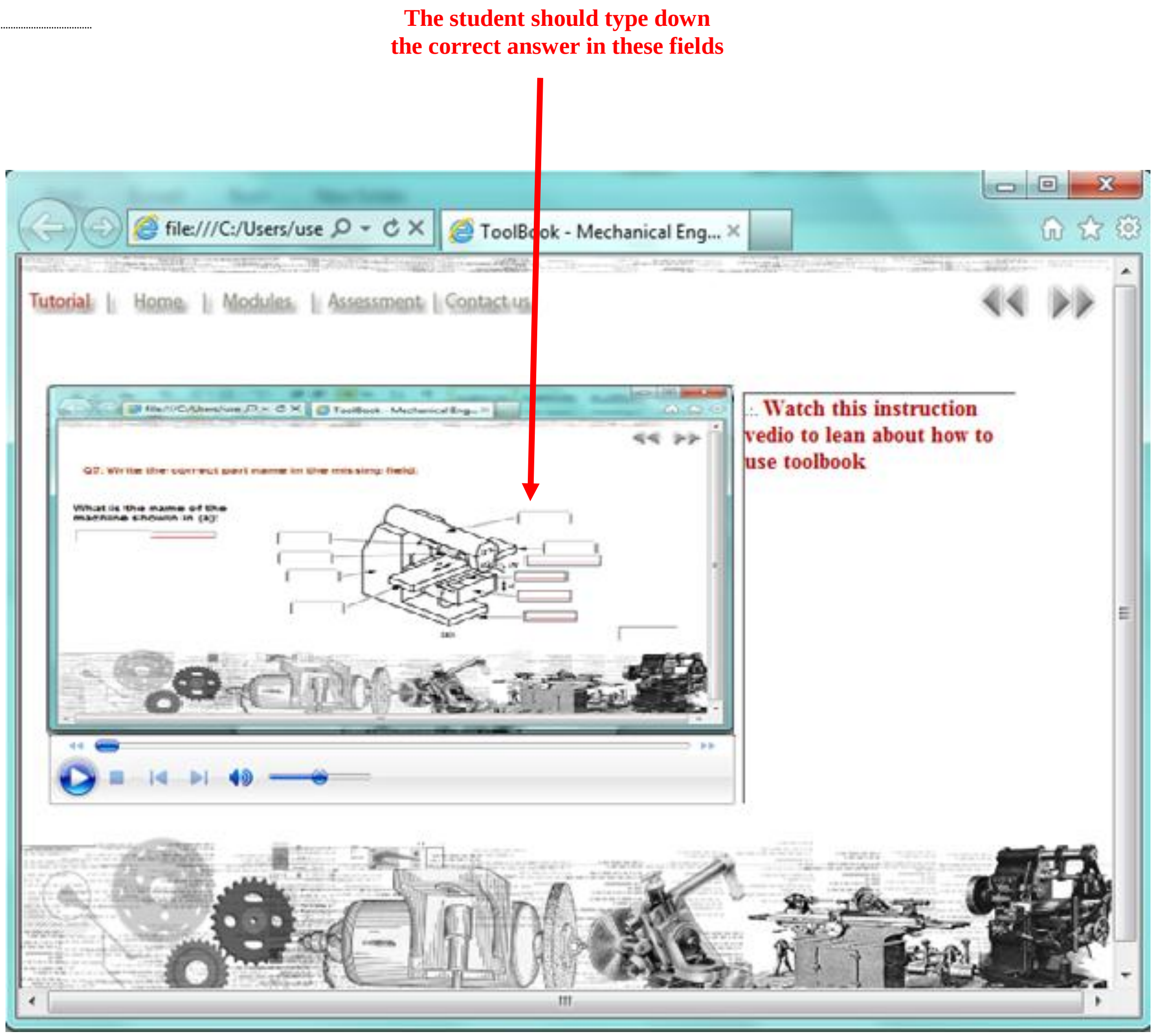

In order to answer such a question, the students should choose the right answer by clicking on it and choosing it.
To navigate between different pages of the assessment please click on previous or next page.
file:///C:/Users/use
ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Watch this instruction vedio to lean about how to use toolbook

In order to answer such questions, the student should drag the picture to its correct place, that by clicking on the mouse and moving the picture while still clicking.



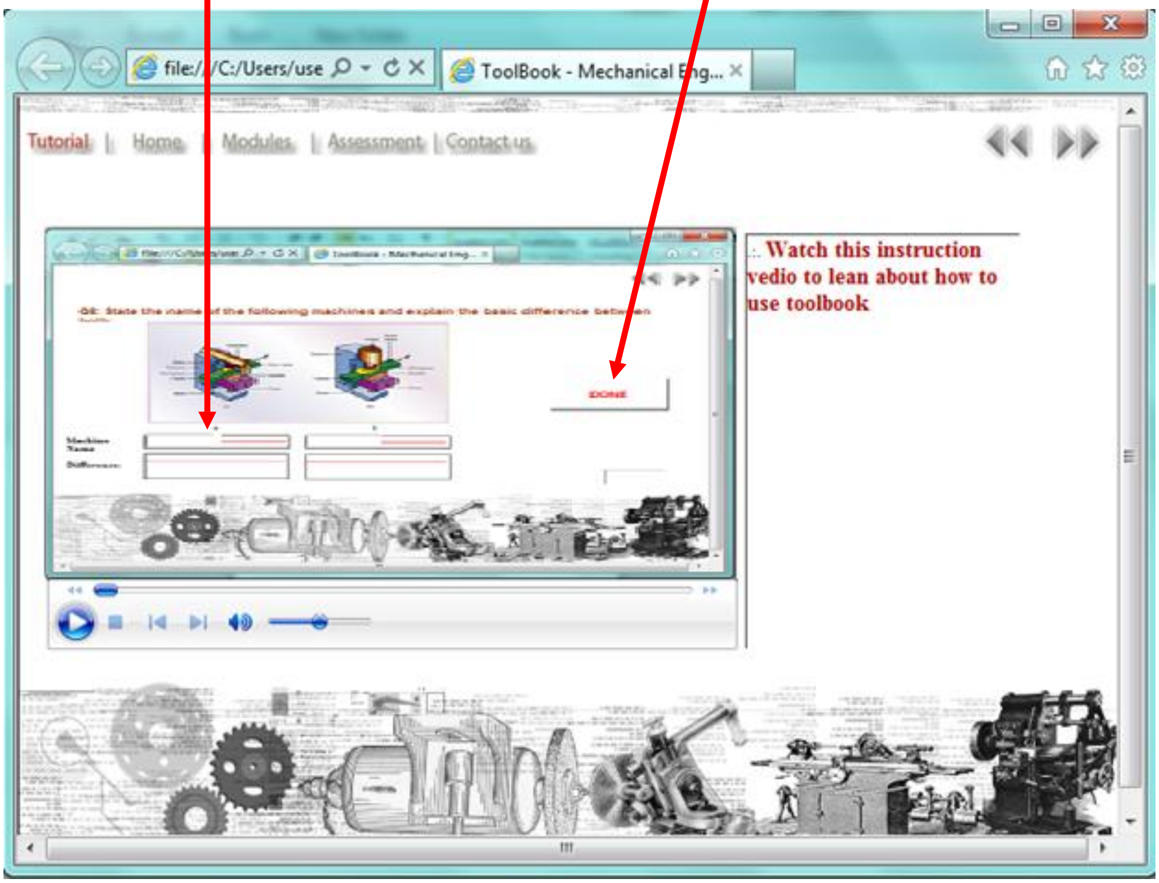
In order to answer such a question, the student should connect the picture to its appropriate answer, that by clicking on the picture and dragging the mouse to the correct position and release the button.




The student should type down
the correct answer in these fields
file:///C:/Users/use
ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Watch this instruction
vedio to lean about how to
use toolbook

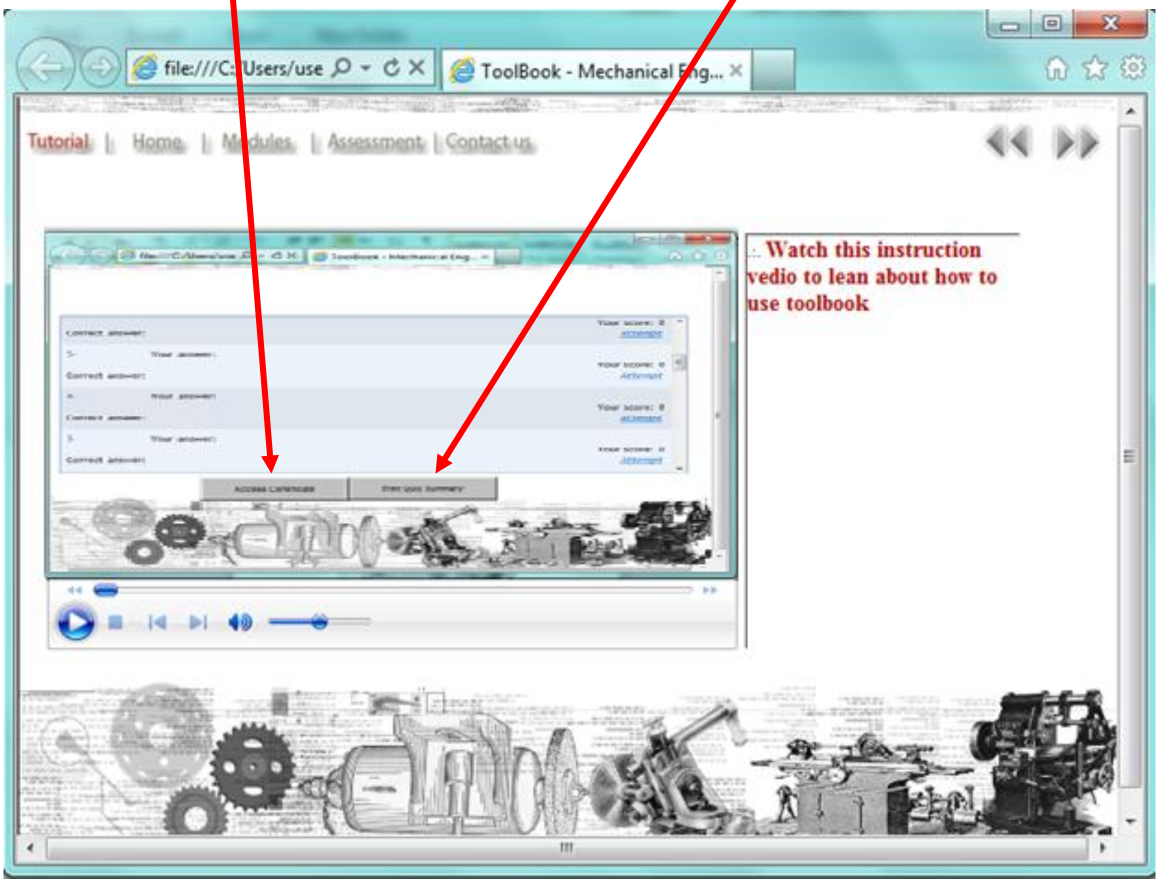
In order to answer such a question, the student should type down the answer in the assigned field.

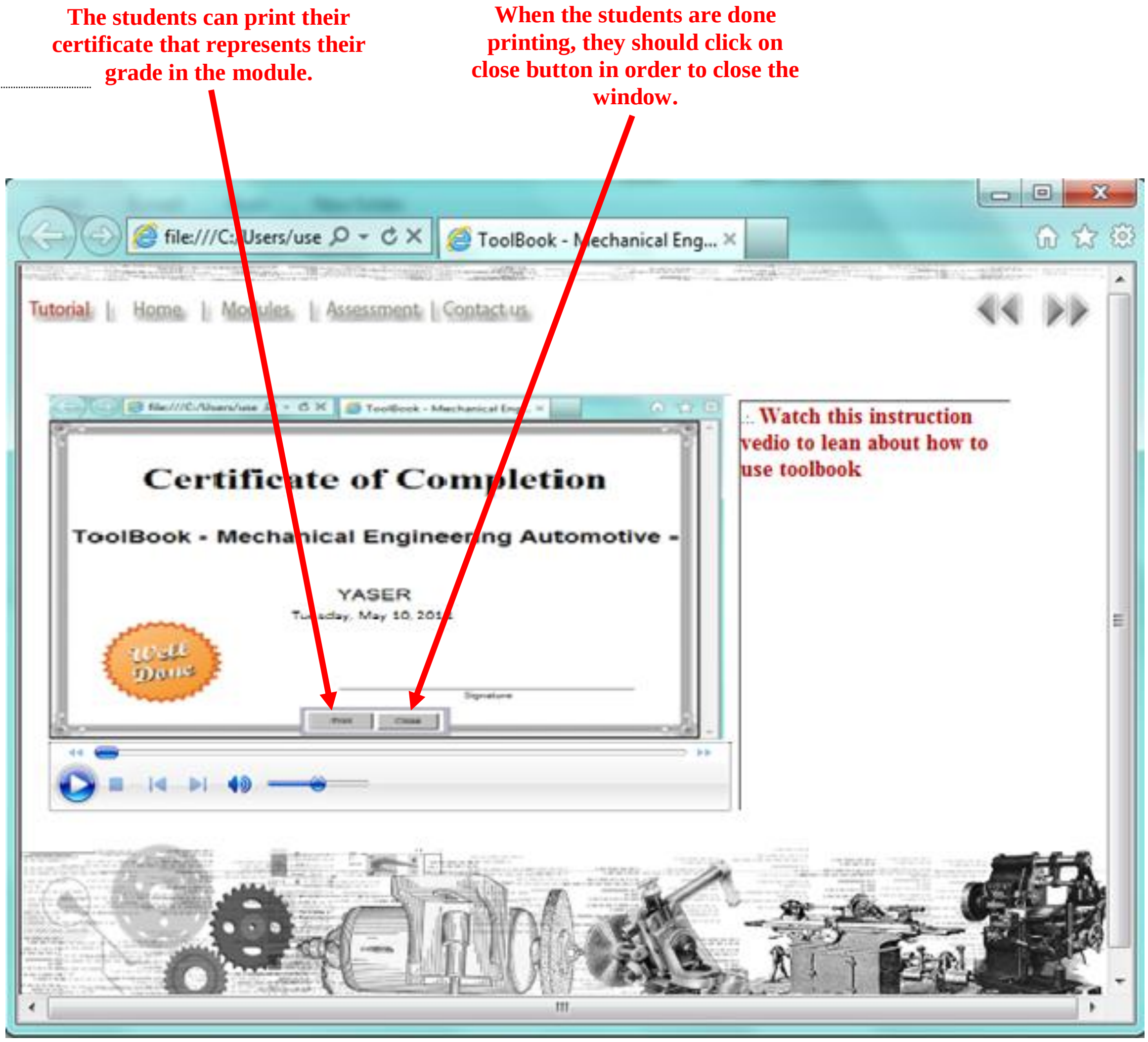
When the student is done answering the assessment, he/she should click on done button in order to submit the answers to the instructor's computer.



If the students are looking for their certificate for the module, they should click on this button.

The students should print out the results report scored in the assessment by clicking on the print button here.




The students can print their certificate that represents their grade in the module.
When the students are done printing, they should click on close button in order to close the window.
ToolBook - Mechanical Eng...
Tutorial | Home | Modules | Assessment | Contact us
Watch this instruction vedio to lean about how to use toolbook
Certificate of Completion
ToolBook - Mechanical Engineering Automotive -
YASER
Well Done

APPENDIX TWO
Thesis Questionnaire

a- Lecturers Workshop Questionnaire
Lower and Higher Order of Cognitive Skills (LOCS & HOCS) (Pre-Post)

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 engineering subject area using six level of blooms taxonomy.

The questionnaire aims to identify the perceptions of mechanical engineering teachers who teach in technical and Vocational Education.

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.

Thank you for your co-operation

Salah Al - Hamad

Ph.D. Student

Huddersfield University

This part of questionnaire is about educational issues in teaching method which the level of blooms taxonomy based on it.

No	Statement	Agree	Undecided	Disagree
The First Level of Bloom's Taxonomy: Remembering; Teaching Lower Order Thinking Skills				
1	I allow students to define concepts in my class.			
2	I allow students to memorize concepts in my class.			
3	Allow students to repeat concepts in my class.			
4	I allow students to name concepts in my class.			
5	I allow students to recall concepts in my class.			
6	I allow students to label concepts in my class.			
The Second Level of Bloom's Taxonomy: Understanding; Teaching Lower Order Thinking Skills				
1	I encourage students to describe concrete concepts in my class.			
2	I encourage students to discuss concrete concepts in my class.			
3	I encourage students to explain concrete concepts in my class.			
4	I encourage students to identify concrete concepts in my class.			
5	I encourage students to recognize concrete concepts in my class.			
6	I encourage students to locate concrete concepts in my class.			
The Third Level of Bloom's Taxonomy: Applying; Teaching Lower Order Thinking Skills				
1	I help students apply rules and principles in my class.			
2	I help students demonstrate rules and principles in my class.			
3	I help students translate rules and principles in my class.			
4	I help students manipulate rules and principles in my class.			
5	I help students practice rules and principles in my class.			
6	I help students illustrate rules and principles in my class.			
The Fourth Level of Bloom's Taxonomy: Analysing; Teaching Higher Order Thinking Skills				
1	I let students distinguish rules and principles in my class.			
2	I let students differentiate rules and principles in my class.			
3	I let students compare rules and principles in my class.			
4	I let students contrast rules and principles in my class.			
5	I let students critique rules and principles in my class.			

6	I let students examine rules and principles in my class.					
The Fifth Level of Bloom’s Taxonomy: Evaluating; Teaching Higher Order Thinking Skills						
1	I create conditions within which students evaluate their cognitive strategy.					
2	I create conditions within which students rate their cognitive strategy.					
3	I create conditions within which students judge their cognitive strategy.					
4	I create conditions within which students justify their cognitive strategy.					
5	I create conditions within which students summarize their cognitive strategy.					
6	I create conditions within which students appraise their cognitive strategy.					
The Sixth Level of Bloom’s Taxonomy: Creating; Teaching Higher Order Thinking Skills						
1	I plan activities that will encourage students to plan problem solving in my class.					
2	I plan activities that will encourage students to propose problem solving in my class.					
3	I plan activities that will encourage students to design problem solving in my class.					
4	I plan activities that will encourage students to arrange problem solving in my class.					
5	I plan activities that will encourage students to organize problem solving in my class.					
6	I plan activities that will encourage students to modify problem solving in my class.					

b- Lecturers Questionnaire

Dear Teacher

The attached questionnaire aims to learn your opinion about the teaching learning methods you adopt in the classroom, and your point view toward the teaching learning of Mechanical Engineering subject.

The questionnaire aims to identify the perceptions of Sheikh Khalif Institute Instructors and teachers who teach in Mechanical Subjects.

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.

Thank you for your co-operation
Salah Al - Hamad
Ph.D. Student
Huddersfield University

This part of questionnaire is about educational issues in teaching learning (T&L) methods

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1 %	G 2 %	G3 %	G 1 %	G 2 %	G3 %	G 1 %	G 2 %	G3 %
1	I always plan my lesson with the use of computer									
2	You find difficult to Understand or Experience subject matter.									
3	I use my own techniques when I prepare lessons									
4	The majority of my students are interested in the way I present my lessons.									
5	Most of your lessons have the same pattern									
6	You use lots of practical examples in your teaching									
7	The syllabus is crowded so it is difficult to do more tasks work									
8	I use audio -visual aids in my lessons									
9	0nly the most able students like my lesson									
10	Students find it difficult to understand some mechanical tasks lessons because they cannot be presented simply									
11	All tasks of my lesson can be presented simply									
12	Group work is an effective way of your teaching style									

13	I would like to end my theory class time very quickly so i can do more practicing.									
14	When you prepare lessons you follow the techniques given in the teacher's guide									
15	You encourage the students to ask Questions									
16	The students find difficulties in seeing the relevance of what you teach in Automotive Maintenance and Manufacturing Technology									
17	You ask your students after the lesson if they understand the lesson or not									
18	I add many examples to explain my lessons									
19	You find it difficult to encourage the students in your lesson									
20	You repeat the lesson if the students still have difficulties in understanding									
21	You concentrate on hands on tasks when you teach Mechanical lessons									
22	You use dialogue with students during classroom activities									
23	It is difficult to understand everything in the subject textbook									
24	You use standard when you teach to judge the work									
25	You enjoy your teaching style									
26	You use many shape and different exercises to improve the students' skills									

27	You use many mechanical exercises to Measure student's performance.									
28	You start the subject lesson by examples and then you explain the learning Materials									
29	You start the lessons tasks by explaining the concept of the subject and then you present the examples									
30	You use group learning when you teach.									
31	You have friendly relationships with students									
32	You keep formal relationships with students									
33	Students decide for themselves where they can sit in the classroom for teamwork									
34	Students are distributed inside the classroom to places or groups on the basis of their ability									
35	The desks are arranged in the classroom in rows for batter visualisation									
36	The desks are arranged in the classroom in groups to learn from each others.									
37	Your students work together co-operatively on work that you gave to them									
38	Your students work individually on work that you gave to them									
39	Most of your questions can be answered by remembering previous lessons									

40	It is difficult to ask questions which require students to apply knowledge									
41	You often ask questions that require students to make improvements.									
42	To evaluate the students' level in knowledge.									
43	To help them to Diagnosed and adjust weaknesses in Mechanical parts									
44	Assessment feedback to treat their weaknesses.									
45	You correct your students' mistakes									
46	Easy mark the student's activities or exam tasks.									
47	Easy to rate your students when they have the correct answer									
48	It is easy for me to teach with current method									
49	I do not like to use another teaching method to teach Mechanical Engineering subjects									
50	The present method does not help me to take into account the individual needs of students									
51	The present method is successful in the field of teaching Automotive Maintenance and Manufacturing Technology									
52	Students are bored when I use the present method of your teaching									

53	When I use the present method I don't need to use lots of teaching aids.									
54	The present method encourages the students to learn.									
55	I like to have training about the present method									
56	The present method strengthens students skills in mechanical engineering subject									
57	Part of students' weaknesses coming from i teaching method and learning style									
58	The present method encourages the students to think Highly and logically									
59	The present method increases the students' achievement in.									
60	Teaching by the present method helps the student's to understand subject.									
61	The present method enables me to control the class.									
62	The present method is suitable for a class with a large number of students.									
63	The variety of the examples in the present method helps the students to understand									
64	The present method helps me to finish the tasks in time									
65	The present method needs lots of time when I use it in teaching.									
66	The present method does not encourage the students 'self- direct learning.									

c- Students' Questionnaire

Dear Student

The attached questionnaire was developed to identify how you think about Teaching Learning (T.L) of Mechanical Engineering Subject, 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

Ph.D. Students

University of Huddersfield

Students' Questionnaire

This part of questionnaire is about educational issues in teaching learning (T&L) methods

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G1 %	G2 %	G3 %	G1 %	G2 %	G3 %	G1 %	G2 %	G 3 %
1	I do not like the subject.									
2	I like to participate in activities during Automotive maintenance and manufacturing (AIM) lesson.									
3	Learning style used in Engineering subject developed my learning abilities.									
4	I feel comfortable during Mechanical lesson when the teacher use the same style.									
5	1 likes to have more subject lessons using this method.									
6	Learning mechanical subject with this methods wasting of time.									
7	I feel bored in mechanical subjects when the teacher using this methods.									
8	Learning this type of tasks improves my skills.									
9	Learning engineering subjects with computer improves my knowledge.									
10	I like to spend more time in practicing Engineering subjects.									
11	I do not like to watch traditional (TCA) simulation program in my subject.									
12	I like more than other institute subjects.									

13	It is difficult to understand Procedure of practical session.									
14	I like Teaching methodology of this subjects									
15	I find other since subjects are more enjoyable than in mechanical subject									
16	In this methods teacher correct my mistake very easily									
17	I feel boring in this method									
18	My teacher is always in control of the class.									
19	Teacher makes links between the classroom teachings and laboratories work.									
20	Motivating you and attract your attention toward to the subject matter.									
21	Teacher in this methods work with less effort than the other methods.									
22	In this method my teacher teaches an interesting way.									
23	The teachers rely too much on the text book.									
24	My teacher does not pay attention to the students' individual differences.									
25	My teacher enjoys teaching this subject.									
26	My teacher encourages me to learn engineering.									
27	My teacher always follows the same teaching method to teach.									
28	The teacher does not explain the target of the lesson.									
29	My teacher does not follow up my work.									

30	My teacher respects me when I work with simulation work or computer assisted instruction.									
31	My teacher is fair when he marks the students' work.									
32	Easy to evaluate students work and assessing their performance.									
33	The teacher does not use educational aids when he teaches with this methods									
34	The teacher follows the textbook in his teaching method to teach Starting with examples and displaying the procedures.									
35	My teachers always prepares their subject plan									
36	My teacher encourages the students to work in parallel with the simulation software or computer assisted instruction.									
37	My teacher has an adequate knowledge of this method.									

APPENDIX THREE
Questionnaires' Data Analysis

a- Lecturer's Questionnaire Results

Teacher's responses on the questionnaire

G: Group

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1 %	G 2 %	G3 %	G 1 %	G 2 %	G3 %	G 1 %	G 2 %	G3 %
1	I always plan my lesson with the use of computer	80	100	100	10	0	0	10	0	0
2	You find difficult to Understand or Experience subject matter.	60	70	60	20	0	20	20	30	20
3	I use my own techniques when I prepare lessons	60	80	70	20	0	20	20	20	10
4	The majority of my students are interested in the way I present my lessons.	0	80	70	10	10	20	90	10	10
5	Most of your lessons have the same pattern	8	9	6	1	1	2	1	0	2
6	You use lots of practical examples in your teaching	30	80	90	20	20	10	50	0	0
7	The syllabus is crowded so it is difficult to do more tasks work	8	2	2	1	0	0	1	8	8
8	I use audio -visual aids in my lessons	50	90	90	10	10	10	40	0	0
9	0nly the most able students like my lesson	70	10	30	100	40	100	20	50	60
10	Students find it difficult to understand some mechanical tasks lessons because they cannot be presented simply	80	30	30	0	0	10	20	70	60
11	All tasks of my lesson can be presented simply	0	50	50	10	20	20	90	30	30
12	Group work is an effective way of your teaching style	20	90	80	20	10	0	60	0	20
13	I would like to end my theory class time very quickly so i can do more practicing.	100	30	30	0	0	0	0	70	70

14	When you prepare lessons you follow the techniques given in the teacher's guide	**4**	**4**	**4**	**2**	**2**	**1**	**4**	**4**	**5**
15	You encourage the students to ask Questions	**60**	**80**	**90**	**10**	**20**	**10**	**30**	**0**	**0**
16	The students find difficulties in seeing the relevance of what you teach in Automotive Maintenance and Manufacturing Technology	**80**	**40**	**30**	**0**	**10**	**0**	**20**	**50**	**70**
17	You ask your students after the lesson if they understand the lesson or not	**100**	**100**	**90**	**0**	**0**	**10**	**0**	**0**	**0**
18	I add many examples to explain my lessons	**9**	**10**	**7**	**0**	**0**	**0**	**1**	**0**	**3**
19	You find it difficult to encourage the students in your lesson	**100**	**30**	**20**	**0**	**0**	**20**	**0**	**70**	**60**
20	You repeat the lesson if the students still have difficulties in understanding	**30**	**70**	**100**	**10**	**10**	**0**	**60**	**20**	**0**
21	You concentrate on hands on tasks when you teach Mechanical lessons	**70**	**20**	**20**	**10**	**10**	**30**	**20**	**70**	**50**
22	You use dialogue with students during classroom activities	**10**	**70**	**50**	**50**	**30**	**10**	**40**	**0**	**40**
23	It is difficult to understand everything in the subject textbook	**100**	**20**	**20**	**0**	**20**	**10**	**0**	**60**	**70**
24	You use standard when you teach to judge the work	**90**	**40**	**30**	**10**	**20**	**10**	**0**	**40**	**60**
25	You enjoy your teaching style	**10**	**70**	**60**	**30**	**20**	**10**	**60**	**10**	**30**
26	You use many shape and different exercises to improve the students' skills	**70**	**20**	**20**	**0**	**20**	**10**	**30**	**60**	**70**

27	You use many mechanical exercises to Measure student's performance.	80	10	20	0	10	10	20	80	70
28	You start the subject lesson by examples and then you explain the learning Materials	70	30	30	10	20	0	20	50	70
29	You start the lessons tasks by explaining the concept of the subject and then you present the examples	60	100	70	0	0	20	40	0	10
30	You use group learning when you teach.	40	90	80	0	10	10	60	0	10
31	You have friendly relationships with students	60	90	70	40	10	20	0	0	10
32	You keep formal relationships with students	0	30	20	50	10	10	50	60	70
33	Students decide for themselves where they can sit in the classroom for teamwork	70	90	90	30	0	0	0	10	10
34	Students are distributed inside the classroom to places or groups on the basis of their ability	80	10	20	10	30	10	10	60	70
35	The desks are arranged in the classroom in rows for batter visualisation	40	80	70	10	10	10	50	10	20
36	The desks are arranged in the classroom in groups to learn from each others.	10	20	70	20	50	0	70	30	30
37	Your students work together co-operatively on work that you gave to them	40	70	60	10	10	20	50	20	20
38	Your students work individually on work that you gave to them	40	50	60	10	10	20	50	40	20
39	Most of your questions can be answered by remembering previous lessons	70	90	90	20	0	0	10	10	10

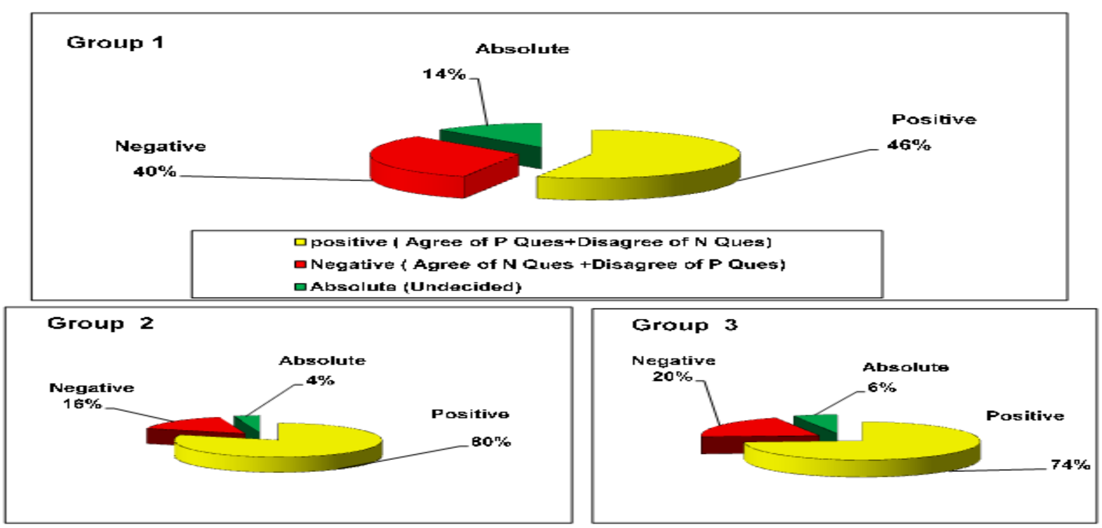
40	It is difficult to ask questions which require students to apply knowledge	80	40	30	0	20	20	20	40	50
41	You often ask questions that require students to make improvements.	60	80	90	20	10	10	20	10	0
42	To evaluate the students' level in knowledge.	50	90	90	20	0	0	30	10	30
43	To help them to Diagnosed and adjust weaknesses in Mechanical parts	40	90	90	10	10	10	50	0	0
44	Assessment feedback to treat their weaknesses.	90	90	90	10	10	10	0	0	0
45	You correct your students' mistakes	100	80	90	0	0	0	0	20	10
46	Easy mark the student's activities or exam tasks.	20	90	60	0	10	20	80	0	20
47	Easy to rate your students when they have the correct answer	10	70	60	0	10	20	90	20	20
48	It is easy for me to teach with current method	90	90	90	10	10	10	0	0	0
49	I do not like to use another teaching method to teach Mechanical Engineering subjects	80	30	30	0	0	10	20	70	60
50	The present method does not help me to take into account the individual needs of students	80	10	20	0	10	10	20	80	70
51	The present method is successful in the field of teaching Automotive Maintenance and Manufacturing Technology	10	80	80	0	20	20	90	0	0
52	Students are bored when I use the present method of your teaching	100	0	0	0	30	30	0	0	0

53	When I use the present method I don't need to use lots of teaching aids.	0	90	90	0	10	10	100	0	0
54	The present method encourages the students to learn.	30	70	80	0	10	10	70	20	10
55	I like to have training about the present method	20	90	90	30	0	0	50	10	10
56	The present method strengthens students skills in mechanical engineering subject	40	70	70	0	30	30	60	0	0
57	Part of students' weaknesses coming from i teaching method and learning style	90	20	30	0	30	10	10	50	60
58	The present method encourages the students to think Highly and logically	0	80	80	0	10	20	100	10	0
59	The present method increases the students' achievement in.	0	70	80	0	20	0	100	10	20
60	Teaching by the present method helps the student's to understand subject.	0	80	70	0	10	20	100	10	10
61	The present method enables me to control the class.	20	60	70	0	10	10	80	30	20
62	The present method is suitable for a class with a large number of students.	20	60	70	0	10	10	80	30	20
63	The variety of the examples in the present method helps the students to understand	10	80	70	0	0	10	90	20	20
64	The present method helps me to finish the tasks in time	20	70	70	0	20	10	80	10	20
65	The present method needs lots of time when I use it in teaching.	100	20	20	0	10	10	0	70	70
66	The present method does not encourage the students 'self- direct learning.	100	30	20	0	10	20	0	60	60

Teacher's Organisation

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
		%	%	%	%	%	%	%	%	%
1	I always plan my lesson with the use of computer	**80**	**100**	**100**	**10**	**0**	**0**	**10**	**0**	**0**
3	I use my own techniques when I prepare lessons	**60**	**80**	**70**	**20**	**0**	**20**	**20**	**20**	**10**
7	The syllabus is crowded so it is difficult to do more tasks work	**80**	**20**	**20**	**10**	**0**	**0**	**10**	**80**	**80**
14	When you prepare lessons you follow the techniques given in the teacher's guide	**40**	**40**	**40**	**20**	**20**	**10**	**40**	**40**	**50**
18	I add many examples to explain my lessons	**90**	**100**	**70**	**0**	**0**	**0**	**10**	**0**	**30**
positive		**230**	**280**	**240**	**30**	**0**	**20**	**40**	**20**	**40**
Negative		**120**	**60**	**60**	**30**	**20**	**10**	**50**	**120**	**130**
Absolute					**0**	**0**	**0**			

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	280	400	370
Negative (Agree of N Ques +Disagree of P Ques)	160	80	100
Absolute (Undecided)	60	20	30

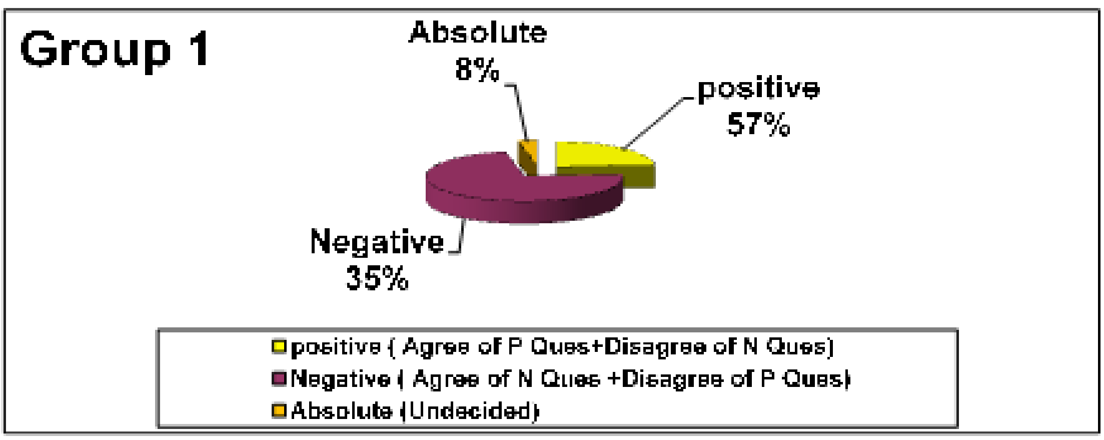


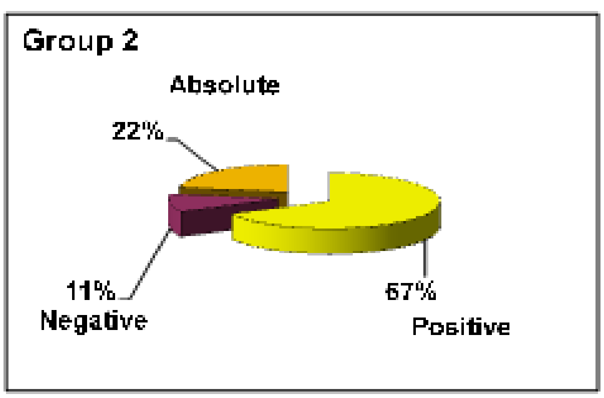
Teachers Presentation

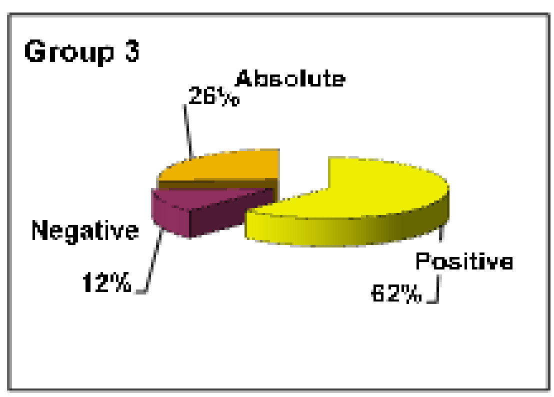
N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
		%	%	%	%	%	%	%	%	%
4	The majority of my students are interested in the way I present my lessons.	0	80	70	100	100	20	90	100	100
9	0nly the most able students like my lesson	70	10	30	100	40	100	20	50	60
6	You use lots of practical examples in your teaching	30	80	90	20	20	100	50	0	0
8	I use audio -visual aids in my lessons	50	90	90	10	10	10	40	0	0
10	Students find it difficult to understand some mechanical tasks lessons because they cannot be presented simply	80	30	30	0	0	10	20	70	60
11	All tasks of my lesson can be presented simply	0	50	50	10	20	20	90	30	30
16	The students find difficulties in seeing the relevance of what you teach in AIM	80	40	30	0	10	0	20	50	70
5	Most of your lessons have the same pattern	80	90	60	10	10	20	10	0	20
28	You start the subject lesson by examples and then you explain the learning Materials	70	30	30	10	20	0	20	50	70
29	You start the lessons tasks by explaining the concept of the subject and then you present the examples	60	100	70	0	0	20	40	0	10
21	You concentrate on hands on tasks when you teach Mechanical lessons	70	20	20	10	10	30	20	70	50
52	Students are bored when I use the present method of your teaching	100	0	0	0	30	30	0	0	0

53	When I use the present method I don't need to use lots of teaching aids.	**0**	**90**	**90**	**0**	**10**	**10**	**100**	**0**	**0**
63	The variety of the examples in the present method helps the students to understand	**10**	**80**	**70**	**0**	**0**	**10**	**90**	**20**	**20**
Positive		**220**	**590**	**550**	**150**	**170**	**200**	**520**	**8**	**10**
Negative		**330**	**6**	**7**	**100**	**80**	**140**	**60**	**31**	**30**
Absolute		**150**	**120**	**90**	**20**	**30**	**40**	**30**	**50**	**90**

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	280	90	85
Negative (Agree of N Ques +Disagree of P Ques)	850	14	17
Absolute (Undecided)	36	30	35





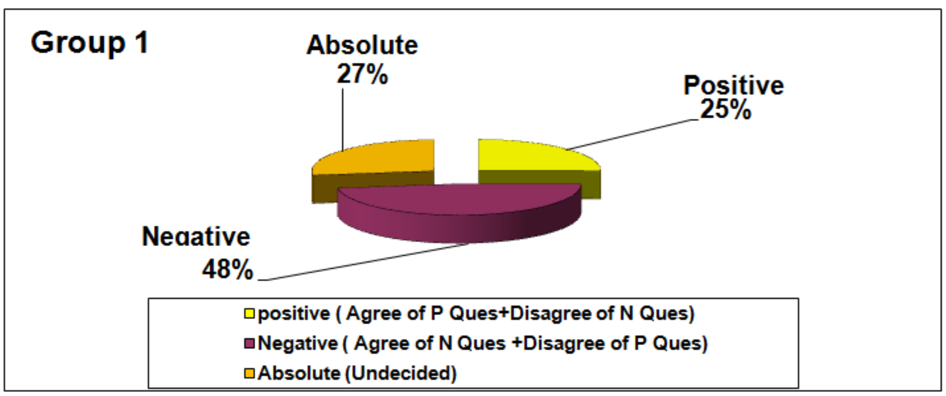


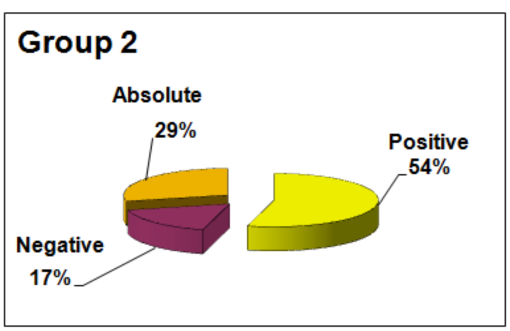
Teachers Classroom Management

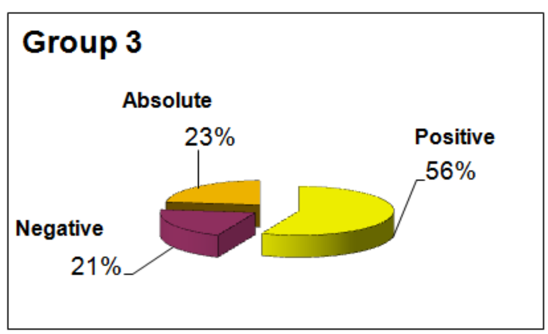
N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
		%	%	%	%	%	%	%	%	%
30	You use group learning when you teach.	40	90	80	0	10	10	60	0	10
12	Group work is an effective way of your teaching style	20	90	80	20	10	0	60	0	20
13	I would like to end my theory class time very quickly so i can do more practicing.	100	30	30	0	0	0	0	70	70
15	You encourage the students to ask Questions	60	80	90	10	20	10	30	0	0
19	You find it difficult to encourage the students in your lesson	100	30	20	0	0	20	0	70	60
22	You use dialogue with students during classroom activities	10	70	50	50	30	10	40	0	40
33	Students decide for themselves where they can sit in the classroom for teamwork	70	90	90	30	0	0	0	10	10
34	Students are distributed inside the classroom to places or groups on the basis of their ability	80	10	20	10	30	10	10	60	70
35	The desks are arranged in the classroom in rows for batter visualisation	40	80	70	10	10	10	50	10	20
36	The desks are arranged in the classroom in groups to learn from each others.	10	20	70	20	50	0	70	30	30
37	Your students work together co-operatively on work that you gave to them	40	70	60	10	10	20	50	20	20
38	Your students work individually on work that you gave to them	40	50	60	10	10	20	50	40	20
61	The present method enables me to control the class.	20	60	70	0	10	10	80	30	20
62	The present method is suitable for a class with a large number of students.	20	60	70	0	10	10	80	30	20

64	The present method helps me to finish the tasks in time	**20**	**70**	**70**	**0**	**20**	**10**	**80**	**10**	**20**
65	The present method needs lots of time when I use it in teaching.	**100**	**20**	**20**	**0**	**10**	**10**	**0**	**70**	**70**
Positive		**400**	**750**	**790**	**140**	**220**	**120**	**660**	**230**	**290**
Negative		**100**	**30**	**20**	**0**	**0**	**2**	**0**	**70**	**60**
Absolute		**290**	**200**	**210**	**3**	**0**	**0**	**0**	**15**	**15**

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	400	820	850
Negative (Agree of N Ques +Disagree of P Ques)	760	260	310
Absolute (Undecided)	433	435	347





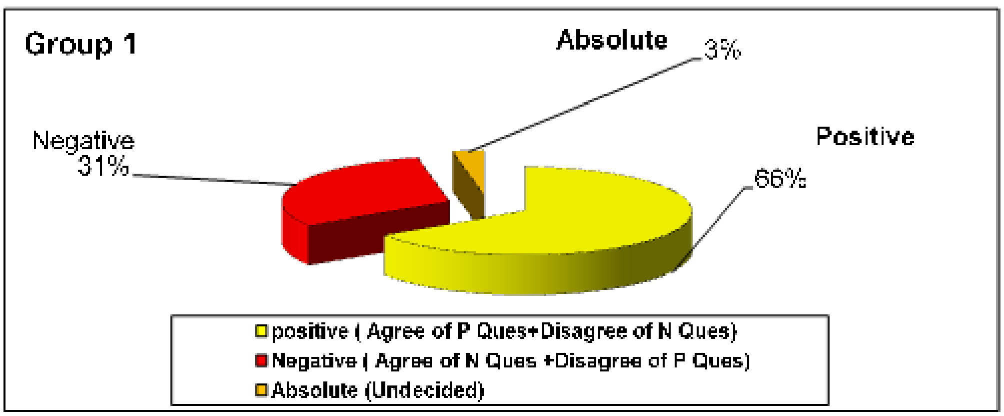


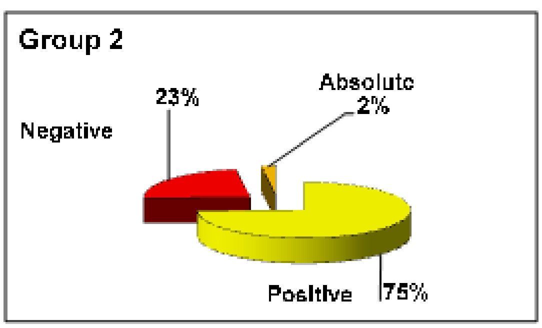
Assessment Mechanisms

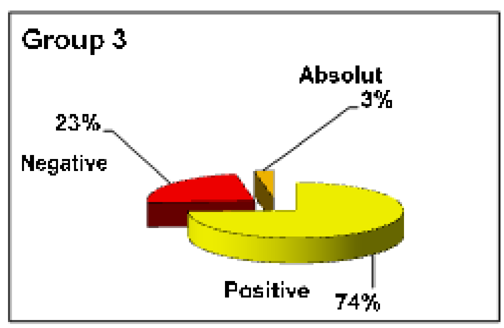
N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
		%	%	%	%	%	%	%	%	%
17	You ask your students after the lesson if they understand the lesson or not	100	100	90	0	0	10	0	0	0
20	You repeat the lesson if the students still have difficulties in understanding	30	70	100	10	10	0	60	20	0
24	You use standard when you teach to judge the work	90	40	30	10	20	10	0	40	60
26	You use many shape and different exercises to improve the students' skills	70	20	20	0	20	10	30	60	70
27	You use many mechanical exercises to Measure student's performance.	80	10	20	0	10	10	20	80	70
39	Most of your questions can be answered by remembering previous lessons	70	90	90	20	0	0	10	10	10
40	It is difficult to ask questions which require students to apply knowledge	80	40	30	0	20	20	20	40	50
41	You often ask questions that require students to make improvements .	60	80	90	20	10	10	20	10	0
42	To evaluate the students' level in knowledge.	50	90	90	20	0	0	30	10	30
43	To help them to Diagnosed and adjust weaknesses in Mechanical parts	40	90	90	10	10	10	50	0	0
44	Assessment feedback to treat their weaknesses.	90	90	90	10	10	10	0	0	0
45	You correct your students' mistakes	100	80	90	0	0	0	0	20	10
46	Easy mark the student's activities or exam tasks.	20	90	60	0	10	20	80	0	20
47	Easy to rate your students when they have the correct answer	10	70	60	0	10	20	90	20	20

59	The present method increases the students' achievement in.	0	70	80	0	20	0	100	10	20
Positive		740	920	830	80	110	110	280	260	240
Negative		80	40	30	0	20	20	20	40	50
Absolute					20	20	0			

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	760	960	880
Negative (Agree of N Ques +Disagree of P Ques)	360	300	270
Absolute (Undecided)	35	28	34



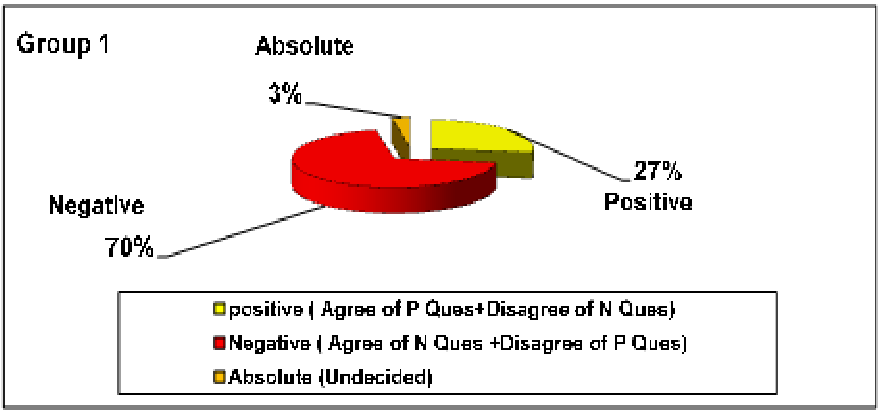


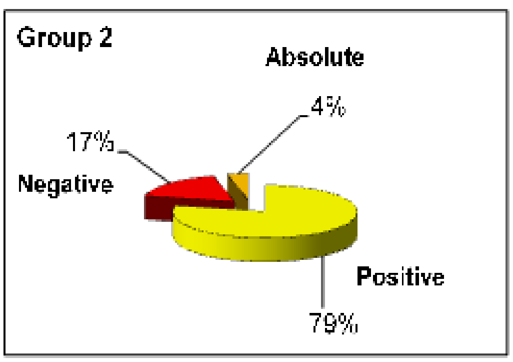


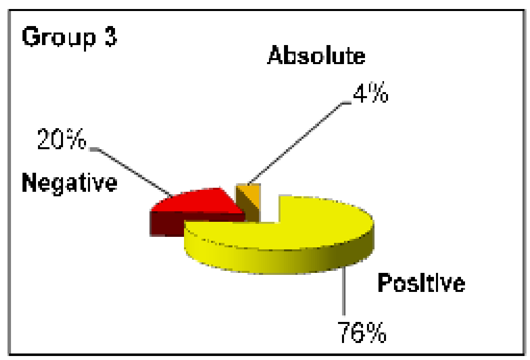
Teacher's Perception of Teaching

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G 3	G 1	G 2	G 3	G 1	G 2	G 3
		%	%	%	%	%	%	%	%	%
2	You find difficult to Understand or Experience subject matter.	60	70	60	20	0	20	20	30	20
23	It is difficult to understand everything in the subject textbook	100	20	20	0	20	10	0	60	70
25	You enjoy your teaching style	10	70	60	30	20	10	60	10	30
31	You have friendly relationships with students	60	90	70	40	10	20	0	0	10
32	You keep formal relationships with students	0	30	20	50	10	10	50	60	70
51	The present method is successful in the field of teaching AIM	10	80	80	0	20	20	90	0	0
54	The present method encourages the students to learn.	30	70	80	0	10	10	70	20	10
55	I like to have training about the present method	20	90	90	30	0	0	50	10	10
56	The present method strengthens students skills in mechanical engineering subject	40	70	70	0	30	30	60	0	0
57	Part of students' weaknesses coming from i teaching method and learning style	90	20	30	0	30	10	10	50	60
58	The present method encourages the students to think Highly and logically	0	80	80	0	10	20	100	10	0
60	Teaching by the present method helps the student's to understand subject.	0	80	70	0	10	20	100	10	10
66	The present method does not encourage the students 'self- direct learning.	100	30	20	0	10	20	0	60	60
Positive		270	650	620	100	100	100	530	120	140
Negative		190	50	50	0	40	30	10	110	120
Absolute					70	40	70			

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	280	760	740
Negative (Agree of N Ques +Disagree of P Ques)	720	170	190
Absolute (Undecided)	29	35	40







b- Students' Questionnaire Results

Student's responses on the questionnaire

G: Group

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G1 %	G2 %	G3 %	G1 %	G2 %	G3 %	G1 %	G2 %	G 3 %
1	I do not like the subject.	93	0	0	0	0	0	7	100	100
2	I like to participate in activities during Automotive maintenance and manufacturing (AIM) lesson.	47	87	73	0	7	13	53	7	13
3	Learning style used in Engineering subject developed my learning abilities.	7	93	87	0	0	0	93	7	13
4	I feel comfortable during Mechanical lesson when the teacher use the same style.	0	80	67	0	13	13	100	7	20
5	1 likes to have more subject lessons using this method.	0	93	73	0	7	20	100	0	7
6	Learning mechanical subject with this methods wasting of time.	87	7	6	13	0	27	0	93	67
7	I feel bored in mechanical subjects when the teacher using this methods.	80	7	13	7	0	13	13	93	74
8	Learning this type of tasks improves my skills.	67	100	93	7	0	7	26	0	0
9	Learning engineering subjects with computer improves my knowledge.	93	87	93	0	13	7	7	0	0
10	I like to spend more time in practicing Engineering subjects.	13	100	93	0	0	7	87	0	0
11	I do not like to watch traditional (TCA) simulation program in my subject.	7	13	7	0	0	13	93	87	80
12	I like more than other institute subjects.	33	80	73	20	7	13	47	13	14

13	It is difficult to understand Procedure of practical session.	80	35	30	0	7	0	20	58	70
14	I like Teaching methodology of this subjects	7	87	60	0	7	33	93	6	7
15	I find other since subjects are more enjoyable than in mechanical subject	93	20	20	0	13	20	7	67	60
16	In this methods teacher correct my mistake very easily	0	80	73	0	7	27	100	13	0
17	I feel boring in this method	100	7	40	0	13	20	0	80	40
18	My teacher is always in control of 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	6
20	Motivating you and attract your attention toward to the subject matter.	13	100	80	0	0	13	87	0	7
21	Teacher in this methods work with less effort than the other methods.	0	80	80	0	0	0	100	20	20
22	In this method my teacher teaches an interesting way.	0	60	67	0	27	27	100	13	6
23	The teachers rely too much on the text book.	100	7	13	0	13	20	0	80	67
24	My teacher does not pay attention to the students' individual differences.	73	27	20	0	7	13	27	66	67
25	My teacher enjoys teaching this subject.	67	100	87	7	0	13	26	0	0
26	My teacher encourages me to learn engineering.	47	100	93	0	0	7	53	0	0
27	My teacher always follows the same teaching method to teach.	93	53	46	7	40	27	0	7	27
28	The teacher does not explain the target 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

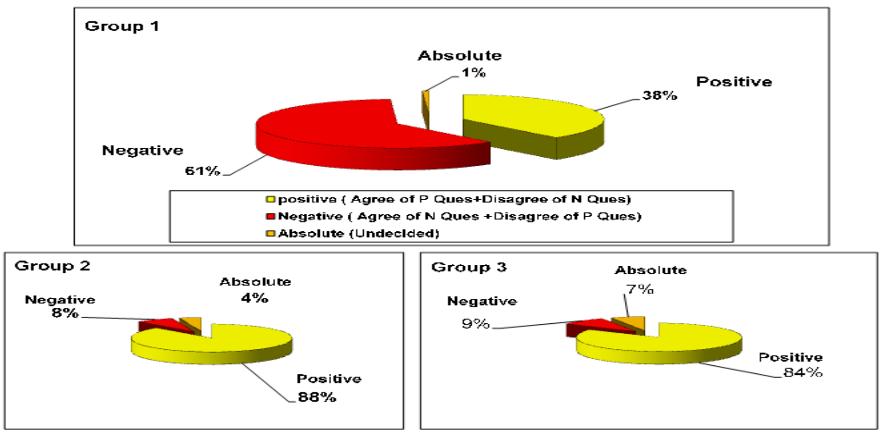
30	My teacher respects me when I work with simulation work or computer assisted instruction.	0	73	73	40	27	27	60	0	0
31	My teacher is fair when he marks the students' work.	20	73	73	0	27	27	80	0	0
32	Easy to evaluate students work and assessing their performance.	0	80	74	0	20	13	100	0	13
33	The teacher does not use educational aids when he teaches with this methods	70	0	0	0	0	5	30	100	95
34	The teacher follows the textbook in his teaching method to teach Starting with examples and displaying the procedures.	100	20	20	0	10	15	0	70	65
35	My teachers always prepares their subject plan	100	93	80	0	7	0	0	0	20
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
37	My teacher has an adequate knowledge of this method.	73	67	73	7	27	20	20	6	7

The Student's Attitudes Towards the Learning

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G3	G1	G2	G3	G 1	G 2	G3
1	I do not like the subject	93	0	0	0	0	0	7	100	100
2	I like to participate in activities during AIM lesson	47	87	73	0	7	13	53	7	13
3	Learning style used in Engineering subject developed my learning abilities	7	93	87	0	0	0	93	7	13
4	I feel comfortable during Mechanical lesson when use the same style.	0	80	67	0	13	13	100	7	20
8	Learning this type of tasks improves my skills	67	100	93	7	0	7	26	0	0
9	Learning engineering subjects with computer improves my knowledge.	93	87	93	0	13	7	7	0	0
10	I like to spend more time in practicing Engineering subjects	13	100	93	0	0	7	87	0	0

11	I do not like to watch traditional (TCA)simulation program in my subject	7	13	7	0	0	13	93	87	80
13	It is difficult to understand Procedure of practical session .	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			

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

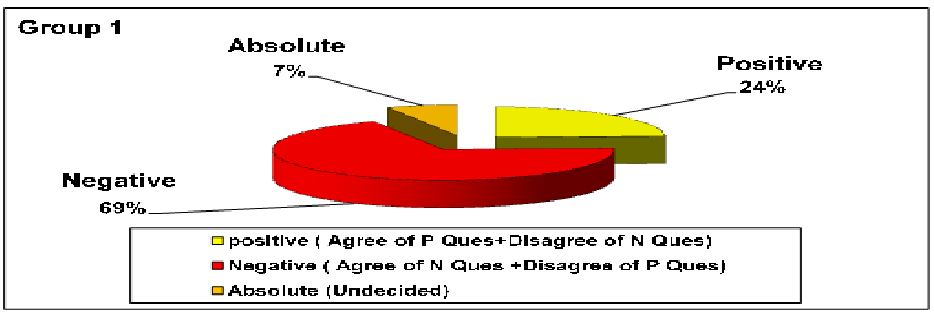


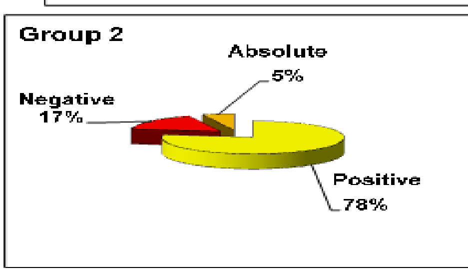
The Student's Attitudes Towards the Lecturer Teaching Method

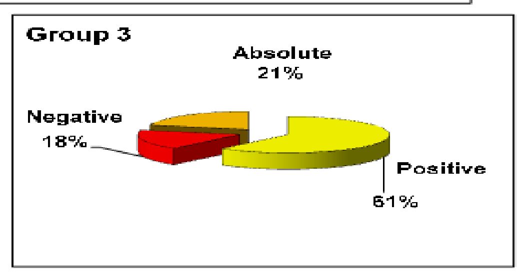
N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G1	G2	G3	G1	G2	G3	G 1	G 2	G3
5	1 likes to have more subject lessons using this method.	0	93	73	0	7	20	100	0	7
6	Learning mechanical subject with this methods wasting of time.	87	7	6	13	0	27	0	93	67
7	I feel bored in mechanical subjects when the teacher using this methods,	80	7	13	7	0	13	13	93	74
12	I like more than other institute subjects	33	80	73	20	7	13	47	13	14

14	I like Teaching methodology of this subjects	**7**	**87**	**60**	**0**	**7**	**33**	**93**	**6**	**7**
15	I find other since subjects are more enjoyable than in mechanical subject	**93**	**20**	**20**	**0**	**13**	**20**	**7**	**67**	**60**
Positive		**133**	**280**	**226**	**20**	**34**	**86**	**247**	**86**	**88**
Negative		**167**	**14**	**19**	**20**	**0**	**40**	**13**	**186**	**141**
Absolute										

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







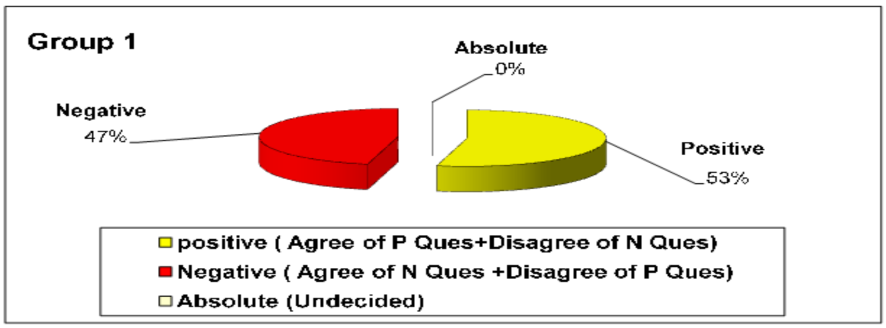
The student's Opinions and Views About Teaching and Learning

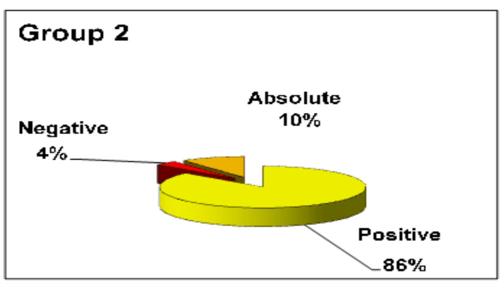
Planning and organising

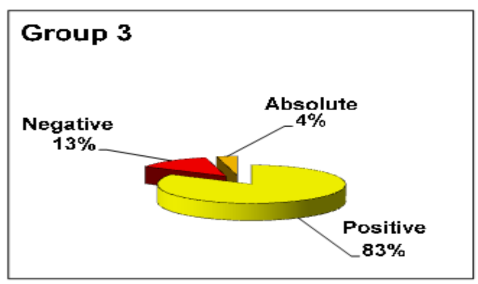
N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G1	G2	G3	G1	G2	G3	G1	G2	G3
19	Teacher makes links between the classroom teachings and laboratories work.	7	80	87	0	13	7	93	7	6

35	My teachers always prepares their subject plan	100	93	80	0	7	0	0	0	20
Positive		107	173	167	0	20	7	93	7	26
Negative		0	0	0	0	0	0	0	0	0
Absolute		0	0	0	0	0	0	0	0	0

	G1	G2	G3
positive (Agree of P Ques + Disagree of N Ques)	107	173	167
Negative (Agree of N Ques +Disagree of P Ques)	93	7	26
Absolute (Undecided)	0	20	7







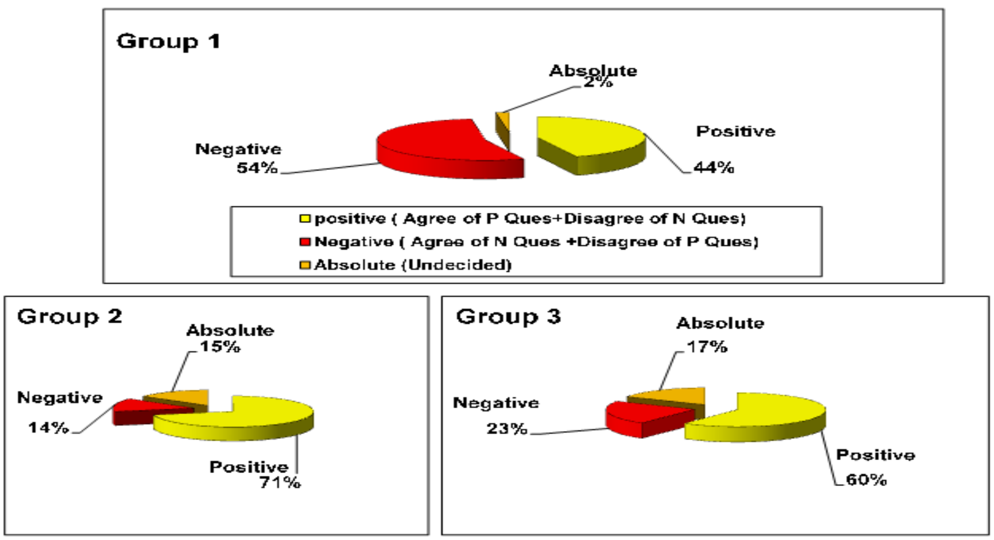
The student's Opinions and Views About Teaching and Learning

Students Opinion about Presenting

No	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G3	G1	G2	G3	G 1	G 2	G3
17	I feel boring in this method	**100**	**7**	**40**	**0**	**13**	**20**	**0**	**80**	**40**
20	Motivating you and attract your attention toward to the subject matter.	**13**	**100**	**80**	**0**	**0**	**13**	**87**	**0**	**7**

23	The teachers rely too much on the text book	**100**	**7**	**13**	**0**	**13**	**20**	**0**	**80**	**67**
27	My teacher always follows the same teaching method to teach.	**93**	**53**	**46**	**7**	**40**	**27**	**0**	**7**	**27**
33	The teacher does not use educational aids when he teaches with this methods	**70**	**0**	**0**	**0**	**0**	**5**	**30**	**100**	**95**
34	The teacher follows the textbook in his teaching method to teach Starting with examples and displaying the procedures.	**100**	**20**	**20**	**0**	**10**	**15**	**0**	**70**	**65**
37	My teacher has an adequate knowledge of this method.	**73**	**67**	**73**	**7**	**27**	**20**	**20**	**6**	**7**
Positive		**279**	**240**	**219**	**14**	**77**	**75**	**107**	**83**	**106**
Negative		**270**	**14**	**53**	**0**	**26**	**45**	**30**	**260**	**202**
Absolute		0	0	0	0	0	0	0	0	0

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	309	500	421
Negative (Agree of N Ques +Disagree of P Ques)	377	97	159
Absolute (Undecided)	14	103	120

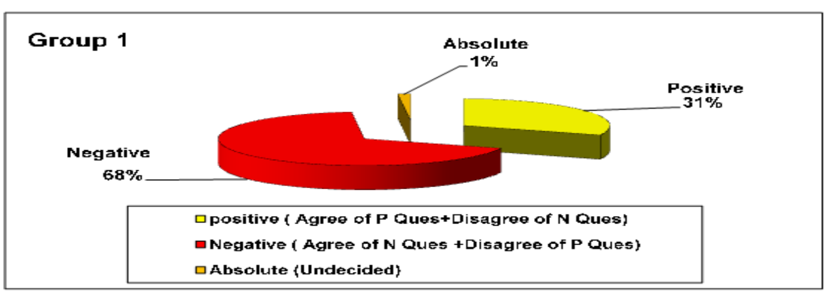


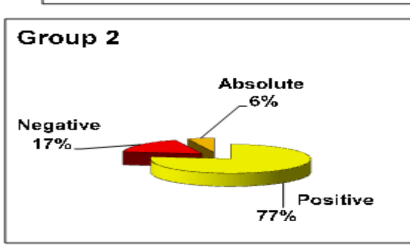
The student's Opinions and Views About Teaching and Learning

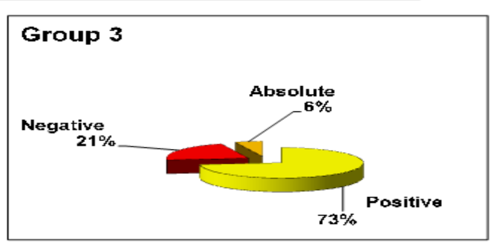
Classroom Management

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G3	G1	G2	G3	G 1	G 2	G3
18	My teacher is always in control of the class	20	80	93	7	13	0	73	7	7
21	Teacher in this methods work with less effort than the other methods.	0	80	80	0	0	0	100	20	20
24	My teacher does not pay attention to the students' individual differences	73	27	20	0	7	13	27	66	67
28	The teacher does not explain the target 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
Positive		20	160	173	7	13	0	173	27	27
Negative		166	60	80	0	14	27	134	226	193
Absolute					0	0	0			

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





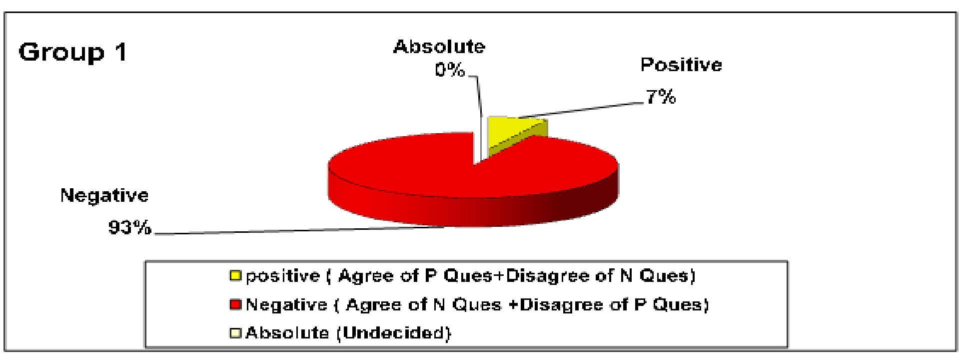


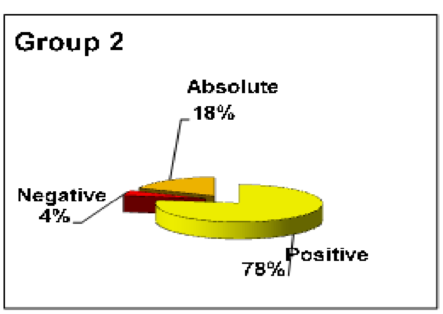
The student's Opinions and Views About Teaching and learning

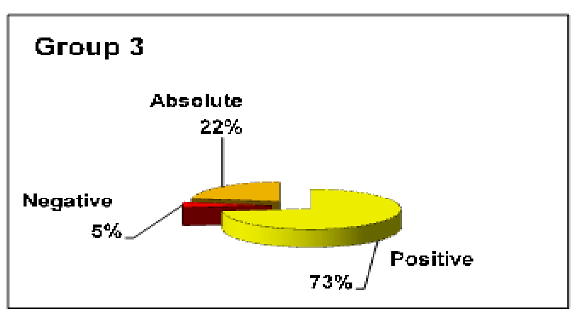
Assessment the Students' Performance

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G3	G1	G2	G3	G 1	G 2	G3
16	In this methods teacher correct my mistake very easily	0	80	73	0	7	27	100	13	0
31	My teacher is fair when he marks the students' work.	20	73	73	0	27	27	80	0	0
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										

	G1	G2	G3
positive (Agree of P Ques+Disagree of N Ques)	20	233	220
Negative (Agree of N Ques +Disagree of P Ques)	280	13	13
Absolute (Undecided)	0	54	67



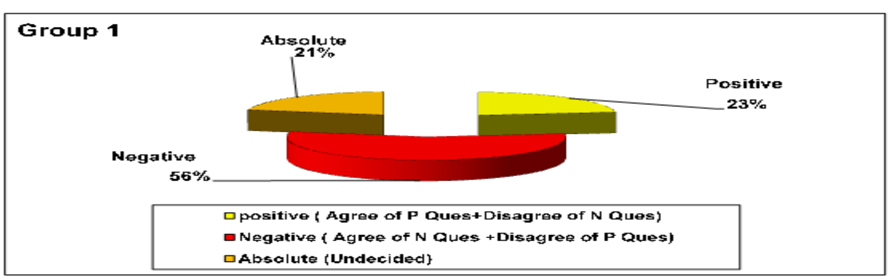


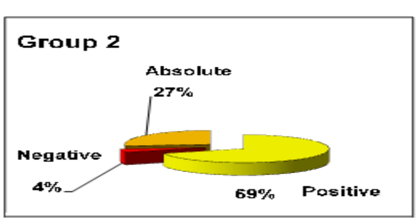


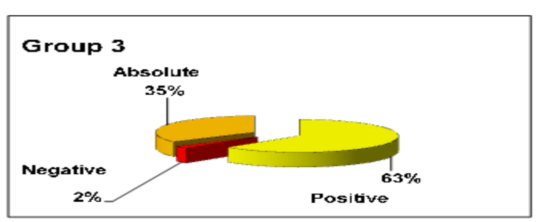
The student's Opinions and Views About Teaching and learning Interaction and Enjoyment

N0	Statement	AGREE			UNDECIDED			DISAGREE		
		G 1	G 2	G3	G1	G2	G3	G 1	G 2	G3
22	In this methods my teacher teaches an interesting way	0	60	67	0	27	27	100	13	6
25	My teacher enjoys teaching this subject	67	100	87	7	0	13	26	0	0
26	My teacher encourages me to learn engineering	47	100	93	0	0	7	53	0	0
30	My teacher respects me when I work with simulation work or computer assisted instruction.	0	73	73	40	27	27	60	0	0
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
Negative		0	0	0	0	0	0	0	0	0
Absolute		0	73	73	40	27	27	60	0	0

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







APPENDIX FOUR
Students Checklist

معهد الشيخ خليفه بن سلمان للتكنولوجيا
Sh.Khalifa Bin Salman Institute of Technology

a- Students Checklist 2

Group 1 : Teacher Centered Approach - Outcomes Results (Cognitive)

No	Learning outcomes	Marks	Students														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demonstrate rang of transmission applications.																	
1	Explain Front and Rear Gear Drive Applications	3	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2
2	State Front Rear Gear Drive Troubleshooting	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
3	Identify Clutch Applications	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	State Clutch Troubleshooting Procedure	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diagnose, adjust and Repair Manual Gearbox.																	
1	Analyse Gearbox Faults	4	2	2	2	2	2	2	2	2	3	2	3	2	2	2	2
2	Write Gearbox - Removal Steps	4	2	2	3	2	2	2	3	2	3	2	3	2	2	2	2
3	Name Gearbox Parts and State Repair Steps	4	2	2	2	3	2	2	2	3	2	3	2	2	2	2	2
4	Evaluating Procedure of Gearbox Installation	4	2	2	2	2	3	2	3	2	2	3	2	2	2	2	2

Diagnose, Adjust and Repair Manual Clutch.																
1	Analysing of Clutch Faults	**5**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**3**	**2**	**3**	**3**
2	Evaluating Removal Steps of Clutch	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**4**	**2**
3	Name Clutch Parts and State Repair Procedure	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**4**	**2**
4	Writ application of Clutch Installation	**5**	**2**	**3**	**2**	**3**	**3**	**2**	**3**	**3**		**3**	**2**	**3**	**2**	**2**	**2**
Demonstrate a range of Manufacturing tools and Measurements Skills.																
1	Demonstrate a range of Centre lathe and milling Cutting tools	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
2	Demonstrate Application of Vernier and Micrometer	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
3	Evaluate a range of Vernier Caliper Demonstration	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
4	Evaluate a range of Micrometers Demonstration	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Demonstrate a range of Milling, Centre Lathe and Shaping Machine setting.																
1	Demonstrate Steps of Setting Procedure of work Holding on Milling	**5**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**
2	State Setting Procedure of work Holding on Center Lathe and Shaping	**5**	**3**	**4**	**4**	**4**	**3**	**3**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
3	Demonstrate Milling Machine Application of cutting Speed and feed	**5**	**3**	**3**	**3**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

4	Calculate Center Lathe and Shaping Machine cutting Speed and feed	5	3	3	3	3	4	4	3	3	3	3	3	3	3	3	2
Demonstrate a range of operations on Machine tools																	
1	Demonstrate Machining Steps of (Flat surface) on Milling and Shaping .M	5	2	3	2	2	3	4	3	3	3	2	2	3	2	2	2
2	Calculate Gear Cutting on Milling .M	5	2	3	2	3	3	2	3	2	3	2	2	3	2	2	2
3	Demonstrate Parallel and Taper Turning Procedure on Center Lathe	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	Demonstrate Screw Cutting Steps (V & Square Shape) on Center Lathe	5	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3
Results		**100**	**59**	**63**	**61**	**64**	**65**	**62**	**65**	**62**	**62**	**62**	**61**	**60**	**56**	**59**	**52**

معهد الشيخ خليفه بن سلمان للتكنولوجيا
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Group 2 : Student Centered Approach - Outcomes Results (Cognitive)

No	Learning outcomes	Marks	Students														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demonstrate rang of transmission applications.																	
1	Explain Front and Rear Gear Drive Applications	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	State Front Rear Gear Drive Troubleshooting	3	2	2	2	2	2	2	2	2	2	3	2	2	3	2	3
3	Identify Clutch Applications	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2
4	State Clutch Troubleshooting Procedure	3	2	2	2	2	2	2	2	2	2	3	2	2	3	2	2
Diagnose, adjust and Repair Manual Gearbox.																	
1	Analyse Gearbox Faults	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	3
2	Write Gearbox - Removal Steps	4	2	3	2	2	2	2	2	2	2	2	4	2	4	2	4
3	Name Gearbox Parts and State Repair Steps	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4
4	Evaluating Procedure of Gearbox Installation	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4

Diagnose, Adjust and Repair Manual Clutch.																
1	Analysing of Clutch Faults	**5**	**4**	**4**	**4**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
2	Evaluating Removal Steps of Clutch	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**3**	**5**	**5**	**5**	**5**
3	Name Clutch Parts and State Repair Procedure	**5**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**3**	**4**	**4**
4	Writ application of Clutch Installation	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**4**	**5**	**4**	**5**	**5**
Demonstrate a range of Manufacturing tools and Measurements Skills.																
1	Demonstrate a rang of Centre lathe and milling Cutting tools	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
2	Demonstrate Application of Vernier and Micrometer	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
3	Evaluate a range of Vernier Caliper Demonstration	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
4	Evaluate a range of Micrometers Demonstration	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
Demonstrate a range of Milling, Centre Lathe and Shaping Machine setting.																
1	Demonstrate Steps of Setting Procedure of work Holding on Milling	**5**	**3**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**3**	**3**	**3**
2	State Setting Procedure of work Holding on Center Lathe and Shaping	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**

3	Demonstrate Milling Machine Application of cutting Speed and feed	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5	5
4	Calculate Center Lathe and Shaping Machine cutting Speed and feed	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Demonstrate a range of operations on Machine tools																	
1	Demonstrate Machining Steps of (Flate surface) on Milling and Shaping .M	5	4	4	4	4	4	4	4	5	4	4	3	4	4	4	4
2	Calculate Gear Cutting on Milling .M	5	4	5	4	4	4	4	4	4	4	4	3	4	3	5	3
3	Demonstrate Parallel and Taper Turning Procedure on Center Lathe	5	5	5	5	5	4	3	5	5	4	4	5	4	3	3	4
4	Demonstrate Screw Cutting Steps (V & Square Shape) on Center Lathe	5	5	4	5	5	4	3	5	5	5	4	5	5	3	3	4
Results		**100**	**86**	**86**	**86**	**86**	**81**	**84**	**85**	**87**	**85**	**86**	**81**	**85**	**83**	**83**	**84**

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Group 3 : Interactive Learning - Outcomes Results (Cognitive)

No	Learning outcomes	Marks	Students														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demonstrate rang of transmission applications.																	
1	Explain Front and Rear Gear Drive Applications	3	3	3	2	3	3	3	3	3	3	2	3	3	3	2	3
2	State Front Rear Gear Drive Troubleshooting	3	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
3	Identify Clutch Applications	3	3	3	2	3	3	3	3	3	2	3	2	3	2	3	2
4	State Clutch Troubleshooting Procedure	3	2	2	2	3	2	3	2	2	2	2	2	2	3	2	2
Diagnose, adjust and Repair Manual Gearbox.																	
1	Analyse Gearbox Faults	4	4	3	3	4	4	4	4	4	4	3	4	3	4	3	2
2	Write Gearbox - Removel Steps	4	2	3	2	3	2	2	2	2	2	2	3	2		2	2
3	Name Gearbox Parts and State Repair Steps	4	4	4	4	4	4	3	4	4	4	2	3	4	3	3	2
4	Evaluating Procedure of Gearbox Installation	4	4	4	3	4	4	3	3	4	4	3	3	4	3	4	2

Diagnose, Adjust and Repair Manual Clutch.																
1	Analysing of Clutch Faults	**5**	**4**	**4**	**3**	**4**	**4**	**5**	**4**	**4**	**4**	**3**	**4**	**4**	**4**	**3**	**3**
2	Evaluating Removal Steps of Clutch	**5**	**5**	**4**	**3**	**4**	**4**	**5**	**5**	**5**	**3**	**3**	**2**	**3**	**3**	**4**	**3**
3	Name Clutch Parts and State Repair Procedure	**5**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**2**	**4**	**3**	**3**	**4**
4	Writ application of Clutch Installation	**5**	**5**	**5**	**4**	**4**	**4**	**5**	**4**	**5**	**5**	**3**	**2**	**3**	**3**	**5**	**3**
Demonstrate a range of Manufacturing tools and Measurements Skills.																
1	Demonstrate a rang of Centre lathe and milling Cutting tools	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**2**
2	Demonstrate Application of Vernier and Micrometer	**3**	**2**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**2**
3	Evaluate a range of Vernier Caliper Demonstration	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**2**
4	Evaluate a range of Micrometers Demonstration	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**
Demonstrate a range of Milling, Centre Lathe and Shaping Machine setting.																
1	Demonstrate Steps of Setting Procedure of work Holding on Milling	**5**	**3**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**3**	**3**	**3**
2	State Setting Procedure of work Holding on Center Lathe and Shaping	**5**	**3**	**3**	**4**	**3**	**4**	**4**	**3**	**4**	**4**	**3**	**4**	**3**	**4**	**3**	**2**
3	Demonstrate Milling Machine Application of cutting Speed and feed	**5**	**3**	**3**	**4**	**4**	**4**	**3**	**3**	**3**	**4**	**3**	**4**	**3**	**4**	**3**	**3**

4	Calculate Center Lathe and Shaping Machine cutting Speed and feed	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**3**	**4**	**4**	**3**	**4**	**3**	**3**	**2**
Demonstrate a range of operations on Machine tools																	
1	Demonstrate Machining Steps of (Flat surface) on Milling and Shaping .M	**5**	**3**	**4**	**5**	**4**	**4**	**3**	**3**	**3**	**4**	**4**	**3**	**4**	**3**	**3**	**4**
2	Calculate Gear Cutting on Milling .M	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**3**	**4**	**3**	**4**	**3**	**3**	**3**
3	Demonstrate Parallel and Taper Turning Procedure on Center Lathe	**5**	**4**	**4**	**5**	**3**	**4**	**3**	**4**	**3**	**4**	**4**	**5**	**3**	**3**	**3**	**4**
4	Demonstrate Screw Cutting Steps (V & Square Shape) on Center Lathe	**5**	**3**	**4**	**5**	**4**	**4**	**3**	**4**	**3**	**4**	**4**	**5**	**3**	**3**	**3**	**4**
Results		**100**	**78**	**82**	**78**	**80**	**80**	**80**	**76**	**78**	**78**	**72**	**73**	**72**	**72**	**70**	**64**

معهد الشيخ خليفه بن سلمان للتكنولوجيا
Sh.Khalifa Bin Salman Institute of Technology

b- Students Checklist

Group 1 : Teacher Centered Approaches - Outcomes Results (Psychomotor)

No	Learning outcomes	Marks	Students														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demonstrate rang of transmission applications.																	
1	Front and Rear Gear Drive Applications	3	3	2	2	3	3	3	3	2	3	2	3	3	2	2	2
2	Front Rear Gear Drive Troubleshooting	3	2	2	2	2	2	2	2	2	2	2	3	2	3	2	2
3	Clutch Applications	3	3	2	2	2	3	3	3	3	2	3	2	3	2	2	2
4	Clutch Troubleshooting	3	2	2	2	3	2	3	2	2	2	2	2	2	3	2	2
Diagnose, adjust and Repair Manual Gearbox.																	
1	Diagnose and analyse Gearbox Faults	4	3	3	3	2	3	4	4	3	4	3	4	3	4	3	2
2	Gearbox - Removal	4	2	3	2	4	2	2	2	2	2	2	3	2		2	2
3	Gearbox Parts Inspection and Repair	4	3	3	2	4	3	3	4	3	4	2	3	4	3	3	2
4	Gearbox Installation and Testing	4	3	4	3	2	4	3	3	3	4	3	3	4	3	2	2
Diagnose, Adjust and Repair Manual Clutch.																	

1	Diagnose and analyse Clutch Faults	5	4	4	3	4	4	3	4	4	4	3	2	4	2	2	2
2	Clutch - Removal	5	3	4	3	4	4	3	3	4	3	3	2	3	3	2	2
3	Clutch Parts Inspection and Repair	5	3	3	2	4	4	3	4	4	3	4	2	4	2	3	3
4	Clutch Installation and Testing	5	3	3	4	3	3	4	3	3	4	3	2	3	3	3	3
Demonstrate a range of Manufacturing tools and Measurements Skills.																	
1	Use a rang of Centre lathe and milling Cutting tools	3	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2
2	Vernier and Micrometer Applications	3	2	3	2	2	3	3	3	2	3	2	3	2	2	2	2
3	Demonstrate a range Vernier Caliper	3	3	3	2	2	2	3	3	2	3	3	2	2	3	2	2
4	Demonstrate a range Micrometer	3	2	2	2	2	2	3	2	2	2	2	3	2	3	2	2
Demonstrate a range of Milling, Centre Lathe and Shaping Machine setting.																	
1	Set Milling Machine for work and cutter Holding	5	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3
2	Set Center Lathe and Shaping Machine for work and cutter Holding	5	3	3	3	3	4	3	3	3	4	3	4	3	2	3	2
3	Set Milling Machine for cutting Speed and feed with sutable Direction	5	3	3	3	4	4	3	3	3	3	3	4	3	2	3	3
4	Set Center Lathe and Shaping Machine for cutting Speed and feed with suitable Direction	5	4	3	3	3	3	3	3	4	3	3	3	4	4	3	2

Demonstrate a range of operations on Machine tools																	
1	Flate surface on Milling and Shaping Machine	5	3	4	4	3	4	3	3	3	3	3	3	4	3	3	3
2	Gear Cutting on Milling machine	5	3	3	4	3	3	3	3	4	3	3	4	3	3	4	2
3	Parallel and Taper Turning on Center Lathe	5	4	4	4	3	4	3	3	3	4	3	4	3	4	3	3
4	Screw Cutting (V & Square Shape) on Center Lathe	5	3	4	5	3	3	3	3	4	4	4	4	3	3	3	3
Results		100	69	73	67	70	74	71	71	70	74	67	70	71	64	61	55

معهد الشيخ خليفه بن سلمان للتكنولوجيا
Sh.Khalifa Bin Salman Institute of Technology

Group 2 : Student Centered Approaches - Outcomes Results (Psychomotor)

No	Learning outcomes	Marks	Students														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demonstrate rang of transmission applications.																	
1	Front and Rear Gear Drive Applications	3	3	3	2	3	3	3	3	3	3	2	3	3	2	3	3
2	Front Rear Gear Drive Troubleshooting	3	2	3	2	3	2	2	3	2	2	2	3	2	2	3	2
3	Clutch Applications	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3
4	Clutch Troubleshooting	3	2	3	2	3	2	3	2	2	2	2	2	2	2	3	2
Diagnose, adjust and Repair Manual Gearbox.																	
1	Diagnose and analyse Gearbox Faults	4	4	3	3	4	4	4	4	4	4	3	4	4	3	4	4
2	Gearbox - Removal	4	2	3	3	4	2	3	3	2	3	4	4	2	4	4	2
3	Gearbox Parts Inspection and Repair	4	4	4	4	4	4	3	4	4	4	4	3	4	4	4	4
4	Gearbox Installation and Testing	4	4	4	4	4	4	3	3	4	4	3	3	4	3	4	4
Diagnose, Adjust and Repair Manual Clutch.																	
1	Diagnose and analyse Clutch Faults	5	4	4	3	4	4	5	4	4	4	5	4	4	5	4	4

2	Clutch - Removal	5	5	4	3	4	5	5	5	5	4	5	4	5	5	4	5
3	Clutch Parts Inspection and Repair	5	4	5	4	4	4	4	5	4	4	4	3	4	4	4	4
4	Clutch Installation and Testing	5	5	5	4	4	5	5	4	5	5	5	4	5	5	4	5
Demonstrate a range of Manufacturing tools and Measurements Skills.																	
1	Use a rang of Centre lathe and milling Cutting tools	3	2	2	2	2	3	3	3	3	2	3	3	2	3	2	2
2	Vernier and Micrometer Applications	3	2	3	3	2	3	3	3	3	3	3	3	2	3	2	2
3	Demonstrate a range Vernier Caliper	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	Demonstrate a range Micrometer	3	2	2	3	2	3	3	3	3	2	2	2	2	2	2	2
Demonstrate a range of Milling, Centre Lathe and Shaping Machine setting.																	
1	Set Milling Machine for work and cutter Holding	5	4	5	4	5	5	4	4	5	5	4	4	4	4	4	4
2	Set Center Lathe and Shaping Machine for work and cutter Holding	5	4	3	5	5	5	4	4	4	4	4	4	4	4	4	4
3	Set Milling Machine for cutting Speed and feed with sutable Direction	5	4	4	5	4	5	4	4	5	4	5	4	5	5	4	4
4	Set Center Lathe and Shaping Machine for cutting Speed and feed with sutable Direction	5	4	4	5	4	3	4	4	3	4	4	4	4	4	4	4

Demonstrate a range of operations on Machine tools																	
1	Flate surface on Milling and Shaping Machine	5	5	4	5	4	5	3	5	5	4	4	5	5	4	4	4
2	Gear Cutting on Milling machine	5	4	5	4	5	4	4	5	4	5	4	5	4	4	4	4
3	Parallel and Taper Turning on Center Lathe	5	5	4	5	4	3	4	4	3	4	4	5	5	4	4	4
4	Screw Cutting (V & Square Shape) on Center Lathe	5	4	4	5	4	5	4	4	5	4	4	5	4	4	4	4
Results		**100**	**85**	**87**	**86**	**88**	**89**	**86**	**89**	**88**	**86**	**86**	**86**	**86**	**86**	**85**	**83**

Group 3 : Interactive Learning - Outcomes Results (Psycohomotor)

No	Learning outcomes	Marks	Students														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Demonstrate rang of transmission applications.																	
1	Front and Rear Gear Drive Applications	3	3	2	2	3	3	3	3	3	3	2	3	2	2	2	2
2	Front Rear Gear Drive Troubleshooting	3	2	3	2	3	2	2	3	2	2	2	3	2	2	2	2
3	Clutch Applications	3	3	2	3	3	3	3	3	3	3	3	2	3	3	3	2
4	Clutch Troubleshooting	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2	2
Diagnose, adjust and Repair Manual Gearbox.																	
1	Diagnose and analyse Gearbox Faults	4	4	3	3	4	3	3	3	3	3	3	3	3	3	3	3
2	Gearbox - Removal	4	3	3	3	4	2	3	3	2	3	3	4	2	3	3	2
3	Gearbox Parts Inspection and Repair	4	4	4	4	4	4	3	3	3	4	4	3	3	3	4	3
4	Gearbox Installation and Testing	4	4	4	4	4	3	3	3	4	3	3	3	4	2	3	2
Diagnose, Adjust and Repair Manual Clutch.																	
1	Diagnose and analyse Clutch Faults	5	4	4	3	4	4	4	4	4	3	3	3	4	4	3	2

2	Clutch - Removal	5	3	4	3	4	4	3	3	3	5	3	3	3	4	3	2
3	Clutch Parts Inspection and Repair	5	4	3	4	4	3	4	3	4	4	4	3	4	3	3	3
4	Clutch Installation and Testing	5	3	5	4	4	4	4	4	4	4	3	4	3	4	3	3
Demonstrate a range of Manufacturing tools and Measurements Skills.																	
1	Use a rang of Centre lathe and milling Cutting tools	3	2	2	2	2	3	3	3	3	2	3	3	2	3	3	2
2	Vernier and Micrometer Applications	3	2	3	3	2	3	3	3	3	3	3	3	2	2	3	2
3	Demonstrate a range Vernier Caliper	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	2
4	Demonstrate a range Micrometer	3	2	2	3	2	3	3	3	3	2	3	2	2	2	3	2
Demonstrate a range of Milling, Centre Lathe and Shaping Machine setting.																	
1	Set Milling Machine for work and cutter Holding	5	4	4	4	3	4	4	4	3	4	4	3	4	5	3	3
2	Set Center Lathe and Shaping Machine for work and cutter Holding	5	4	3	4	3	4	4	3	4	4	4	3	4	4	4	4
3	Set Milling Machine for cutting Speed and feed with suitable Direction	5	4	3	5	4	5	5	3	4	4	3	4	3	3	3	3
4	Set Center Lathe and Shaping Machine for cutting Speed and feed with suitable Direction	5	4	4	4	4	3	4	3	4	4	4	4	4	3	3	3

Demonstrate a range of operations on Machine tools																	
1	Flat surface on Milling and Shaping Machine	**5**	**5**	**4**	**4**	**3**	**4**	**3**	**4**	**3**	**4**	**2**	**4**	**3**	**4**	**2**	**3**
2	Gear Cutting on Milling machine	**5**	**4**	**4**	**4**	**3**	**4**	**4**	**4**	**4**	**3**	**3**	**4**	**4**	**3**	**3**	**4**
3	Parallel and Taper Turning on Center Lathe	**5**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**3**	**4**	**4**	**3**	**3**	**3**	**3**	**4**
4	Screw Cutting (V & Square Shape) on Center Lathe	**5**	**4**	**4**	**4**	**4**	**5**	**4**	**4**	**5**	**4**	**4**	**3**	**4**	**4**	**3**	**4**
Results		**100**	**81**	**80**	**82**	**81**	**82**	**82**	**78**	**79**	**80**	**75**	**75**	**73**	**73**	**70**	**64**

APPENDIX FIVE
Cognitive Skills Worksheet (Group 1, 2 and 3)

Cognitive Skills Worksheet (Group 1, 2 and 3)

St No	Learning outcome average marks- Pre			Different cognitive levels of learning domain for (AIM)																		Learning domain average marks- Post		
				Knowledge			Comprehension			Application			Analysis			Evaluations			Create					
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	60	54	61	66	78	77	70	90	93	78	90	70	80	88	82	60	86	73	60	82	70	59	86	78
2	62	59	60	80	80	91	76	88	95	76	86	70	68	90	92	69	89	71	68.5	84	73	63	86	82
3	60	60	61	80	89	77	80	89	93	75	79	70	69	87	91	56	88	67.5	70	82	70	61	86	78
4	61	66	69	80	83	84	80	87	92	78	89	85	67	89	93	65	89	70	80	81	68	64	86	82
5	62	62	61	79	89	85	76	90	93	89	88	75	78	70	92	68	70	69	67	77	68	65	81	80
6	55	65	58	65	84	82	71	77	89	89	85	86	78	87	86	65	86	68	64	82	68	62	84	80
7	60	59	61	75	89	77	77	88	89	89	70	75	80	87	82	67	90	65	65	86	69	65	85	76
8	54	62	62	70	87	87	81	90	90	89	90	80	71	88	80	60	85	63	61	83	68	62	87	78
9	54	69	63	70	86	80	80	87	90	83	89	83	78	83	84	65	90	65	60	77	65	62	85	78
10	59	57	61	78	90	75	90	95	80	80	87	80	56	70	80	70	90	59	60	83	60	62	86	72
11	59	59	50	80	88	70	80	77	81	79	70	80	64	81	77	60	82	60	62	85	70	61	81	73
12	60	63	60	81	91	70.5	73	88	82	76	85	81	63	83.5	80	60	80	61	66	85	59	60	85	72
13	61	56	59	80	86	69	76	78	84	61	77	80	60	87	72	66	81	62	70	87	65	59	83	72
14	60	54	60	66	90	65	80	77	82	58.5	86	77	66	84	75	51	81	60	70	80	59	56	83	70
15	56	56	54	55	88	60	70	89	68	70	89	73	63	81	70	50	76	59	55	79.7	53	52	84	64
16	56	59	62	65	70	69	78	88	70	80	99	70	58	80	86	88	91	77	69	86	77	63	86	75
17	66	65	61	70	89	89	55	75	60	57	84	50	77	70	70	54	68	73	70	82	55	55	78	67
18	70	65	55	57.5	80	70	63	79	80	86	95	58	70	79	54	59.5	79	70	77	90	79	59	84	69
19	63	61	50	75	70	74	64.5	80	64	58	90	75	60	90.5	55	70	90	75.5	76	85	59	58	84	67
20	80	60	59	59	89	85.5	70	89	70	86.5	88	68	80	91	68.5	78	85	80	80	90	79	65	89	75
21	67	66	56	74	90	86	80	84	79	78	79	70	95	89	80	84	80	56	88	87	75	71	85	74
Average	58.867	60.07	60.00	73.67	86.53	76.63	77.33	86.00	86.73	78.03	84.00	77.67	69.40	83.70	82.40	62.13	84.20	64.83	65.23	82.25	65.67	60.83	84.45	75.66
STDEV	2.75	4.43	4.14	7.89	3.80	8.59	5.22	5.78	7.21	9.50	6.80	5.33	7.78	6.20	7.32	6.17	5.86	4.68	6.08	2.98	5.51	3.45	2.02	5.06

APPENDIX SIX

Psychomotor Skills Worksheet (Group 1, 2 and 3)

Psychomotor Skills Worksheet (Group 1, 2 and 3)

St No	Learning outcome average marks- Pre			Different Psychomotor levels of learning domain for (AIM)																					Learning domain average marks- Post		
				Diagnose and Explore			Plan and Design			Action and Implement			Evaluate			Improve			Experiencing (Work placement)			Conclude					
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
1	60	54	61	66	78	90	70	90	93	78	87	89	80	87	82	60	86	73	60	82	70	69	87	67	**69**	**85**	**81**
2	62	59	60	80	80	91	76	88	95	76	86	70	68	90	92	69	89	71	68.5	84	73	70	89	66	**73**	**87**	**80**
3	52	60	61	82	89	87	80	89	93	75	79	85	69	87	91	56	88	67.5	52	82	70	53	89.2	78	**67**	**86**	**82**
4	61	66	69	78	83	84	80	87	92	78	89	85	67	89	93	65	89	64	64	81	68	60	97	80	**70**	**88**	**81**
5	62	62	61	79	89	85	76	90	93	89	91	75	78	89	92	68	89	69	67	89	68	64	87	90	**74**	**89**	**82**
6	55	65	58	65	84	82	71	89	89	89	85	86	78	87	86	65	86	68	64	82	68	67	86	97	**71**	**86**	**82**
7	60	59	61	75	89	81	77	91	89	84	93	75	75	87	82	67	90	65	65	86	69	56	89	83	**71**	**89**	**78**
8	54	62	62	70	87	87	81	90	90	85.5	90	80	71	88	80	60	85	63	61	83	68	61	90	86	**70**	**88**	**79**
9	54	69	63	70	86	80	80	87	90	83	88	83	78	83	84	65	83	65	60	86	65	79	86	90	**74**	**86**	**80**
10	59	57	61	78	90	75	79	95	80	80	87	80	56	84	80	50	81	59	60	83	60	65	80	94	**67**	**86**	**75**
11	59	59	50	80	88	70	80	89.5	81	79	82	80	64	81	77	60	82	60	62	85	70	62	84	86	**70**	**85**	**75**
12	60	63	60	81	91	70.5	73	88	82	76	85	81	63	83.5	80	60	80	61	59	85	59	83	87	77	**71**	**86**	**73**
13	61	56	59	80	86	69	76	86	84	61	85	80	59	87	72	57	81	62	59	87	65	56	87	80	**64**	**86**	**73**
14	60	54	60	66	90	65	80	88	82	58.5	81	82	53	84	75	51	81	60	55	80	59	61	90	64	**61**	**85**	**70**
15	56	56	54	55	88	60	63	89	68	57	89	73	53	81	70	50	76	59	55	79.7	53	50	80	62	**55**	**83**	**64**
16	56	59	62	65	70	69	78	88	70	80	99	70	58	80	86	88	91	77	69	86	77	80	87	62	**74.00**	**85.86**	**73.00**
17	66	65	61	70	89	80	55	75	60	57	84	50	77	70	70	54	68	75	70	82	55	88	92	67	**67.29**	**80.00**	**66.57**
18	70	65	55	57.5	80	70	63	79	80	86	95	58	70	79	54	59.5	79	70	77	90	79	90	80	67	**71.86**	**83.14**	**68.29**
19	63	61	50	75	70	74	64.5	80	64	58	90	75	60	90.5	55	70	90	75.5	76	85	59	56	79	65	**65.64**	**83.50**	**66.79**
20	80	60	59	59	89	85.5	70	89	70	86.5	88	68	80	91	68.5	78	85	80	80	90	79	80	85	76	**76.21**	**88.14**	**75.29**
21	67	66	56	74	90	86	80	84	79	78	79	70	95	89	80	84	80	56	88	87	75	90	87	70	**84.14**	**85.14**	**73.71**
Average	58.33	60.07	60.00	73.67	86.53	78.43	76.13	89.10	86.73	76.60	86.47	80.27	67.47	85.83	82.40	60.20	84.40	64.43	60.77	83.65	65.67	63.73	87.21	80.00	68.37	86.17	76.85
STDEV	3.24	4.43	4.14	7.93	3.80	9.60	5.03	2.12	7.21	10.22	3.81	5.20	9.32	2.88	7.32	6.41	4.19	4.46	4.55	2.67	5.51	9.02	4.13	11.10	5.22	1.67	5.29

APPENDIX SEVEN

Time Management Analysis

Time Management Analysis Worksheet

Proposed Cognitive Skills	Students achievement																	
	T1			T2			T3			T4			T5			T6		
	Demonstrate rang of transmission applications.			Diagnose, adjust and repair manual Gearbox.			Diagnose, adjust and repair manual clutch.			Demonstrate a range of Manufacturing tools and Measurements Skills.			Demonstrate a range of Milling and Centre Lathe setting.			Demonstrate a range of operations on Machine tools		
	G1	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
Knowledge	12	14	12	14	15	14	11	12	10	10	13	13	12	15	9	11	12	10
Comprehension	10	15	13	13	13	12	12	12	12	12	13	13	9	13	9	11	10	10
Application	11	12	12	12	11	12	13	13	10	11	13	13	9	13	9	11	11	9
Analysis	11	12	11	13	13	13	12	12	12	12	12	13	9	12	9	8	10	5
Evaluation	12	13	11	11	11	14	11	13	12	10	13	12	9	12	10	8	14	10
Creating	12	11	11	11	13	15	12	14	13	10	12	12	6	10	9	10	14	15
Proposed Psychomotor-Skills	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
Diagnose	10	15	12	10	15	12	12	13	12	10	13	12	12	12	9	12	15	15
Plan and Design	11	15	12	11	15	11	12	12	11	10	13	12	12	13	11	13	13	15
Implement	9	15	13	11	14	12	12	12	13	10	13	12	9	14	12	11	10	7
Improve	11	12	11	11	11	12	11	12	12	10	12	12	10	13	10	9	11	12
Experiencing	11	12	11	11	13	13	12	13	12	10	13	13	9	13	9	8	12	5
Evaluation	12	13	11	11	11	14	11	13	12	10	12	11	9	12	9	6	14	2
Conclude	12	11	11	11	13	15	11	13	12	10	12	11	6	11	12	9	14	14
Achievement % / group	**74%**	**87%**	**77%**	**77%**	**86%**	**87%**	**78%**	**84%**	**78%**	**69%**	**84%**	**82%**	**62%**	**84%**	**65%**	**65%**	**82%**	**66%**
Average time	23%	16%	19%	19%	16%	18%	24%	20%	22%	27%	20%	23%	20%	16%	19%	19%	15%	17%
Average number of trial	**6%**	**2%**	**4%**	**5%**	**2%**	**4%**	**4%**	**2%**	**3%**	**5%**	**2%**	**4%**	**5%**	**2%**	**4%**	**5%**	**2%**	**3%**

APPENDIX EIGHT

Mathematical Models Data Analysis

a- Table A8.1 Students' results data for cognitive learning (MPhil Data) (Salah 2009)

Knowledge			Comprehension			Application			Analysis			Synthesis			Evaluations		
G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
77	100	90	86	98	93	84.5	96	89	80	95	82	60	94	73	60	93	70
85	100	96	76	97	95	95	95	70	68	95	92	69	93	71	68.5	90	73
87	96	93	80	95	93	92	94	85	69	89.5	91	56	88	67.5	52	87	70
80	99	94	80	96	92	91	93	85	67	89	93	65	89	64	64	87	68
79	93	97	76	95	93	89	95	75	78	91	92	68	89	69	67	89	68
65	98	89	90	95	89	89	96	86	78	95	86	65	86	68	64	88	68
83	96	89	81.5	95	89	84	93	75	75	92	82	67	93	65	65	89	69
80	96	87	80	94	90	85.5	90	80	71	88	80	60	85	63	61	87	68
80	94	80	80	94	90	83	88	83	78	83	84	65	83	65	60	86	65
78	96	75	79	95	80	80	87	80	56	84	80	50	81	59	53	83	60
80	92	70	80	89.5	81	79	82	80	64	81	77	60	82	60	62	89.5	70
84	94	70.5	79	88	82	76	85	81	63	83.5	80	60	80.5	61	59	85	59
80	94	69	76	86	84	61	85	80	59	87	72	57	81	62	59	80	65
67	90	65	80	88	82	58.5	81	82	53	84	75	51	81	60	50	80	59
55	88	60	63	90	68	57	89	65	53	81	70	50	76	59	50	79.7	53

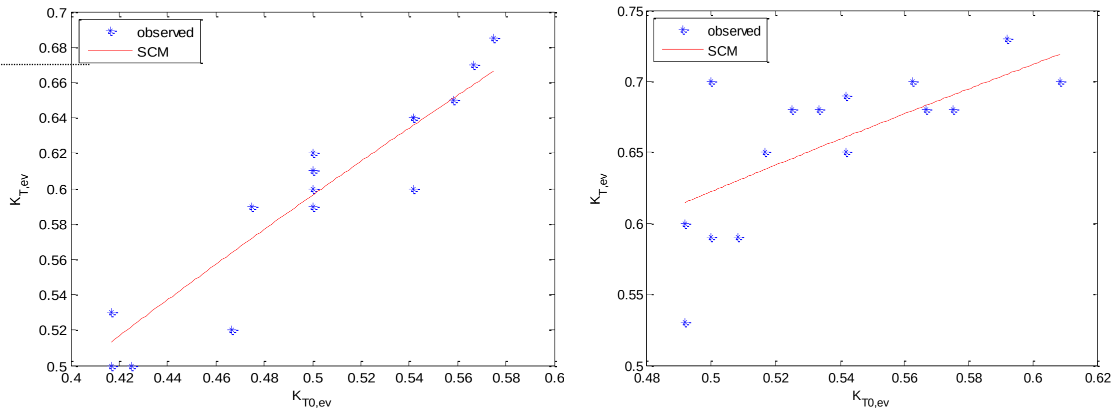
b-**Table A8.2 Students' results data for cognitive learning**

Knowledge			Comprehension			Application			Analysis			Evaluations			Creating		
G1	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
66	78	77	70	90	93	78	90	70	80	88	82	60	86	73	60	82	70
80	80	91	76	88	95	76	86	70	68	90	92	69	89	71	68.5	84	73
80	89	77	80	89	93	75	79	70	69	87	91	56	88	67.5	70	82	70
80	83	84	80	87	92	78	89	85	67	89	93	65	89	70	80	81	68
79	89	85	76	90	93	89	88	75	78	70	92	68	70	69	67	77	68
65	84	82	71	77	89	89	85	86	78	87	86	65	86	68	64	82	68
75	89	77	77	88	89	89	70	75	80	87	82	67	90	65	65	86	69
70	87	87	81	90	90	89	90	80	71	88	80	60	85	63	61	83	68
70	86	80	80	87	90	83	89	83	78	83	84	65	90	65	60	77	65
78	90	75	90	95	80	80	87	80	56	70	80	70	90	59	60	83	60
80	88	70	80	77	81	79	70	80	64	81	77	60	82	60	62	85	70
81	91	70.5	73	88	82	76	85	81	63	83.5	80	60	80	61	66	85	59
80	86	69	76	78	84	61	77	80	60	87	72	66	81	62	70	87	65
66	90	65	80	77	82	58.5	86	77	66	84	75	51	81	60	70	80	59
55	88	60	70	89	68	70	89	73	63	81	70	50	76	59	55	79.7	53

c-Table A8.3 Students' results data for psychomotor learning

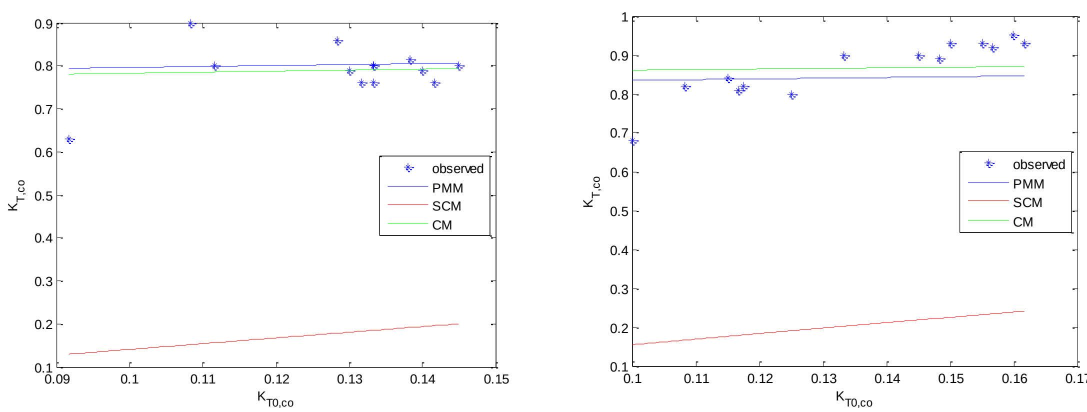
Diagnose and Explore			Plan and Design			Action and Implement			Evaluate			Improve			Experiencing (Work placement)			Conclude		
G1	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**	**G1**	**G2**	**G3**
66	78	90	70	90	93	78	87	89	80	87	82	60	86	73	60	82	70	69	87	67
80	80	91	76	88	95	76	86	70	68	90	92	69	89	71	68.5	84	73	70	89	66
82	89	87	80	89	93	75	79	85	69	87	91	56	88	67.5	52	82	70	53	89.2	78
78	83	84	80	87	92	78	89	85	67	89	93	65	89	64	64	81	68	60	97	80
79	89	85	76	90	93	89	91	75	78	89	92	68	89	69	67	89	68	64	87	90
65	84	82	71	89	89	89	85	86	78	87	86	65	86	68	64	82	68	67	86	97
75	89	81	77	91	89	84	93	75	75	87	82	67	90	65	65	86	69	56	89	83
70	87	87	81	90	90	85.5	90	80	71	88	80	60	85	63	61	83	68	61	90	86
70	86	80	80	87	90	83	88	83	78	83	84	65	83	65	60	86	65	79	86	90
78	90	75	79	95	80	80	87	80	56	84	80	50	81	59	60	83	60	65	80	94
80	88	70	80	89.5	81	79	82	80	64	81	77	60	82	60	62	85	70	62	84	86
81	91	70.5	73	88	82	76	85	81	63	83.5	80	60	80	61	59	85	59	83	87	77
80	86	69	76	86	84	61	85	80	59	87	72	57	81	62	59	87	65	56	87	80
66	90	65	80	88	82	58.5	81	82	53	84	75	51	81	60	55	80	59	61	90	64
55	88	60	63	89	68	57	89	73	53	81	70	50	76	59	55	79.7	53	50	80	62

d- Student's Results – Learning Data Analysis

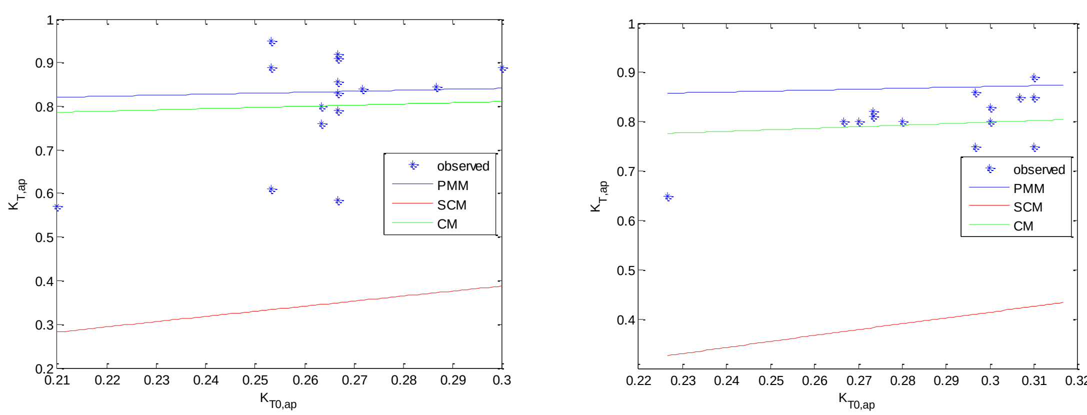


(a) (b)

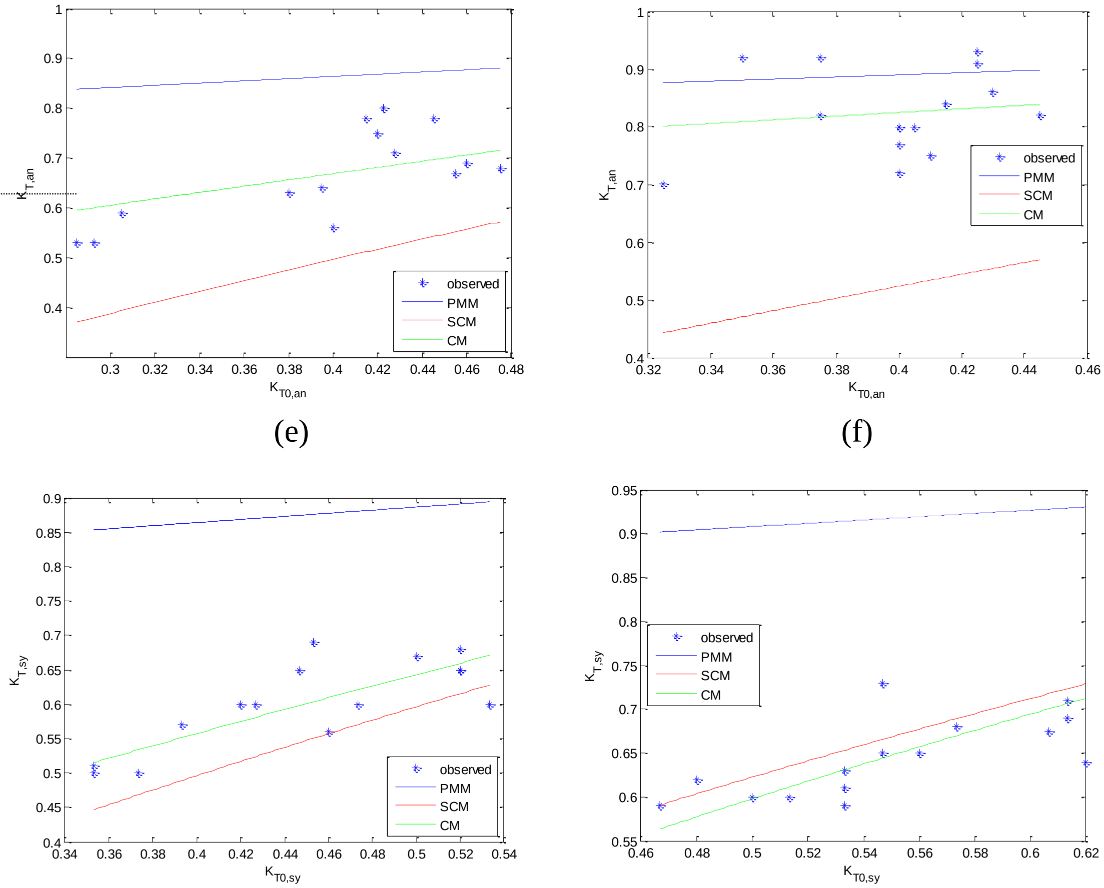
Fig. A8.1: Curve fitting on data for evaluation domain (simple connect model – SCM) for (a) Group 1, (b) Group 3



(a) (b)



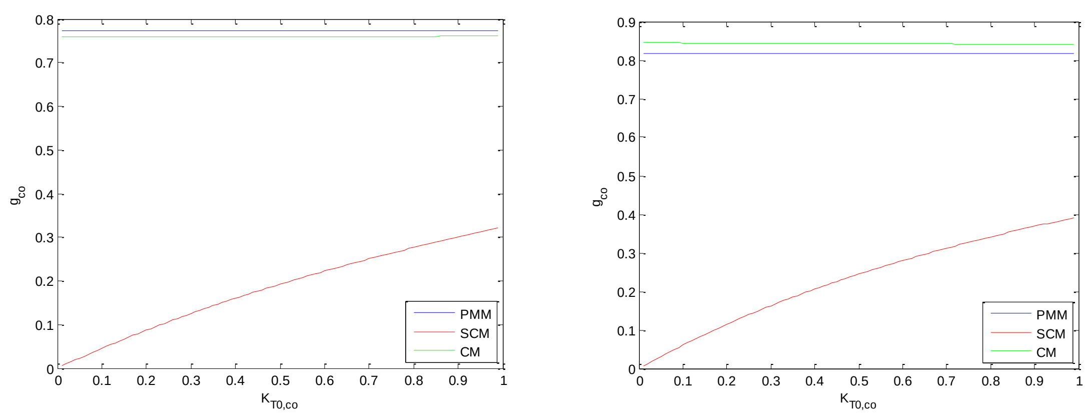
(c) (d)



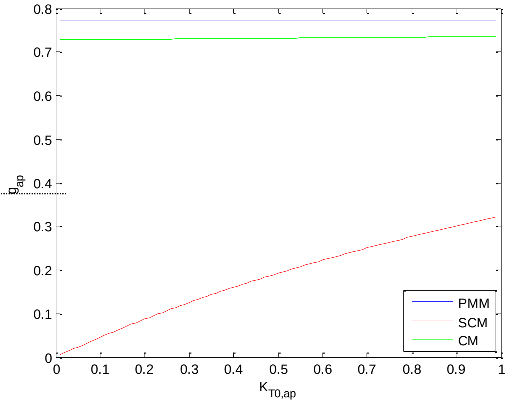
(e) (f)

(g) (h)

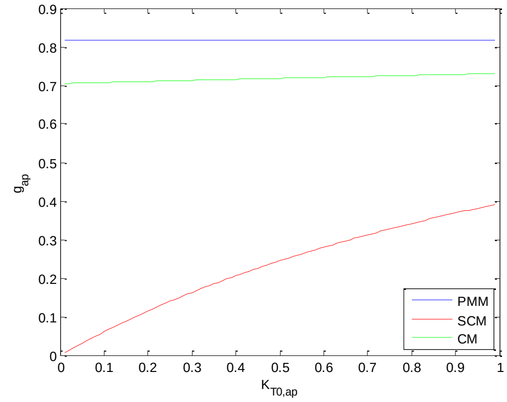
Fig. A8.2: Curve fitting on data (connectedness model – CM) for (a) Group 1, comprehension, (b) Group 3, comprehension, (c) Group 1, application, (d) Group 3, application, (e) Group 1, analysis, (f) Group 3, analysis, (g) Group 1, synthesis, (h) Group 3, synthesis domains, PMM – pure memory model, SCM – simple connect model



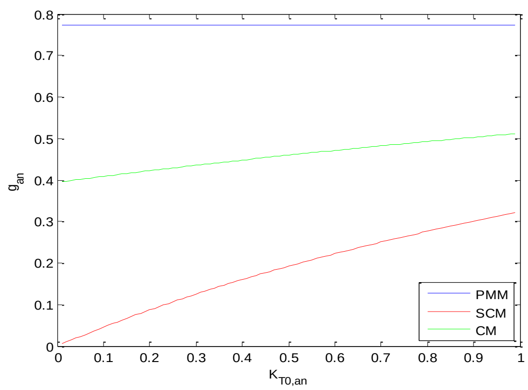
(a) (b)



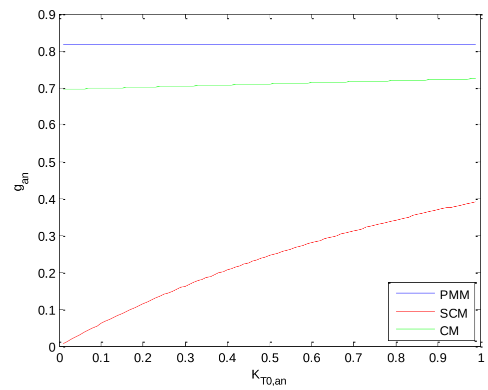
(c)



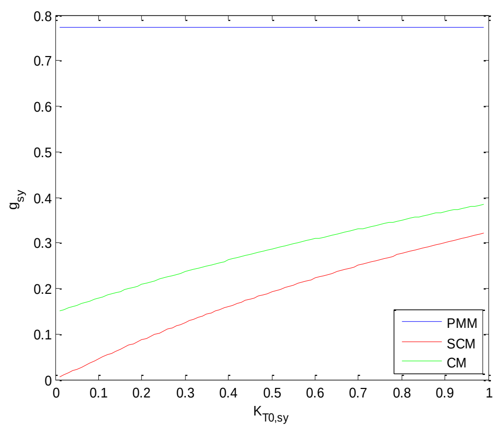
(d)



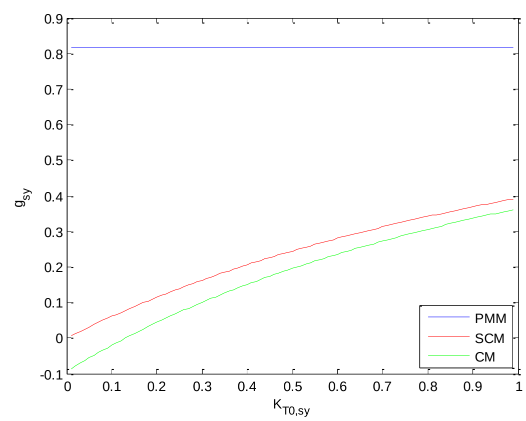
(e)



(f)



(g)



(h)

Fig. A8.3: Normalized gain for knowledge domain (pure memory model – PMM, blue), evaluation domain (simple connect model – SCM, red), (a) Group 1, comprehension, (b) Group 3, comprehension, (c) Group 1, application, (d) Group 3, application, (e) Group 1, analysis, (f) Group 3, analysis, (g) Group 1, synthesis, (h) Group 3, synthesis domains (connectedness model – CM, gree