Microelectronics Teaching Environment at the Universiti Malaysia Perlis

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Abstract

Significant change in Malaysia's microelectronic industry at the turn of the century has created new challenges for the institutions in the region. To cater for the resulting workforce market changes, the development and implementation of microelectronics teaching environment at Universiti Malaysia Perlis is herein presented. The basic VLSI design courses consist of two different subjects namely Introduction to IC Design and Digital IC Design. As an exposure for the semiconductor manufacturing area, student will learn the subjects of Semiconductor Process Technology and Microelectronic Fabrication. Skills development is increased through inclusion of significant practical components in all those courses using state-of-the-art lab facilities in VLSI Design lab and Micro-fabrication lab. These papers address the course content and format as well as laboratory development and activities of the VLSI design and semiconductor manufacturing discipline.

Keywords: VLSI; IC

1. Introduction

Universiti Malaysia Perlis (UniMAP), previously known as Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM), is the 17th public university in Malaysia and among a few public universities which offer microelectronic engineering as an undergraduate program. Till this moment, there is still debate over the best way to structure VLSI courses. Some instructors teach the course primarily through lecture, some use projects and some argue that VLSI is so fundamental that it should be part of the introductory digital electronics course. However, the author strongly believes that the only way to really understand the VLSI courses is actually to keep VLSI design and VLSI fabrication as separate disciplines. Nevertheless, it is becoming increasingly evident that the consummation of a successful VLSI design depends on sophistication of processing technology, especially as the device-dimensions are shrinking.

This paper presents the development of the VLSI courses for microelectronic engineering students at UniMAP. The courses have been divided into 4 different subjects. Students enroll the Introduction to IC Design and Semiconductor Process Technology courses during the second year of their study. Then, they enter the Digital IC Design and Microelectronic Fabrication course in the third year. Through these courses, students gain familiarity with the graphical schematic and layout tools, design rule checking, simulation modes and command files, and the concept of hierarchical design. Furthermore, they will also experience practically the micro fabrication process and device simulation. All these lab activities are conducted in the industrial standard IC design lab and micro fabrication lab.

This paper is divided into 4 sections. In the following section (Section 2), we present the curriculum development of the VLSI courses. In Section 3, the laboratory development and activities are discussed. Finally, the conclusion is presented in Section 4.

2. Curriculum development

In order to meet the challenge of innovation in microelectronic technology, essential ingredients are needed for preparing the students in the VLSI design and semiconductor manufacturing discipline. This endeavor resulted in four different courses namely Introduction to IC Design, Digital IC Design, Semiconductor Process Technology and Microelectronic Fabrication. In addition, two industrial standard lab facilities known as IC Design laboratory and Micro-fabrication (Cleanroom) laboratory were established to achieve this goal. The requisite equipment for the laboratories worth nearly five million dollars, which includes the state-of-the-art design hardware and software, photolithography, processing and characterization instruments.

2.1. VLSI Design Course Development

In addition to great demand for highly skilled electronic engineers in the area of VLSI design from the already booming and established semiconductor industry nationwide, the VLSI course is now among the essential course required in many electronic and microelectronic engineering programs. In UniMAP, two different VLSI courses have been developed in two-consecutive semesters which are known as Introduction to IC Design and Digital IC Design. The courses emphasize the full and semi custom design thereby exposing the students to the lower and higher level of the design stage. On the other hand, several shorter design projects will also be given in ensuring the students to be familiar with the CAD tools. At the moment, only the electronic and microelectronic programs have conduct the courses with approximately 120 students in each semester.

2.1.1. Course Content and Format

Introduction to IC Design course is a 4-credit hour course whereby students have to attend 3-hour lecture session and 2-hour lab session weekly. Throughout this course, students gain familiarity with the graphical view of schematic and layout of CAD tools, design rule checking, layout versus schematic, simulation mode and command files, and the concept of the hierarchical design. Lectures during this period will also cover conventional VLSI topics such as transistor sizing, rise-time and fall-time predictions, precharge/evaluate logic, power dissipation, static and dynamic design, basic fabrication processing and CMOS design rules. Mini project will be assigned individually for familiarizing with the CAD tools and an oral presentation at the conclusion of their project.

On the other hand, Digital IC Design course is also a 4-credit hour course. The course concentrates on the writing skills for the right syntax encoding in Verilog HDL. The objective of the course is to produce students who would be able to learn the methods on how to design the digital IC circuits using Verilog HDL. Besides that, students are also aimed to be able to understand the working principles of the field programmable gate array (FPGA) device as a platform of Verilog design implementation. Finally, the students should also be able to design and simulate a complete digital system for their mini project as a proof of their Verilog design skills. It is not expected that students will become highly competent at the end of the course, but by actually implementing a mini project, they do mature significantly as IC designers.

2.2. Semiconductor Manufacturing Course Development

The goal of micro-fabrication related course is to produce high-quality graduate in microelectronics who are well prepared with hands-on experience in micro fabrication to make immediate technical contributions theoretically and practically to the semiconductor industry in particular. To meet the goal requires a so call “hands-on” or lab-oriented teaching approach in which students have the opportunity to become familiar with cleanroom environment, cleanroom work etiquette, cleanroom protocol, processing equipments and metrology test equipment. This hands-on experience combined with good and promising curriculum will give added advantage to the student in the market place. Currently, the course is only offered to the microelectronic program students. Due to the lab size limitation, the course enrolment is only restricted to 60 students for each semester. Thus, every year 120 students will be utilizing the micro-fabrication cleanroom.

2.2.1. Course Content and Format

There are two micro fabrication based subjects, which require cleanroom to conduct the experiment namely semiconductor process technology and microelectronics fabrication. Semiconductor process technology is the first course offered by the microelectronics program to the second year student which is in the second semester and then followed by the microelectronics fabrication subject which is a third year course offered in the first semester. Generally, semiconductor process technology is pre-requisite subject to the microelectronics fabrication.

Semiconductor process technology is a 3-credit hour course. Despite having 2-hour lectures in the classroom, each enrolment students are requested to attend 2-hour practical section conducted in the cleanroom. The course enrolment in only limited to 60 students. Due to the limited space and high maintenance cost, only 12 students are allowed to enter the cleanroom at every session. Therefore, five-laboratory sessions are created to accommodate 60 students for each semester. In each lab session, the student will be guided and supervised by two engineers to assist them to do the experiment. With this format, the student will have more exposure and obtain valuable hand-on experience in micro fabrication process, which is difficult to obtain in other universities in Malaysia.

The second course, which is microelectronic fabrication, is a 4-credit hour course that offer 3-hour lectures and 2-hour laboratory section. The maximum enrolment for the course and lab section still remains unchanged. It is an advanced course in micro fabrication based subject which emphasis on advance processes and integration covering both digital and analog devices. In addition to the advance processes, students are also taught process and device simulation. It will help the student to understand the operation of the device.

3. Laboratory Development and Activities

This section will elaborate the IC design and micro fabrication laboratory in terms of their development and activities.

3.1. IC Design Lab

The VLSI IC Design laboratory is equipped with 30 seats of Mentor Graphics industry standard tier-1 tools which are used by IC design centres worldwide. The Mentor Graphics design tools in the laboratory allow UniMAP to expose its undergraduates to the world of IC design. Fig. 1 shows some of the IC design practical activities carried out in this laboratory.

On the front-end, design entry and simulation is done with Mentor's integrated Design Architect-IC and Eldo circuit simulator. Digital and ASIC simulation is executed with Mentor's Modelsim. For the back-end physical layout, verification and tape-out, the de-facto industry standard tools such as Mentor's Calibre (standardized by local foundries such as Silterra and 1st Silicon), Calibre xRC and IC-Station are available.

To further enhance the industry-like environment, the IC Design laboratory runs on the Linux platform so that students become familiar with UNIX and Linux which are the operating systems preferred by almost all design centres. All these valuable practical or hands-on approach for the students is imperative and has been the focus and niche of the programme.

The complete suite of tools available in the VLSI IC design lab is not only suitable for teaching, but is also powerful to be utilized for research and support collaboration with the industry in areas of digital, analog and mixed-signal design. Mentor's schematic-driven-layout (SDL), parasitic extraction, back-annotation, auto-routing and nanometer simulator allows the lab to support all the current and future technologies used by the industry – from 0.35u, 0.18u, 0.13u and below.

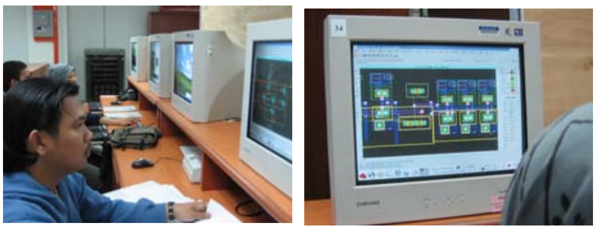

Fig. 1. Students carrying out IC design work in the VLSI IC design laboratory.

The combination of complete industry standard IC Design tools, hands-on approach to teaching, industry trained staff and strong industry support will produce microelectronic graduates that are much sought after for Malaysian IC design centres and offer the School of Microelectronic Engineering the capability to venture into leading edge research, design and development of integrated circuits.

3.2. Micro Fabrication Lab

3.2.1. Cleanroom Design and Development

The main strength of this emerging engineering program is a newly developed cleanroom for micro fabrication laboratory experiments. This facility is primarily used for teaching undergraduate microelectronics program leading to a degree. Like all other teaching laboratory in the world, besides teaching the education aspect of the course, our intention is also to expose our student to a fully functional cleanroom environment.

The clean rooms, which is designed and developed by UniMAP is the first and largest purpose build for teaching the undergraduate program by a university in Malaysia. It was completed in December 2003 as shown in Fig. 2 and Fig. 3. The cleanroom was built in an existing empty building. The size of the cleanroom built is approximately 115m^2 with cleanliness class from ISO Class 5 to ISO Class 8. The total area of the cleanroom comprise of yellow room (ISO Class 5), white room (ISO Class 6), characterization room (ISO Class 6), preparation room (ISO Class 6), changing room (ISO Class 7) and grey area (ISO Class 8). The cleanroom layout is shown in Fig. 4.

Fig. 2. The completed micro fabrication cleanroom.

Fig. 3.The completed micro fabrication cleanroom with equipment.

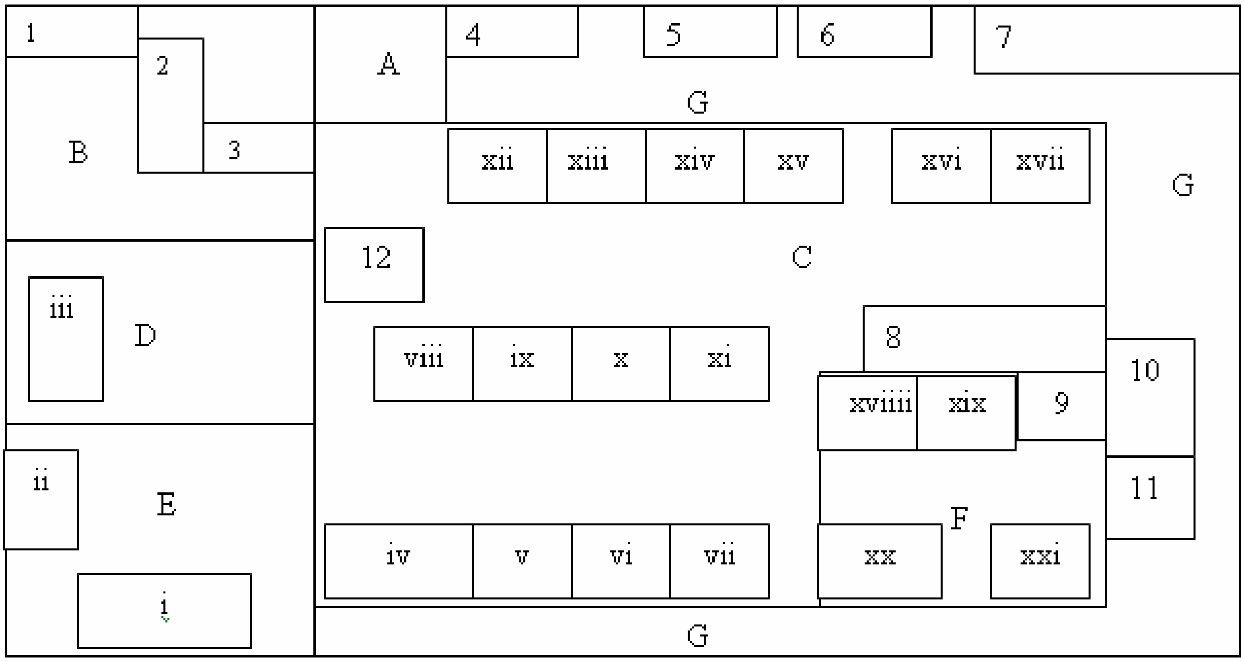

Fig. 4. UniMAP cleanroom layout, facility and equipment.

Legend:

Cleanroom layout
A = Shower room
B = Changing room (ISO Class 7)
C = White room (ISO Class 6)
D = Preparation room (ISO Class 6)
E = Characterization room (ISO Class 6)
F = Yellow room (ISO Class 5)
G = Grey Area (ISO Class 8)

Cleanroom facility
1 = Garment Cabinet
2 = Shoe bench 1
3 = Shoe bench 2
4 = Electrical Main Switch Board
5 = Consumable Cabinet 1
6 = Consumable Cabinet 2
7 = Gas Corridor
8 = Fume Hood 1 & 2
9 = Fume Hood 3
10 = Scrubber system
11 = DI Water System
12 = Particle Counter

Process and Characterization Equipment
i. = SEM & EDX
ii = E-beam Lithography System
iii = Sputter Coater
iv = CV/IV System and Micro Probe Station
v = Optical Microscope 1
vi = Optical microscope 2
vii = Mask Making Station
viii = Spectrophotometer
ix = Stylus Step Height Measurement
x = Four Point Probe
xi = Conduction Gauge
xii = Evaporator
xiii = Diffusion Furnace (n-type)
xiv = Diffusion Furnace (p-type)
xv = Wet/Dry Oxidation Furnace
xvi = Wet Etching Bench
xvii = Wet Cleaning Bench
xviii = Spin Coater & Hot Plate
xix = Mask Aligner
xx = Convection Oven
xix = Optical Microscope 3

With the ceiling height available of the existing building, we construct a cleanroom with a negative plenum to house the fan filter unit as well as accommodating the installation of the raised floor. AAF AstroFan fan filter units with stainless steel casing complete with AAF Astrocel II HEPA at 99.9995% rated for 0.12 um. The schematic is as shown in Fig. 5. The raised floor system within the white and yellow were 600 mm x 600 mm x 35 mm anti static steel panel. The return air slots were located at low levels along the perimeter wall panels adjacent to the grey area.

The cleanroom are equipped with distributed process gases such as purified nitrogen (N_2), oxygen (O_2) and compressed dry air (CDA). A 18.0MΩ ultrapure de-ionized water system was provided for three fume hoods within the cleanroom, which two set located in the white room, and one set in yellow room. Exhaust air from the fume hood are exhaust to the laboratory scrubber system for treatment.

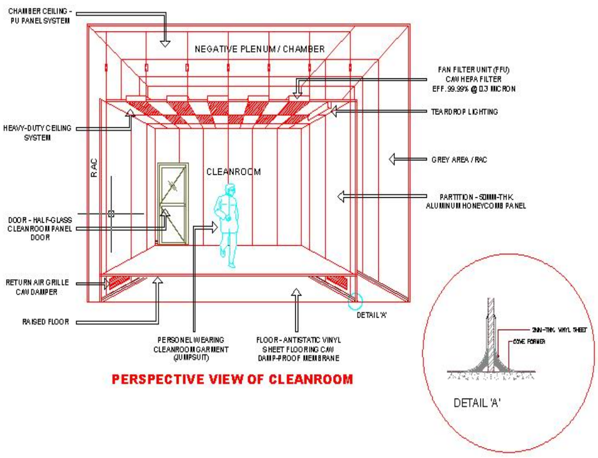

Fig. 5. Crossection view of the cleanroom.

The cleanroom constructed despite being a teaching facility, was designed and specified to ISO Class 5 cleanroom standard, and provided with features such as air shower, talk through and pass box usually found in commercial facilities, it is our intention to expose and teach students to appreciate the stringent cleanroom protocols, health and safety requirement in addition to the formal course works.

3.2.2 Equipment and Process Setup

The cleanroom is currently equipped with ten-process module comprising of oxidation, diffusion, photolithography, physical vapor deposition, wet etching, wet cleaning, wafer test and characterization, scanning electron microscope and E-beam lithography module. With this tool set up, the student should be able to fabricate micro electronic devices. The equipment is categorize as such to simplify the process undertake by the student so that they have better understanding of the processes. On the other hand, it helps the laboratory management to maintain the equipment as well as process and easier to manage the experiment undertaken by the student. Table 1 shows a list of the equipment for each process module, which are currently available.

Three process modules are located in the yellow room as a requirement of the photoresist process namely lithography module, scanning electron microscope module and e-beam lithography module. Photolithography module is accommodated in the cleanness room, which is ISO Class 5 at the size of 9.3 m^3. Whereby the other two modules, which also require yellow room, are place in the cleanroom ISO Class 6. The other seven modules are operated in the white room at ISO Class 6. This set-up has been designed to allow up to 12 student, plus two engineers and one lecturer, to efficiently work simultaneously. Table 2 shows the particle count of the cleanroom during operation.

Table 1. Process module and equipment

Process Module	**Equipment list**
Oxidation Module	i. Wet oxidation furnace ii. Dry oxidation furnace
Diffusion Module	i. n-type diffusion furnace ii. p-type diffusion furnace
Photolithography Module	i. Photoresist spinner ii. Hot plate iii. Convention oven iv. Exposure system v. Mask Making software
Physical Vapor Deposition Module	i. PVD system ii. In-situ deposition rate measuring system
Wet Etching Module	i. Wet etch bench ii. Spin dryer iii. Oxide etch solution iv. Aluminum etch solution v. Photoresist stripping solution
Wet Cleaning Module	i. Wet cleaning bench ii. Spin dryer iii. RCA cleaning solution iv. Hot plate
Wafer Test Module	i. IV/CV test system ii. Electrical probe station iii. Four point probe iv. Conduction gauge
Wafer Characterization Module	i. High power microscope ii. Low power microscope iii. Spectrophotometer iv. Stylus surface profiler
Scanning Electron Microscope Module	i. Scanning electron microscope ii. Sputter coater iii. EDX
E-beam Lithography Module	i. E-beam lithography system ii. PMMA resist

Table 2. Particle count of the cleanroom during operation

Particle Size	White Room		Yellow Room	
	95% UCL	ISO Class	95% UCL	ISO Class
0.1 um	40,041.00	4.6	764	2.9
0.3 um	21,040.00	5.3	299	3.5
0.5 um	16,064	5.7	120	3.5
Design to ISO Class		6.0		

Although the yellow room lithography was designed and built to ISO Class 5 or class 100 in conventional standard, we found that it is actually closer to ISO class 4 standards.

Currently, our facility and equipment setup is mainly for MOSFET process and devices that allows us to produce NMOS, PMOS, diode, resistor and simple MEMS on 4 inch (100 mm) wafers at the minimum resolution of 25 um. Nevertheless, with the existing of E-beam lithography, we are now able to produce structure down to 50 nm. This combination allows us to extend our current capability to nano technology application.

4. Conclusion

In conclusion, our VLSI courses have been successful in exposing students to the design and fabrication process. The course and the laboratory are fully compatible with the requirements of the industrial standard. We are proud to offer our innovative VLSI courses as a possible model for implementation at other institutions.

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A Proposed Undergraduate Geotechnical Engineering Laboratory Module via Centrifuge Testing

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Abstract

Theoretical information provided in geotechnical engineering textbooks can be supported with physical simulation to strengthen students' understanding on a particular concept. However, simulating a geotechnical concept or event (i.e. slope failure) at field condition often is time consuming and costly to perform. Small scale testing in laboratory is the other alternative which can correctly simulate field condition. This paper aims at introducing a module of undergraduate geotechnical engineering laboratory in UNIMAS; which involves the use of small geotechnical centrifuge. The module will focus on designing a stabilizing technique of a vertical wall which is then tested and validated in the centrifuge. In this paper, some introductions on centrifuge and its usage in geotechnical engineering will be provided. Next, a proposed centrifuge facility for teaching purposes will be presented followed by presentation on proposed slope models, modeling techniques and testing procedure for the intended laboratory module. Possible analysis of results from the testing is presented followed by defining the learning outcomes attained from this proposed laboratory module.

Keywords: centrifuge; slope; undergraduate laboratory; learning outcomes

1. Introduction

To date, undergraduates have been introduced to classical geotechnical testing to improve their understanding on fundamental theories of soil mechanics. In addition to these testing, new laboratory module that shall give them a field-like experience and a structured learning process; which includes their involvement from designing to analyzing results is proposed. A way to perform this is by allowing them to experiment geotechnical models by simulating geotechnical events in a small geotechnical centrifuge machine. In a centrifuge machine, a model is centrifuged at high radial acceleration and thus, experiencing high gravitational action. Figure 1 shows a configuration of a large centrifuge machine.

Fig. 1 Fixed Beam Centrifuge [2].

The need to appreciate reliable and accurate modeling should also be addressed in this module. Hence, centrifuge modeling is selected as it allows a model structure to be in as close similarity to its prototype structure as possible. A centrifuge model is able to reach required stress levels of its prototype as inertial radial acceleration action (similar to gravitational action) on the model is increased. In other words, in centrifuge testing, using the same type of soil for example, a model is accelerated through an N (gravitational factor) x g (gravitational acceleration) to achieve similar stress-strain condition as its prototype [9][10]. N value plays a major role as the scaling number to be used in modeling all properties of a prototype. An example of scaling a model length is shown, where:

$L_m/L_p = g_p/g_m = 1/N$
(1)

Subscript m represents model, p represents prototype; L=length; g=gravitational acceleration; N= gravitational factor. With an N value of 100, a prototype of length 10 m can be modeled by a model of length 10 cm which shall then experience a gravitational action of 100g. Table 1 shows other scaling ratios assuming identical model and prototype material.

Table 1 Scaling ratios assuming identical model and prototype materials [1].

Properties	**Full Scale : Model at Ng**
Length, Particle size	1:1/N
Acceleration (gravitational, inertial)	1:N
Area	$1:1/N^2$
Volume	$1:1/N^3$
Density	1:1
Mass	$1:1/N^3$
Force	$1:1/N^2$
Stress	1:1
Strain	1:1
Displacement	1:1/N
Bending Stiffness	$1:1/N^4$
Time: Fluid flow, Diffusion phenomena	$1:1/N^2$

In addition to scaling ratio, other factors such as effect of side boundary, particle size, variation in stress distribution and rotational acceleration field which are inherent to the application of centrifuge need to be considered when modeling and should be addressed theoretically in this module [5][9][10][11]. The following paragraphs are to discuss briefly these factors.

Models are subjected to side shear effects due to being constrained in model boxes. Side shear which exists due to contact between model and model box inner side walls can be significant if not handled appropriately. Several slope models of varying preparation methods, soil types, angles and height have been investigated by Fulsgang and recommendations on suitable model height to width ratio to reduce the problem are provided [5].

As mentioned earlier, scaling laws are important in centrifuge testing. Ideally, the particle size of soil grain should also be scaled down by a factor of N. Problems would arise if a model maintains identical soil material as its prototype; which consists of coarse grained soil. In this case, the model cannot mimic the 'real event' because of its different stress-strain relationship when compared to the prototype. Simple guidelines on the ratio between a major model dimension and the average grain diameter can be used to avoid particle size effects in coarse grained samples [10].

The inertial radial acceleration is proportional to the model radius, which leads to a variation in stress distribution with depth in the model. Ratio of model stress to prototype stress should be considered and generally be kept under 3% [10]. A lateral component of acceleration can also exist in wider models and is quite significant if major activities occur near the side wall of a model container.

In addition to lateral acceleration, movement of the model in the plane of rotation may also pose a problem. This phenomenon is known as Coriolis' effect. The ratio of the Coriolis acceleration, a_c to inertial acceleration a, should be kept below 0.1[10].

2. The Proposed Small-Scale Centrifuge

A small scale centrifuge machine is suggested for this proposed geotechnical laboratory module which is intended for final year civil engineering students in one of their geotechnical elective courses.

The proposed centrifuge shall rotate in horizontal plane and has a drive system which acts on the axis of rotation. This 1 m diameter centrifuge will have a rotating arm on which a model container will be fixed at each end of the arm. Model containers with viewing window are proposed to be 15x15x5 cm in size and are made of aluminum. Preferably, models of identical configuration are to be tested simultaneously at each end of the arm in order to maintain a balanced weight on both arms.

The centrifuge will be enclosed and will be run by an electric motor drive system with driving capacity between 800 and 1000 rpm (maximum of 600 g). A strong bench; which can resist dynamic effect from the centrifuge, is required to place the machine which will also be secured to it. A viewing window is also needed on top of the centrifuge enclosure to allow viewing of the model while centrifuging. A stroboscopic lighting is also required for viewing. Other possible alternatives for viewing model during centrifuging are by installing a digital camera placed on top of the enclosure and installing an onboard video camera system attached to one of the centrifuge arm. The latter method requires a consideration on balancing the weights across the arm. Via a digital camera, capturing fast moving object could be performed by increasing the shutter speed. Instrumentation is not required for this module.

This small geotechnical centrifuge is to be initially designed in its simplicity as to sufficiently satisfy the requirements of this module. However, in the future, the machine can be upgraded to expand its ability to model other geotechnical structures and events for more advanced work. Figure 2 shows a profile view of the proposed centrifuge.

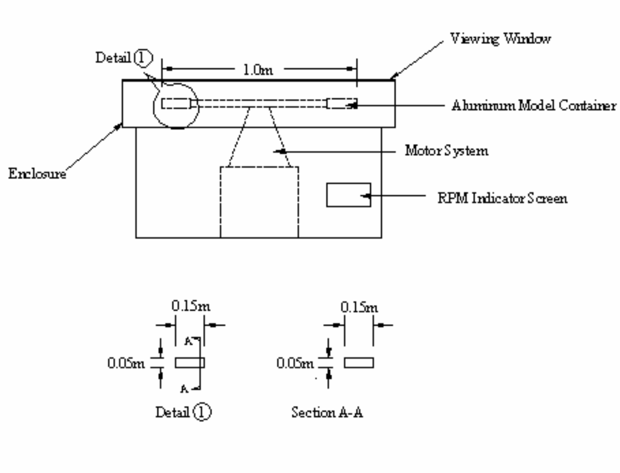

Fig. 2 Profile view of proposed centrifuge.

3. Description of Laboratory Module

Prior to the start of this laboratory, students will be given a theoretical lecture on centrifuge in the intended elective course; Advanced Geotechnical Engineering. This laboratory is to be performed in groups of 4 or 5 due to the extensive tasks required to be completed. A 2 hour lecture will be given on explaining background and theories of centrifuge testing. Designing the test program and models will require 3 hours of discussion session; while sample preparation and testing will require 6 hours; that is 2 laboratory sessions. Data interpretation shall require another 2 hours of discussion. In each discussion, instructor is to observe, guide and evaluate the progress of the discussion. Each member is designated to perform different tasks in the module. However, decision is left to the students on designating tasks among themselves and planning their work plan. Such exercise is performed in order to promote teamwork and communication skills in the students [8].

Two geotechnical structures are required to be modeled in this module based on scaling ratios shown in Table 1. As the purpose of the module is to show important geotechnical structures and events, unsupported vertical slope model can be suggested (Figure 3a, 3b) and tested at serviceability and failure states. Students are then to decide the suitable method to strengthen the vertical slope i.e. retaining wall in Figure 3a. Students can also propose an inclined slope which is a simpler model (Figure 3b) or a staged slope as other alternatives to strengthen the wall. The improved slope is then tested at both serviceability and failure states.

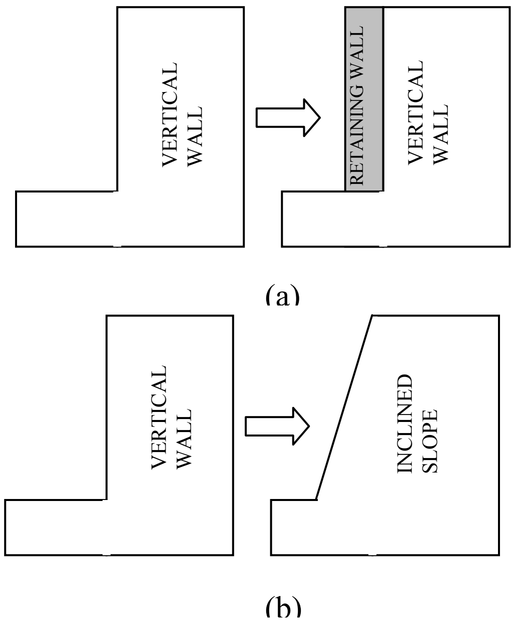

Fig. 3 Proposed models.

Dimensions of unsupported wall prototype, soil sample and its properties are provided in this module. For example a clay slope prototype of 10 m high is proposed for modeling the unsupported wall. From the information, students shall decide on the appropriate size for the model; subsequently, the N value, based on the available model box dimension, capacity of the machine and the need to address the suitable height to width ratio of the model in order to reduce the side boundary effect. In a case that retaining wall is the chosen method for improvement; modeling supported model shall require students to model the supporting element (i.e. concrete retaining wall). Soil type and supporting material to be used in the models are of the same type as in the prototype; hence, reducing the complexities of modeling with different materials.

Next, model preparation will take place which requires students to understand the importance of proper model preparation technique for producing reliable and consistent results.

Prepared models are next tested in the centrifuge. These models will be tested to failure by a method called ‘gravity turn-on’ method. In this method, centrifuge acceleration is increased and therefore increasing the gravitational action on the models. Prior to increasing the acceleration, model has to undergo a bedding run stage followed by its serviceability stage and stages of incremental increase of acceleration. Students shall plan these stages of event beforehand which requires them to refer to the time scaling ratio in order to simulate duration of event in the field. While centrifuging, changes on the models shall be observed where determination of failure is crucial in the analysis to be performed after testing. Once failure is reached the test will be stopped. Table 2 shows steps that students have to undergo in this module.

Table 2 Laboratory procedures.

Step	Procedure	Detail
1	Design	Design improved slope
2	Modeling	Decide on scaling ratio (N) to model slope and size Decide on stages and duration of event
3	Model Preparatio n	Consider careful model preparation
4	Model Testing	Observe and record on changes during serviceability and failure states on models
5	Post-Test	Identify failure mechanisms Perform additional tests on tested models

Fig. 4 Example of a failed slope tested in a centrifuge [9].

4. *Expected Results*

Speed or N value at which failure occurs shall be recorded during testing. In post test analysis, students shall observe the failure mechanisms of the models and measure the configuration of failure surfaces on the models. Example of a failed slope tested in a centrifuge is shown in Figure 4. Other geotechnical tests to obtain value of soil properties after testing shall also be performed.

Back calculation analysis is significant in this module as a mean to investigate the safety factor of both models during serviceability and failure states. As an example, a retaining wall as in Figure 3a could be showing failure mechanisms as listed; overturning about its toe, sliding along its base, loss of bearing capacity of the soil supporting its base, deep seated shear failure and experiencing excessive settlement [7]. Thus, this requires students to perform analytical discussion on the failure mechanisms and to reproduce the geometry of failure surfaces on the models for safety factor calculation. Unsupported wall and inclined slope in Figure 3a and 3b would show different mechanisms of failure and therefore requires different analysis method. A group written report and an oral presentation involving all members are required for assessments.

5. *Learning Objectives and Outcomes*

Various teaching and learning activities can be established in this module and are summarized according to the listed learning objectives and outcomes.

Learning objectives for this laboratory are to:

- introduce students to significant geotechnical events/behaviors (i.e. failure, soil-structure interaction) encountered in the field,
- emphasize on the importance of reliable and accurate testing attained from the usage of centrifuge testing for geotechnical models,
- familiarize students to the process involved in performing a geotechnical testing,
- introduce students to the process involved in analyzing failure mechanisms,
- show students validation of several theories discussed in lecture.

The learning outcomes are:

- ability to relate theories with laboratory findings,
- ability to design and develop models to solve for technical problems,
- ability to analyse and interpret data attained from laboratory module and translate results into comprehensive conclusions,
- ability to present and discuss project findings in a written form,
- ability to work in a team and show satisfying communication skills.

6. Discussions and Conclusions

Numerous countries have adapted the use of the centrifuge as a tool of instruction for students grappling the complexities of soil behavior and soil- structure interactions [3]. This fact shows that many agree, centrifuge testing offers more than the classical geotechnical testing which undeniably has been successful in introducing students to methods of obtaining different soil properties. Centrifuge testing, on the other hand, exposes students to the whole process involved in geotechnical events (serviceability to failure) and this allows them to investigate the occurrence of failure in a manner similar to the process that would be applied in a real situation. In addition, improving laboratory activities shall also improve teaching and learning process and thus, inclusion of centrifuge testing in laboratory module is needed due to its ability to provide a structured learning process; i.e. designing to analyzing which is crucial in equipping undergraduates with sufficient technical ability.

Bear in mind that laboratory training for engineers is needed not only to merely expose them to the practical explanation of some fundamental theories but also to improve their technical skills and to prepare them to the activities that they will experience in the industry. Walton in Innovative Teaching in Engineering mentions that *the design of a course of practical work in engineering mirrors the engineering design process itself* [12]. A laboratory module as proposed in this paper is seen as an alternative approach in improving geotechnical laboratory training in UNIMAS.

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Experience in laboratory and the ability to diagnose equipment faults

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Abstract

Experience in an engineering laboratory is an important element for engineering students and likely to enhance engineering concepts, which they have learned theoretically. Although the aim of the laboratory is giving opportunities to learn and gain experience, we do not know what actually happens in the laboratory. The development of experience either intentionally or unintentionally, will happen when the students are 'doing' the laboratory. Through their experience, they may possibly be able to detect and solve problems or easily diagnose faults of the equipment. Therefore the purpose of this research is to find the correlation between unintentional knowledge and experience in laboratory with the ability to diagnose equipment faults. Proposed methodologies of the research are described in this paper.

Keywords: experience; unintentional; tacit; laboratory; diagnose; fault

1. Introduction

In the engineering profession, the main task is to manipulate material and energy for the benefit of humankind. This task will successfully be achieved if the engineers, technicians and others have knowledge and experience related to the specific engineering field. Therefore, at university or college level, engineering education plays important roles to produce related knowledge and experience for engineering students.

Over recent decades have been periods of rapid change in engineering education. With the development of even more sophisticated technologies, there has been an increasing need for a new approach to engineering education [1], especially to cater the challenging of global scenario in engineering. Even the modern university needs to extend lifelong learning opportunities to its students anytime and anyplace, via online laboratory, to be successful in the global educational marketplace [2].

For engineering students, experience in an engineering laboratory is an important element. By attending laboratory classes and handling (working with) the equipment, the students are likely to realize its task and function. Instead of traditional or hands-on laboratory, there has been a trend towards providing online laboratory classes through remote or simulated access. This trend is driven by a demand to provide increased flexibility and opportunities in the delivery of laboratory classes to students. An online laboratory class is made possible by advancements in network infrastructure and development of multimedia protocols for seamless transport of information [3]. These laboratory experiences are likely to enhance related concepts, which they have learned theoretically.

Although the aim of the laboratory is giving opportunities for students to learn and enhance engineering concepts, we do not know what actually happens in the laboratory. In running the laboratory, it has the possibly unintended consequences of affecting the learning outcomes. Hence in designing a laboratory, the developer must ensure good pedagogy and learning practices given to the users [2]. Furthermore, for hands-on laboratory, usually students are divided into groups of four or five people, to run a single exercise. Sometimes, not every single student has contact with or handles the equipment. In contrast, remote access laboratory normally give opportunities to individual students to run the laboratory remotely. In this scenario, it is assumed that students learn what there are supposed to.

Previous research shows that the development of experience will happen when the students are '*doing practical job*' in the laboratory. In general, researchers [4-8] believed that to achieve high achievement in practical job, the persons should have an element of practical know-how knowledge. Furthermore, Sternberg and his colleague [9, 10] believed that this type of know-how knowledge or they have called '*practical intelligence*' is what [11] has called '*tacit knowledge*', which it is not openly expressed or stated, and it usually is not taught directly. In this paper, the authors used the term '*unintentional knowledge',* the knowledge gaining unintentionally, through experience rather than direct instruction.

Through their experience, they may possibly be able to detect and solve problems or easily diagnose faults of the equipment. Their experience develops either intentionally or unintentionally and gaining experience unintentionally is believed to play an important role in laboratory work. However, the question is, do the students who gain experience during their laboratory classes possess a high level of unintentional knowledge which allow them to diagnose the faults of equipment easily. Therefore, in this study, we examine the effect of unintentional knowledge and experience in the laboratory work and the ability to diagnose equipment faults.

2. Theoretical basis

2.1. Tacit or unintentional knowledge

Much of the 'personal knowledge' is used in this life is unintentional learning. Unintentional learning is often acquired without the intention or awareness to learn. [12] defined personal knowledge is the cognitive resource, which a person brings to a situation, that enables them to think and perform. Skills are part of this knowledge, thus allowing representations of competence, capability or expertise. Personal knowledge is identified by the context and manner of its use and may be either explicit or tacit.

. Regarding to [11, 13], explicit knowledge is knowledge that can be expressed, either verbally or in written form, can be captured and codified into manuals, procedures, and rules and is easy to disseminate. Tacit knowledge refers to knowledge that cannot be easily articulated and exists in people who manifest it through their actions. In discussing knowledge that is difficult to put into words, [11] stated that "*. . . we know more than we can tell*" (p. 4) and that "*the aim of a skilful performance is achieved by the observance of a set of rules which are not known as such to the person following them*" (p. 49).

The concept of unintentional knowledge is closely related to the concept of skills, used mostly to describe practical know-how [14] and is gained through practical experience in various contexts. For instance, Sternberg and his colleagues [15] explored unintentional knowledge in academia as practical intelligence, and they insisted that in order to succeed in academic, the person need expert knowledge of that kind of environment. In the daily environment, the problem are tackled by using unintentional knowledge, which emphasizes procedures or "knowing how," but for formal academic environment, academic knowledge is considered "knowing what". Regarding to [10], practical intelligence is "*a person's ability to apply the components of intelligence to everyday life*". It is based on procedural information relevant to one's daily life [16].

For this study, 'unintentional knowledge' means the gaining of knowledge without intention to learn or through experience rather than direct instruction. For example, in one of the questions, students will be asked why we do not tighten a nut too hard. The knowledge for this question is likely to have been learned without direct instruction but develops through observation, 'trial-and-error' experience, mistake, repeated jobs etc.

2.2. Experience in laboratory classes

One of the most important factors in forming engineering graduate qualities is the practical component of the engineering curriculum. To achieve these qualities, laboratory classes are valuable learning tools, which can be used in an attempt to teach the link between practical skills and theory effectively. Work in the engineering laboratory environment provides students with opportunities to validate conceptual knowledge, to work collaboratively, to interact with equipment, to learn by trial and error and to perform analysis on experimental data. Regarding to [17] the underlying reason for the value of laboratory classes is that they are a fundamentally different context for the students' learning. In a laboratory class, their environment is different compared to other learning modes, such as lectures or tutorials. They engage with the real hardware, components and materials. They embed their learning into a different context, and construct different knowledge as a result.

There has been a long debate on whether current technology can replace conventional method of delivering laboratory classes. It is clear that the choice of laboratory technologies, i.e simulation or remote laboratory, could change the economics of engineering education, and it is also clear that changing the technology could change the effectiveness of education [18]. Referring to [18], researchers on hands-on mode think that engineer needs to have contact with the apparatus and that labs should include the possibility of unexpected data occurring as the result of apparatus problems, noise or uncontrollable real-world variables. While simulation researchers often begin by invoking the spectre of cost; hands-on laboratories take-up space, impose time and location constraints. Many educators claim that simulation is not only cheaper, but it is also better, in that more laboratories can be conducted than with hands-on laboratories.

In contrast, a serious concern was that valuable practical experience would be lost by using a simulation [19]. As example, referring to [20], proficiency in the use of basic equipment such as oscilloscopes and signal generators is an important skill for engineers. Handling real components, and taking the necessary precautions when circuit-building, are important abilities. For instance, the need to connect a power supply correctly reinforces the differences between active and passive components in a way which is lost on the simulator. Finally, there was a concern that students would place a large premium on the use of real equipment, and that the place of practical work in helping to bridge the gap between theory and reality may be lost [20]. Although the debate is about the method of delivering laboratory classes, researchers of both modes were agreed the importance of experience through laboratory work and concern about the lost of valuable practical experience.

2.3. Fault Diagnosis

An on-going task in engineering work is to increase the reliability, availability and safety of technical processes [21]. To achieve the task, monitoring and diagnosis process among the effort should be done [22-24]. The aim of monitoring is to detect failures, proceed within the shortest period of time to avoid additional damage, while diagnosis includes fault localization and identification, and can apply further actions, therefore has no noticeable time limit [25]. Furthermore, according to [26], fault diagnosis or troubleshoot is simply the process of finding the best solution that allows movement from the present state to the goal state. "A problem arises when we have a goal – a state of affairs that we want to achieve – and it is not immediately apparent how the goal can be obtained [27]. While [28] described the key to effective troubleshoot as the ability to recognize and select the most efficient solution path from the myriad of potential solution paths present in the solution space.

In current situation, complicated engineering process and systems need a systematic method of diagnosis. Thus, in recent years research efforts have shown that the technical problem due to faults can be detected in an early state by using diagnostic system. The diagnostic system must be equipped with the programming knowledge of how to relate faults and their effect to the operating state [21], but the programmers through their explicit knowledge develop that programming knowledge. In term of human, the troubleshooter must be well self-enhancing knowledge of how to relate faults and the implications, which to learn from experience. This self-enhancing knowledge is developed through their working experience, and either explicit or tacit, but is expected mostly tacit knowledge. By utilizing this knowledge, they will be expected to provide information of diagnostics for failure localization, planned preventive maintenance and service staff [25].

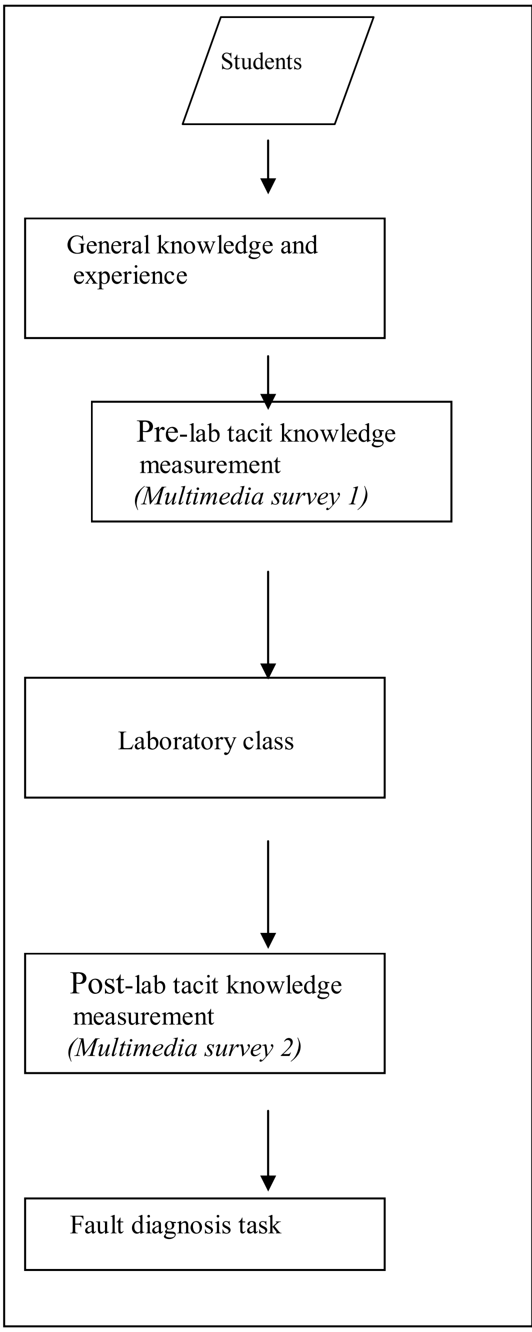
Therefore, [29] stated that fault diagnosis as a special category of problem solving and indicate that when a system is not functioning properly, the troubleshooter must attempt to locate the reason for the malfunction and then must repair or replace the faulty component. According to them, three skill sets are essential to diagnose technical equipment faults: a) the ability to test, b) the ability to replace or repair faulty components, and c) the ability to employ some kind of strategy in searching for the source of the fault. This is congruent with [28] who indicated that the key component of the problem solving process was the ability to recognize and select the most efficient solution path from among all possible solution paths and concluded that identifying and employing an effective strategy was the most difficult skill set for troubleshooters to develop.

In order to identifying and employing an effective strategy, there is an increasing of need about awareness and critical thinking in terms of the equipment's fault. Therefore the need for training in fault diagnosis has been identified [21, 25, 30-33]. Thus, to become an engineer who will be able to diagnose the equipment faults, the engineering students have the opportunity to practice these qualities in their laboratory work. Hence the exercise on diagnosis of equipment fault is good practice for them. However, to achieve the performance in the exercise, pedagogical support was needed. Regarding to [34] in his experiential learning theory, four stages in experimental i.e. active experimentation, concrete experience, reflective observation and abstract conceptualization, should be incorporated in the practical exercise. When this practical exercise placed in this sequence, the stages form the experimental learning cycle, i.e. learning-by-doing [22-24].

The learning-by-doing method was considered the most effective and powerful method for acquiring knowledge and influencing behavioral change [22-24]. Hence it is predicted that through learning-by-doing processes, the students will develop their critical thinking and awareness of the equipment faults in their working environment. It is also believed that tacit knowledge plays the main role in this area.

2.4. Theoretical framework

The aim of this research is to explore unintentional experience and knowledge gained by students after attending laboratory experiments. Gaining experience unintentionally is believed to play an important role in laboratory work and is predicted that has a correlation with the ability to diagnose equipment faults. The related unintentional experience and knowledge will be explored through an on-line multimedia survey which will include 15 questions developed according to the observations and informal interviews during the experiments. Fig. 1 below shows the theoretical framework of this research.



- Subjects: First Year Mechanical and Mechatronics Engineering student.
- Having tacit & explicit knowledge from previous experience
- Before attending the lab, what is the level of tacit knowledge they have?
- e.g Do they have knowledge about screws, wires, multimeters etc and their basic operation?
- Students attend a laboratory class and do an experiment to develop *LED Circuit & Crystal Radio* (they follow the sequences or direct instruction)
- This exercise also involves tacit knowledge: e.g.: to tighten/loosen screws, cut wires, remove wire insulation, use multimeters, etc.
- After attending the lab, what is the level of tacit knowledge they have?
- e.g Do they gain the tacit knowledge about screws, wires, etc (compared to pre-lab)?
- Technical faults diagnosis exercise: diagnosis task requiring knowledge from above (tacit knowledge)

Fig. 1. Theoretical framework.

2.5. Research hypothesis

There is scarce literature based on experience in laboratory classes; few similar studies address instructional methods for enhancing the unique unintentional experience-exploring approach during laboratory experiments. A quasi-experimental study was proposed to examine the effectiveness of exploration strategies. The strategies will be used as an experimental treatment with university-level first year engineering students as they attend basic electronics laboratory experiments.

The following research questions were developed to explore the impact of laboratory experiments in producing unintentional experience and knowledge:

1. Do the students gain unintentional experience and knowledge during laboratory experiments?
2. Do the students who gain unintentional experience during their laboratory classes possess the ability to diagnose equipment faults easily?

Therefore, the hypotheses of this research are:

1. We predict that in laboratory class: [unintentional knowledge = 0, explicit knowledge ≠ 0] is FALSE.
2. We predict that in faults diagnosis task: [unintentional knowledge = 1, ability to diagnose ≠ 1] is FALSE.

3. Suggestion of methodologies

3.1. The experiments and samples of population

The purpose of these laboratories was to introduce engineering students to the concept and application of electrical and electronic engineering in a practical and enjoyable way. The laboratories built on the work covered in lectures, reinforcing the concepts needed in the design of systems. The laboratory consists of four experiments: Crystal Radio, Diode and Optical Sensor, Operational Amplifiers, and Digital Logic. In these experiments, the students had to develop the fundamental skill of practical electronics; read a circuit diagram and used it to construct a working circuit, understood the fundamental components in electronic engineering such as resistors, capacitors, inductors, diodes and transistors, understood and explored operational amplifiers, and constructed a control system that capable of guiding a vehicle around a track.

The population for this study consisted of first year engineering students who enrolled unit GENG1002 (Introduction to Electrical and Electronic Eng) in Semester 2 Session 2007, The University of Western Australia. The sample population consisted of 20 students which were chose randomly.

3.2. Proposed methodologies

Proposed methodologies of the research are described in this paper. In the first part of this research (Semester 2, 2007), the students were observed individually during the experiments and they were involved in an informal interview. Through the observations and interviews, it was predicted that the students would gain unintentional experience and knowledge when they were doing the experiments. Thus in the second part (Semester 1, 2008), the related experience, i.e the ability to recognize basic knowledge of mechanical (and electronic) parts and activities, will be explored by an on-line multimedia survey. The students will answer the survey twice, before and after attending the laboratory experiments. Then, for further research, the students will be given an activity to diagnose simple faults which are related to the experiments.

3.3. Individual observation and informal interview

The author had been observing the students during them doing the experiments and asking them questions related to the tasks they had done, as informal interviews. For example, one of the instructions students had to follow was to strip both ends of green wire. First they had to cut the wire in half, one for an antenna and the other one for a ground. The students could request pliers from lab demonstrators because they were not provided in the first instance. The author noticed that some of the students used their creativity to strip ends of wires; they used a cutter to cut around the insulation and pull it off. One of the students used an alligator clip to clip the insulation and tried to pull it off; another students used their teeth to cut and pull off the insulation. But some of the students were able to do in the correct way, used pliers to strip both ends of the wires. Many students asked lab demonstrators to show them how to do that.

During the observation, the author asked the students few question, as an example:

"Do you know how to strip the wire ends?"

The examples of the answers:

Some of the students: "I had to use pliers; it was easy to strip the wires."
Student 2: "It was difficult to do that. I used a cutter, but always cut the whole wire."
Student 3: "I tried to cut and slice the insulation carefully, because the wires were too small."
Student 4: "I used pliers, gripped the insulation tight enough to pull it off."
Student 5: "I couldn't do that, the lab demonstrator helped me."
Student 6: "I used my teeth to cut the insulation and pull it off."

Following the observations and informal interviews, the author believed that some of the students having unintentional experience and knowledge to strip the wire ends before doing the tasks, while the others haven't. From the example above, some of the students used pliers to do the tasks included Student 4; probably they have experience and knowledge about the task before the experiments.

3.4. On-line multimedia survey

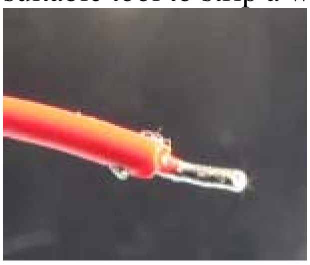
The aim of this survey is to know the level of unintentional experience and knowledge of the students, related to the laboratory experiments. In this research, an on-line multimedia survey on the ability to recognize basic mechanical and electronics parts, apparatus and activities, will be given to the students. The electronic survey contains graphics, pictures, sound and videos.

There are two surveys will be given to the students; *pre-lab multimedia survey* before attending the laboratory and *post-lab multimedia survey* after attending the laboratory. The purpose of the pre-lab survey is to explore either the students already have an unintentional knowledge related to the experiment or not. Therefore, in the pre-lab survey, the level of unintentional experience and knowledge that the students already have before attending the laboratory will be measured through the scores of the correct answers.

Then, the students will attend the laboratory and during the experiments, it is predicted that the students will gain the experience and knowledge unintentionally. After doing the experiments, again the students will be given the post-lab survey, to measure the level of unintentional experience (score of the correct answers) they gained after attending the laboratory. The expected results may show the differences between the level of unintentional experience and knowledge among students after attending the laboratory experiments and the level of that knowledge before the experiments.

The pictures and arrangement of the questions for post-lab are slightly different to pre-lab, but still bring the same meaning. Correlation of these surveys may show the level of unintentional experience and knowledge gained during the experiment. The example of the survey question is shown in Fig. 2.

Question:
Which picture does **NOT** illustrate a suitable tool to strip a wire end?



Stripped wire end

Multiple answers:

(a) 

(b) 

(c) 

(d) None of these

(e) All of these

(f) Not sure

Fig. 2. Example of the survey question.

3.5. Unintentional experience involved in the experiment tasks

During the experiments, the students had to follow the sequences or direct instruction in the experimental sheet, as explicit knowledge. At the same time, without realize, they had to use their unintentional experience and knowledge. See Fig. 3 for an example of the unintentional experience and knowledge involved in the task of stripping the wire ends.

LAB1 – the instruction to strip wire ends. Students will do this

↑

Students haven't learned how to strip wire ends before and the experiments sheet also does not explain how to do that. Then the students will do that by trial and error, through previous

↑

Unintentional knowledge involved in this action is 'how to cut the insulation and pull it off'. For

↑

Unintentional knowledge involved here is:
- How to use a cutter to cut around the insulation (cut only the insulation material, not the whole wire)
- How to use pliers to pull off the insulation (grip the insulation tight

↑

Unintentional knowledge involved here is:

Fig. 3. Unintentional experience involved in the task.

3. Discussion

3.1. Implementation of methodologies

Following the observations and informal interviews during the experiments, the author believed that some of the observed students having unintentional experience and knowledge to do some tasks in the experiments, while the others haven't. After doing all the experiments, it is also believed that they may gain the experience unintentionally because they may repeat the same tasks or get the experience through trial and error.

From this observation, the author noticed that there are few areas that the students lack of experience and knowledge to do the tasks during the experiments. Then the multimedia survey will be developed and tested, to explore the lacking of experience and knowledge before the experiments and will be compared with the results after experiments. The results of this comparison are believed have a significance correlation between unintentional experience before and after the experiments. If this happens, the first hypothesis of this research:

"We predict that in laboratory class: [unintentional knowledge = 0, explicit knowledge ≠ 0] is FALSE" are true. That means, the students gained unintentional experience and knowledge during them doing the experiments.

3.2. Further research

Further research will be conducted in Semester 2, 2008, to investigate the correlation between gaining unintentional experience in laboratory experiments and the ability to diagnose equipment faults. For this further research, the students will follow the same methodologies; will do the laboratory experiments, will be observed and interviewed and will answer the pre-post surveys; additionally they will be given an activity to diagnose simple faults which are related to the experiments. This diagnosis activity will be observed and recorded.

The results of qualitative analysis of diagnosing activity are believed have a significance correlation between unintentional experience in laboratory experiments and the ability to diagnose equipment faults. If this happens, the second hypothesis of this research:

"We predict that in faults diagnosis task: [unintentional knowledge = 1, ability to diagnose ≠ 1] is FALSE" are true. That means, unintentional experience and knowledge plays an important role in faults diagnosis tasks.

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Development of a framework and System for remote electronics experiment

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Abstract

In this paper, the development of a framework and system to facilitate remote electronics experiments is presented. Through the system, a student is able to design an electronic circuit for a specified purpose and observe/analyze the response from the circuit to excitation, while being physically distant from the laboratory where the electronic circuit and instrumentation/measurement systems are housed. The construction of the overall system, including the hardware architecture and the software development platform with the user interface will be elaborated in the paper.

Keywords: remote experiment; distant learning; engineering education

1. Introduction

Distance learning has been steadily becoming vital and widespread for several reasons. The rapid growth of information and technology, coupled to sustained demand in skills upgrading and education, sets the ground for ongoing learning and professional development. With the tremendous potential in terms of the flexibility of time and space which it enables, distance learning has so much to offer. The present generation of distance learning is geared towards the powerful integration of computers and telecommunications to bring on near real-time interaction between the users and the remote resources [1, 2]. Many learning institutions have already incorporated such forms of distance learning as an integrated part of their programmes [3-11].

This paper is an attempt to instill a more realistic spin to the second class of virtual experiments. It is focused on the development of an electronics design experiment which will allow as close as possible the experience of actually patching up an electronic circuit in the laboratory, and configuring the instruments and measurement systems for display and analysis purposes. A prototype circuit will be used for illustration throughout the paper, although the approach is applicable to full and specific electronic circuits. The user is able to interact with the actual electronic components and instruments, including placing and connecting electronic components into a circuit according to his design as though the breadboard and components are right with him.

2. Prototype Circuit

For the purpose of illustration in this paper, a simple prototype circuit as shown in Fig. 1 will be used. The system developed can be equally applicable to full fledged functional electronic circuits. Essentially, the student will design this circuit and patch it up on a virtual breadboard, according to the guidelines laid out in the laboratory experiment sheet. Subsequently, the design will be uploaded to a server in the laboratory housing the equipment and an actual circuit corresponding to the design will be automatically configured via relay switches. The student can then request to input an actual excitation signal or request to view signals at a specific point in the circuit. Thus, the student will be able to undergo a typical electronics experiment and analyse the response of his own circuit design. The requested signals, arising from an actual physical circuit, will be transmitted to the student and displayed on his client personal computer.

In the following sections, the components necessary to put together the system, as well as other considerations/issues necessary for the efficient running of the experiment will be highlighted.

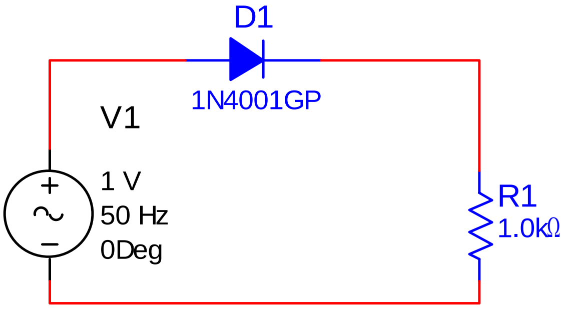


Fig. 1. Prototype circuit.

3. Hardware architecture

The overall system is centred around virtual instrumentation. A virtual instrument (VI) consists of an industry-standard computer or workstation equipped with powerful application software, cost-effective hardware such as plug-in boards, and driver software, which together perform the functions of traditional instruments. With virtual instrumentation, engineers use graphical programming software to create user-defined solutions that meet their specific needs. Additionally, virtual instrumentation capitalizes on the ever-increasing performance of personal computers to enable functionalities not possible in traditional instruments. A schematic of the overall system is shown in Fig. 2. In what follows, the constituent components of the system will be elaborated.

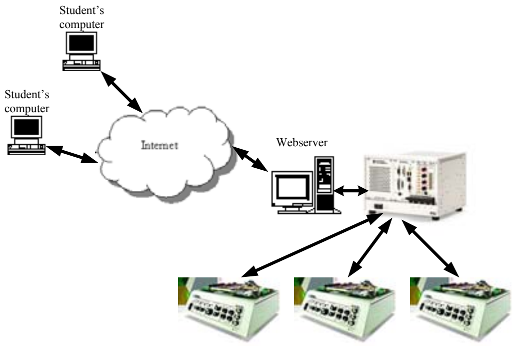


Fig. 2. Overall schematic of the remote electronics experimental system.

4. Software Architecture

In this section, the software components used in the development of the system along with the user interface will be highlighted. The overall flowchart of the conduct of the remote electronics experiment is shown in Fig. 3.

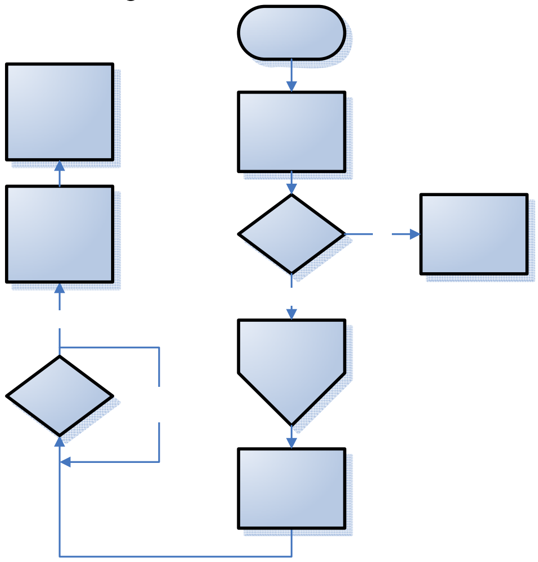


Figure 3: Software flowchart of the system for the remote electronics experiment.

4.1. Laboratory Virtual Instrument Engineering Workbench (LabVIEW)

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications.

The block diagram contains the program for checking of the design circuit, closing the relay switches to complete the experiment circuit connection and other additional features, including the verification of hardware functionality and reliability and a text messaging function for communication with the laboratory personnel when necessary. The block diagram will only be available for editing and viewing by the administrator, and is transparent to the user. An example of the block diagram is shown in Fig. 4.

The VI for remote control and monitoring of the experiment contains the code that executes the reading of the experiment output, the hardware reliability check and the activation of the text messaging function (to be elaborated in Section V). The VI is saved in the PXI chassis for the command and control of NI ELVIS, NI PXI-2570 and NI PXI-6281. The "Web Publishing Tool" of NI LabVIEW allows the VI to be published on the web and thereafter, the user is able to gain control of the VI via a standard web browser.

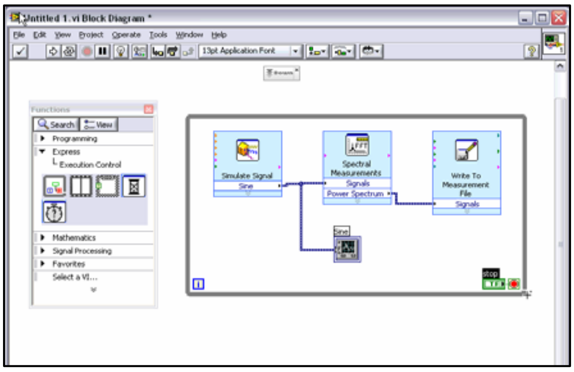


Fig. 4. LabVIEW block diagram

4.2. NI Electronics Workbench Multisim

Multisim combines intuitive graphical setups with simulation to efficiently design and validate a circuit. With NI Multisim, a schematic can be built quickly with a comprehensive component library and the circuit behaviour can be emulated using the industry-standard SPICE simulator. Multisim provides an easy-to-use interface to SPICE, ensuring accurate and immediate simulation results. Professional designers can uncover the flaws earlier in the design process, reducing prototype errors and time to market.

In this system, the student can construct his design circuit using the "Virtual ELVIS" in Multisim, which is shown in Figure 5 which emulates the behaviour of its real-world counter-part, the NI ELVIS. Planning, prototyping and testing of the circuit can be carried out on the virtual version before it is configured on the real NI ELVIS workstation in the laboratory.

Fig. 5. 3D virtual ELVIS

Students at the user end will first place the experiment circuit components on the 3D rendering of the prototyping board of the 3D Virtual ELVIS, as shown in Fig. 6, to complete the circuit design. The zooming and rotating capability of the 3D Virtual ELVIS prototyping board provides an interactive feel for students when they are patching up the circuit on the virtual board.

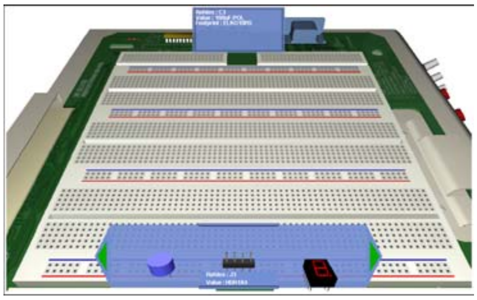
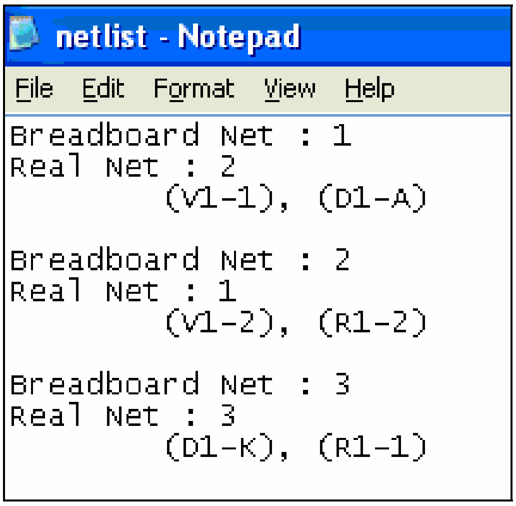


Fig. 6. Placing of components on the 3D virtual ELVIS prototyping board.

The final circuit design will be converted to the form of a text file which is named as Netlist. The Netlist used for the prototype circuit for this project is shown in Fig. 7. Fig. 8 shows the corresponding labels of the circuit nodes of the circuit as referred to in the Netlist.



netlist - Notepad

File Edit Format View Help

```
Breadboard Net : 1
Real Net : 2
        (V1-1), (D1-A)

Breadboard Net : 2
Real Net : 1
        (V1-2), (R1-2)

Breadboard Net : 3
Real Net : 3
        (D1-K), (R1-1)
```

Fig. 7. Netlist of prototype circuit.

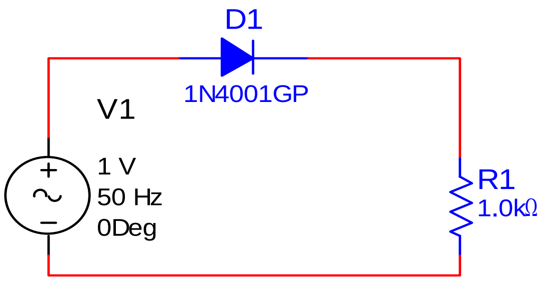


Fig. 8. Labeling of the circuit nodes.

4.3. User Interface

The user interface provides a frontal instrument panel whereby the user can interact with and control the different functions available in the experiment. This interface determines the user-friendliness of the overall application. The user interface comprises four portions: *Experiment output indicators*, *hardware* *reliability and netlist checks' indicators*, *text messaging* and *experiment flow control*. The user interface developed for the remote control and monitoring of the laboratory experimental setups is shown in Fig. 9. The *experiment output indicators* include numerical and graphical output blocks. The numerical and graphical output blocks display the results of the experiment in numerical format and the graphical format, respectively. These results could be the potential of a point or a current in the circuit. The *hardware reliability and netlist checks' indicators* are alarm blocks that alert the user in the event of any error or abnormality arising during the course of the experiment. Due to the limited life cycles of electronic components, it is pertinent to eliminate any hardware components failure during the course of the experiment in order to obtain meaningful results. The *text messaging controls and indicators* creates a facility whereby the students can communicate with the laboratory administrator. These are discussed in more details in the following section. The user controls the initiation and termination of the experiment via a 'Stop' button.

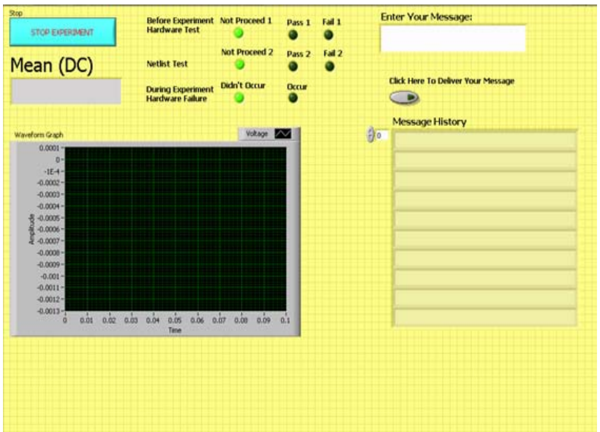


Fig. 9. User interface.

5. Conclusion

The development of the framework and system structure which allows the hands-on experience of electronics experiment from a remote location, using virtual instrumentation devices and software is described in this paper. The hardware and software components constituent in the system, along with their interactions, are also elaborated.

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Development of Manually Guided Robot with Minimum 5kg of Load

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Abstract

Manually Guided Robot basically has 4 major electrical components. There is power source, motor controller, electric DC motor and gripper / handler. Typically, the motor controller is a microcontroller device which controlled the movement of the robot. The motor controller circuit is realized by using 16F877 PIC microcontroller. Using the mikro C software to writes the C programming for PIC microcontroller. The manually guided robot will be control by a keypad. For robot movement, an H-bridge configuration allows the motor to run in both ways whether to move forward or reverse directions. It also allows for a simple implementation of regenerative braking. 2 DC motor will be used for the robot base. The gripper of the robot also will be controlled by the DC motor for gripped object and robot movement.

1. Introduction

In Malaysia, National Robofest was started in 2001 and jointly organised by Ministry Science, Technology and Environment and SIRIM Berhad. At state level, Robofest was under State, Ministry of Education (state) and SIRIM Berhad Branch. Robofest aimed at creating and stimulating interest of Malaysia at all spectrum of society from educational, industry to general public in robotics and artificial intelligence (AI) technology.

Robofest is an annual Robot Games Festival aimed at creating and stimulating interest of Malaysia at all spectrum of society from educational, industry to general public in robotics and artificial intelligence (AI) technology. To achieve this objective, the related activities such as robot contest, robot clinics, drawing contest, exhibitions and seminars are organised.

Robofest is an annual robot contest starting from 2002, just for university, college and polytechnic students in the Asia-Pacific region. Under a common set of rules, participants will compete with their peers in other countries to create a robot using their creative and technological abilities in an open competition. This contest aims to create friendship among young people with similar interests who will lead their countries in the 21 st Century, as well as help advance engineering and broadcasting technologies in the region. This event will be broadcast in your country through an ABU member broadcaster.

RoboCon Malaysia is a contest to design and construct robot that can perform certain task based on theme and rules. The winner will be representing Malaysia to the international level organized by Asia Pacific Broadcast Union (ABU).

It is within this context that SIRIM Berhad has actively promoting robotic competition to encourage and promote creative and innovative minds among the younger generation. Robofest was Robocon are robotic competition will give an opportunity to secondary school and higher education to develop creative and critical minds in Artificial Intelligence and Robotic Technology whilst providing avenue for students to display their engineering skills and capabilities.

University Technical Malaysia Melaka (UTeM) has send participation in the Robocon and Robofest competition. From this competition, this project will using creativevity, technological abilities and knowledge that have been learned in this 4 year of degree to find the realiable and stable base to create the manually guided robot with 5kg of load. In future, this project can be used and modified for all the Robocon and Robofest competition.

2. Development project

This project have 3 major parts, there is software part, electrical part and mechanical part. In the software part, the Mikro C will be used to design the programming for the microcontroller PIC 1617877, IC Prog and Proteus Professional 6 used to testing and troubleshooting the circuits. For the electrical parts, there are circuit H-bridge, circuit microcontroller PIC and programmer PIC. To build the structure for the robot body, all the materials that are needed to build up the robot was prepared. The aluminum bars in hollow and L ship, screws, wheel and power windows motor. Next, was to design the robot base according to the specification then the finally next step is to cut the aluminum into the side follow the design and using the screw to tie between the join and build up the base of the robot.

2.1. Software Development

Mikro C is a powerful, feature rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution for developing applications for embedded systems, without compromising performance or control. PIC is the most popular 8-bit chip in the world, used in a wide variety of applications, and C, prized for its efficiency, is the natural choice for developing embedded systems. Micro C provides a successful match featuring highly advanced IDE, ANSI compliant compiler, broad set of hardware libraries, comprehensive documentation, and plenty of ready-to-run examples.[1] Fig. 1 show that software mikro C.

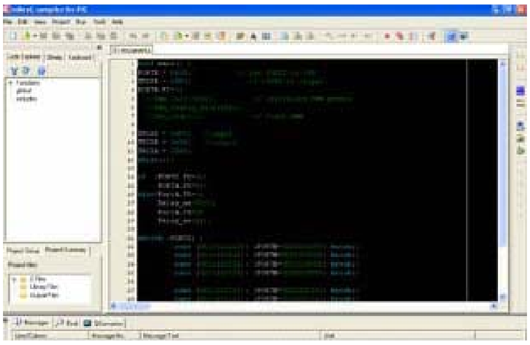

Fig. 1.Software mikro C.

Proteus has been created with this in mind. It has evolved over twelve year research and development and has been proven by thousands of users worldwide. The strength of its architecture has allowed user to integrate first conventional graph based simulation and now - with PROTEUS VSM - interactive circuit simulation into the design environment. For the first time ever it is possible to draw a complete circuit for a microcontroller based system and then test it interactively, all from within the same piece of software. Meanwhile, ISIS retains a host of features aimed at the PCB designer, so that the same design can be exported for production with ARES or other PCB layout software. For the educational user and engineering author, ISIS also excels at producing attractive schematics. It provides total control of drawing appearance in terms of line widths, fill styles, colors and fonts. In addition, a system of templates allows user to define a ‘house style’ and to copy the appearance of one drawing to another[2].

After the programming C completed design, Proteus Professional 6 will used to simulated the programming. Before starting the simulation, circuit for the microcontroller is drawn first in Proteus. Fig. 2 Show the Proteus Professional 6 Software.

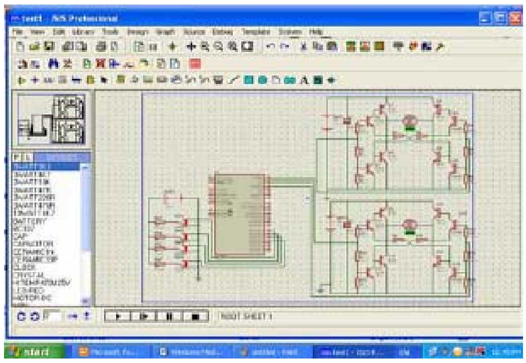

Fig. 2. Software Proteus Professional 6.

IC-Prog is windows based software to control a development programmer for PIC microcontrollers. To operate this software, a basic knowledge about electronics and windows is necessary. In order for this software to operate, user has to attach a programmer to the computer and set up the hardware & software appropriately. Please note, that because of differences in programmers, the software might not work on some combinations of programmer hardware and PC's. IC-Prog requires Windows 95, 98, ME, NT, or 2000 and an internal or external math coprocessor to operate. All processors that are upwardly compatible with 386 processor with 8Mb of ram should work.

Before starting using the IC Prog, set up must done first. The IC Prog program, compiled HTML Help file and IC Prog system file must put in the same folder. If using Win XP, NT, or 2000, must enable the NT/2000/XP driver. Firstly, go to Settings/Options/Misc and check the Enable NT/2000/XP Driver check box. After that, choose the type of microcontroller. Then open the settings and click the hardware. Windows hardware settings will appear as below. After that, choose the JDM programmer, com 1 and Windows API. [3] Fig. 3 shows that software IC Prog.

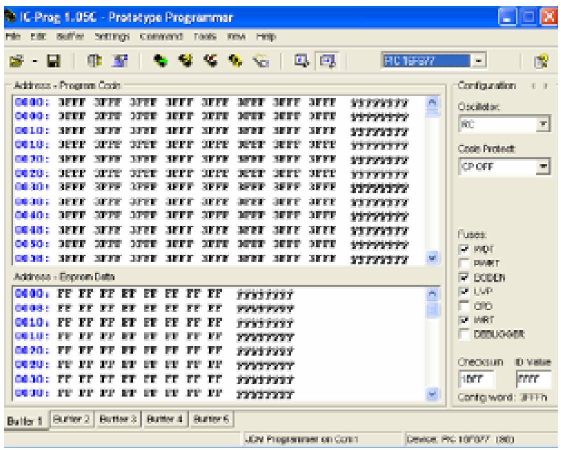

Fig. 3. Software IC Prog.

Bootloader is used to quickly download a new program into PIC micro directly through the PC talk box (rather than through expensive external programming hardware interface). The advantage to allow the PIC microcontroller programmed without being taken out of an existing circuit. For the new PIC microcontroller, the bootloader software in HEX file (choose the type microcontroller and clock used) have to burn into the PIC first then only can download the program into the chip without taken out the PIC. For download the HEX file into the PIC, using a hardware/software PIC programming interface (such as the EPIC programmer).

2.2. Electrical Development

A transistor H-bridge circuit is another type to control the motor directions. The power supply for the power window motor is 24Vde. For the Q1 and Q2, the transistor are type PNP and for the Q3 and Q4 the transistor are type NPN. When the input A high and B low that will cause the motor turn in 1 direction, making the input A low and B high that will cause the motor turn other direction. But for the input A and B should never both be low together, because it will make the Hbridge short circuit and the transistor will burn. Fig. 4 show that H-bridge using transistor.

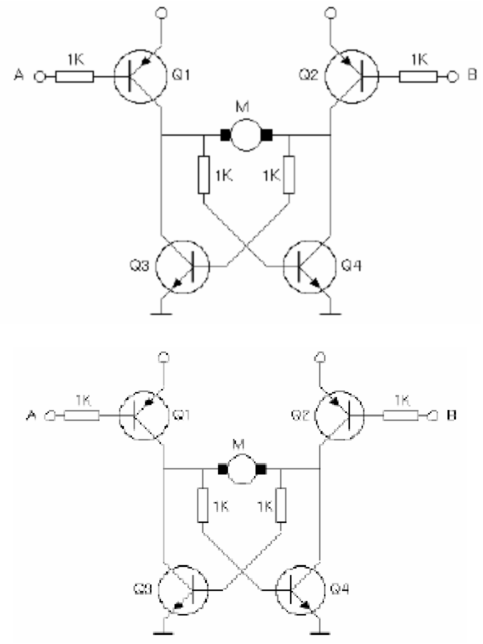

Fig. 4: Circuit Transistor H-bridge.

Microcontroller is a device to control the action taken by controller module to on/off the electrical appliances based on caller's needed. The type of the microcontroller chip for this project is 1617877. This series is considered in medium level among microcontroller family. The process of miniaturization, all of the components deeds for a controller was build right onto one chip. A microcontroller is highly integrated chip which includes, on one chip, all or most of the part needed for the controller. It typically includes : CPU, RAM, EPROM, I/O, Timer and Interrupt controller. Fig. 5 show the features and main pin of PIC 1617877 microcontroller.

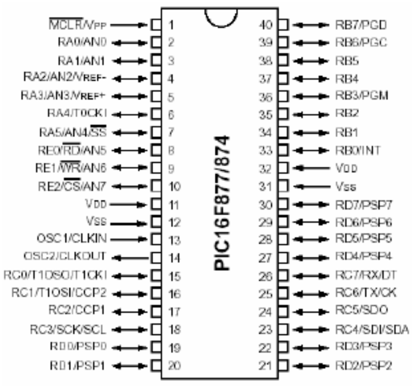

Fig. 5: Microcontroller 16F877.

A PIC programmer is a circuit which interfaces the PC to the microcontroller using the PC's parallel, serial or USB port. It can write data to the microcontroller and read it back for verification. The PIC programmer translates digital logic levels from the PC to suitable logic levels for the microcontroller - most levels are ok as they are, but for 'normal' (or high volt) programming of a PIC microcontroller the following voltage at the MCLR pin is needed minimum Vdd +3.5V and maximum Vdd +I3.SV.

The 13.5 volt level complicates the interface circuit since the voltages from the parallel port or USB port are not high. Typical digital logic levels are nominally SV so usually these programmers require use of an external power supply to generate the higher voltage. The serial port generates higher voltages and this fact is used by programmers such as a JDM PIC programmers. To program older PIC devices, a high voltage programmer are required. The programmer should isolate the microcontroller so that user can test the microcontroller program while the programmer is still attached.

The JDM serial port PIC programmer cleverly uses the serial port to provide a high voltage programmer that does not require an external power supply. It is cheap and easy to construct and is useful for programming one off chips but user have to insert and remove the chip from the programmer to the development board.

All PIC programmers work the same they generate a serial data stream using two signal lines clock and data. Another pin controls the programming voltage (at MCLR) and two others supply power and ground.

Another program running on the PC (the programming software) takes the HEX file generated from the compiler translating it into a serial data stream. This is routed to programmer through the correct interface (Serial, Parallel or USB). From the interfaces, the programmer presents the signals to the microcontroller. After all the data iserrt; a serial configuration word is sent, and oila - the microcontroller is programmed ready t-or use.

Serial or Parallel programmers describe the PC interface used not the programming method - all PIC microcontrollers are programmed serially. Serial programmers connect to the Serial port and Parallel programmers connect to the parallel port. The signals used at the parallel port interface still generate serial data - this is why a parallel port programmer is no faster than a serial port programmer. In fact the speed of programming is determined by the PIC programming algorithm and is much slower than any of the PC interfaces. In general programming a Flash PiC device is quite slow (16F877A 30 seconds).

Programming seems slow when user make minor code changes and want to see the result quickly but compare this to old style EPROMs - user have to remove the chip from the board and put it under a UV light for 30 minutes [4].

For the remote control (keypad), the PS control have been modified. The rainbow cable connects the keypad to the microcontroller. Each buttons are supplied with SVdc and all button shares the same ground. Fig. 6 show the PS control that has been modified and used to control the robot.

Fig. 6. Remote control (keypad).

2.3. Mechanical Development

Firstly, to build the structure for the robot body, all the materials that are needed to build up the robot was prepared. Next, the structure of the base robot built used the aluminum bar and tie it with screw. Fig. 7 show that base robot has been built.

Fig. 7. Base robot.

For the movement of the robot, 2 dc power windows motor was used which combine with the wheel. Fig. 8 show the back wheel for the movement robot.

Fig. 8. Back wheel robot.

The ball transfer is used to let the robot movement freely and smooth from friction. Fig. 9 show the ball transfer install in front of the robot base.

Fig. 9. Ball transfer.

After the base robot has been built, the next part of the robot is the gripper of the robot. Before starting to build the gripper, design is very important because it has to follow the ROBOCON 2007 rules.

Fig. 10 shows the gripper that was built using the aluminum L ship.

Fig. 10. Gripper robot.

The next step is to build the slider robot so that the gripper moving up and down easily and smoothly. Eight window rollers are required to grip the hollow mast robot. Fig. 11 show the slider robot and Fig. 12 shows the sliders were the mast robot

Fig. 11. Slider robot.

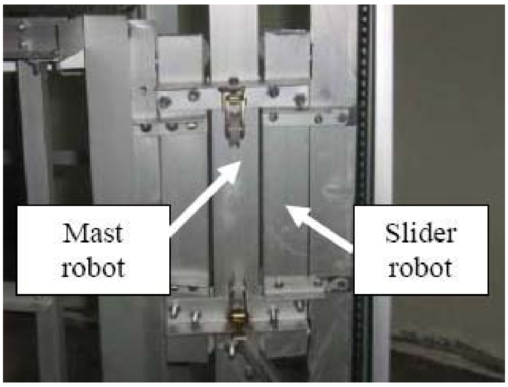

Fig. 12. Slider combines with the mast robot.

After parts of the robot are built, now it is the task to combine the base robot with the aluminum hollow mast and then the slider robot combine with the gripper. After that, the slider robot is put into the mast robot. A power window motor is used to move the gripper up and down by using the gear system. The gear track was made by the car timing belt. Fig. 13 show the track power windows motor are used to moving the gripper up and down.

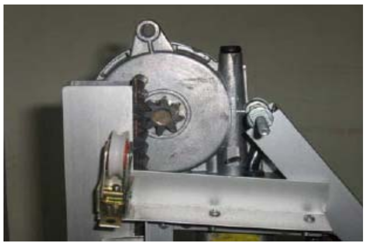

Fig. 13. Track power windows motor.

Lastly, after all the mechanical and electrical parts were combined, the manually guided robot with minimum 5 kg of load project has been completed. Fig. 14 show the completed manually guided robot.

Fig. 14. Manually Guided Robot.

3. Conclusion and Recommendation

Overall, the objectives of the project hav~y been achiev this project can be implemen n at only in ROBOCON contest 2007 but also in future From the project, new knowledge has learned in designing the microcontroller PIC and learned the new simulation software to test the circuit before build in PCB board.

In general, the difference between Microcontroller and Microprocessor is the processing unit of Microprocessor is in a computer. The microprocessor need external IC like ROM, RAM and Timer while the microcontroller is just a single chip with the CPU, RAM, ROM, and timer integrated inside one IC. There are several advantages that using the microcontroller : it most suitable device to use in a small application or project and the concept of programming is easy to understand and learned compare to microprocessor.

The concept of this project can be modified and change to manually guided vehicles (MGV). It helps to reduce costs of manufacturing and increase efficiency in the manufacturing system. MGV can carry or tow the raw materials into line to get ready to be manufactured. MGV also can combine with the fork lifts to lift objects for storage. Not only for manufacturing and automation, this project also can apply at hospital for transporting materials such as medicine in hospital. For the disable people, the project can be modified to be manually guided chair for helping disable people movement.

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Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka Exit Survey of Graduating Students.

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Abstract

The Engineering Accreditation Council (EAC) of Malaysia has mandated that Outcome-Based Education (OBE) learning approach is to be adopted in engineering programs in Malaysia. OBE is a method of curriculum design and teaching that focuses on what students can actually do after they are taught [1]. The underlying belief that drives OBE is the conviction that all students can learn, regardless of ability, race, ethnicity, socioeconomic status, and gender [2]. OBE also urges schools to generate "exit outcomes" based on the challenges and opportunities that students will face after graduation, and then to "design down" from the outcomes for all other aspects of educational delivery [3]. The Faculty of Manufacturing Engineering has identified five areas that specially focus on students learning and a survey from graduating students of session 2006/2007 was conducted to obtain feedback on the quality of education received. It was found that the students are satisfied with the quality of education and the level of preparation they received for the Bachelor of Manufacturing Engineering (Manufacturing Design) program.

Keywords: graduating students; manufacturing design programme; quality of education

1. Introduction

The quality of an educational system can be judged from at least three perspectives: the inputs to the system, what happens within the system and the outputs from the system [4]. Students, as the output, are one of the important elements in ensuring the quality of Manufacturing Design program. There is an argument that the current engineering graduates does not provide enough emphasis on teamwork, communication, knowledge retention and the ability to synthesize and make connections between courses and fields [5]. Therefore, this exit survey has been done on final semester students to obtain their perception on the level of education quality of Manufacturing Design program at the Faculty of Manufacturing Engineering, UTeM.

The questions are based on the Faculty of Manufacturing Engineering eleven program outcomes [6]. The survey is design to seek the graduating students input on the quality of education and the level of preparation they received in the Manufacturing Design engineering program. The main observations from the latest surveys and recommendation for improvements will be discussed in further sections. The exit survey contains sections that specifically focus on student learning (knowledge, skills, and abilities) in addition to the traditional questions of student satisfaction. The questions are related directly to the faculty program outcomes that have been made familiar to the students throughout the curriculum.

2. Methodology

For this survey, a total of 35 responses were received from graduating students in academic year 2003-2007. This survey was conducted on April 2007. The tables in next section present the results of the survey in terms of number and weighted average out of five. The following scale is used in calculation of weighted average: Strongly agree=5; Agree=4; Neutral=3; Disagree=2; Strongly disagree=1. The analysis involves the calculation of percentage, frequency, and min in terms of tables, figures and chart with the aid of Microsoft Office 2003 and SPSS for Windows (version 14.0). The survey consists of 5 different sections as listed below:

I. Faculty contribution in Students Learning & Development
II. Program Outcomes and Skills
III. Students Professional Skills
IV. Departmental Aspects
V. Facility Rating

3. Results

For the purpose of analysis, the responses obtained are divided into five tables as follows:

i) Table 1: Faculty contribution in Students Learning & Development
ii) Table 2: Program Outcomes and Skills
iii) Table 3: Students Professional Skills
iv) Table 4: Departmental Aspects
v) Table 5: Facility Rating

4. Discussion

4.1. Discussion for Table 1: Faculty contribution in students learning & development

Based on the survey, 38% of the students agree and 26% strongly agree that the program contributes in their learning and development. The highest portions (29 students in total) of students agree and strongly agree that the program incorporate teamwork as part of learning process. This is the result of group assignments, projects, etc. conducted within the program. It can also clearly be seen that there is no student disagree or strongly disagree for the first and second item in Table 1. They believed that the program does set high expectations for students and also encourage students to be active in learning.

4.2. Discussion for Table 2: Program outcomes and skills

Based on the survey, 54% of the students agree and 18% strongly agree that the program meets the program outcome and skills. Table 2 also shows that 16 students have neutral opinions regarding time management skills enhancing by the program, which is the highest count of neutral scores. The students are not exactly sure regarding this matter. However, most of them are absolutely sure that this program is effective in developing computer knowledge and skills (84% of the students are either agree or strongly agree), which is the result of computer software based subject they learned in the program.

Table 1. Faculty contribution in students learning & development

No	Items	Frequency (Score)					N	Mean	Sd
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
1	Set high expectations for you as a student			15	13	7	35	3.77	0.77
2	Encourage you to be active in learning.			8	16	11	35	4.09	0.742
3	Use different approaches (models, computer, labs, etc) to explain concepts.		1	5	15	14	35	4.20	0.797
4	Capable of explaining critical concepts and ideas.		3	9	22	1	35	3.60	0.695
5	Incorporate teamwork as part of learning process.		1	5	17	12	35	4.14	0.772
6	Encourage student-faculty interactions, in and outside the classroom.	1	4	12	11	7	35	3.54	1.039
7	Provide advising and consulting in your major.	1	5	12	9	8	35	3.51	1.095
Total		2	14	66	86	60			
Percentage (%)		1.01	6.04	28.95	37.70	26.30			

Average Mean: 3.84

Table 2: Response to program outcomes and skills

No	Items	Frequency (Score)					N	Mean	Sd
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
1	The mathematical content of the program is adequate for pursuing the advanced courses in the program.			13	20	2	35	3.69	0.583
2	The program developed my science and engineering skills.			8	18	8	34	4.00	0.696
3	The program is effective in developing analytic skills.		2	10	17	5	34	3.74	0.790
4	The program develops the ability to think critically and logically.			7	24	3	34	3.88	0.537
5	The program is effective in developing problem formulation and problem solving skills.			11	19	5	35	3.83	0.664
6	The program develops experimentation skills.			4	23	8	35	4.11	0.583
7	The program is effective in developing data collection, analysis and interpretation abilities.		1	7	20	7	35	3.94	0.725
8	The program enhances the skills for developing performance measures and standards.		4	3	24	4	35	3.80	0.797
9	The program enables to understand technology applications relevant to your field of study.		1	7	19	7	34	3.94	0.736
10	The course offering in the program is adequate to meet students' needs.	2	5	11	1	3	34	3.29	0.031
11	The program enhances time management skills.		3	16	5	1	35	3.40	0.695
12	The program is effective in developing computer knowledge and skills.		1	2	17	15	35	4.14	0.772
13	The program is effective in developing oral and written communication skills.		1	9	18	7	35	3.89	0.758
14	The program is effective in developing presentation skills.			7	16	12	35	4.14	0733
Total		2	18	118	263	87			
Percentage (%)		0.41	3.70	24	53.90	17.80			

Average Mean: 3.84

4.3. Discussion for Table 3: Students professional skills

Based on the survey, 58% of the students agree and 16% strongly agree that the program provides students the professional skills. Item no. 7 and no. 8 shares the largest number of students agree and strongly agree, which means majority of the students total believed that the program is effective in enhancing multi-disciplinary team working abilities and also enhances the ability to participate in projects. Again, this is the positive result expected as the program offers numerous team projects throughout the course, which require students to work and communicate in team or group to successfully accomplish the tasks given.

Table 3: Response to students professional skills

No	Items	Frequency (Score)					N	Mean	Sd
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
1	The program is effective in developing system or process design skills.	1	2	5	19	8	35	3.89	0.932
2	The program contributes in understanding the role of your discipline in the local university.			8	23	4	35	3.89	0.583
3	The program is effective in developing planning abilities.		1	12	20	2	35	3.66	0.639
4	The program is effective in developing the abilities to apply process control and improvement techniques.		3	8	23	1	35	3.63	0.690
5	The program enhances the skills for evaluating the quality and reliability of systems.			10	22	1	33	3.73	0.517
6	The program is effective in developing independent thinking.			9	18	7	34	3.94	0.694
7	The program is effective in enhancing multi-disciplinary team working abilities.			5	18	10	33	4.15	0.667
8	The program enhances the ability to participate in projects.			7	18	10	35	4.09	0.702
9	The program is effective in making students aware of ethical and professional growth.		2	10	18	5	35	3.74	0.780
10	The program enables to continue professional development, self-improvement and life-long learning.			9	20	6	35	3.91	0.658
Total		1	8	84	199	54			
Percentage (%)		0.28	2.30	24	58	16			

Average Mean: 3.84

4.4. Discussion for Table 4: Departmental aspects

Based on the survey, 43% of the students agree and 4% strongly agree on the departmental expects of the program. It means less than 50% of the students either agree or strongly agree to this aspects, which most of the students would like to have neutral opinion. Item no. 1 shows that the numbers of students disagree and strongly disagree exceeding the ones agree and strongly agree. They did not believe that the workload in the program is reasonable and induces a fair level of pressure. This result however is a positive sign which shows that the students were given sufficient works.

Table 4: Response to departmental aspect

No	Items	Frequency (Score)					N	Mean	Sd
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
1	The workload in the program is reasonable and induces a fair level of pressure.	6	6	17	5	-	34	2.62	0.954
2	The academic advising in the program is highly adequate in supporting students' needs.	1	5	17	11	1	35	3.17	0.822
3	The learning environment within the department is challenging and stimulating.		1	20	14	-	35	3.37	0.547
4	The program develops the ability to carry out tasks independently.		1	15	19	-	35	3.51	0.562
5	The program develops the ability to work with individuals from diverse backgrounds.	1		8	24	2	35	3.74	0.701
6	The program administration is effective in supporting learning.	2	1	16	13	2	34	3.35	0.884
7	The quality of support from the administration and staff is adequate.		3	13	16	2	34	3.50	0.749
8	The faculty members within the department are highly accessible.	1	2	14	16	1	34	3.41	0.783
9	The Program helps you to identify your academic strengths and weaknesses.		1	12	16	5	34	3.74	0.751
Total		11	20	132	134	13			
Percentage (%)		3.55	6.45	42.58	43.22	4.19			

Average Mean: 3.38

4.5. Discussion for Table 5: Facility rating

Based on the survey, 26% of the students rated excellent, 10% rated very good and 33% rated good for the facility rating. These ratings show the good level of students satisfaction for the facilities provided. However, majority of students gave poor rating for the sports facilities and parking services, since the sports complex is still under construction and students' vehicle need to be parked outside the industrial campus. But these situations will change once the sports complex and main campus constructions are completed.

Table 5: Response to facilities rating

No	Items	Frequency (Score)					N	Mean	sd
		Poor	Fair	Good	Very Good	Excellent			
1	Computer lab	-	3	6	19	7	35	3.86	0.845
2	Machine shop	2	5	10	11	7	35	3.46	1.146
3	Laboratories	1	2	9	17	6	35	3.71	0.926
4	Support from technical staff	1	6	13	14	1	35	3.23	0.877
5	Secretarial personnel	-	2	19	13	1	35	3.37	0.646
6	Class rooms	2	5	8	14	6	35	3.49	1.121
7	Counseling and advising center	5	7	15	8	-	35	2.74	0.980
8	Library	2	3	13	6	11	35	3.60	1.193
9	Internet access	9	8	10	5	3	35	2.57	1.267
10	Local networking	6	13	6	8	2	35	2.63	1.190
11	Sports facilities	15	5	11	4	-	35	2.11	1.105
12	Housing	6	8	13	8	-	35	2.66	1.027
13	Food services	2	6	21	2	3	34	2.94	0.919
14	Health services	4	3	14	7	7	35	3.29	1.226
15	Parking services	20	8	3	3	1	35	1.77	1.114
16	Security services	3	9	13	7	3	35	2.94	1.083
Total		78	94	184	146	58			
Percentage (%)		13.90	16.79	32.86	26.07	10.36			

Average Mean: 3.02

5. Conclusion

As a result from this analysis, it is discovered that quality of education and the level of preparation of Manufacturing Design Programme is appropriate and at a good level. This analysis enables the Faculty of Manufacturing Engineering to conduct systematic evaluation on the quality of education and the level of preparation particularly for the Manufacturing Design Program based on the graduating students views, in order to verify on arising weaknesses. Thus, the survey provides a great help in assessing the quality of the academic program and to plan future improvement.

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New Development in the Theory of Design of Complex Manufacturing Systems

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Abstract

Manufacturing automation engineering has the main direction - the creation of highly productive automated facilities on base developed technological processes that give high quality of products. The evaluation and predicting of these new machines can be based by the theory of manufacturing productivity. A new analytical approach for calculating the productivity rate and optimization of structure of new automatic machines and automated lines should be developed. This paper describes new analytical dependencies of productivity rate of rotary type automated production lines. Any type of industrial machines have limit of productivity rate due to technical and technological reasons. The mathematical optimization of structural design of complex industrial machines by criterion of maximum productivity rate gives solution to designers. This enables them to calculate the number of stations into automated lines, sections needed in complex industrial machines, etc. The developed equations of productivity rate of rotary type automated production lines enable to solve engineering problems and this result is very useful for experts in different industrial areas.

Keywords: productivity rate**,** rotary type production lines

Introduction

Industrial processes in different areas such as press-works , assembling, liquid filling for different types of container involve very short operation cycle time. It is practically impossible to have further segmentation of the technological processes with the aim of increasing productivity rate of industrial machines [1-3]. The demand to increase machines productivity rate leads to the introduction of parallel machines on one work-bed.

Practically, the design of automated lines of parallel-serial action is executed by two types of structure of automated production line [4, 5]. One of them has a rotor type arrangement (Fig.1) with p parallel and q serial stations structured on a one work-bed machine Rotary principle of work can be used to produce work-pieces in one zone, and that makes it possible to easily build the automatic machine into an automated rotor type line. The application of rotor type automatic machine is especially effective for machining of parts with short operating cycles, and with high frequency of loading and unloading of work-pieces. Fig. 1 presents a sketch of rotor type automated line and it is easy to trace its work process. In the center of the working rotor, which has a continuous transport motion, there are working spindles with tool blocks for fulfilling the assigned operations. During the rotation of working rotor by means of the transport rotor, the work-pieces are pushed into the working positions which are equipped with tool blocks. In zone β_1, the tool approaches the work-piece rapidly and in zone α performs the technological displacement (stamping, drawing, assembling etc.). In zone β_2, the tool is withdrawn. In zone γ, the tool block is located back in the open and initial position. During this time, the finished part is produced, the tool inspected, cleaned or replaced, and a new work-piece loaded. Zone α represents the machining time t_m, and zones β_1 and β_2 represent auxiliary time t_a.

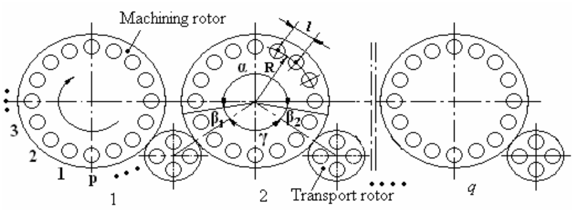

Figure 1. The work structure arrangement of automated lines of parallel-serial action with p parallel stations and q serial ones.

Thus, a rotor type machine is characterized by the fact that the working zones are stationary, and the loading/unloading mechanisms are identical that lead to the easiness and simplicity in creating automatic rotor type lines [6]. An analytical approach in calculating the productivity rate of this type of automated line and optimization of its structure is considered at this paper.

Analytical approach

Rotary automated production lines with complex technological processes can have variable structures based on number of parallel stations and number of serial machines. The structure of such automated lines depends on duration of a cycle of technological process of a part processing, reliability of automated line mechanisms and demanded productivity rate.

Calculations of productivity rate of the rotor type automated lines have certain complexities and currently are made on certain factors which do not consider some characteristics. In the analysis of the productivity rate of the automatic machines of parallel-serial action, it is necessary to consider the influence of all factors involved in the manufacturing process, such as technological parameters of machining process, reliability of production line units and its structure [6]. The known analytical expression of the productivity rate of an automatic machine of the parallel-serial action, Eq. (1), has drawback, i.e. it represents a machine where all operations are accomplished simultaneously without the displacement in time [6].

$$Q_{pq} = \frac{p}{(t_{mo} / q) + t_a + t_{co} + t_{ci}pq}$$

(1)

where Q_{pq} is productivity rate (parts/min) of rotor type automated lines having p parallel stations a

Analysis of the Eq. (7) shows that there is no decision on the optimal number of parallel stations p, because this equation gives negative result.
nd q serial stations; t_{mo} is machining time (min/part) of non segmented technological process of a part machining; t_a is auxiliary time (min/part) of a single station in rotary automated line; t_{co} is an index of productivity rate losses (min/part) due to faults of general mechanisms; t_{ci} - is an index of productivity rate losses (min/part) due to fault of one station mechanisms.
A new analytical expression, Eq. (2), of the productivity rate of the rotor type automatic machine of parallel- serial action has been developed, where operations are accomplished with displacement in time [8].

$$Q_{pq} = \frac{p}{(\frac{t_{mo}}{q} + t_a)(2 - \frac{1}{p}) + t_{co} + t_{ci}pq} \qquad (2)$$

The new formula of productivity rate of the rotor type automated line, Eq. (2), also has mathematical expression that can give the extreme of this function. It means that it is possible to find the optimum values of the two variables p and q of the productivity rate function. In such case it is possible to decide the mathematical task of optimization of the structure of rotor type automated lines [8-11].

The maximum productivity rate of rotary automated lines with optimal number of serial stations q and optimal number of parallel stations p is found by taking the first partial derivatives of Eq. (2) with two variables q an p. Differentiating this equation with first variable q gives

$$\frac{\partial Q_{pq}}{\partial q} = -\left[\left(-\frac{t_{mo}}{q^2}\right)\left(2 - \frac{1}{p}\right) + t_{ci}p\right]p = 0,$$

giving $\left(-\frac{t_{mo}}{q^2}\right)\left(2 - \frac{1}{p}\right) + t_{ci}p \;\; = 0,$

$$q_{opt} = \sqrt{t_{mo}\left(2 - \frac{1}{p}\right) / t_{ci}p} \qquad (3)$$

The expression for maximum productivity rate can be found by substituting Eq. (3) into Eq. (2). After transformation and simplification the equation for maximum productivity of the rotor type automated line gives the next expression:

$$Q_{pq(\max)} = \frac{p}{2\sqrt{t_{ci}pt_{mo}\left(2 - \frac{1}{p}\right) + (t_a + t_t)\left(2 - \frac{1}{p}\right)}}$$

(4)

Similarly, the optimum number of parallel stations p, is derived as below:

$$\frac{\partial Q_{pq}}{\partial p} = \left(\frac{t_{mo}}{q} + t_a\right)\left(2 - \frac{1}{p}\right) + t_{co} + t_{ci}pq -$$
$$p\left[\left(\frac{t_{mo}}{q} + t_a\right)\left(\frac{1}{p^2}\right) + t_{ci}q\right] = 0$$

After transformation and simplification,

$$p_{opt} = \frac{1}{1 + t_{co}\left(\frac{t_{mo}}{q} + t_a\right)} \qquad (5)$$

Analysis of the Eq. (5) shows that there is no decision on the optimal number of parallel stations p, because this equation gives result. that always less of number 1, ($p < 1$)

Productivity rate of a single automatic rotor type machine with one serial station $q = 1$ and p parallel stations can be calculated by modifying Eq. (2), thus

$$Q_p = \frac{p}{(t_{mo} + t_a)\left(2 - \frac{1}{p}\right) + t_{co} + t_{ci}p} \qquad (5)$$

This equation does not have extreme of function. The maximum productivity of this automatic rotor type machine is calculated by taking mathematical limit of Eq. (2), where $p \to \infty$ $\lim_{p\to\infty} Q_p = 1/t_{ci}$. This solution is the same if we were to take the mathematical limit of Eq. (1). It means the limit of productivity rate is restricted by the reliability of machine unit.

Case study

Assume that the rotor type automated line has machining time, $t_{mo} =$ 1 min/part, auxiliary time, t_a = 0.1 min/part, transportation time, t_t = 0.1 min/part, reliability indexes: an index of productivity rate losses due to faults of the general mechanisms, t_{co} = 0.01 min/part; an index of productivity rate losses due to fault of one station mechanisms, t_{ci} = 0.02 min/part.

The productivity rate change as functions of p and q calculated using Eqs. (1) and (2) is shown in Fig. 2. The equations give quite different results, and Eq. (2) gives the accurate result. Errors in calculation are reduced to 15% and depend on the number of parallel stations in automated line. Fig. 2 shows, for the automated line with different number of parallel stations p, with increase in the number of stations p, the productivity rate growth is decelerated and does not give significant effect. Finally, the optimal number of stations p in the automated line should be solved by economical criterions.

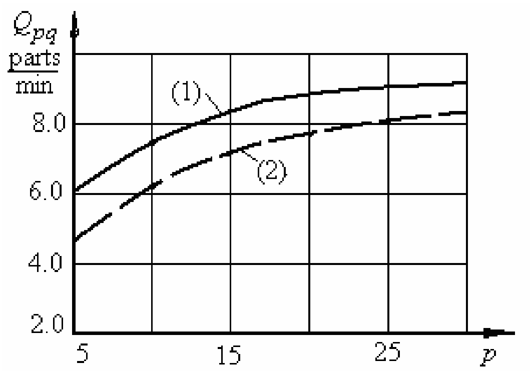

Figure 2. Productivity rate Q_{pq} calculated using Eqs (1), and (2), when the number of serial stations q = 5.

Variations of productivity rate with similar dependencies calculated from Eqs. (1), and (2), for single rotor type machine (q = 1) are shown in Fig. 3. The difference in results of productivity grows with increase in the number parallel stations. This situation is also confirmed by industrial practice on use of rotor type machines.

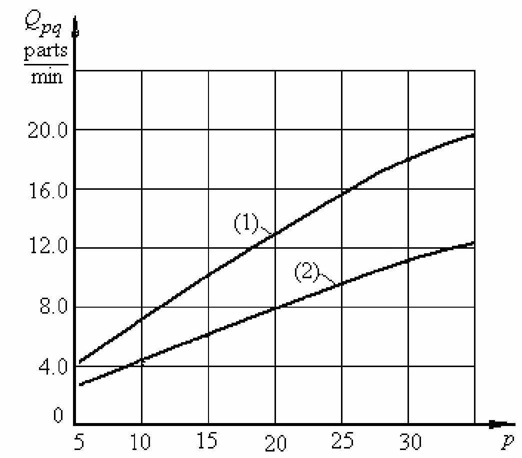

Figure 3. Productivity rate Q_q calculated using Eqs (1), and (2) for single rotor type machine, q = 1.

Increasing the number of parallel stations in automated line leads to some limit (Fig. 2). The rotor type machine has higher productivity rate with large number of parallel stations if compared with automated line (Fig. 3). This means that manufacturers have a choice on type of equipment and this depends on programmed output of products.

Fig. 4 presents productivity rate variations calculated from Eq. (1) and (2) for rotor type automated line of parallel-serial stations. The diagram shows differences in results and productivity rate grows with increase in number of serial stations q at the beginning, reaches its maximum at some number of serial stations and then decreases. Also, there is a tendency that maximum productivity increasing with number of parallel stations p and decreasing with number of serial stations q.

The optimal number of the serial stations q with different numbers of parallel stations p of the automated line calculated from Eq. (2) gives the following results (Table 1):

Table 1. The 0ptimal number of serial stations q for given number of parallel stations p.

Given number parallel stations p	Number serial stations q	
	Calculated	Accepted
2	6.1	6
6	3.9	4
10	3.1	3

For the case with many parallel stations (e.g. the last case in consideration), the higher side is taken since the slope to the right of the optimum point is more gradual compared to the left side, thus giving less error. In the case for small number of parallel stations, the final decision depends on cost considerations (E.g. the first case).

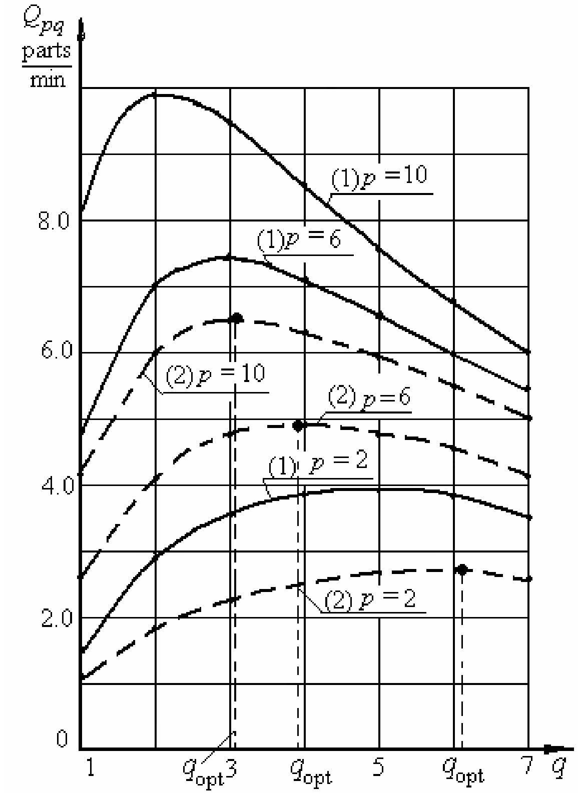

Figure 4 Productivity rate Q_{pq} calculated using Eq. (1) and (2).

Results and discussion

Relevant formulae presented, respectively for productivity rate of rotary automated machine of parallel-serial action, Eq. (2), optimal number of the serial stations, Eq. (3), and maximum productivity rate, Eq. (4) enable the calculation of more trustworthy technical characteristics and their productivity rate as a function of the number of parallel and serial stations. These equations enable evaluation on the variations of productivity of automated line with different structures. It is shown there is no optimal number of parallel stations in rotor type automated line. Single rotor type automated machine gives growth of productivity rate to some limit with increasing number of parallel stations and subsequent increase in the number do not reflect on productivity output of automated line.

Fig. 4 shows some trends, i.e. increasing the number of parallel stations p leads to decrease in the number of serial stations q according to the new formula of productivity rate, Eq. (2). To decrease or increase the number of optimal serial stations $q_{(opt)}$, on one station, when there are large number of parallel stations p, is not dangerous. This is because the new formulae give more desirable plot compared to those presented in [7]. In case initial technical data of rotary productive line is not accurate, results for productivity rate will not differ very much.

Summary

Analytical investigations of productivity rate and influence of technological and technical parameters and their results are still not perfect and cannot give reliable dependencies for designers and manufacturers to produce industrial machines, whose output can be predicted with high guarantee. The main contribution of this research paper is in the development of analytical formulae that give more trustworthy results for calculation of productivity of rotor type automated line as function of parameters of technological processes, reliability of units of production line, number of parallel stations and number of serial station in line.

The formulae for productivity rate of rotor type automated production line, optimal number of serial stations for given number of parallel stations, and maximum productivity of rotor type automated line have been obtained. These will be useful in modeling the output of rotor type automated production line and calculating the economical parameters. The presented formulae for calculation of the productivity rate of rotor type automated line, Eq. (2), the optimal number of serial for given number of parallel stations Eq. (3) and maximum productivity, Eq. (4) allows prediction of more authentic calculations and can be used at the project stage of designing the rotor type of automated lines. The expressions developed in this paper can be used by designers and manufacturers in obtaining optimum solution to productivity rate for rotary-type automated production lines.

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Robot Design : A Case Study of Team Learning Experience and Outcome

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Abstract
This paper discusses competition robotics as an ideal subject for project based education in technology based curricula. Learning through designing, building and operating robots can lead to acquisition of knowledge and skills in high-tech electrical, mechanical and computer engineering areas that are in high demand in industry. Competition robotics can promote development of systems thinking, problem solving, self-study and teamwork skills. Involvement of students in this project to participate in a robot contest among peers can lead to further education and benefits including a focused self-directed learning and research. Through cooperation and the development of professional relationships within and beyond the community, student will develop and strengthen teamwork and communication skills.

Keywords: robotics, robot competition, undergraduate education

1. Introduction
The field of technology education world-wide is undergoing intensive curricular revision to accommodate the contents and practices to meet the requirement of modern technological operations. One of the items that are look into is the project component in engineering the engineering syllabus. Project component is undertaken during the final stage in engineering student education. Many technological educators characterized the project as a model for integrating vocational and academic education. Accordingly, the project carried out would include hands-on experience in vocational workshop, research, problem solving and presenting findings.

The project-oriented education leads to contructivist theory of learning as a counterpart to behavioristic pedagogy [1]. The assumption behind the approach is that knowledge is not passively received neither by sensing nor communicating, but it is actively built up by the cognitive subject. Thus one can be assumed that knowledge and model of the world can be developed in the learner's mind through active engagement to particular processes of designing and experiencing with external artifact. The amount of student participation in the robotic design process is also important factor in the constructivist theory of learning and outlined by MIT's Epistemology Learning Group [2] [3]. Students are supposed to design robots and software in the project as opposed to assembling or simulating a machine designed by someone else. During the design process students will develop their model of the artifacts based on the physics concepts and kinematics modeling in their mind. When fully explored, a robotic based project requires a broad range of skills from basic mechanical design, electronics, programming and artificial intelligence. In many cases, trying incorporate all of these areas is beyond the capability of students and imposes a major burden to lecturers. Thus projects can be designed to focus on specific aspects of overall design with emphasis on integrating such knowledge with other skills by gradually expanding the necessary skills of students. Competition as discussed here is participation in a contest where the product contested requires a series of experimentation to develop. During the competition the students are also exposed to unexpected element where the situation could not have been anticipated. Through this series of experimentations, students are expected to learn how to anticipate the unexpected and cope with unexpected situations. In addition students become naturally motivated to analyze design of opponents, and reflect these design to improve their own design. The skills to be fostered are analysis skill, and skills to apply the acquired knowledge to existing artifacts. Due to the nature on the competition students are extremely motivated to work on the project. In addition the goal of building a team of robot to compete in the competition is a well defined goal that can be visualized in each student mind. A series of workshops can be designed along the way to accomplish the goal, and both teacher and student can be well aware of where they stand in each course.

It has been proven that motivation of students has a major impact in the effectiveness of the educational result [4].
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1.1 Research and Educational Outcome
Thus the primary goal in undertaking the competition robot contest to build a robotic system that could complete the task in a reasonable manner. The main robotic system comprises of a group of automatic robots that can navigate towards set targets in reasonable time during competition environment and act on the objectives using a sets of actuators. The secondary robotic system is made of a remote control robot that is mechanically sound and able to complete the supporting tasks to the main system.

The term reasonable in the primary goals stated can be elaborated as research goals of this exercise and can be phrased into three statements, where the involvement of the institution in the robotic competition will:

Towards Successful Inculcation of Generic Skills: Issues and Strategies

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Abstract

The inculcation of generic skills in higher learning education is one of the efforts to enhance the employability of university graduates. The graduates are expected to acquire both the technology know-how and the generic skills. For Universiti Teknologi Malaysia (UTM), seven attributes of generic skills have been identified, namely Communication, Critical Thinking and Problem Solving, Team-working, Life-long Learning, Entrepreneurship, Ethic and Professional Integrity and Leadership. The objective of this paper is to highlight issues and challenges that could constraint the inculcation of generic skills. Issues such as governance, structural changes and scholarship of teaching are addressed. It is important that the governance of a university is to be in line with the trend of the global challenges. Method of teaching needs be diversified and encourage the adoption of student-centered teaching and learning approach such as active learning, problem-based learning and cooperative learning. Strategies towards successful inculcation of generic skills are proposed such as the structural changes and infusing the element of scholarship in teaching. Conducive and properly maintained teaching and learning facilities should be provided. The above changes need to be properly managed. Issues and strategies discussed in this paper could be used as basis for further elaboration.

Keywords: generic skill; outcome-based-education; change management

1. Introduction

The issue of unemployment among graduates is being associated to the notion that graduates have not adequately acquired employability skill during their studies in universities. The increased in complexity at the workplace and the accelerated pace of technological change demand the graduates to acquire both rapidly advancing technological know-how and the generic skills. The generic skills are characterized as:

- skills/attributes such as problem solving, communication, technology usage and working in teams
- be promoted as contributing to 'life-long learning'
- be advocated by employers and government organizations
- be able to be transferred into contexts different from ones in which they were learned

For Higher Learning Institutions in Malaysia, seven attributes of generic skills has been identified, namely, Communication, Critical Thinking and Problem Solving, Team-working, Life-long learning, Entrepreneurship, Ethic and Professional Integrity and Leadership.

The traditional teaching and learning approaches which are teacher-centered is unable to effectively inculcate generic skills amongst students. An alternative approach is to adopt student-centered teaching and learning approaches. This paper attempts to highlight existing scenarios and issues that could constraint the inculcation of generic skills as provided in Section 2. Some measures towards successful inculcation of the generic skills are then given in Section 3. Section 4 highlights challenges in managing changes. Section 5 concludes the paper.

2. Issues and existing scenarios

This section discusses selected issues that need to be addressed towards successful inculcation of the generic skills. Examples of existing scenarios are also highlighted.

2.1. Governance

A typical governing structure of a university can be divided into system level, institutional level and faculty level. The University Board of Directors is the governing board which overseas policy matters. The operational matters are being coordinated through various functional committees namely, Executive Committee, Finance Committee, Tender Committee, Quality Council, Committee for Integrity of Management, Internal Audit and Corporate Planning among others. The executive functions can be divided into: (i) Academic and International Affairs, (ii) Students and Alumni Affairs and (iii) Development, and Innovation. The academic matters is governed through the Senate which comprises members representing various heads of faculties and appointed members. At the faculty level, the Academic Committee has the highest authority related to academic matters.

In general, public universities are well governed. However, some aspects of governances need to be rectified to facilitate the inculcation of the generic skills among students. The following are some of the governing issues that need to be revisited:

- The bureaucratic management style which are inclined towards satisfying the procedures constraints have negatively hampered effective implementation of generic skills (GS). Long and redundant process for approval has contributed to delays and frustration among academics. All related and outdated procedures need to be reengineered.

- The organization structure which is still heavily centralized for decision making also demand attention. These could be achieved by decentralizing the decision making process particularly related to operational matters.

- There is a need to established web portal, newsletters, publicity materials to disseminate and increase awareness. Perhaps banners or bunting need to be put around the campus to create awareness on the implementation of generic skill.

2.2. Policy, mission and vision

Policy on GS needs to be established and communicated to all staff. This includes the GS mission, vision and procedures to guide the activities during the implementation. From our observation, existing implementation still lacking in standardization and integration.

2.3. Academic programs and curriculum

The globalization of higher education demand rapid response. Scott [1] noted that if they do not response appropriately, their very existence is threatened. He suggested that two approaches for higher education to respond: (i) Move into flexible learning (ii) Use more on-line learning. As such, the academic programs and curriculum need to be regularly revised to suit the existing and projected expectation of the industry. Outcome-based education (OBE) should be given due attention.

2.4. Academic monitoring system

Some lecturers are inculcating the generic skills on volunteering and ad hoc basic. To facilitate and coordinate the GS implementation, it seems necessary to establish a formal coordinating unit at the faculty or department level. The academic monitoring framework also needs to be in-place. Periodical monitoring is necessary to ensure remedial action could be timely taken. The implementation of current academic monitoring system through OMR provides the feedback to lecturers much later after the semester finish. The electronic feedback system should be fully exploited to provide speedy feedback. There is also a need to establish a monitoring system which leads to documented evidence on the achievement of graduate attributes

2.5. Reward and recognition

The reward and recognition system is already in-place for many high learning institutions such as through the Annual Award and Recognition Day (Hari Kualiti). Various awards are given such as awards for research, consultation, sports, publication, social services, quality awards, and excellent service award among others. In the case of UTM, the recently introduced “Anugerah Pengajar Terbaik” is commendable and it is in-line with the goal to enhance quality of teaching in UTM. The authors believe that the impact of the existing reward and recognition system can be further improved by implementing the following:

(i) The number of rewards needs to be increased considering UTM is a very big organization. There are many who qualified for excellent service awards, but they are excluded form the list due to quota which limits the number of awards. It is importance to acknowledge the contribution of every good performer.

(ii) In addition to the centralized reward and recognition ceremony, it would be good if such ceremony could also be held at faculty level. This may give more impact when everyone in the faculty gets involved.

2.6. Resources

Proper and conducive learning and teaching environment are crucial for effective delivery of outcome-based education and generic skills inculcation. Sufficient funds need to be allocated for upgrading and maintaining the physical and information structures.

a) Teaching and learning facilities - Infrastructure and information structure

Based on our observation, most of the existing teaching and learning facilities need to be upgraded to support the implementation of outcome-based education. Most of the classrooms were designed for traditional lecturer-cantered learning environment. The chairs and tables were arranged in rows sequentially which is not conducive for group discussion. Many of the classrooms do not have audio-video facilities and connection to internet. Quite often lecturers have to self carried their lab top computers and LCD to classes. This is time consuming and ineffective practice.

b) Supporting facilities – Residential colleagues, library, resource centers

It is acknowledged that UTM has well equipped centralized main library, common hall, and residential hostels. However, these facilities were designed without considering the needs and requirements of out-come based education. It is still insufficient places for group discussion at library or within residential colleagues. The operating hours of library need to be revised to provide more time for students to use facilities for group discussion and searching for references. Localized resource centers should be established at all faculties for easy and quick access to reference materials.

c) Maintenance system

Having an effective maintenance system is a prerequisite for achieving conducive teaching and learning environment. It is not too extreme to say that many of maintenance activities are done based on ceremonial and breakdown maintenance. There were occasions where the centralized air-conditioning system is not functioning as expected during classes. The cleanliness of the classrooms also needs to be maintained at all the time.

UTM has large numbers of well-equipped teaching laboratories. However, some of the facilities and equipment in the laboratories need to be maintained and upgraded.

d) Security and safety

Theft and lost of valuables items have been rampant recently. It seems that the culprits were easily intruded into lecturers' rooms and academic buildings. It also has become a concern among staff and students on the safety of their motorcycles and cars. If the trend continues unchecked, the implementation activities towards achieving generic skill may be fruitless. Students and staff need to have peace in their mind to fully focus on teaching and learning activities.

2.7. Quality of teaching

Quality of teaching refers to how good the teaching is and how students can benefit from a particular course. Teaching is not just as tools and techniques but as serious intellectual work. It is not only transmitting knowledge, but transforming and extending it as well.

To evaluate the quality of teaching, ideally the university should asses the staff subject knowledge, pedagogical knowledge, commitment to growth as an educator and involvement in educational research and development. How well the faculty member's teaching can motivate students to learn and promote their acquisition of desired knowledge, skills and attitudes. A system to manage teaching profiles and portfolios can be useful.

3. Strategies for implementation

Some of the possible actions have been presented while discussing the issues and existing scenarios in Section 2. This section provides further suggestions on possible changes necessary for effective implementation of the general skills.

3.1. Physical facilities

As noted earlier physical resources are very important to perform activities towards achieving generic skills. The teaching and learning facilities are to provide conducing and stimulating learning environment to students and lecturers. Broadly the physical facilities can be further divided into:

- Infrastructure
- Information structure.
- Supporting facilities

The OBE/GS implementation demands the students and lecturers to be provided with total conducive teaching and learning environment, easy movement between academic centers, information structure which are accessible anywhere and anytime, and "save and secure" learning environment.

a) Infrastructure

Fig. 1 shows some basic infrastructure needed. The provision of total conducive learning and teaching environment is crucial.

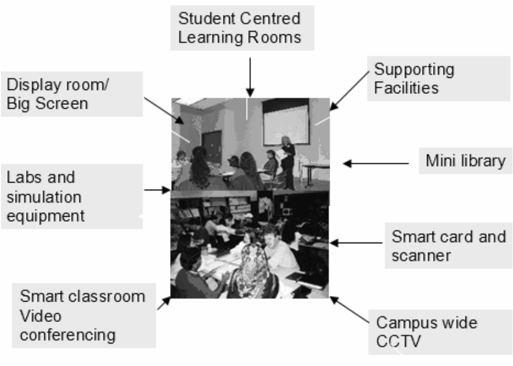


Fig. 1. Infrastructure facilities

The provision of conducive infrastructure is a must for generic skill to be effectively inculcated. It is expected that by year 2012 student centered learning (SCL) classrooms to be common features on campus. The SCL Rooms are to be provided for all faculties and equipped with round table and U-shape tables. Other facilities needed are: (i) display room equipped with Big Screen (ii) well equipped laboratories and simulation equipment (ii) smart classroom (iv) video conferencing facilities (v) smart card and scanner to monitor student and staff movement (vi) decentralized mini libraries at faculties, department and residential colleagues (vii) ICT facilities (viii) campus wide CCTV facilities to provide safe and secured learning environment.

b) Information structure

Reliable information structure needs to be provided. Hot spots should be installed at strategic places throughout campuses. Other facilities are (i) high speed broad band highway, (ii) well equipped resource centre with ICT facilities, digital library, books, computers, and audio – video, (iii) video streaming equipment (for self administered on-line learning). The students and computer ratio has to be improved to acceptable ratio.

Besides providing world class infrastructure, the university also needs to establish reliable and competent support staff to operate and service the campus-wide info structure. The objective must be set to achieve zero breakdowns in the computer network. The office of students' affairs should also coordinate with financing body to enable each student to own at a lap top or desk top.

c) Supporting facilities

Supporting facilities also need to be upgraded. The cafeteria, hostels, library are to be provide with more round tables for students discussion. Students' activity rooms and other areas are to be equipped with discussion tables. Personal lockers are to be provided to students to minimize their necessity to carry heavy bags and to facilitate their movements between activities. This may minimize the need for students to travel back and forth to their residential colleges between classes.

It is also necessary to provide reliable transportation service to ferry students between residential colleges to faculty and academic centers. The bus system must operate according to specified timetables and students should be able to move between academic centers without too much delay and wasteful waiting. To avoid congestion and delay on arrivals for classes or meeting, the bus route also need to be studied. Bad practices among bus drivers, such as stopping at non designated stops can cause traffic congestion at certain road sections.

Related aspects to the above issues are maintenance system, safety and security. Student must feel they are in "safe and secure learning environment". This could be realized through installation of CCTV campus wide, in addition to surveillance by security guards.

3.2. Nurturing scholarship of teaching

To promote the scholarship of teaching, the followings are suggested:

a) To encourage international networking

b) Continuous training on contemporary teaching and learning tools and techniques. We need to conduct courses like train the trainer so that champions of the subjects can produce more champions.

c) To organize more academic colloquiums where every lecturer has the chance to present their recent findings and also the forefront research ideas.

d) To promote high impact research that is internationally recognized trough publication in international journals.

e) To reform the existing annual appraisal system so that it will emphasis more on quality rather than merely on quantity.

f) To formulate and clearly communicate key performance indices to every staff

3.3. Revision of academic program and curriculum

The academic programs and their respective curriculums are the most important references in delivering the teaching and learning activities. The curriculum must be designed with an aim to equip graduates with both soft and hard skills. The academic programs should consider to incorporate the following characteristics:

- They are immediately relevant to background, abilities, needs, and experiences of the students concerned and are delivered by staff who are accessible, responsive, up-to-date, and effective teacher.

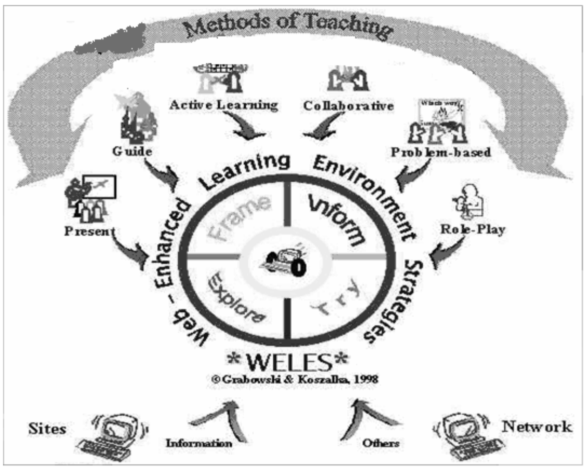
- They provide more opportunities for active learning with frequent opportunities for students to work in groups.

- To constantly link theory and practice, perhaps through guided practice-based learning opportunities, real-life learning, and work-placement.

- Provide students the opportunity to pursue flexible learning pathways

3.4. Methods of teaching and assessment

Good and balanced curriculum need to be coupled with appropriate teaching technique. Studies have suggested that incorporation of active learning, problem-based learning and cooperative learning can resulted in graduates having good generic skill. Fig. 2 shows the web-enhanced learning environment. Such techniques promote the student-centered environment as opposed to teacher-centered. The method of assessment also needs to be aligned with the new approach in teaching and learning.



Source: Grabowski and Koszalka (1998)

Fig. 2. Methods of teaching [2]

4. Challenges in managing change

The above discussion shows that changes are inevitable. Probably the most challenging task for the university administrators in generic skill inculcation is how to manage the change.

4.1. Resistance to change

Change is a complex event that cannot just happened but must be led by the managers to ensure the academics can accept and commit to the change. The heads have the responsibility to facilitate and enable change. They must anticipate the reactions from their staffs so that they can take it in an open heart and manage these situations rationally. Patience and tolerance is required. Communication is an important tool to accomplish the change process. The academics should be communicated the reasons and the directions of the new change, so that they will share the same information and vision. All queries regarding the implementation of inculcating generic skills in teaching and learning should be entertained objectively by the administrators.

4.2. Dealing with resistance

Resistance has been major constraint in managing change. Different approaches can be used to overcome these resistances as shown in Fig. 3. Proper strategy need to be adopted in managing changes.

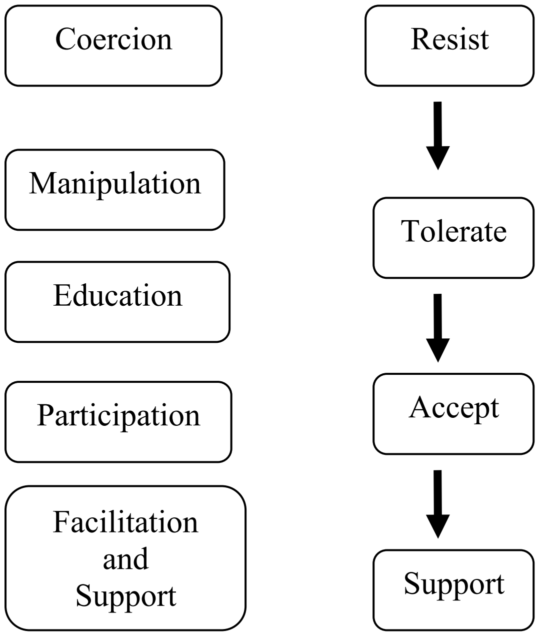


Fig. 3. Approach to overcome resistance [3]

5. Conclusion

The inculcation of generic skills amongst students requires proper planning and implementation. The traditional teacher-centered learning and teaching need to be replaced by student-centered teaching and learning. Various management issues such as governance, structural changes and scholarship of teaching have been highlighted in this paper. In general the main management issues can be categorized into four main themes which are lack of formal entity to effectively promote the OBE/GS related activities, quality of teaching, quality of program and existing facilities are not designed for GS activities. In nurturing the scholarship of teaching, efforts are necessary to improve the quality of the lecturers by promoting doctoral study, encouraging research environment amongst the academics as well as provides necessary trainings for them. Academics should be encouraged to employ innovative and creative teaching methods such as active and problem based learning. In addition to this, the university must set a proper generic skills steering committee to facilitate the implementation of generic skills. The mission and vision on generic skills implementation need to be formulated and communicated to all staff. The management is responsible to ensure the appropriate facilities are available. The effort to inculcate generic skills must therefore be an integrated approach and involving all parties in the university. Continuous monitoring and improvement must be implemented.

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