TEAM-BASED ELECTRONIC PORTFOLIO AS AN ASSESSMENT OF AND FOR LEARNING OF ORDINARY DIFFERENTIAL EQUATIONS

by

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PORTFOLIO ELEKTRONIK BERPASUKAN SEBAGAI SUATU PENTAKSIRAN TENTANG DAN UNTUK PEMBELAJARAN PERSAMAAN PEMBEZAAN BIASA

oleh

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Tesis yang diserahkan untuk
memenuhi keperluan bagi
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LIST OF ABBREVIATIONS

ABET	Accreditation Board for Engineering and Technology
BEM	Board of Engineers Malaysia
CD	Compact Disc
CIP	Continuous Improvement Process
CLO	Course Learning Outcome
DE	Differential Equations
ECET	Electrical and Computer Engineering Technology
EAC	Engineering Accreditation Council
ECPD	Engineers' Council for Professional Development
E-DELP	Electronic Differential Equations Learning Portfolio
EEE	Electrical and Electronic Engineering
IBO	International Baccalaureate
IHL	Institutions of Higher Learning
MQA	Malaysian Qualifications Agency
MQAA	Malaysian Qualifications Agency Act
NCCA	National Council for Curriculum and assessment
NCEES	National Council of State Boards of Engineering Examiners
OBE	Outcome-Based Education
ODE	Ordinary Differential Equations
PO	Program Outcome
PEO	Program Educational Objective
UTP	Universiti Teknologi PETRONAS
TAC	Technology Accreditation Commission
WA	Washington Accord

POTFOLIO ELEKTRONIK BERPASUKAN SEBAGAI SUATU PENTAKSIRAN TENTANG DAN UNTUK PEMBELAJARAN PERSAMAAN PEMBEZAAN BIASA

ABSTRAK

Dengan had kemampuan pentaksiran pembelajaran kaedah tradisional dan wujudnya keperluan pendidikan berasaskan hasil yang memerlukan bukti-bukti kukoh hasil pembelajaran, suatu kajian dijalankan menggunakan potfolio elektronik berpasukan sebagai suatu pentaksiran tentang dan untuk pembelajaran Persamaan Pembezaan Biasa. Kajian melibatkan 242 mahasiswa kejuruteraan di sebuah universiti swasta di Perak, di mana sebilangan besarnya terdiri dari pelajar Malaysia dan sebilangan kecilnya merupakan pelajar antarabangsa. Pentaksiran potfolio elektronik dikendalikan sebagai suatu projek berpasukan untuk memberi suatu senario di tempat kerja dengan masalah situasi kehidupan sebenar. Objektif kajian adalah untuk mengukur kemahiran kognitif, psikomotor dan afektif dalam pengajaran dan pembelajaran Persamaan Pembezaan Biasa dengan kaedah potfolio elektronik berpasukan, untuk mengetahui sikap pelajar terhadap integrasi potfolio elektronik berpasukan dan untuk memberi laporan keberkesanan pedagogi potfolio elektronik berpasukan sebagai suatu pentaksiran tentang dan untuk pembelajaran. Berpandukan arahan dan rubrik pemarkahan berkriteria, setiap pasukan menggunakan kemahiran sedia ada dan yang baru diperlolehi dalam pembinaan suatu potfolio elektronik yang mengandungi empat komponen bersama-sama ahli sepasukan dalam jangka masa yang ditetapkan untuk menghasilkan suatu Potfolio Elektronik Persamaan Pembezaan Berpasukan yang unik. Bagi memastikan pengagihan markah secara adil dan untuk mengelakkan sebarang cubaan mengambil kesempatan secara percuma dalam sesuatu projek berpasukan, setiap ahli pasukan dikehendaki membuat pentaksiran bagi rakan sepasukan. Instrumen yang berbeza;, pentaksiran potfolio elektronik berpasukan, pentaksiran rakan sepasukan, penilaian dan penyampaian kursus oleh pelajar, imbasan semula pengalaman pembelajaran, penyelesaikan masalah secara lisan, temuduga, penarafan potfolio elektronik, soal-selidik, temuduga kumpulan sasaran, ujian pra dan pasca, penilaian berterusan dan sumatif digunakan untuk pengumpulan data. Bagi perwakilan grafik dan analisis data kuantitatif, penyelidik menggunakan Microsoft EXCEL dan SPSS versi 11.5, dan untuk analisis data kualitatif, NVivo versi 8 digunakan. Hasil kajian menunjukkan kemahiran bekerja berpasukan kukuh, kreatif, kemampuan meluahkan pendapat dan memberi cadangan, penghargaan tentang aplikasi kursus dalam situasi kehidupan sebenar, memahami tujuan pembelajaran, mempunyai keyakinan dan motivasi dalam pembelajaran kursus, serta peningkatan prestasi yang ketara dalam kemahiran penyelesaikan masalah aplikasi Persamaan Pembezaan Biasa. Hasil kerja pelajar-pelajar menunjukkan suatu spektrum kemahiran teknikal dan bukan teknikal seperti peningkatan ketara dalam kemahiran menyelesaikan masalah aplikasi Persamaan Pembezaan Biasa, kemahiran berkomputer, komunikasi, persembahan, kerja berpasukan, kebolehan membimbing, kepimpinan dan organisasi. Imbasan semula pengalaman pembelajaran oleh pelajar dan pendapat yang kritikal terhadap kursus merupakan maklum balas tak ternilai demi peningkatan kualiti berterusan. Jelas pelaksanaan potfolio elektronik berpasukan diterima baik walaupun ianya suatu yang baharu kerana bagi pelajar, ianya menimbulkan keseronokan dalam pembelajaran dan merupakan persediaan asas yang penting bagi menjanakan tenaga kerja kejuruteraan di masa hadapan.

TEAM-BASED ELECTRONIC PORTFOLIO AS AN ASSESSMENT OF AND FOR LEARNING OF ORDINARY DIFFERENTIAL EQUATIONS

ABSTRACT

Due to the limitations of the traditional mode of measuring students learning and inspired by outcome-based education that requires concrete evidence of learning, a study is conducted to employ team-based electronic portfolio as an assessment of and for learning of Ordinary Differential Equations. It involves 242 engineering undergraduates at a private university in Perak, with majority Malaysians and a minority international mix. The electronic portfolio assessment is made project-based and team-based, embracing on-the-job scenario with real-life application problems. The objectives of the study are to measure students' cognitive, psychomotor and affective skills using team-based electronic portfolio in the teaching and learning of Ordinary Differential Equations, to discover students' attitude towards the integration of team-based electronic portfolio assessment and to report on the pedagogical efficacy of team-based electronic portfolio as an assessment of and for learning. Guided by instructions and a criterion-based scoring rubric, each team utilises existing and newly-acquired skills necessary in the event of developing a four-component electronic portfolio within a given time frame to create the team's distinctive electronic Differential Equations Learning Portfolio. To ensure fairness and discourage free-riders in the team-based project, each team member is required to assess his or her colleagues. Team-based electronic portfolio assessment, peer assessment, students' evaluation of the course and delivery, reflections of learning experience, interviews, electronic portfolio rating, questionnaire, focus group interview, verbal test on problem-solving, pre and post-tests, continuous and summative tests are used to collect data. For graphical representation and analysis of quantitative data, the researcher uses Microsoft EXCEL and SPSS version 11.5, and for the analysis of the qualitative data, NVIVO version 8 is used. Findings depict strong teamwork, creativity, ability to express opinion and suggestions, appreciation of the course applications in real-life situations, self-confidence and motivation in learning the course, and a significant improvement in problem-solving. The deliverables parade a spectrum of technical and non-technical competencies; problem-solving, computer usage, communication, presentation, teamwork, mentoring, leadership and organization skills. Students' substantial reflections of learning experience and critical thoughts exposed in the course evaluation yield valuable information for continuous quality improvement of the course. The novelty of this research lies in the team-based concept of electronic portfolio implementation and is found favourable although it is new to many, as it accentuates fun in learning and promotes the basic and essential preparation in generating the future engineering workforce.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Under normal circumstances, students spend four years in the undergraduate programs before graduating with an engineering degree from most universities in Malaysia. After graduating many will be looking for jobs. However, unemployment amongst graduates is on the rise in Malaysia and is a growing concern, nationwide. It was reported that "Of 66,000 identified unemployed graduates between October and December 2004, the majority are from the fields of Business Administration (19,000), Computer and IT (9,500) and Engineering (7,500)" (Sibat, 2005,p.4). Further, Sibat mentioned that the Public Services Commission reported in the New Straits Times dated February 22, 2005 that more than 80,000 graduates were unemployed, and one of the main reasons identified was the lack of soft skills amongst the graduates, the inability to express oneself and generally lack communication skills. According to the Department of Statistics Malaysia, the Statistics of the Graduates in the Labour Force Malaysia 2011 has shown that since 2005, the unemployment rate of graduates declined from 3.8% to 3.1% in 2010. In the year 2010, the majority of unemployed graduates were in social sciences, business and law followed by engineering, manufacturing and construction. The Engineering School Directory (2010) listed the top ten qualities of an engineer as: (1) possesses a strong analytical aptitude, (2) shows an attention to detail, (3) has excellent communication skills, (4) takes part in continuing education,(5) is creative, (6) shows an ability to think logically, (7) is mathematically inclined, (8) has good problem solving skills, (9) is a team player, and (10) has excellent technical knowledge.

Apparently, becoming an engineer is not all about acquiring technical skills but soft skills are even more important. How does an engineer acquire those non-technical skills? Kumar and Hsiao (2007) noted that currently, engineers learn leadership and management skills while working, and that certainly is learning soft skills the hard way. It would be much easier for these engineers if they had been trained much earlier, i.e. by learning these skills at the tertiary level before being employed on the job. Engineering programs curriculum at institutions of higher learning is now designed to embed alternative instruments that could appropriately measure the desired soft skills.

Traditional education practices focus on ‘inputs’ (Killen, 2000). According to Rust (2002), limitations of a traditional exam-based approach are clear where students are offered a choice of questions, it may be entirely rational for them to question-spot, revise selectively and think of the subject in terms of a series of discrete topics rather than attempt to develop their understanding of it as a whole, while often all that may actually be being assessed are the students' memorizing and essay-writing skills. This inability to display their knowledge in action, such as the inability to effectively communicate with others will pose potential problems, in terms of employment and employability. It has long been recognised that assessment can support learning as well as measure it (Black & William, 2003). The pencil and paper test is not able to measure student’s ability in explaining or relating in person of their knowledge. According to Fantegrossi (2001), assessment is an important facet of mathematics education, and it is an issue that has been the focus of some debate and is widely believed that traditional pencil-and-paper assessment, which is still the norm, is an inefficient method of measuring what students know and can do. (Serafini, 2001) mentioned that the shift in assessment frameworks from those that emphasize standardized, norm-referenced testing programmes to those that involve more classroom-based assessment reflect the understanding that assessment needs to align more with student-centred curriculum, based on constructivist learning theories.

Clearly, the training provided by the institutions of higher learning (IHL) lack the skills that industries seek for; it is not merely technical skills and competencies but also non-technical skills namely communication, management, presentation, teamwork and leadership, amongst others. The education delivery, assessment approaches and quality for such undergraduate programs genuinely require looking into in order to fulfil updated job demands. The ninth Malaysia plan 2006 – 2010 published by the Economic Planning Unit, Prime Minister's Department (2006), section 11.55, stated that "The implementation of the school-based assessment system will be accelerated to enable continuous evaluation and support the development of creativity as well as analytical and problem-solving skills". In section 11.61 of the same source, it was noted that to enhance quality in education in the country, measures will be taken to enhance the quality of public and private institutions of higher education to be at par with world-renowned universities. The planned system has been implemented and it is now apparent that the traditional education system is slowly losing its grip as the engineering programs; nationwide and worldwide, are now geared towards the student centred learning that focuses on learning outcomes; Outcomes-Based Education.

1.1.1 Outcome-Based Education

According to Fitzpatrick (1995) and Furman (1994), Outcomes-Based Education (OBE) is a method of teaching that emphasizes what students can actually do after they are trained. Decisions on teaching and learning are made based on how best to facilitate the desired outcome, which in turn leads to a planning process that is different from traditional educational planning.

Spady (1994) specified 3 goals that drive this approach to creating academic curricula; All students can learn and succeed, but may be not on the same day or in the same way, each success by a student breeds more success, and academic institutions control the conditions of success. OBE is a methodology of curriculum design and teaching that focuses on key questions such as; What should the students learn? What is the motivation for the students to learn it? How can the academic institution and its resources help students learn it? How to determine what the students have learned (assessment)?

According to Spady (1994), OBE involves students in a complete course of learning- from developing their skills in designing to completing a whole process. OBE also identifies higher levels of thinking (e.g. creativity, ability to analyse and synthesize information, ability to plan and organize tasks). Such skills are emphasized especially when students are assigned to organize and work as a community or in teams to propose solutions to problems and market their solutions.

The OBE's instructional planning process is a reverse of that associated with traditional educational planning. Spady (1994) mentioned that the desired learning outcomes are determined first before designing the curriculum, instructional materials and assessments that best support and facilitate the intended outcome for a specific time frame. Being student-centred and focussed on students' abilities, OBE demands teaching and learning approach that is different from the traditional system and thus assessment styles or approaches would consequently be different from that of the pencil and paper approach. The Engineering Accreditation Council (EAC) Malaysia workshop on September 21, 2006, acknowledged that OBE is a process that involves restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of high order learning and mastery rather than accumulation of course credits.

OBE has changed the focus of learning institutions from the content to the learner. In the practices of OBE, the curriculum must be designed to meet the intended learning outcomes. The Course Learning Outcomes (CLOs) must be linked to the Program Outcomes (POs) and the POs in turn must be linked to the Program Educational Objectives (PEOs). In other words, the design of the CLOs must support the POs, while the design of the POs must support the PEOs, which are determined by stakeholders; comprising of sponsors (government or private sectors), alumni, industries, employers, parents and students. There is no one particular method or authoritative model of implementing OBE. It is more a student-centred form of learning where the teacher plays the role of a facilitator and the focus is on students’ acquisition of the required skills. The tools that are used to determine students’ abilities at the end of any course, for example must be able to measure the desired course learning outcomes. Learning outcomes must be observable and measurable, so specific measuring tools must be made available so that psychomotor, affective and cognitive skills can be measured as evidence of student learning.

Willis and Kissane (1995) suggested two techniques for assessing students’ learning outcomes; Standard-referenced assessment (similar to criterion-referenced assessment but with a clearer description of expected performance), and student portfolios documenting their progress. The Electrical Engineering Technology program of the Electrical and Computer Engineering Technology Department of Purdue University, Calumet, for instance, has in place an on-going assessment and continuous improvement plan since the year 1995. As indicated by Sekhar et al (2008), it has since then modified to produce a more refined Continuous Improvement Process (CIP) that was developed and implemented by the Department of Electrical and Computer Engineering Technology (ECET) to embrace and encompass all aspects of OBE conforming to Technology Accreditation Commission / Accreditation Board for Engineering and Technology (TAC/ABET). TAC/ABET’s model is as shown in Figure 1.1.

What is reflected in Figure 1.1 is the ECET Program Assessment Methodology, showing the stakeholders who determine the PEOs, mapped in terms of the POs, which is mapped in terms of the CLOs, closing of the loops at all levels for continuous quality improvement which must be observed for the success of the system. Figure 1.1 also tells us clearly that the assessment tools are the means of measuring the course learning outcomes at the course level, the program outcomes at the program level and the program educational objectives at the professional level, measured years after graduation. Clearly the instruments used to measure the learning outcomes are as important at each level, particularly at the course level in ensuring continuous quality improvement of the graduates produced.

Universities and other IHL, public and private are now embarking on OBE. However, in fulfilling the OBE expectations, the important areas that need revisiting would be the curriculum documentations, delivery styles, assessments and most importantly, how these can be implemented successfully. Amongst these areas, the most difficult being the assessment part for which stakeholders has a great concern.

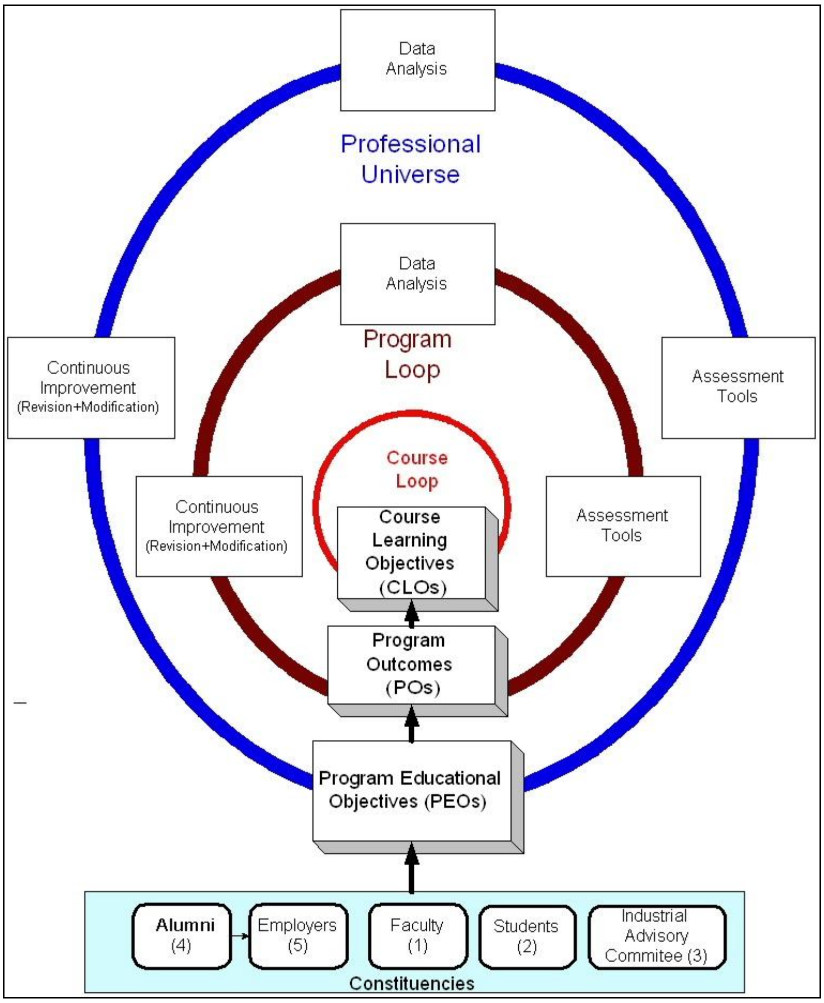

Figure 1.1. ECET program assessment methodology

The issues of assessment in OBE surfaced as stakeholders have confidence in the traditional pencil and paper test taking which measures students' academic performance by considering their ability in test taking which is mainly testing how well they prove themselves on paper. However, in using this traditional summative form of assessment, it is not necessarily true that a technically competent student is able to apply the knowledge that they had gained throughout their years of study at their workplace. The implementation of OBE at any IHL or at tertiary level requires justification. These come in the form of the achievements of the CLOs, POs and PEOs as learning evidences at the course level, program level and at the professional level respectively if the programs were to be recognized by the accreditation bodies locally and abroad in ensuring the quality of programs.

In the UTP (2008) undergraduate program guide to university academic policies and procedures, the Electrical & Electronic Engineering Department, for an example, documented its POs, amongst those being as follows: At the end of the program, the graduates should be able to apply mathematics, physical sciences, and engineering principles in problem identification, formulation and solution in relation to practical situations, and communicate effectively in a variety of professional context as an individual and in a group with the capacity to be a leader or manager and undertake independent study and engage in life-long learning.

1.1.2 Accreditation

Towards this end, the quality of institutions of higher education in Malaysia that offer engineering programs must obtain recognition and approval by the EAC Malaysia, under the umbrella of the Board of Engineers Malaysia (BEM). As such, universities in Malaysia step up efforts in acquiring recognition for all programs that are offered to obtain approval, recognition and accreditation for Engineering and Technology programs by EAC and Malaysian Qualifications Agency (MQA), respectively. The set of requirements for accreditation that are specified by EAC and MQA is benchmarked against those determined by Accreditation Board for Engineering and Technology (ABET) (2008) Inc., the founding member of the multinational Washington Accord (WA).

EAC Malaysia (2009) confirmed that the International Engineering Alliance reported that Malaysia, represented by the BEM, besides thirteen other signatories, officially became a full member of WA in 2009. WA is an agreement signed in 1989 between Australia, Canada, Hong Kong, Ireland, Japan, New Zealand, South Africa, United Kingdom, the United States and Singapore. It recognizes the substantial equivalency of accreditation systems of signatory organizations and the engineering education programs accredited by them and establishes that graduates of programs accredited by the accreditation organizations of each member nation are prepared to practice engineering at the entry level. For international accreditation purposes, WA placed the requirement that EAC must reinforce; the requirement that teaching and learning of all engineering courses must be in line with the OBE in order to fulfil the general criteria for the basic level programs (Engineers Australia, 2008).

In the distributed manual Criteria for Accrediting Engineering programs, effective for evaluations during the 2005-2006 accreditation cycle, that incorporated all changes approved by the ABET Board of Directors as of November 1, 2004, PEOs are defined as broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve, POs are defined as statements that describe what students are expected to know and be able to do upon graduation and CLOs are statements that describe what students should be able to do after going through the course at the end of a learning period of study. The CLOs should contribute to the achievement of the POs. Likewise; the POs should contribute to the achievement of the PEOs. For accreditation purposes, all engineering programs in universities in Malaysia currently, public and private alike, are required by EAC and MQA to implement OBE. The Malaysian Qualifications Agency Act 2007 (MQAA, 2007) stated the assessment of students as the third of the nine areas for its quality evaluation process. MQA (2012) stated that student achievements are measured by learning outcomes. These learning outcomes distinguish the varying competencies as to what a student will be able to do at the end of a period of study. Learning outcomes are based on eight domains: Knowledge; Practical skill; Social skills and responsibilities; Values, attitudes and professionalism; Communication, Leadership and

Team skills; Problem solving and scientific skill; Information management and lifelong learning skill; and Managerial and Entrepreneurial skills. Clearly the learning domains require various measures of students' learning. The benchmarked standards of MQAA (2007) further included that the programme must demonstrate how the component modules contribute to the fulfilment of the programme's learning outcomes, and the programme must show how the student is able to demonstrate the learning outcomes, for example, through summative assessments. In the second stage of a five-stage implementation of OBE curriculum, the learning domains and taxonomy were identified for each learning outcome of a course (Mohd. Zain, 2011). In an EAC Malaysia workshop on September 21, 2006 at Equatorial Hotel, Bangi, Wan Hamidon Wan Badaruzzaman, Chairman for the working group of the EAC (third revised version) manual stressed that a variety of assessments are expected to measure learning outcomes. Apparently, communication skills, verbal and written communication skills top the list of the employers rating of skills/qualities 2002 revealed during the workshop as shown in Table 1.1.

Table 1.1

Employers' Rating of Skills/Qualities 2002

	Skills	**Rating (/ 5)**
1.	Communication (verbal and written)	4.69
2.	Honesty/Integrity	4.59
3.	Teamwork skills	4.54
4.	Interpersonal skills	4.50
5.	Strong work ethics	4.46
6.	Motivation and initiative	4.42
7.	Flexibility/adaptability	4.41
8.	Analytical skills	4.36
9.	Computer skills	4.21
10.	Organisational skills	4.05
11.	Detail oriented	4.00
12.	Leadership skills	3.97
13.	Self-confidence	3.95
14.	Friendly/outgoing personality	3.85
15.	Well-mannered / polite	3.82
16.	Tactfulness	3.75
17.	GPA (3.0 or better)	3.68
18.	Creativity	3.59
19.	Sense of humour	3.25
20.	Entrepreneurial skills/risk taker	3.23

Towards meeting the requirements set by EAC Malaysia (2009), and being a member of WA, IHL in Malaysia now seek for accreditation of programs and Universiti Teknologi PETRONAS (UTP), a private university is one such institution that seeks for such quality continuous improvement.

1.1.3 Differential Equations

Differential Equations (DE) is an undergraduate mathematics course that is taken up by students in branches of science, engineering, biology, life sciences, social sciences, business, economy, and in other disciplines in their first or second undergraduate years.Generally, the DE course is a fundamental mathematics course made compulsory for all students taking up any engineering or in a mathematics major program and assumes the prerequisites; basic Algebra, Trigonometry and Calculus. Students must at least pass all these prerequisites before being able to sit for a DE course. How important is the DE course and what are the various practices of measuring students learning at various IHL? Some benchmarking could perhaps provide an insight into what are the common practices of DE learning, globally.

Ekol (2010) pointed out that DE is studied for various perspectives such as those noted by Braun (1978) and Spiegel (1981). Braun indicated some examples where DE is used to solve real life problems which included diagnosis of diseases and various population growths. Spiegel mentioned that first order and higher order DE has also found numerous applications in problems of mechanics, electric circuits, geometry, biology, chemistry, economics, engineering and rocket science. According to the latest update on February 8, 2012, University of Southampton for instance, has made DE a core course for Masters in Math, BSc Mathematics, BSc Mathematical Studies, Mathematics with Astronomy, Mathematics with Biology, Mathematics with Computer Science, Mathematics with Music, Mathematics with Physics, Mathematics and Modern Language. It is also made compulsory for Mathematics with Actuarial Science, Mathematics with Economics, Mathematics with

Statistics, Mathematics with Finance, Mathematics with Management Sciences and Mathematics with Operational Research. In Texas A&M University (2012), the Ordinary and Partial Differential Equations course MATH611 is made mandatory for the Mathematical Biology Track. For COMSATS Institute of Technology, Islamabad (2009), Ordinary Differential Equations (ODE) course is made a prerequisite for MS in Networks.

In the School of Mathematics, University of Bristol, U.K. for the academic year 2011/2012, the ODE 2 (MAT20101) is described as "The subject of DE is a very important branch of applied mathematics. Many phenomena from physics, biology and engineering may be described using ODE." The assessment method here allocates 100% from a 2½-hour written examination in May/June. In the School of Mathematics and Statistics, Newcastle University, U.K. (2011), the Methods for Solving DE (MAS2105) course offered in year 2011 used the assessment method that was made up of 90% written examination and 10% coursework. DE with Applications with course code MATH210 in Spring 2011at Bryn Mawr College, Pennsylvania are assessed beyond the capacity to solve mathematical problems, where the students are expected to be able to communicate their findings clearly, both verbally and in writing, and to explain the mathematical reasoning behind their conclusions. Assessment methods included weekly homework, class participation and quizzes were worth 25%, a mid-term exam worth 25%, a final project worth 25% and a final exam worth 25%, contributing towards 100% of the entire student evaluation. At the Faculty of Computing, London Metropolitan University, the assessment of DE with course code MA 2031(2011/2012) included in-course test worth 40% and an examination worth 60%.The School of Mathematics Intranet, University of Southampton, UK (2011), DE with course code MATH1052 is core for Masters in Mathematics, BSc Mathematics, BSc Mathematical Studies, Mathematics with Astronomy, Mathematics with Biology, Mathematics with Computer Science, Mathematics with Music, Mathematics with Physics, Mathematics and Modern Language. It is also made compulsory for Mathematics with Actuarial Science, Mathematics with Economics, Mathematics with Statistics, Mathematics with Finance, Mathematics with Management Sciences and Mathematics with Operational Research. The assessment requirements include 70% written examination, 10% class test, 20% coursework. The status of DE with course code MA133, Mathematics Institute (2011) at Warwick Mathematics Institute is as a core course. The assessment included 15% from fortnightly assignments and 85% from a 2 hour examination.

At Monash University, Melbourne (2008), the assessment method for Advanced Method of ODE was based on about 40% problem sheet and 60% final examination. Similarly for Athabasca University, Canada's Open University, where students' learning of ODE , MATH 376, (2010) was based on assignments (40%) and final examination (60%). City University of Hong Kong (2012) indicates that instructors assess Advanced Engineering Mathematics with course code MATH3151, consisting first order and second order ODEs, systems of linear DE, Fourier series, introduction to complex variables and Laplace transforms by allocating 30% for coursework and a 70% for examination with duration of 2 hours, at the end of the semester.

The DE course EAB1113 of UTP (2009) discussed introductory concepts of ODE, series solutions of second order linear equations and Laplace transform and Fourier series. The ODE course is a compulsory common engineering core course that forms the basic requirement for the subsequent higher level engineering mathematics course such as Numerical Methods as well as other engineering courses. The Electrical and Electronic Engineering (EEE) courses in UTP such as Digital and Signals Processing, Signals and Systems and Electromagnetic Theory, for instance depend heavily on a strong basis of acquiring the learning outcomes of the ODE course. Students definitely must acquire the required skills in order to excel in the EEE courses. So far, students doing the ODE course at UTP are evaluated using written tests and quizzes that make up 40% coursework and a 60% written final examination. For engineering mathematics courses in UTP, the pencil and paper type of assessment remains as the main means of assessing students' abilities.

Thus far, the major portion of evaluation of the mathematics courses in eight out of the nine mentioned institutions of higher learning focused on written assessments. While many other IHL employ assignments as project-based, allocating a major assessment measure that depends on written final examination, Bryn Mawr College, Pennsylvania includes quite a different approach to ensure students communication skills are measured verbally and in writing. The following section shows some examples of the stated desired learning outcomes found in five IHL and the respective assessment methods that are used to measure the CLOs.

1.1.4 Measures of Differential Equations Learning Outcomes

Based on the stated desired CLOs, appropriate measures are designed. With regards to the need of identifying learning domains and taxonomy for each learning outcome of each course, and the need of training students for communication skills that are highly rated by stakeholders, assessment techniques of courses must thus be designed as such to fulfil these requirements accordingly. The discussions that follow show some of the practices in four universities, selected at random, mentioning the respective assessment methods that are used to measure the desired CLOs of the DE course.

In City University of Hong Kong, the CLOs of DE are to explain at high levels concepts from DE, transforms and complex variables, to implement basic operations in Fourier series, Laplace transforms and complex variables, to solve first and second order ODE and systems of linear differential equations, to solve DE by series and Laplace transforms, to develop advanced mathematical models through DE, and appropriately apply advanced mathematical and computational methods to a range of problems in engineering involving DE. The assessment strategies include summative assessments; a test, hand-in assignment and an examination, as well as formative assessments. The test consists of questions designed for the first part of the course to see how well the students have learned concepts and techniques of ODE, worth 15-30%. The hand- in assignment is skills-based assessment to see whether the students are familiar with advanced concepts and techniques of ODE, transforms and complex variables and some applications in engineering, worth 0-15%. The examination consists of questions that are designed to see how far students have achieved their intended learning outcomes. Questions will primarily be skills and understanding-based to assess the student's versatility in ODE, transforms and complex variables, worth 70%.The formative assessments are take-home assignments, which provide students with chances to demonstrate their achievements on ODE, transforms and complex variables and their applications in engineering learned in this course, worth 0%. For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

In University of Bristol (2012), MAT20101 is ODE 2 that offers the following Learning Objectives: to formulate ODE and seek understanding of their solutions, either obtained exactly or approximately by analytic or numerical methods, understand the concept of a solution to an initial value problem, and the guarantee of its existence and uniqueness under specific conditions, to identify basic types of solvable DE and understand the features of linear equations in particular, to use geometrical and numerical approaches to investigate equations which are not easily solvable; be familiar with phase plane analysis, be proficient with the notions of linearization, equilibrium, stability; to use the eigenvalue method for autonomous systems on the plane, develop skills in the use of computer tools for the study of DE. The assessment methods making up the final mark for ODE calculation are: 10% from completed problem sets (best 8 of 10), 10% from a course project, and 80% from a 2½-hour written examination. Credit points are gained only by passing the unit, i.e. gaining an assessment mark of 40 or more.

In University of Oslo (2012), the course MAT2440 is DE and Optimal Control Theory stated the Learning Outcomes: to solve ODE both analytically and numerically and an understanding of how such equations are used in modelling, to solve systems of linear

ODE, describe and determine the stability properties of dynamical systems based on ODE, and to solve control problems by means of central mathematical techniques such as calculus of variation and dynamic programming. The instruments used to measure the CLOs are: A minimum requirement of a pass for a compulsory assignment within given deadlines before taking the final exam. The final mark is based on a written examination at the end of the semester. The use of all reference material and cooperation among students are allowed. However, the assignments that students submit must be formulated and written individually and should reflect the students' understanding of the material. Students may be asked to orally defend the content of a mandatory assignment. No specific weightage is provided on the website.

In UTP (2011), EBB1113 (previously known as EAB1113) is ODE and offers the CLOs: to identify DE by its type, order, and linearity, to solve first-order ODE by using the methods of separable, homogeneous equation, exact, linear, integrating factor, and Bernoulli's equation, to solve a second ODE by using the methods of undetermined coefficients, variation of parameters, reduction of order, Euler's equation and power series, to determine the Laplace transform by applying the derivative rules, s-shifting theorem, t-shifting theorem and unit step function and to construct Fourier series. The assessment strategy comprises 20%, tests, 10% written quizzes and10% assignment, making up 40% of the coursework and a 3-hour written final examination contributing 60%. A minimum of 40% score in the final examination must be achieved in order to pass the course.

The variety of approaches in assessing the CLOs of DE course in the respective universities in Hong Kong, England and Norway include a combination of written tests and final examination, verbal tests or presentations, skill-based and project-based using computer skills, take-home individual assignments but with consent of using materials and working with colleagues. Apparently, the use of the traditional written assessment still takes up a major portion of the assessment techniques in all the four universities discussed. However, in

Hong Kong, Bristol and Oslo, there are other assessment approaches such as the skill-based and take-home assignments in City University Hong Kong, problem-based and project-based assessments in Bristol and computer-based assignment and individual oral presentation that are included as a condition before sitting for a final examination in Oslo. In contrast, the practice in UTP is that the traditional individual-based pencil and paper approach is effectively 90%. The traditional pencil and paper test is still commonly used as a measure of Differential Equations CLOs.

1.1.5 Alternative Assessments

Assessment methods that are other than the pencil and paper tests mode of measuring students' learning abilities are termed as alternative assessment methods. National Capital Language Resource Centre, Washington D.C. (2003) reported that alternative assessment uses activities that reveal what students can do with language, emphasizing their strengths instead of their weaknesses. Alternative assessment instruments are not only designed and structured differently from traditional tests, but are also graded or scored differently. Effective alternative assessment relies on observations that are recorded using checklists and rubrics. Smith et al. (1993) studied different performance-based assessment methods such as open-ended questions, mathematical research projects, writing, observations, interviews, enhanced multiple-choice questions, and portfolio assessments and found that all were positive assessments that are in line with conceptual understanding and alternative instruction. Wetzel (2012) listed technology-based alternative assessments such as using student blogs and presentations, while the non-technology-based assessments include those using mental math, creating problems and solving them and lastly using math and science terminology. Prus and Johnson (1994) quoted some indirect measuring methods: survey and questionnaires, exit interviews, archival records and assessment by peers and some direct measuring methods: commercial standardized exams, focus group, portfolios, simulations, performance appraisals, external examiner, oral examinations, behavioural observations, locally developed exams, quizzes, etc. It was also suggested that at least one of the tools for measuring the learning outcomes should be a direct measuring method. According to Gijbels et al. (2008), recent research shows that, as students interpret the demands of the assessment tasks, they vary their approaches to learning in order to cope with the assessment tasks.

1.1.5 (a) Portfolio Assessment

Educators claim that traditional measures fail to assess significant learning outcomes and thereby undermine curriculum, instruction, and policy decisions (Dietel et al., 1991). The Northwest Evaluation Association (Paulson, Paulson & Meyer, 1991) offers a similar defines the portfolio as: A purposeful collection of student work that illustrates efforts, progress, and achievement in one or more areas (over time). The collection must include: student participation in selecting contents, the criteria for selection, the criteria for judging merit, and evidence of student self-reflection (Paulson, Paulson & Meyer, 1991, p. 60). A critical component of an educational portfolio is the learner's reflection on the individual pieces of work (often called "artefacts") as well as an overall reflection on the story that the portfolio tells about the learner. Portfolio assessment is commonly used in teaching training throughout the world, including Malaysia. The National Learning Infrastructure Initiative (Cambridge, 2004) defines the electronic portfolio (e-portfolio) as a collection of authentic and diverse evidence, drawn from a larger archive representing what a person or organization has learned over time on which the person or organization has reflected, and designed for presentation to one or more audiences for a particular rhetorical purpose.

Yeo (2006) conducted a research on portfolio assessment for children with learning disabilities. However, Zubairi et al. (2008), in a study conducted at the International Islamic University or IIUM investigating faculty members competency in the Assessment Practices Inventory, mentioned that amongst 67 assessment items investigated, pencil and paper tests and quizzes are still the most preferred assessment method and alternative assessments such as portfolio assessment is considered one of the difficult items to engage. Wray (2008) mentioned about the efforts in promoting a shift of focus of the current teaching portfolio in the Master of Arts in Teaching or MAT Elementary Certification Program, Montclair State University, from an exit or employment summative type to a formative teaching portfolio requirement.

Portfolio assessment is an alternative assessment method that can provide evidence of learning, in not only skills in the cognitive domain, but also those in psychomotor and affective domains. Besides being a measuring tool of learning, portfolio is also beneficial for accreditation purposes. Developing it electronically can reduce the problem of physical storage. However, preparing a learning electronic portfolio or e-portfolio assessment for an engineering mathematics course such as DE requires specific components that are really necessary and relevant to measure the specified course learning outcomes.

To enhance students understanding of the first order ODE, the researcher assesses students' abilities in solving application problems involving first order ODE by integrating team-based electronic Differential Equations Learning Portfolio (e-DELP) assessment. Using e-DELP, this research in particular focuses on measuring the psychomotor, affective and cognitive skills acquired by students in the process of developing the e-DELP, as well as measuring students' attitude towards the integration of e-DELP as an alternative assessment method in the teaching and learning of ODE amongst students in the engineering discipline and reporting on the pedagogical efficacy of the e-DELP as an assessment of and for learning. The team-based e-DELP is to function as an assessment of and for learning. Stiggins (2002) defines the crucial distinction between assessment of learning and assessment for learning as follows: Assessment of learning is how much students have learnt as of a particular point of time, whilst assessment for learning is how we can use assessment to help students learn more. Figure 1.2 shows the team-based e-portfolio as an assessment of and for learning, adapted from Barrett (2004).

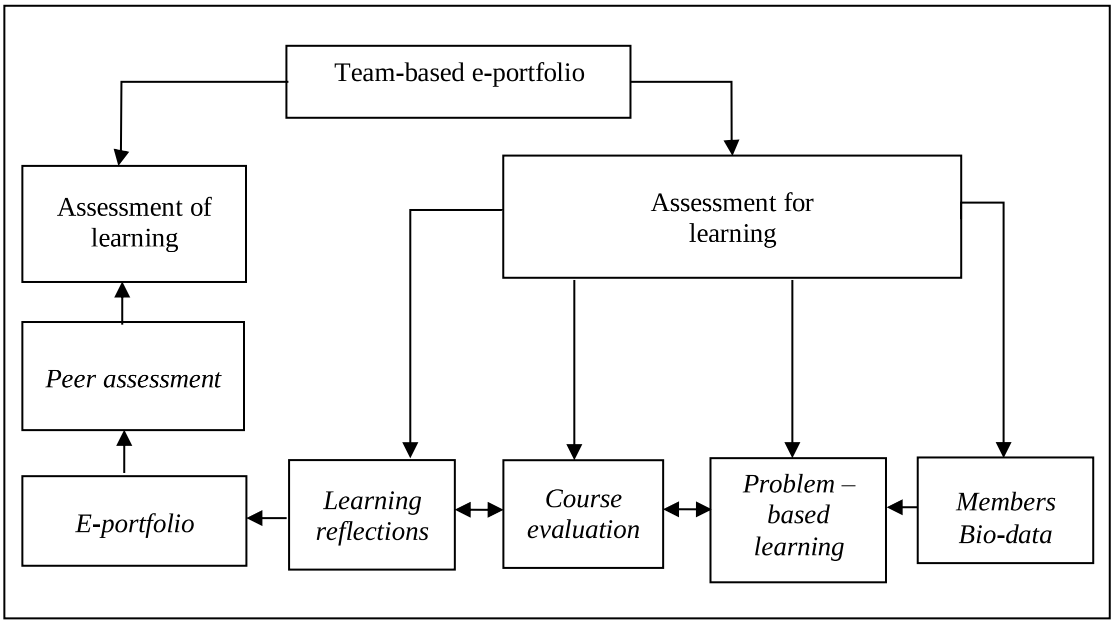

Figure 1.2. Team-based e-portfolio as an assessment of and for learning

The team-based electronic portfolio in this research aims to serve as an assessment of learning by measuring the stated learning outcomes achievement. In presenting and displaying the solutions as team-based effort inevitably requires skills such as teamwork, leadership, time management such as communication, computer and multi-media to make the task work. These non-technical skills which are also skills sought by the accreditation bodies' act as evidence of learning that are supporting the program outcomes.

The major components of the learning portfolio in this research include the following:

1. Students' personal details
2. Problems solving section
3. Students' evaluation of the course and its delivery
4. Students' reflections of learning experience

Being team-based, the individual information of team members is important to provide a sense of ownership of each member in the team responsible for the development of each respective e-DELP. The problem solving section displays the team effort solutions to the application problems involving first order ODE, presented with explanations using relevant software and multimedia. The students' evaluation of the course and delivery is the opportunity given to students to provide critics as useful feedback to the instructors of the strengths and weaknesses of the course conducted and suggestions for improvement. Finally the students' reflections of learning experience forms an avenue for students to voice out their thoughts while developing e-DELP. For the purpose of this research, the team-based electronic portfolio assessment focuses on the scope of application of the learning portfolio between the student and instructor/researcher.

The goal of the team-based electronic portfolio is as an assessment method of and for the learning of ODE. A criterion-based scoring rubric is used to evaluate the deliverables, and the categories for evaluation are determined by the researcher and the subsequent description for award of scores is done online using RubiStar (2006). This scoring rubric for the evaluation of the team-based e-portfolio, showing the criteria for each category is made known to all students at the onset of the study so that they are informed of the evaluation criteria. It is important for students to know how their portfolios will be evaluated because this will affect the construction of their portfolios (Johnson-Taylor, 2006). The students are also informed of the intentions of the team-based e-portfolio assessment; to assess their psychomotor, affective and cognitive skills in the development of the e-portfolio.

1.1.5 (b) Electronic Portfolio Development

In the development of an electronic learning portfolio by participants working in their respective teams, many important abilities contribute in making it a reality. These include abilities to acknowledge team members, getting to know each other, recognizing face and learning names of team members is an important aspect in social activities and working in a team. Another ability is collecting the required and relevant items or artefacts for the construction of the portfolio, the skills in creating an organized presentation of the product using technical and the physical abilities of incorporating audio-visual aspects with the computer, all working buttons and linkages also contribute in featuring an impressive end product that fulfil the required criteria. Other important aspects include cooperation, motivation and leadership qualities while working together in a group to produce the portfolio. Some level of tolerance and leadership is expected for a group of 4 or 5 persons to be able to work together. The ability to express and make constructive comments, individually or collectively is derived from a certain level of commendable confidence. Students also require technical competency in solving the application problems. Without a sound background in the different approaches of problem solving in DE, the students would have difficulties solving the modelling problems. Therefore students need to revisit the methods of solutions for the various types of first order ODE in order to be able to solve the problems. Many studies have found that engineering graduates, even though they solve more than 2,500 exercises in their undergraduate work, lack the essential problem solving skills needed to tackle real world problems (Woods et al., 1997).

The responses with regards to the evaluation of the course and education delivery of the course are structured according to the following: What are the strengths and weaknesses of the course and its delivery? What are your suggestions for improvement? The electronic portfolio in this research is made team-based to propel students in scaffolding their colleagues through the zone of proximal development (as cited in Tharp & Gallimore, 1988). Vygotsky (1978) explained that the distance between the actual development level as determined by individual problem solving and the level of potential development as determined through problem solving under adult guidance or collaboration with more capable peers.

Figure 1.3 also shows the contributing elements in the development of the electronic portfolio as an assessment method adapted from Barrett's Linking Two Dynamic Processes to Promote Deep Learning (2004). Appendices 2 and 3 explicitly show the concept developed by Barrett (2004) that is adapted by the researcher. Appendix 2 describes how the portfolio is linked to promote deep learning, whilst Appendix 3 shows the portfolio as an assessment of and for learning and it is from here that the researcher adapted the e-DELP development process.

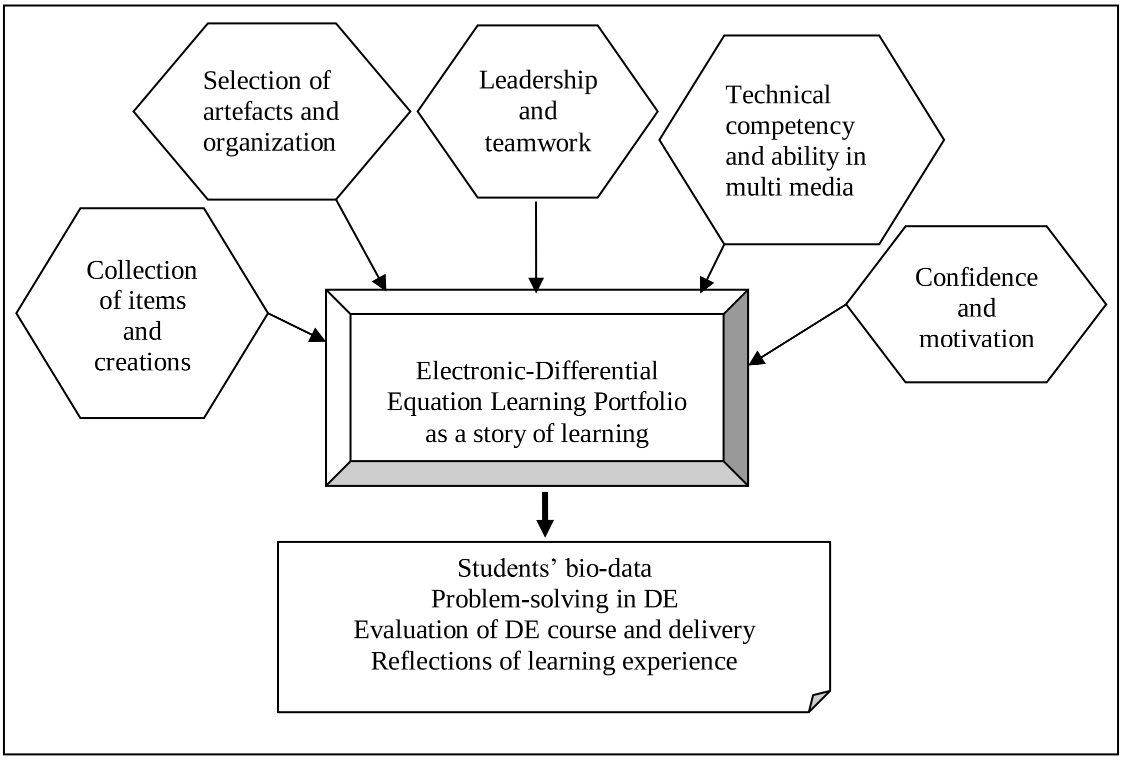

Figure 1.3. Team-based e-DELP development

1.1.5 (c) E-Portfolio as an Assessment of Learning

Assessment of learning is where students are assessed for their skills, knowledge and attitude i.e. cognitive, psychomotor and affective respectively, by using a scoring rubric. It is based on criterion referenced type of assessment. Apart from evaluating the learning portfolio, each student is evaluated on their presentation of their work. Participants' work is assessed as a group and individually measured using criterion-based scoring rubrics. Participants select the works to be included for display and evaluation.

With regards to the e-DELP, the assessment of skills achieved is based on the criteria that encompass skills ranging from problem solving (cognitive), computer (psychomotor) to teamwork and communication (affective). The development of the portfolio is constructed electronically and implemented as a team-based assignment. Reward of scores is done by using the criterion-based scoring rubrics, made known explicitly to students at the onset of the study period.

1.1.5 (d) E-Portfolio as an Assessment for Learning

The Assessment Reform group (2002) formally defined assessment for learning as the following: "Assessment for learning is the process of seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there" (p.2). In this research students are expected to relate their learning experience in two ways; evaluating the course and delivery, and reflecting how the problems were solved. Adapting from linking Two Dynamic Processes to Promote Deep Learning (Barrett, 2004), the reflections of learning provided a means for participants to describe their learning experience in writing, linking the past, present and the future by answering the following questions: "What have we learnt?", "Why did we learn DE?", "How did we learn DE?" and "What can be done to improve our learning?". In this research, the feedback in the forms of their thoughts and feelings are analysed as the assessment for the learning of the course. The communication, teamwork and other soft skills that are entailed amongst the students while developing e-DELP; either coaching peers or learning from peers in doing the problem solving, enhances the process of learning and understanding of the course.

1.2 Problem Statement

Several factors contribute to students having difficulties in doing mathematics. Blai (1975) conducted a study at Harcum Junior College in Pennsylvania and found that 30.5% selected poor study habits; 29.2% selected lack of knowledge and skills; 22.2% selected lack of motivation; and 18.1 % selected poor classroom participation.

As indicated in the curriculum structure in the guide to university academic policies and procedures of the UTP undergraduate program (2008), the courses taken up in the first semester Electrical and Electronic Engineering students, for example are Technical and Professional Writing Skills or Academic Writing, Digital Electronics, Bahasa Kebangsaan, Differential Equations (DE), Circuit Theory and Co-curriculum. Students cannot afford to fail in DE which is the compulsory fundamental core course that is offered in their first semester of undergraduate study. Academic records of the EEE Department of UTP (2007/2008) indicated that an average of 8 – 10 % first semester EEE students failed to make the passing grades for DE. Other courses like Technical and Professional Writing, Digital Electronics, Circuit Theory, taken up by the same cohort of students have 0.2%, 0.7-0.9% and 11% failures, respectively. It reflected that there were more students facing difficulties in Circuit theory and DE courses which were taken in the first semester of their four-year program. Zainal Abidin (2011) recorded a failure rate of slightly more than 13% in January 2009 for the same course among all first semester engineering students. Lack of practice, misunderstanding of concepts and correct steps, poor performance in Calculus and lack of self-motivation are amongst the reasons UTP students claimed to be the reasons for failing the ODE course (Zainal Abidin, 2011). The employment of the traditional pencil and paper test to measure the desired learning outcomes of the DE course; a compulsory core course in many institutions of higher learning for engineering undergraduates, is a common practice, locally and abroad. Students in UTP who experienced difficulties in learning a three credit-hour ODE course, using the pencil and paper tests, confessed that among the problems encountered were due to poor performance in Calculus (a prerequisite course), lack of