International Journal of Soft Computing 8 (1): 1-7, 2013
ISSN: 1816-9503


# E-Learning as an Alternative Mode for Learning Vector Calculus for UKM Engineering Students

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**Abstract:** This study discusses a study on e-Learning as an alternative mode for teaching mathematics for engineering students, focusing on vector calculus as an instance of application. Mastery of mathematics is vital for engineering students. A strong foundation in mathematics is necessary to ensure engineering students mastery of other engineering courses. Difficulties in mastering mathematics often adversely affect the achievement of enginering students academically. Among the mathematics courses, vector calculus stand out as challenging to many students. This study thus covers the strategy of this alternativemode to enable students comprehension and mastery of the vector calculus. Implementation of e-Learning is supported by learning softwares, maths websites, Wiley-Plus® and Hot Potatoes®. The e-Learning mode enabled students to communicate with the lecturer at any time through an interactive facebook. Similarly, the use of wordpress and google.doc enabled students to communicate or access learning materials at any time. Evidently, the method has enabled students to master vector calculus and engineering mathematics, through visualization enabled by the e-Learning tools.

**Key words:** Vector calculus, e-Learning, engineering mathematics, satisfaction level, perception level

## INTRODUCTION

Mathematics is generally regarded as a difficult subject among students at schools or higher learning institutions. It is perceived as complex and threatening by some students despite its important applications in the field of science and technology. Various studies have indicated correlations between students attitudes and their competency in mathematics. Students who are positive to the subject tend to excell not only in mathematics but also in other subjects (Aiken, 1970, 1976; Reyes, 1984).

The corelations between mastery in mathematics and competency in other courses for engineering students such as physics and aeronautics are strong (Morsi, 2006). For students who were positive to mathematics at primary education tend to become competent in the subject. This type of students, upon joining engineering programmes at tertiary level were predisposed to hande enginering courses requiring complex mathematical solutions such as calculus vector and structure courses.

Integrated learning is a blending of e-Learning and conventional learning. The challenges in learning mathematics to students are due to their inability to comprehend the various theories and formulae which they need to visualise and apply in various engineering situations.

Yushau (2006) showed that students attitudinal factors were contributory to their having difficulties in learning mathematics. However, despite such challenges, the teaching of mathematics at engineering faculties must enable students to acquire the level of competency to analyse issues and provide solutions in the engineering field. Quite often, when students failed to master mathematics, they are also likely to fail other engineering courses. Although, there are variance in the applications of vector calculus in mathematics vis a vis engineering courses such as electromagnetic solutions nevertheless for both disciplines, the basis of the application is still subject to ones mastery of fundamental mathematics.

Vector calculus in mathematics consists of various elements which require students ability to visualise a process for example directed emission of head transfer (Zill and Cullen, 2006). Conventional teaching and learning mode via chalk and talk limit students ability to see an occurrence of the process. It also limits tutor-student interaction due to timetables and office hours.

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Hence, this study is therefore to highlight the need to implement e-Learning as a mediator for learning vector calculus to aid students to master the subject. This is similar to an e-Learning strategy for teaching mathematics by Morsi (2006). Morsi's new e-Learning strategy was found to be effective for teaching and learning mathematics for engineering students at the Rose Hulman College in the United States. Students at the UKM Faculty of Engineering and Built Environment had also provided positive feedback on the need for e-Learning mode for mathematics for engineering courses and engineering statistics (Tawil *et al*., 2011; Razali *et al*., 2010).

## VECTOR CALCULUS IN ENGINEERING

Vector calculus is an element of mathematics which is important to support the various mathematical requirements for studying engineering courses. Vector calculus often poses formidable challenges to students due to the demand for them to have a quick mastery of the subject within a 3 months period of semester timetable. The course includes partial differential equations, directed output, depression level, integrals, multiple integrals and Green theorem. These are complex elements, requiring students to both master and accomplish proper selection of techniques for engineering applications. Figure 1 shows the elements for the vector calculus course which students need to master as a prerequisite to attaining competency of its applications in other engineering courses.

There are eight elements required for mastery of vector calculus by engineering students for competency in the various engineering courses. These include electromagnetic, thrust force and et cetera. They are taught over a 14 weeks semester. The duration of a weekly 3 h lecture on the subject is actually short and limited. The challenge being that most of the topics under vector calculus require students to visualise all the concepts learned such as surface plane, surface area, volume and plane drawing. An example (Thomas *et al*., 2009) is the determination of volume through multiple integrals using coordinate cylinder at Eq. 1 whereby students need to be competent to change original values into cubic form to be followed with selection of angles $\phi$ and $\rho$ and radius.

$$\iiint_D f(x, y, z)\,dx\,dy\,dz = \iiint_T f(\rho\cos\phi, \rho\sin\phi, z)\,\rho d\rho d\phi dz \quad (1)$$

Not all students have the capacity to fully understand the topics. Nevertheless, the emphasis on visualization is actually to aid comprehension. Figure 2

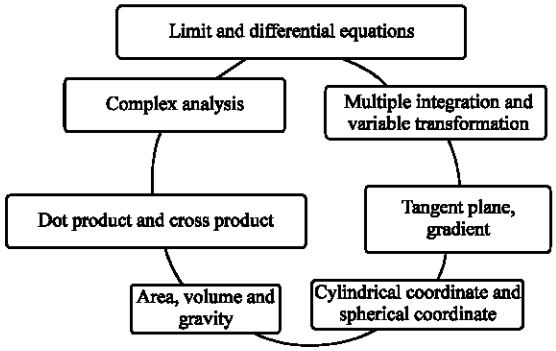


Fig. 1: Elements of vector calculus

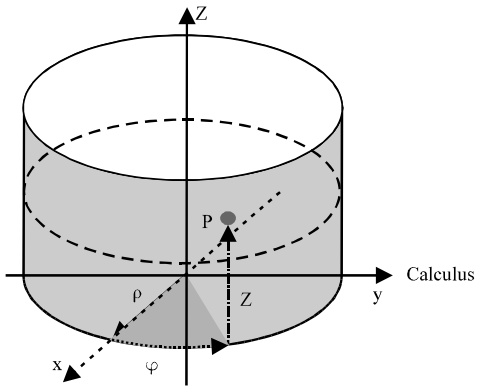


Fig. 2: Visual of solid cylinder volume

shows a cylinder for Eq. 1. For an elecrical engineeering programme, calculus vector is applied in electricity circuit, electromagnetic, systems control, linear and non linear circuits and signal, computer design, microprocessor and computer engineering. For instance, a student need to master the electromagnetic topic such as Faraday law, Ampere law and Gauss law.

To be competent with the electromagnetic laws, it requires an indepth understanding of the results of scalar division and those of the vectors and also partial differences (Ben, 2000). According to Anino *et al*. (2010) on relationship between mathematics and biology for a biological engineering programme at the Universidad Nacional de Entre Rios, Argentina indicated that mathematics does interact with computer and biology in modelling and simulation of human organs and computer-aided surgery. The findings revealed that students who mastered vector calculus and its similarity and differences were able to follow the program well. Being a first and second year foundational course, vector calculus is vital to ensure the students a high level of competency during the beginning years; an to attain higher average grade point to sustain engineering studies.

## E-LEARNING AS AN ALTERNATIVE MEDIATOR FOR LEARNING CALCULUS VECTOR

Astounding advent of the computer and Internet age has seen their extensive applications in various fields of human endevour including education. Rapid development in computer technology and Internet applications has become the platform for e-Learning as contemporary learning initiatives (Liaw *et al*., 2007). e-Learning has been playing a vital role in mediating teaching and learning (Chang and Chen, 2009) other than direct applications in the classroooms, e-Learning is also employed as an extra support to enhance learning of any subject.

Generally, e-Learning is teaching and learning mediated through electronic media inclusive of the internet, extranet, satellite, audio/video discs, interactive TV and CD-ROMS. Specifically, e-Learning refers to the use of Internet technology to convey information for knowlegde enhancement and learning performance (Chang and Chen, 2009). Through e-Learning, students are able to perform various learning tasks in the virtual classroom (Hiltz, 1994; Stefansson, 2004; Veermans and Caserini, 2005; Chang and Chen, 2009). Evidently, e-Learning is an online learning strategy enabling students to access learning materials any time and any place of convenience. It may even be a potentially efficient and cost-effective learning mode (White, 2003).

Acceptance of computer and Internet-mediated teaching and learning mode has not only affected students learning behaviour but also their attitues towards courses; even potentiality as future professionals (Aiken, 1976). This predisposition facilitates the practice of computer and Internet-mediated teaching and learning mode. Several studies have indicated that e-Learning applications in education have positively altered the attitudes of students towards mathematics.

The internet has significantly shifted learning from solely conventional mode to that of virtual learning. Internet-based leaning programme is based on the World Wide Web or www for creative support for meaningful learning (Khan, 1997). Internet enhances access to information, knowledge and skills beyond geographical boundaries, Internet-based learning as mode of lecturer-student interactions at Malaysian higher educational institutions has been advancing rapidly with studies on its efficacy and user competencies have been on the increase.

e-Learning also relates to distance learning, a term brought to the mainstream education when ICT began to be applied to certain courses at higher learning institutions (Cheol, 2003). The American Council on Education, 1996 has defined distance learning as a system and process which link students with outlying sources of learning such as the Internet, computer-based training, sattelites, virtual reality or teleconference. The National Council for Open and Distance Education of Australia, defined distance learning as an integration of various strategies to promote student-centered learning, through an integrated sources and interactive media.

More specifically, distance learning is a just in time learning process whereby leaners are at the right time and place to learn through the Internet in a virtual classroom. Learners can also directly interface with the lecturers online such as through teleconferencing. Therefore, learning occurs without the constraints of conventional classroom and timetable.

## HOT POTATOES®

It is not quite easy to apply Hot Potatoes® as interactive material for mathematics for Hot Potatoes® is more commonly applied for social science applications. Nevertheless it is still applicable for mathematics and science learning. There are five application categories of Hot Potatoes® which can be exploited by the lecturers for engineering students such as JCloze, JMix, JMatch, JCross, JQuiz and The Masher. Each one with ts own disctinctive advantages.

For students at the UKM Faculty of Engineering and Built Environment, drill materials were prepared for use through the Jquiz. Several initial attempts of preparing the mathematics questions met with failures for the software was not compatible for mathematical equations. Finally, it was resolved through conversion of the matematical equations into jpeg format. One hundred questions were prepared for students to do drill exercises. Eventhough, the materials were then available, there were still issues to be resolved. Each time the students attempted the exercise, only ten questions were available and they kept changing with each attempt. This technique required students to key in an ID before questions were issued as shown in Fig. 3.

Other than drills and quizzes, the software could also be used as induction materials to initiate a class discussion or to fill-up the extended learning hours. Softwares such as JCross dan Jclozed could be used as shown in Fig. 4. Students did the crosswords puzzles and matching words to reduce stress and create cheerful athmosphere in the class while learning the challenging mathematics.

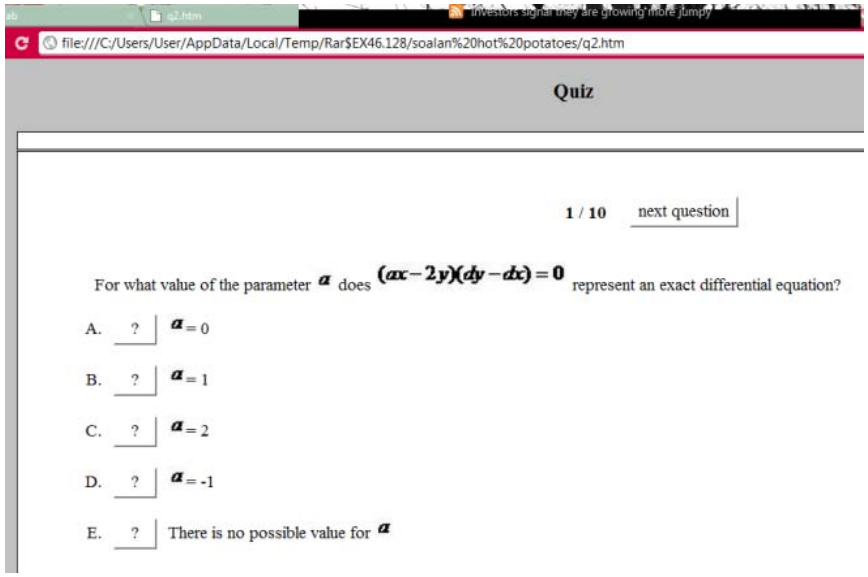


Fig. 3: Drill tasks in JQuiz, Hot Potatoes®

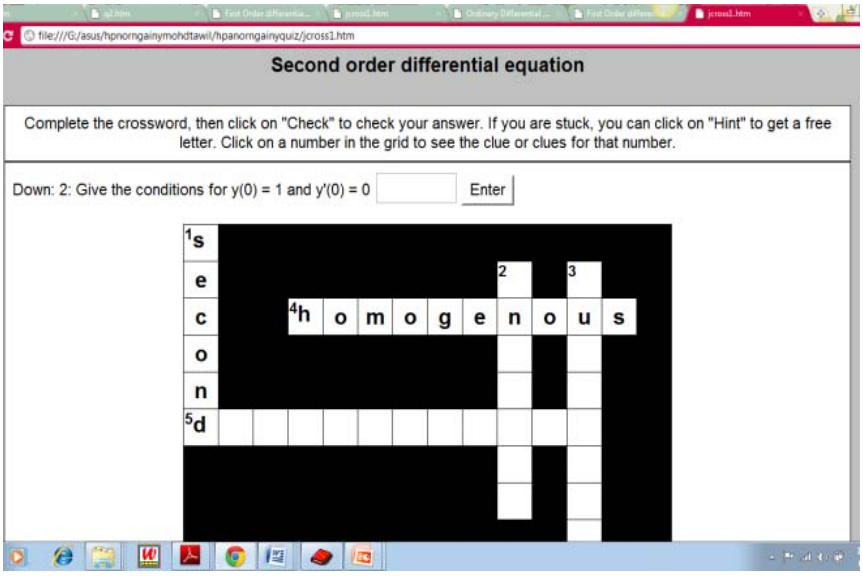


Fig. 4: JCross for induction

## WILEY PLUS®

Wiley-Plus® is a web-based application which helps the lecturers to prepare teaching materials and enable automatic process of assessment and grading. This application enables students to complete tasks online and receive simultaneous feedback. The Wiley-Plus® also contains full texts which facilitates students to make automatic referencing for the task at hand without resorting to conventional textbooks. Hence, the technology provides added advantage to students enabling them to use online notes any time and anywhere. Furthermore, the learning outcome is enhanced for those combining the two modes of conventional and online learning, compared to those who uses only one.

Both lecturers or students can access the Wiley-Plus® account via www.wileyplus.com, Fig. 5 shows a front page of Wiley-Plus®. There are three major components of Wiley-Plus® namely read, study and practice, assignment and gradebook. Read, study and practice enable learners to conduct self-study with the available texts and learning materials on a given topic.


Fig. 5: Wiley-Plus® front page

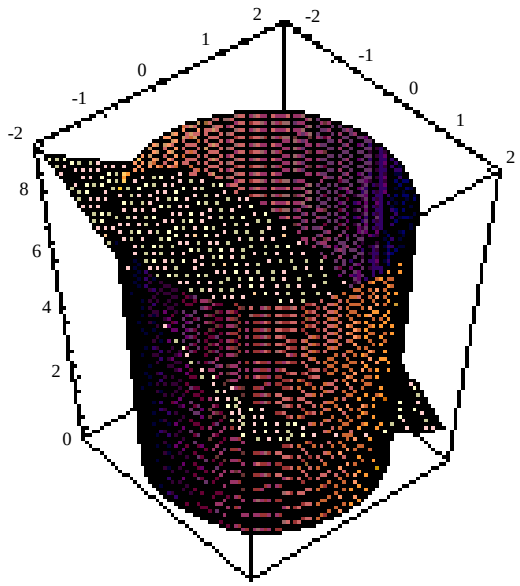

Fig. 6: Visual of solid cylinder delineation by $x^2+y^2 = 4$, $x+y+z = 5$ and $z = 0$

For assignment component, students may view all the tasks specified for them as well as the deadlines. The assignments which could be self-assessed or otherwise are available in various texts and animation. Gradebook is a component in Wiley-Plus® which records students attainment for all the tasks assigned. Students can view marks obtained for their assignments and lecturers can evaluate and determine the difficulty level of the tasks given.

Given the e-Learning diversity of electronic technology and internet-based sources, it could indeed assist engineering students to learn vector calculus more effectively. Studies on the use of various tools such as matematica® have shown how to determine the gravity center of solid cylinder limited by $x^2+y^2 = 4$, plane $x+y+z = 5$ and $z = 0$. Parametric Plot 3D instrutions can be used for the graphic cylinder while the Plot 3D may be used for plane graphics. Two initial lines from the programme provide instruction for graphic items, i.e., output using selection DisplayFunction->Identity. The last line can integrate the cylinder programme and plane by using instruction display and combine the output by using Display Function (Swokowski *et al.*, 1994).

Figure 6 shows a solid cylinder delineated by $x^2+y^2 = 4$, $x+y+z = 5$ and $z = 0$. Observe that the solid bottom is a circular area given as $x^2+y^2 = 4$. Therefore, it is a better option to use coordinate cylinder to evaluate the integrals (Kreyszig, 2006; O'Neil, 2003). Through e-Learning, students could use their creativity to graphically illustrate the outcomes of the e-Learning.

## DISCUSSION AND ANALYSIS

In this study, the students levels of acceptance of the importance and satisfaction of learning vector calculus via the e-Learning are as follows:

**Mean analysis:** The mean analysis on the importance and satisfaction indicated by the 214 students were analysed based on a five-criteria Likert scales, ranging from 1 = less important to 5 = very important as shown in Table 1.

**ANOVA:** The ANOVA test was used to determine the significant difference between the mean for importance and the mean for satisfaction levels. The ANOVA

Table 1: Mean values for students computer usage

| Departments | Experience of using computer |
|---|---|
| JKAS | 4.384 |
| JKMB | 4.066 |
| JKKP | 4.220 |
| JKEES | 4.264 |

hypothesis is $H_O$ is null hypothesis; $H_1$ is at least one difference If F-statistics from the ANOVA table is less than p-value, the null hypothesis cannot be rejected by i refers to student i; p refers to p attribute; n refers to total number of students.

Table 1 shows that all engineering students at their respective departments at the Faculty of Engineering and Built Environent UKM, possessed computer skills with the scores exceeding 4. JKAS with 4.384 was the highest score; followed by JKEES with 4.264. For JKKP, the score was 4.220 and JKMB with 4.066. Overall all departments showed computer skills above 3. This indicated that all students could use computers to do their assignments. The results have shown that most students indicated their level of importance and satisfaction as exceeded 3 as shown in Fig. 2. Nevertheless, there were variance in personal impressions of the students as indicated by the ANOVA analysis which showed p-value at less than $\alpha = 0.05$. This indicated a significance difference between importance and satisfaction across departments. The across departments p-value for importance and satisfaction in using Wiley-Plus® indicated that F-values exceeded p-values. This indicated the necessity and effectiveness of e-Learning for engineering students.

## CONCLUSION

The study has thus revealed that e-Learning has the capability to assist students to master vector calculus. The employment of Wiley-Plus®, Hot Potatoes®, Maple, Mathematica softwares have been effective for clear illustration of cline, tangent, surface areas and volumes. The ability to visualise vector calculus is a basic requirement for determination of solutions to graphic-related problems. Access to learning websites has also aided the students to study outside lecture hours. The mean and ANOVA analyses indicated that the positive attitudes of the students towards e-Learning and high level of satisfaction in its usage. Lecturer-readiness to assist students in the usage of the sofware package and the interactive websites should be enhanced so as to enable the teaching of calculus vector to be highly effective.

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