The Prospect of Teaching and Learning Engineering Mathematical Courses using Learning Tool

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Abstract: Mathematic is often perceived as difficult subject by most students, even from engineering background. However, previous studies have shown that technology has proven to help students learn mathematics in a fun and easy way. In this study, we developed a learning tool with the objective to determine the prospect of learning engineering mathematical courses using an interactive learning tool developed with Maple 2016. We also measure the inclination of using the tool as part of teaching and learning in classroom. There are 40 Students from 2 different classes took part in the study. They are in the fourth semester of engineering program at a selected local university. The process starts by briefing the students on how to use the tool. Students are then answering several questions on a selected topic from vector calculus chapter. Later, they were given a set of two-part questionnaire. The first part was used to investigate the students' perception on the learning tool. The second part was used to evaluate the students' willingness in using the tool in classroom for solving vector calculus problems. While the tool require some improvements, students are likely to use it as part of learning in classroom.
Keywords: Learning tool, Maple, Mathematical Engineering Courses

Introduction

E-learning can be defined in several ways. Almanasreh (2017) defined e-learning as a form of distance learning, where the time and geographical flexibility are preserved. Meanwhile, Rosenberg (2006) defines e-learning as the use of internet technologies to deliver a broad array of solutions that enhance knowledge and performance. Even with slightly different definition of the term, the idea of e-learning in general is to provide a different medium of learning to students, rather than the conventional way of teaching and learning. Studies have shown that e-learning is beneficial and should be part of the current education process. Although it is indisputable that e-learning requires teamwork at all levels in the organization and individual involved (Hussain, 2004). For e-learning to be successful, the environment must be in place, also instructors and students must be ready.

There are many mathematical learning tool developed previously to assist teaching and learning process. Özyurt et al. (2013) developed UZWEBMAT for learning probability subjects, which provides most appropriate environment for students. In addition, UZWEBMAT can be used as well to reinforce traditional classroom education. Abdulameer et al. (2016) on the other hands developed a GUI control system analysis to assist engineering students and practicing engineers using MATLAB. Study by Naidoo & Naidoo (2007) suggested that blended learning can enhances understanding of key concepts in elementary calculus based on their research of implementing computer laboratory teaching environment. There are practically more than that. As simple as using calculator for learning integral (Zakaria & Salleh, 2015). And, there is also other mathematical software available to help student working with complicated problems, such as Maple and Mathematica. Some require a bit of programming skills and some are user friendly. Jono et al. (2016) mentioned that students generally found interactive multimedia is interesting as it captures and holds learners' interests which consequently attract the students to get involved into it. This attractiveness is due to its multi-sensory characteristics in terms of sounds, images and text. In addition, this type of learning tool navigates the students to build their own unique mental structures based on their exploration.

Mathematic, especially calculus is always perceived as a difficult subject. Student with engineering background are believed to possess a sound mathematical basic knowledge in order to succeed in their chosen programme. They also need different skills and abilities in order to construct the solution in multi-step of processes (Adam et al., 2017). But unfortunately, recent survey shows that it is not the case. For a few semesters, high failure rate of a mathematical engineering calculus has been recorded, ranging from 25% to 45% (Noor et al., 2018). The rate is significantly increasing. Among factors that contributed to that high failure rate are poor mathematics background, problems in memorizing formulas, misunderstood concept and mathematics anxieties (Noor et al., 2018). Class absenteeism is also one of the main factors that leads to lack of thorough knowledge of the subject (Prakash et al., 2014). Osman & Pa (2015) have found that students used the universal integrated perspective to interpret the acquisition of mathematical knowledge. However, their understandings of mathematical concepts, process of learning mathematics and proper usage of mathematical ideas are mostly at the surface level, rather than deep understanding. In addition to this, students already have the idea that mathematic as a difficult subject. The difficulties in acquiring the mathematic skills and concepts may deteriorate if the teaching and learning process remain ineffective for the students (Noor et al., 2018).

That has motivated us to the development of this learning tool, specifically on vector calculus topic. The intention is to help student to focus more on analysing the mathematical problem and finding ways to solve it, rather than working on calculation. They of course must possess all the basic knowledge on how the solutions work manually, but with the assistance of that learning tool, learning process can be very enjoyable. The focus of this study is measure the prospect of engaging a learning tool in teaching and learning of mathematical engineering subject. It is done by investigating the students' perceptions towards the learning tool and measuring the readiness of using the learning tool in classroom. Research by Ünal et al. (2014), Anuar et al. (2016), Nasir & Ismail (2016) and Akaslan & Law (2011) shows that instructor and students have some level of readiness in using technology in teaching and learning, across many areas.

Methodology

This study was conducted in 2 years, from the development of the learning tool to analysis of the result. Table 1 shows the research flow of this study. Phase I and II are already completed where the tool was developed using Maple 2016 (Noor et al., 2018). In this study, phase III (a), refers to pre-test, where students were asked to answer a set of questions from vector calculus topic manually. Then in phase III (b), they were introduced to the tool and were given the opportunity to use it by answering the same set of questions previously. Once completed, they were given a link to answer an online survey to evaluate the learning tool.

Table 1. Summary of The Research Flow

		Activities
Phase I	:	Preliminary survey
Phase II	:	Development of the application on each topic of the subject
Phase III	:	a. Pre-test b. Test run the application c. Post-test
Phase IV	:	Analysis

Fig 1 to Fig 4 depicted the interface of the tool. Students are able to answer some questions on gradient, curl and divergent of vector field. As shown in Fig 1, students need to enter the scalar function either in 2 or 3 variables. By pressing the solve-for-gradient, the answer will be displayed at the right hand side column. With certain input values, we can determine the vector field at any particular point. Illustrated in Fig 2 is the interface for solving divergent and curl of a vector field. The solution given, will determine whether a vector field is compressed or incompressible, source or sink, rotational or conservative. The application also allows students to plot the vector field as shown in Fig 3. The image is rotatable by simply moving your curser to view the vector field in a different angle or axis. Besides that, students can also evaluate line integral of a vector field in 2 or 3 variables for moving a particle from one point to another point along a straight line, as described in Fig 4.
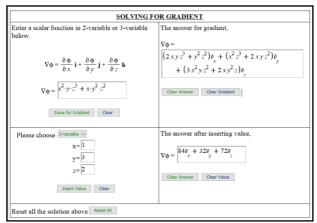

Fig. 1 Interface for solving gradient of function in 3 variables

Fig. 2 Interface for solving divergent and curl for 3-space vector field

Fig. 3 Plotting graph of vector field in 3-space

Fig. 4 Interface for solving line integral

This study used a convenience sampling method where respondents are selected because of their convenient accessibility and proximity to the research. An online survey from was used as the quantitative data collection instrument. The survey contains 3 parts. The first part was to obtain their demographic details. Meanwhile, part two was to investigate the students' perceptions on the learning tool. There are 3 aspects to be evaluated based on perceptions, which are package screen, terminology and system information as well as

perceived usefulness. The last part was to evaluate the students' readiness in utilizing the learning tool in classroom for solving vector calculus problems. Students were also asked to report their perception and readiness for the tool to be implemented in class.

There are a number of measurement instruments available as reported by Ann and Doculan (2016) in assessing the level e-learning of readiness. But in this study, the model used was established by Aydın and Tasci (2005). Akaslan and Law (2011) and also Ünal et al., (2014) adopted this model in their study. This model is adaptable because both e-learning and our learning tool can be considered as instructional content delivered by electronic technology. The survey items were measured based on 5-point Likert scale together with some free text boxes for the students to answer some subjective questions. The Likert scale of 1 being "Very Disagree" and 5 refers to "Very Agree". The model developed by Aydın and Tasci (2005) defines a mean score of less than 3.40 as low level of readiness and requires a lot more work or some work to be done. A mean score in between 3.41 to 4.20 is categorised as a satisfactory level of readiness but requires a few improvement. Meanwhile, a score more than 4.21 shows a very good level of readiness. Thus, based on this model, the anticipated level of readiness for the learning tool to be implemented is with a mean score of 3.41, which was determined by 4 intervals of readiness with 5 levels in Likert scale.

Results and Discussion

A group of 40 students took part in this study. From the survey, it is recorded that 52.5% are male student and 47.5% are female, which is quite common in any Engineering programme that male students are generally larger in number compared to female students. Result shows that 32.5% spend more than 4 hours a day on computer, while 27.5% spend in between 2 to 4 hours. Only 20% of the respondents spend less than 1 hour and in between 1 to 2 hours, respectively. With the amount of hours spend daily on computer; it also reflects their depth knowledge in computer software. 62.5% have fair depth knowledge in computer software, with 15% recorded very good and about 2.5% recorded as excellent. Analysis of the quantitative data was made based on the evaluation criteria as shown in Table 2.

There are three components on finding the students' perceptions on the learning tool, that is 'Package Screen', 'Terminology and System Information' and also the 'Perceived Usefulness'. The mean score for each component, as well as the sub component is shown is Table 1. The grand mean score, $\overline{X}$ for 'Package Screen' is 3.96, indicate that the students are satisfied with screen view but need some improvement. The lowest mean score for subcomponent of 'Package Screen' is 3.88, comes from 'syntax inputs', which is the input box where the students key in the function or vector field. Maple is characters sensitive. Any functions that involve multiplication require students to use asterisk, given by the symbol '*'. For example, to enter a function of $2xyz$, students should enter $2*x*y*z$. The manual of using the learning tool has been given to students prior testing.

The grand score for "Terminology and System Information" is recorded as 3.94, indicates that students are satisfied with some room of improvement. It also shows that the words used and the system data are acceptable and suitable. The subcomponent 'system is suitable for all users' obtained the lowest score that is 3.75. It is undeniable fact that the learning tool is only meant for student taking vector calculus subject. The 'Perceived Usefulness' component recorded a grand mean score of 4.30. It shows that students have good level of readiness. There are a set of questions aimed to measure the students' readiness of using the learning tool in classroom.

Table 2**.** The Survey Mean Score of the Students' Perceptions on the Application

Evaluation Criteria	Mean
Package Screen	
The readability of characters	3.95
The organization of information	4.00
The sequence of actions	3.95
The syntax of inputs	3.88
The display design	4.03
Package Screen $\overline{X}$	3.96
Terminology & System Information	
The prompts for input is clear	4.00
The system is user friendly	3.97
The system speed is fast enough	3.87
The system is suitable for all users	3.75
Terminology & System Information $\overline{X}$	3.94
Perceived Usefulness	
I can easily evaluate the solution for curl and divergence for vector field in 2 dimension	4.25
I can easily evaluate the solution for curl and divergence for vector field in 3 dimension	4.30
I can easily sketch a vector field	4.30
I can easily evaluate the line integral of any vector field along a straight line	4.38
I can accomplish task more quickly	4.25
Perceived Usefulness $\overline{X}$	4.30

Table 3 shows the mean score and grand mean score obtained for the evaluation criteria. Generally, students are satisfied with the learning tool with a grand mean score of 4.11. It is higher than the anticipated mean of 3.41 from the E-learning Readiness Assessment Model. But anyway, the score also indicates that the tool requires a few improvements. It is also recorded that all criteria has mean score that is more than 3.40. A total of 77.5% students agreed to recommend this tool to students from different groups. Also, result shows that more than 50% of the student rated this tool as lower as 8 out of 10. Table 4 lists some of the students' comments on this tool. Comments on 'fast', 'easy', 'convenient', and 'good' appear several times shows that students really enjoy utilizing the tool.

Table 3. The Survey Mean Score of the Students' Readiness on using the Application

Evaluation Criteria	Mean
Learning to operate the tool is easy for me	3.98
I can inquire the tool to do what I want it to do	3.98
The tool is clear and understandable	4.15
The tool is flexible to interact with	3.98
Evaluating curl and divergence is very easy and convenience	4.28

Evaluating gradient of a function is very easy and convenient	4.13
Evaluating line integral for a vector field along a straight line is very easy and convenient	4.23
I believe the tool can increase my understanding in vector calculus	4.15
I believe the tool enables the lecturer to deliver the subject better	4.15
I support the implementation of the tool in classroom	4.15
I am keen to start using the tool in classroom	4.08
I am ready to utilize the tool in solving vector calculus problems.	4.10
Readiness $\overline{\overline{X}}$	4.11

Table 4. Students' Perceptions on the Learning Tool

It is quite hard to use	Good
Helpful but need improvement	Very helpful and functional
needs more troubleshooting, very not user friendly but i am sure it will be useful in future	A software that is helpful in programming mathematical quizzes
Ok if it is used regularly	I prefer lecture
Convenience for students to complete their tasks & exercises.	Very helpful for students who can't determine the curve and etc
Very easy to use	Easy to understand
Need more improvement	fast and easy

Conclusion

This study deals with the evaluation of a learning tool, developed to help students coop with a mathematical engineering subject. The selected topic involved gradient, curl and divergence, plotting vector field and also evaluating line integral across a straight line, which are some sub topics from the chapter vector calculus. The manual calculation of these topics are already complicated, therefore with the help of this tool, student can focus more on understanding the problems. Result from the survey shows that students are ready to use the tool in classroom. Nonetheless, the tool is far from perfect and there are rooms for improvement. Result has also proven that, prospect of using learning this tool in classroom is very promising. It helps increase the students' interest and understanding on the specific topic. The tool can also be used during their independent study. Further study should include measuring the student achievement in tests and examination after utilizing the tool.

Acknowledgement

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