

MODULE FOR LEARNING INTEGRAL CALCULUS WITH MAPLE: LECTURERS' VIEWS

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ABSTRACT

Engineering technology students can attain a meaningful mathematics learning if they are allowed to actively participate in hands-on activities. However, the current dissemination of knowledge in the classroom still focuses on teacher-centered paradigm of teaching. A study to explore lecturers' views regarding a newly developed integral calculus with Maple software module was conducted. Nine lecturers with at least eight years of teaching experience were involved in the evaluation of the module. They were brought to a computer laboratory at the university to evaluate the activities developed in the module using a newly developed manual. Within six hours, they attempted and evaluated the assigned activity in groups. Each of the lecturers wrote his or her comments on the activities, manual and lesson plans booklets. Their comments were qualitatively analyzed to provide a guideline in producing a meaningful module in teaching and learning of integral calculus. From their written comments, there were two main findings obtained. Firstly, they highlighted the importance of giving reflective questions at the end of each subtopic to train the engineering technology students to critically aware about their thinking skills. Secondly, some of the lecturers believed that by giving counter-examples, these students will develop a better conceptual understanding in each newly learnt topic. Apart from these two main findings, other comments were also considered in modifying the manual, lesson plans and set of six integral calculus activities. As a result, a module which emphasized on student-centered learning based on conceptual and procedural understanding and metacognitive awareness teaching approach will be produced. This module will be used to enhance students' procedural and conceptual understanding in learning integral calculus at the university.

Keywords: Integral calculus, Maple software, module, evaluation, engineering technology

INTRODUCTION

Mathematics is a live subject and it is used to solve problems (Thomas & Holton, 2003). Thus, the way to teach the subject by asking students to memorize rules per se is inadequate. For the first six years of schooling, school programs typically regard mathematics as mainly a matter of writing symbols on paper, according to certain set of rules (Davis, 1986). On the other hand, it needs an approach of teaching that can enhance a deep understanding of the concepts underlie in each topic. Deep cognitive understanding can be obtained through a carefully designed teaching that allows students to flexibly cater their pre-knowledge deficiencies and also allows them to do reflection on the concept in different ways (Haripersad, 2011). One reason for these deficiencies is the insufficient means used to disseminate basic concepts to students through classical lecture mode of teaching (Deliktas, 2011). This "one for all" teaching approach most of the time, cannot cater the needs of various types of learning style preferences of students in a big lecture group. On top of that, lecturers have difference preferences in teaching. These circumstances add further complications to students in comprehending newly learnt concept.

In order to gain an insight into students' learning styles at the university involved, a study was conducted prior to the development of a new teaching strategy to teach integral calculus. Students at the university involved in this study are engineering technology students. Therefore the instrument developed by Solomon and Felder for engineering students was chosen as a mean to gather the required information. The instrument adapted is Index of Learning Styles Questionnaire (ILS) 1997 (Felder, 1988, 1993; Felder & Spurlin, 2005; Soloman & Felder, n.d.). The analysis of data obtained gives the following outcomes (Table 1):

Table 1: Engineering Technology Students' Learning Style Analysis

Dimension	Students in every dimension (%)	
A - R	Active	67.47
	Reflective	32.53
S - I	Sensing	50.60
	Intuitive	49.40

VS - VB	Visual	93.98
	Verbal	6.02
SEQ - G	Sequential	55.42
	Global	44.58

The outcomes reveal that engineering technology students at the university involved can be helped to experience a meaningful learning if they are exposed to a certain characteristics of teaching. Specifically, their learning process can be fostered if they are allowed to be actively involved in the process of learning, given an opportunity to explore the hands-on activities of learning, and presented with visual inputs in the linear and sequential manners. In other words, a quality learning experience in a higher education must take into account not only the content but also its dissemination process. From the investigation done, the development of a new strategy was carried out without totally sacrificing the lecture mode of teaching. Instead, the existing lecture mode of teaching practice was enhanced with the advancement of technology in designing a new teaching strategy for integral calculus. In view of that, technology integration approach is adapted in this study.

Technology integration approach uses various activities in the traditional context with computer technology mode of teaching. It combines multiple delivery media which are designed to complement each other to encourage learning. Furthermore, the fast learning process from technology integration benefit students in catching up with the syllabus (Yesilyurt, 2010). In teaching integral calculus, the technology integration approach is designed to include graphical, numerical and analytical presentations of materials during lectures complemented by software applications in tutorial sessions. In this study, Maple software is applied in the teaching and learning integral calculus to foster students' understanding in this topic. Activities are designed to encourage deep learning mindset amongst engineering technology students at the university. Deep learning is defined as examining new facts and ideas critically, tying them into existing cognitive structures and making numerous links between ideas (Houghton, 2004). This definition is similar to what Hiebert and Lefevre (1986) describe as conceptual knowledge. Conceptual knowledge involves a rich network of relationships between pieces of information which allows flexibility in accessing and using the information (Hiebert & Lefevre, 1986). Thus, using technology integration approach, the engineering technology students are able to easily move between listening to lecture, cooperatively work to do the activities using Maple software, involve in class discussion and work individually outside classroom using Maple software as a platform to assess their understanding. With that in mind, the main objective of this research is to evaluate the integral calculus module developed.

METHODOLOGY

A set of a new module to teach integral calculus for engineering technology students at the university was developed. The development of this module was based on APOS theory, where it is the acronym for Action, Process, Object and Schema. This theory is a constructivism theory (Bergsten, 2008; Dubinsky, 2001) and it was developed by Dubinsky based on Piaget's reflective abstraction (Asiala, et al., 1996, 2004; Dubinsky & McDonald, 2001). Piaget's idea was extended to suit the context of college level mathematics. In this theory, the understanding of mathematics concept "...begins with manipulating previously constructed mental or physical objects to form actions; actions are then interiorized to form processes which are then encapsulated to form objects. Objects can be de-encapsulated back to the processes from which they were formed. Finally, actions, processes and objects can be organized in schemas" (Asiala, et al., 1996). This theory suggests that students have to have appropriate mental structures for them to comprehend a given mathematical concept (Maharaj, 2010). In this theory, the mental constructions analysis is known as genetic decomposition of the concept where it describes how the concept is developed in the mind of a student (Asiala, et al., 1996, 2004).

In this study, the module was developed to consist of six parts, which are integral calculus with maple manual, integral calculus notes, lesson plans, integral calculus activities, tutorial questions and exercises. These six parts were developed based on the content of Technical Mathematics 2 at the university involved in this study. In this study, three parts, which are the manual, the lesson plans and the activities, were evaluated by nine lecturers teaching at the university. They were brought to the computer laboratory at the university to try the activities developed using Maple software. The activities were attempted after they went through and evaluated the manual developed. They were asked to work in groups to complete the activities since the activities were developed based on ACE teaching cycle (activities, class discussion and exercises) (Dubinsky & Leron, 1994). Six groups were formed to work on six different activities. Each of them was given six hours to complete the assigned activity. Lecturers who are familiar with Maple software worked individually. However, they were allowed to discuss the activities with members from other groups. Each of them was asked to write comments in order to improve the manual, the lesson plans and the activities developed in teaching and learning integral

calculus. Their comments were qualitatively analyzed to provide a guideline in producing a utility and meaningful manual, lesson plans and set of activities in teaching and learning this topic.

FINDINGS AND DISCUSSION

Lecturer's Profile

Nine lecturers involved are from different fields of expertise (Table 1). Three mathematics lecturers who involved in this study have more than 10 years experience. Two of them have been teaching mathematics for more than 15 years. The most experienced lecturer has been teaching mathematics for 20 years and her field of expertise is mathematics and statistics. The second mathematics lecturer's field of expertise is mathematics and computer science. She has been teaching for 16 years. The third mathematics lecturer has been teaching mathematics for 14 years and her field of expertise is mathematics and mathematics education. Six other lecturers are from Robotics, Artificial Intelligence, Control Engineering, Mechatronics and Automation Engineering, Mechanical Engineering and French Language fields of expertise. All of them have at least eight years of teaching experience and the most experienced lecturer is teaching French language for 16 years. All of them apply integral calculus extensively in teaching their subjects except for the French Language lecturer. This French Language lecturer was selected in order to attain views from a non-mathematics background respondent.

Table 1: Lecturers' Profile

No.	Lecturer's code	Field of Expertise	Teaching Experience (Years)
1	MATH01	Mathematics and Statistics	20
2	MATH02	Mathematics and Computer Science	16
3	MATH03	Mathematics and Mathematics Education	14
4	IA01	Robotics	12
5	IA02	Artificial Intelligence	12
6	IA03	Control Engineering	8
7	IA04	Mechatronics and Automation Engineering	8
8	MM01	Mechanical Engineering	8
9	FR01	French Language	16

Activities

Activity 1

Activity 1 was attempted by a group of two lecturers (MATH01 and FR01). MATH01 is an expert Maple user, whereas FR01 is not familiar with the software. However, MATH01 does not apply Maple in her class. These two lecturers wrote their comments on the activity booklet (Table 2). Comments ICA1.1, ICA1.4, ICA1.5 and ICA1.6 emphasized on the importance of posing a reflective question at the end of each part. Students need to be given some times to do a reflection on their Maple outputs. Thus, reflective questions need to be designed carefully because the quality of reflection has the effect on the achievement test (Chang & Chou, 2011). Moreover, the questions allow students to review their learning process consistently. These questions also serves as an active monitoring, consequent regulation and orchestration agents as what is defined in metacognitive learning objectives and goals (Vos & Graaff, 2004). Metacognitive ability is crucial in learning engineering technology mathematics as students in this field are using this subject to make sense of the real life application in their related field. Thus their comments were considered to improve the activities developed.

Comments ICA1.2 and ICA1.3 give an indication that students need to be given a clue on writing a complete solution for an indefinite integral questions. To respond to these comments, three questions were designed to create a chain of knowledge towards giving students ideas about the format of a complete solution for any indefinite integrals. The questions involved a topic learnt prior integral calculus, i.e. derivative of functions. In the first question, five linear functions were designed as a set of derivatives questions. The functions are the same except for their constant terms, where five different constant values were used (0, 3, -5, 0.4 and $-\frac{3}{5}$). The functions are:

$$x, x + 3, x - 5, x + 0.4 \text{ and } x - \frac{3}{5}$$

In this question, students are asked to differentiate the functions with respect to x . The derivatives will then be used as integrands in the second question. Finally, in the third question, students are asked to compare the integrals with the original linear functions in the first question for them to realize that a complete answer of any indefinite integrals need to be added with a constant.

Comment ICA1.7 is about giving more examples on non-basic trigonometric functions. This comment is considered but the examples are not included in the activity, instead they are included in the tutorial questions. Whereas, the comment on introducing integration of functions with respect to different variables is not used in developing activities in Activity 1 because similar questions were already being asked in Activity 2 questions. Finally comment ICA1.8 emphasized on giving counter-examples to build a deep understanding mindset amongst engineering technology students at the university. This approach is able to create a cognitive conflict or disequilibrium in the students' mind (Gruenwald & Klymchuk, 2003). A cognitive conflict is invoked when students are facing contradiction or inconsistency in his or her ideas (Zazkis & Chernoff, 2008). Cognitive conflict can help students understand areas of mathematics critically through discussing and correcting their mistakes (Irwin, 1997). Furthermore, the disequilibrium enhances the driving force of the development in understanding (Koichu, 2008; Piaget, 1977). Without this, knowledge remains static (Piaget, 1977). Other studies have proven the positive impact of provoking students' critical thinking (Toka & Askar, 2002; Watson, 2007). Thus, in this study, the comment is used to add counter-examples in order to trigger students' critical thinking as it will create a path-dependent logic, in which students are capable of giving different answers to the same questions (Tall, 1977).

Table 2: Lecturers' Comments on Activity 1

Code	Lecturer's code	Activity Number	Comments
ICA1.1	MATH01	1.2: Question 2 Rules for definite integral	Need to be rephrased so that the students can comment on the: (1) Answers (2) Equation format Is the answer for $\int_1^3 x \, dx + \int_4^6 x \, dx$ equivalent to $\int_1^3 x \, dx + \int_3^6 x \, dx$? Give your comments.
ICA1.2	MATH01	1.3: Question 1 Indefinite Integral as an anti-derivative	The students will write down what they see. So, for example $\int e^{2x} \, dx = \frac{1}{2} e^{2x}$. The good students will remember to add "C" to every answer. The weak students may not.
ICA1.3	FR01		C (constant) is not indicated in the expression palette \rightarrow the student needs to add it himself in his answer.
ICA1.4	MATH01	1.4: Question 1 Indefinite Integral as an anti-derivative	Remind students to put C. Separate the positive and negative powers for questions. The students will observe that powers will be different. For questions with negative powers, the students need to remember/recall the process of changing negative powers to positive powers.
ICA1.5	MATH01	1.4: Question 3(h) Indefinite Integral as an anti-derivative	Rephrase this. Make the students realize that they have to adjust their answers according to the variable of interest. I think this activity should come first in the series of anti-derivative.
ICA1.6	MATH01	1.4: Question 5(f) Indefinite Integral as an anti-derivative	Can also get the comment from students on what happened to this function if x becomes a negative power.
ICA1.7	MATH01	1.4: Questions 8,9,10 Indefinite Integral as an anti-derivative	OK but need more examples so that students can conclude on the general property – also try questions with different variables.
ICA1.8	MATH01	1.5: Conclusion	In order for students to come up with actually/general property, they need to also understand constraints to the properties

Activity 2

Activity 2 was attempted by a group of two lecturers (MATH03 and IA03). MATH03 is an expert Maple user who applies this software in her teaching. IA03 is also familiar with the software but he does not use this software in teaching his subject, which is Control Systems. These two lecturers wrote their comments on the activity booklet (Table 3). Comment ICA2.1 is similar to comment ICA1.7 in Activity 1 in which different independent variables were suggested to be included in the activities. The comments were considered in developing questions in Activity 2, and since the questions given by MATH03 are relevant and suitable, they are used in improvising the questions in Activity 2.

Comment ICA2.2 emphasized on the importance of theoretical knowledge prior to practical approach using Maple. IA03 also claims that students may not understand the process even though they managed to reach the final solution using the software. Both comments are actually part of the planning strategy used in developing questions in the set of activities. They were already used to plan the strategy developed, where the theoretical knowledge is taught in the lecture prior to respective tutorial sessions. Regarding the assurance of students' procedural understanding, activities were already carefully designed to not only encourage procedural but also conceptual students' understanding. They were designed based on the characteristics of procedural and conceptual questions highlighted by Arslan (2010) and also Dubinsky (1994).

Comments ICA2.3, ICA2.4, ICA2.5, ICA2.7, ICA2.9 and ICA2.10 are similar to comments ICA1.1, ICA1.4, ICA1.5 and ICA1.6 in Activity 1 where the importance on giving reflective questions was highlighted by MATH03. This mathematics lecturer has given a comprehensive and details comments on improving the questions in Activity 2. She has also suggested questions to be added in each part in this activity. All her suggestions are considered and used to modify the questions.

IA03 proposed in ICA2.6 that the application of Maple software is more appropriate for students in semester 4 and higher. In this study, the module developed is for year one, semester two diploma students because the mathematics subject taught is not only a pre-requisite subject for a higher mathematics subject, but also all mathematics related technical subjects. It is important to ensure the full understanding of this topic during their year one. In addition, calculus is presented as the peak of secondary school mathematics, and it has been applicable to the most capable students only (Kissane, 2007). Since computers have potential for both amplifying and reorganizing mathematical thinking (Drijvers, et al., 2010), it is suitable to help students to master the basic calculus concepts. Furthermore computers can promote mathematical thinking skills through purpose functions and process functions. The purpose functions engage students to think mathematically and the process functions aid them through five categories, namely tools for developing conceptual fluency, tools for mathematical exploration, tools for integrating mathematical representations, tools for learning how to learn and tools for learning problem-solving methods (Drijvers, et al., 2010; Pea, 1987). The final comment for Activity 2, i.e. ICA2.11 can also be related to comment ICA2.6 where the module is designed for measuring students' conceptual and procedural understanding on integral calculus. In other words, the message in comment ICA2.11 is actually part of the consideration taken in the initial stage of developing the module, which is during the planning stage.

Table 3: Lecturers' Comments on Activity 2

Code	Lecturer's code	Activity Number	Comments
ICA2.1	MATH03	2.1: Indefinite Integrals	Add a new question: Use Maple to determine the following integral: (a) $\int 7 dx$ (b) $\int x^7 dx$ (c) $\int k^7 dx$ (d) Compare the results obtained in (b) and (c), what can you conclude about the variable of interest (independent variable), x ?
ICA2.2	IA03	2.1: General Comments	The theoretical explanations on mathematics problem solving were needed before giving the hands-on practical activities. Practical approach will provide a simpler problem solving method, but sometimes... students failed to understand how were the solutions obtained.
ICA2.3	MATH03	2.1: Question 2(f)	Rephrase to: Observe the exponential function given

ICA2.4	MATH03	2.1: Question 3	and the result obtained from Maple. Remove all questions, replace with this: Use Maple to integrate the following <i>trigonometric</i> functions: (a) $\int \cos(2x + 5) dx$ (b) $\int \cos(3x + 5) dx$ (c) $\int \cos\left(\frac{1}{3}x + 5\right) dx$ (d) Based on the coefficient of the result obtained, what can you conclude?
ICA2.5	MATH03	2.1: Question 4	Rephrase the question: use Maple to evaluate <i>the following indefinite integrals</i> : Remove Question 4(e) and 4(f).
ICA2.6	IA03	2.1: General comments	MaLT – IC method is not suitable for Semester 1 and 2 students. (But it is suitable for students in Semester 4 and onwards).
ICA2.7	MATH03	2.2: Question 1 Definite Integrals	Remove Question 1(d), 1(e) and 1(f) Replace with (a) $\int_0^{-2} (4x + 7)^4 dx$. (h) Compare the answer of definite integrals in (a) and (d), determine the property applied to obtain the result in (a) and (d).
ICA2.8	MATH03	2.2: Question 2	Question 2(c), 2(d) and 2(e): outside tutorial class → self learning
ICA2.9	MATH03	2.3: Question 1 Properties of Integrals	Put a break for different type of question. 1(a) and 1(b), 1(c) and 1(d), 1(e) and 1(f)
ICA2.10	MATH03	2.3: Question 2	Put a break for different type of question. 2(a), 2(b) and 2(c), 2(d) and 2(e).
ICA2.11	IA03	2.5: Conclusion	Need to study the effectiveness of MaLT – IC in terms of students' understanding in solving mathematics in details. MaLT – IC can assist students to solve any mathematics problems easily... The value of understanding??

Activity 3

Activity 3 was attempted by IA01 who applies Maple software in his robotics research. However he did not give any comments on questions in Activity 3. Therefore questions in Activity 3 were modified based on the comments given by other lecturers in different set of activities.

Activity 4

Activity 4 was attempted by a group of two lecturers (MATH02 and IA02). Both are not familiar with Maple software and thus, they worked together to complete the activity given. Their comments were written on a set of activity booklet and manual booklet (Table 4). Comments ICA4.1 and ICA4.2 emphasized on a clearer instructions given to students. The statement given in the first draft: Use *Maple command* ... is changed to Use *Maple changevar* command.... The *changevar* command is for substitution technique. Similarly, *intparts* command is used for integration by parts technique and *parfrac* command for partial fraction conversion. They are used to modify the instructions in the second draft. MATH02 and IA02 suggest students to critically synthesis two types of Maple outputs in Comment ICA4.3. This suggestion is not used in modifying questions in Activity 4 because at this university involved in this study, all diploma students are assessed until analysis level only. The different Maple outputs are shown in Figure 1.

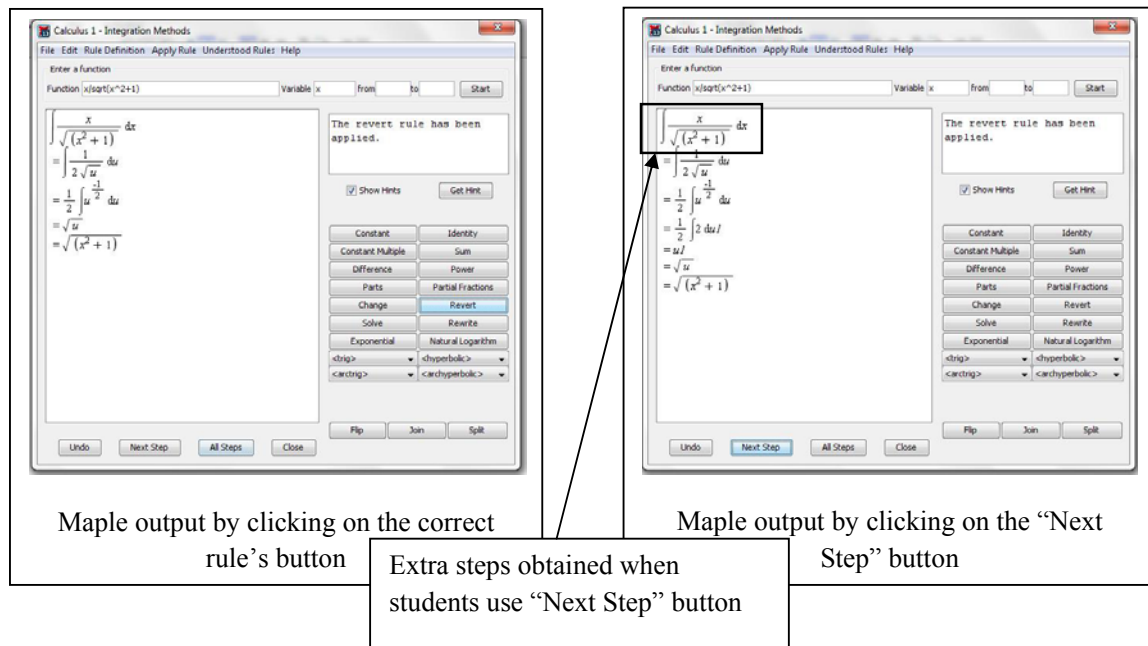


Figure 1: Different Maple Outputs

Table 4: Lecturers' Comments on Activity 4

Code	Lecturer's code	Activity Number	Comments
ICA4.1	MATH02 IA02	4.3: Question 1 Integrating by Using Partial Fractions Technique	Maple Commands: to specify
ICA4.2	MATH02 IA02	4.3: Question 2	Maple Tutors: to specify
ICA4.3	MATH02 IA02	4.5: Conclusion	Need to elaborate/explain on the difference "respond" from Maple's Tutor in terms of different working method to solve a particular question ("Next step" case)

Activity 5

Activity 5 was attempted by MM01. However he did not give any comments on the Activity 5. Similar to what have been done to questions in Activity 3, all questions in Activity 5 were improvised based on comments from similar type of questions from different sets of activities.

Activity 6

Activity 6 was attempted by IA04 who is not familiar with Maple software but he is familiar with programming using other software such as MATLAB and Lab VIEW. He wrote his comments on the activity booklet (Table 5). Comments ICA6.1, ICA6.2 and ICA6.3 were considered in order to give clearer instructions to students in not only questions in Activity 6, but also in all set of activities. In this case, students are clearly guided to refer to the correct part in the manual. Comment ICA6.4 is also used to make the presentation of information more organized and systematic.

Table 5: Lecturers' Comments on Activity 6

Code	Lecturer's code	Activity Number	Comments
ICA6.1	IA04	6.1: Question 1 Exploring Various Types of Graphs	Write: Note: Refer to MaLT – IC Part 4 Manual. Highlight the student to refer the most main part in MaLT – IC manual. In every unit (exercise). Let them refresh/explore by themselves.
ICA6.2	IA04	6.2:	Write: Note: Refer to MaLT – IC Part 4 Manual.

		Area between Curves	Highlight the student to refer the most main part in MaLT – IC manual. In every unit (exercise0. Let them refresh/explore by themselves. Note: Part 5.
ICA6.3	IA04	6.3: Volume of Solid of Revolution	
ICA6.4	IA04	Learning Objectives	At the end of the tutorial session, the student is able to : (1) – (3) Rewrite the paragraph to point form: -Activity 6.1 -Activity 6.2 -Activity 6.3

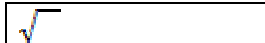

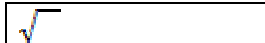

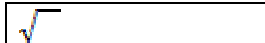

Manual

The comments given by the lecturers are listed in Table 6. Two lecturers (MATH02 and IA02) suggested that a page to list down table of contents should be included. This suggestion is considered to modify the manual developed. Three lecturers (MATH02, IA01 and IA02) highlighted the importance of a clear explanation in order to distinguish between “Document mode” with “Worksheet mode” in Maple interface (comments ICM1, ICM2, ICM3, ICM7, ICM8 and ICM9). The improvement done is by adding more diagram in the explanations, adding a clearer explanation as suggested by MATH02 and IA02: “Need to click on “File” first” and adding a sequential flow of instruction: “File → New → Document Mode” and “File → New → Document Mode”. Nevertheless, the comment from IA01 to include hyperlink to these two modes cannot be considered because students will only be given the hard copy of this manual but not the soft copy. MATH02 and IA02 suggested an additional of step; i.e. STEP 5 to ask students to press ENTER button as the last step. Thus in order to avoid confusion, they also suggested that the word “Enter” initially used in steps 1 and 3 be replaced with the word “Type”.

Three lecturers commented on the logo in terms of its size and location. According to IA01, logo will “pin” readers to the icon thus he suggested putting the page number next to the logo. In ICM12, MATH01 suggested the researcher to include clear instructions on entering non-standard trigonometric functions in Maple document. This suggestion is used in the “Input and Output” section in Part 1 of the manual. Similarly, comments ICM15, ICM18, ICM19, ICM20 and ICM22 suggested additional instructions for saving file, clearing data, opening palettes instruction, entering symbols and defining symbols. All of the comments are used to improve the manual instructions. The comment from IA01 in ICM14 is similar to comment ICA1.8 in which it emphasized on giving counter-examples to build a deep understanding mindset amongst engineering technology students at the university. The comment will be put in the remark to warn students the importance of the instruction. Finally, suggestion from IA01 in comment ICM21 to promote students self-learning is also considered.

Table 6: Lecturers’ Comments on Manual

Code	Lecturer’s code	Manual Number	Comments
ICM1	MATH02 IA02	Part 1 Preface	Add TOC: →precise numbering, sub-topics i.e.: PART 1 1.1 1.2 1.3 PART 2 2.1 2.2 ...
ICM2	MATH02 IA02	Part 1 Getting Started	Brief explanation on Document mode and Worksheet mode.
ICM3	IA01	Part 1 Getting Started	Suggest to be part at page 5 (beginning) Hyperlink to help on the difference between the two modes.
ICM4	MATH02 IA02	Part 1 Getting Started	Reduce size: the logo
ICM5	IA01	Part 1 Getting Started	This will pin the readers view to the icon. Pg x Of x LOGO
ICM6	MM01	Part 1 Getting Started	Reposition the logo either to the left, right or bottom.

ICM7	MATH02 IA02	Part 1 Maple Environment: Document Mode	Let us start with blank Document Mode. <i>Need to click on "File" first.</i>				
ICM8	MATH02 IA02	Part 1 Maple Environment: Document Mode	Suggest put the sequence: File → New → Document Mode				
ICM9	MATH02 IA02	Part 1 Maple Environment: Worksheet Mode	Suggest put the sequence: File → New → Worksheet Mode				
ICM10	MATH02 IA02	Part 1 Input and Output: Rational Expression	Replace the word Enter with Type				
ICM11	MATH02 IA02	Part 1 Input and Output: Rational Expression	Add step 5: Press ENTER				
ICM12	MATH01	Part 1 Input and Output: Powers	To include 'steps to enter derived trigonometric functions'				
ICM13	IA01	Part 1 Input and Output: Powers	Do not type dot.				
ICM14	IA01	Part 1 Input and Output: Products Case 2	Try to show without the cntrl key. There'll be an error. Importance of the cntrl=key.				
ICM15	MATH02 IA02	Part 1	Give option to students: → instruction to save → instruction to clear screen				
ICM16	MATH02 IA02	Part 1 Editing Expressions and Updating Output: To Edit One Computation	Examples? →put more detail instructions				
ICM17	MATH02 IA02	Part 1 Editing Expressions and Updating Output: To Edit a Group of Computations	Suggest putting later at the intermediate or advancing level.				
ICM18	MATH02 IA02	Part 1 Input Modes	Symbol: Such as $\sqrt{\quad}$, \int , \int_0^1				
ICM19	MATH02 IA02	Part 1 Input Modes: Palette Input	4. Now, select default palettes 5. add info on palette "collapse" and "expand"				
ICM20	MATH02 IA02	Part 1 Input Modes: Palette Input	→drag symbol $\sqrt{\quad}$. →add example $\sqrt{\quad}$				
ICM21	IA01	Part 1 Input Modes: Palette Input	Try using the help system for student to learn independently.				
ICM22	MATH02 IA02	Part 1 Input Modes: Symbol Names Input	<table border="1" data-bbox="847 1640 1377 1747"> <tbody> <tr> <td></td> <td>sqrt</td> </tr> <tr> <td></td> <td>...</td> </tr> </tbody> </table>		sqrt		...
	sqrt						
	...						
ICM23	MM01	Part 1 Input Modes: Symbol Names Input	Short cut key in subtopic like...				
ICM24	MATH02 IA02	Part 2 Entering Integration	Remove $\int f(x), x$ and $\int f(x), x=a...b$ in the output column.				

Lesson Plan

There is only one lecturer giving comments on lesson plan. MATH01 suggested to add “*and to agree to a unanimous conclusion*” to the statement written in the first draft: “*Students are asked to discuss their findings*”. Thus, the new statement reads as “*Students are asked to discuss their findings and to agree to a unanimous conclusion*”. It is important for students to reach a conclusion in ensuring their understanding in the newly learnt topic. This is crucial as understanding confers flexibility in thought and action that help students to respond appropriately to novel events (Newton, 2001). During the discussions, not only explanations supported by mathematical reasons given by students but also their mistakes created opportunities to engage further with mathematical ideas. This promotes conceptual thinking which reflect mathematics as not merely doing activities, but also explanations (Kazemi, 1998). MATH01 also suggested that lecturer must do some reflections on students’ answers to ensure the completion of all activities in the limited duration allocated for tutorial slots.

Table 7: Lecturers’ Comments on Lesson Plan

Code	Lecturer’s code	Lesson Plan Number	Comments
ICLP1	MATH01	1.7 Method of Instruction/Learning (3)	...and to agree to a unanimous conclusion.
ICLP2	MATH01	1.7 Method of Instruction/Learning	Self assess?? If a ‘good’ student is chosen → then the allocated time is sufficient. If a ‘weak’ student is chosen → then the 10 minutes may not be sufficient for him. This is because (a) He may not have fully grasped the concept of integration yet. (b) ‘stage-fright’ / inferiority complex. Suggestion: Lecturer reflects an answer sheet, writes down the answer and gets feedback from students.

CONCLUSION

Nine lecturers involved in evaluating the newly developed module. Their comments provide information upon which the researcher can make improvements to the module developed. Based on qualitative analysis, there are two major common inputs highlighted by the lecturers. Firstly, the importance of giving reflective questions after completion of each sub-category in the activities was highlighted by the lecturers. They emphasized that students need to be given some times to do a reflection on their Maple outputs. These reflective activities are able to trigger metacognitive awareness amongst the engineering technology mathematics. It is crucial for engineering technology students to be aware about their thinking skills as they use mathematics to make sense of the real life application in their related field. Secondly, some of the lecturers involved in this study agree that by giving counter-examples, mathematics lecturers are able to help students in mastering the newly learnt concept. Counter-examples may create cognitive conflict which can help students to understand areas of mathematics critically through discussing and correcting their mistakes. This is important to ensure the dynamic nature of the mathematics knowledge. Furthermore, it promotes conceptual thinking which reflect mathematics as not merely doing activities, but also explanations. These comments were used to produce a utility and meaningful manual, lesson plans and set of activities in teaching and learning this topic. Finally, the edited module will be used to enhance students’ procedural and conceptual understanding in learning integral calculus at the university.

REFERENCES

- Arslan, S. (2010). Traditional instruction of differential equations and conceptual learning *Teaching Mathematics and Its Applications*, 29(2), 94-107.
- Asiala, M., Brown, A., DeVries, D. J., Dubinsky, E., Mathews, D., & Thomas, K. (1996). A framework for research and curriculum development in undergraduate mathematics education. *Research in Collegiate Mathematics Education II, CBMS Issues in Mathematics Education*, 6, 1-32.
- Asiala, M., Brown, A., DeVries, D. J., Dubinsky, E., Mathews, D., & Thomas, K. (2004). A framework for research and curriculum development in undergraduate mathematics education. *Research in Collegiate Mathematics Education V, CBMS Issues in Mathematics Education*.
- Bergsten, C. (2008). On the influence of theory on research in mathematics education: the case of teaching and learning limits of functions. *ZDM Mathematics Education*, 40(1), 189-199.

- Chang, C.C., & Chou, P.N. (2011). Effects of reflection category and reflection quality on learning outcomes during web-based portfolio assessment process: A case study of high school students in computer application course. *The Turkish Online Journal of Educational Technology*, 10(3), 101-114.
- Davis, R. B. (1986). Conceptual and procedural knowledge in mathematics: A summary analysis In J. Hiebert (Ed.), *Conceptual and Procedural Knowledge: The Case of Mathematics* (pp. 265-300). Hillsdale, New Jersey: Lawrence Erlbaum Associates
- Deliktas, B. (2011). Computer technology for enhancing teaching and learning modules of engineering mechanics. *Computer Application in Engineering Education*, 19(3), 421-432.
- Drijvers, P., Kieran, C., Mariotti, M.-A., Ainley, J., Andresen, M., Chan, Y. C., et al. (2010). Integrating technology into mathematics education: theoretical perspectives. In C. Hoyles & J.-B. Langrange (Eds.), *Mathematics Education and Technology-Rethinking the Terrain* (pp. 89-132). New York: Springer Science + Business Media.
- Dubinsky, E. (2001). Using a theory of learning in college mathematics course. *Newsletter 12 Of TaLUM (Teaching and Learning Undergraduate Mathematics)*(May 2001), 10-15.
- Dubinsky, E., & Leron, U. (1994). *Learning Abstract Algebra with ISETL*. New York, USA: Springer-Verlag Inc.
- Dubinsky, E., & McDonald, M. A. (2001). APOS: A constructivist theory of learning in undergraduate mathematics education research. In D. Holton (Ed.), *The teaching and learning of mathematics at university level* (Vol. 7, pp. 273-280). Dordrecht The Netherlands: Kluwer.
- Felder, R. M. (1988). Learning and teaching styles in engineering education. *Engineering Education*, 78(7), 674-681.
- Felder, R. M. (1993). Reaching the second tier: Learning and teaching styles in college science education. *Journal College Science Teaching*, 23(5), 286-290.
- Felder, R. M., & Spurlin, J. (2005). Applications, reliability and validity of Index of Learning Styles *International Journal Engineering Education*, 21(1), 103-112.
- Gruenwald, N., & Klymchuk, S. (2003). Using counter-examples in teaching calculus: students' attitudes. *The New Zealand Mathematics Magazine*, 40, 33-41.
- Haripersad, R. (2011). Deep and surface learning of elementary calculus concepts in a blended learning environment. *International Journal of Mathematics and Computers in Simulation*, 5(4), 291-298.
- Hiebert, J., & Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics: An introductory analysis. In J. Hiebert (Ed.), *Conceptual and Procedural Knowledge: The Case of Mathematics* (pp. 1-27). Hillsdale, New Jersey: Lawrence Erlbaum Associates
- Houghton, W. (2004). *Learning and Teaching Theory: The Higher Education Academy - Engineering Subject Centre*.
- Irwin, K. (1997). *What conflicts help students learn about decimals?* Paper presented at the International Conference of Mathematics Education Research Group Australasia, Rotorua, New Zealand.
- Kazemi, E. (1998). Discourse that promotes conceptual understanding *Teaching Children Mathematics*, 4, 410-414.
- Kissane, B. (2007). *Teaching and learning elementary calculus concepts with a graphic calculator*. Paper presented at the 4th East Asia Regional Conference on Mathematics Education.
- Koichu, B. (2008). If not, what yes? *International Journal of Mathematical Education in Science and Technology*, 39(4), 443-454.
- Maharaj, A. (2010). An APOS analysis of students' understanding of the concept of a limit of a function. *Pythagoras* 71(July), 41-52.
- Newton, D. P. (2001). Helping children to understand. *Evaluation & Reseach in Education*, 15(3), 119-127.
- Pea, R. D. (1987). Cognitive technologies for mathematics education. In A. H. Schoenfeld (Ed.), *Cognitive Science and Mathematics Education* (pp. 89-122). Hillsdale: Lawrence Erlbaum.
- Piaget, J. (1977). *The Development of Thought: Equilibrium of Cognitive Structures; Translation of L'equilibration des Structures Cognitives by Arnold Rosin*. New York: Viking Penguin Inc.
- Soloman, B. A., & Felder, R. M. (n.d.). Index of Learning Styles Questionnaire. Retrieved 8 Julai 2010: <http://www.engr.ncsu.edu/learningstyles/ilsweb.html>
- Tall, D. (1977). *Cognitive conflict and the learning of mathematics*. Paper presented at the First Conference of the International Group for the Psychology of Mathematics Education.
- Thomas, M. O. J., & Holton, D. (2003). Technology as a tool for teaching undergraduate mathematics. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick & F. K. S. Leung (Eds.), *Second International Handbook of Mathematics Education* (pp. 351-394). Dordrecht: Kluwer Academic Publishers.
- Toka, Y., & Askar, P. (2002). The effect of cognitive conflict and conceptual change text on students' achievement related to first degree equations with one unknown. *Hacettepe Universitesi Egitim Fakultesi Dergisi*, 23, 211-217.

- Vos, H., & Graaff, E. D. (2004). Developing metacognition: a basis for active learning. *European Journal of Engineering Education*, 29(4), 543-548.
- Watson, J. M. (2007). The role of cognitive conflict in developing students' understanding of average. *Educational Studies in Mathematics*, 65(1), 21-47.
- Yesilyurt, M. (2010). Meta analysis of the computer assisted studies in science and mathematics: A sample of Turkey. *The Turkish Online Journal of Educational Technology*, 9(1), 123-131.
- Zazkis, R., & Chernoff, E. J. (2008). What makes a counterexample exemplary? *Educational Studies in Mathematics*, 68(3), 195-208.