Transforming Teaching and Learning Approach of Mathematics and Image Processing

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***Abstract* - Mathematics can be considered as fundamental elements of many technical subjects in various disciplines. Inability to realize the importance of mathematics and its applications in technical subjects are some of the reasons for poor academic performance of the students. The conventional teaching approach typically separates the teaching of mathematics from technical subject, does not necessarily promote students' awareness in both subjects. Hence, it contributes to their poor understanding in these subjects. This paper discusses a transformation in the teaching approach of image processing from conventional to a new teaching method which involves an integration of mathematics and image processing contents. Mathematics topics that are important to image processing applications are proposed to be taught simultaneously. Both subject lecturers will be collaborating in teaching mathematics application such as matrices and matrix transformation in image processing subject. This could lead to a new teaching approach which is more stimulating and interesting learning environment for the students and more productive and dynamic for lecturers.**

Keywords: mathematics, matrices, matrix transformation, image processing, teaching

I. INTRODUCTION AND BACKGROUND

Like many other Malaysian universities or higher educational institutions, Universiti Kuala Lumpur Malaysia France Institute (UniKL MFI) offer basic courses in mathematics, physics, programming or computer science in the first year of any engineering programs. This strategy has the purpose to provide the engineering students with adequate and valuable skills that they need to further their undergraduate studies. However, in most cases, many students find that these theoretical subjects are not attractive, difficult and useless. They seem to be disappointed to find out that these subjects are quite too similar to their previous studies in high school. Their expectation when enrolling in higher educational program might be that they should directly focus on their chosen area of study such as electrical, robotics or mechatronics engineering. This usually de-motivates the students and decreases their study interest. Furthermore, most students have difficulties to relate the needs of these basic subjects to their engineering subjects.

The importance of motivation and stimulation of interest has often been recognized in the literature [1] [2] [3] [4]. In [2], the authors believed that poor motivation in studying mathematics is one of the key reasons for the students' incomplete skills. They do not see the real use for the mathematical theory that they have learned. In their study, they found that their students failed to acquire sufficient mathematics skills for them to further progress in mathematics-oriented engineering topics such as digital image processing. Even after their first year of study or sometimes after their second year they did not manage to grasp the required mathematical skills. Together with poor motivation and lack of interest in the topic, majority of the students are just taking mathematics subjects with minimum effort and therefore obtain only minimum grades or most of the time they failed the subjects. In this institution, similar to scenario in [2], the students typically do not spend much time doing their mathematics exercises regularly, and only perform last minute study, one or two nights before the examination.

As mentioned in [5], a suitable syllabus is one of the most important strategic for effective learning. This could help the students to increase their motivation, thus improve their skills in the study. The teaching and learning of the subjects especially mathematics could become more interesting by relating directly to the engineering or technical subjects. In this institution, one of the subjects that require important amount of mathematics is image processing (IP). This subject can be considered as one of the main components of computer vision system that has usually been applied in robotics, manufacturing and intelligent systems. In a comprehensive review done in [6], computer vision has grown from a research area to a widely accepted technology that is capable of providing a significant increase in productivity and improving living standards. It is becoming a mainstream subject of study in computer science and engineering. The authors in [6] have also indicated that the students in computer science and engineering fields should receive some basic education related to computation with images. This is crucial for them to catch up with the rapid explosion of multimedia and the extensive use of video and image-based communications over the internet. So, to increase students' motivation and ability in mathematics for image processing or other

engineering subjects in general become one of the huge challenges that the lecturers and universities need to tackle.

In fact, there were some works and studies that have been done to integrate mathematics with image processing or signal processing subjects. In [7], the concepts from digital signal processing have been incorporated into the high school classroom through specialized engineering education. The authors have introduced an Infinity Project, which is a joint effort corporation between university educators, industrial partners, and civic leaders to introduce a signal-processing-based engineering curriculum at the high school educational level. Meanwhile, in [8], it was mentioned in this paper, in Australia, some tertiary courses are reducing formal mathematics from their computer science courses completely. This situation is also happening in this institution. By doing this, the teaching of image processing to students of computer science must use as little mathematics as possible. Therefore, the authors have discussed and introduced methods based on colour image processing to the undergraduate subjects taught at Victoria University of Technology (VUT). Another works that incorporated mathematics and engineering subject was done in [9] where the authors have reviewed and used MATLAB® and Mathcad® for teaching and research in the syllabus of traditional introductory and advanced bio-signal processing subject. All these works had the purpose to increase the student's interest in learning mathematics and engineering subjects.

Like in other higher educational institutions that offer engineering and technical studies for undergraduate, the problems of students' lack of motivation, lost of interest and inability to relate mathematics and engineering subjects become common problems that need to be tackled in this institution. Beside the problems that were mentioned previously which centered more on the students, the other aspect of the problem that was observed could also come from the lecturers themselves. It is usually very difficult for the lecturers from mathematics and engineering departments to have discussion on these problems. This might due to the fact that engineering or technical lecturers usually assume that all basic mathematical knowledge and skills should have been handled by mathematics lecturers and they do not need to bother about it. On the other hand, mathematics lecturers only deliver mathematics lessons based on its syllabus or curriculum without knowing what, where, how, why or when the topics could be useful for the students to apply in their engineering or technical subjects. This is a typical problem between mathematics and engineering lecturers which do not give any benefits to the improvement in teaching and learning of both subjects.

The problems and issues that have been described have motivated this research with the aim to improve the ability, increase the motivation and provide adequate skills to the students in learning mathematics and image processing subjects. There are several tasks that will be involved, including (i) the discussion between mathematics and engineering lecturers to identify and map the topics in both subjects, (ii) the integration of mathematics within image processing topics and finally, (3) the case study on the students that will use this method and compare it with the conventional method of teaching and learning for both subjects.

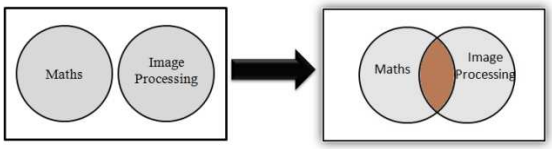


Fig. 1: Left Venn Diagram represents the existing approach of teaching mathematics and image processing which is usually performed separately. In right Venn Diagram, the intersection area represent several topics in these two subjects that could be integrated.

In this paper, the focus was given to produce a conceptual study on the potential integration of mathematics in image processing subject in our institution. As shown in Figure 1, the related topics in these subjects were identified and later integrated. This involved the comparison and study of various topics in mathematics and image processing and how the integration of these two subjects could be done. It is an important step in order to design an alternative teaching approach by incorporating these two subjects.

II. Topics Identification And Mapping

The important task before any integration of topics between two subjects is to study and identify the highly related topics between both of them. In our case, the scope of work was limited to mathematics and image processing subjects which are offered by UniKL-MFI. The subjects are FKB10103: Engineering Technology Mathematics-1 (ETM1), FKB20203: Engineering Technology Mathematics-2 (ETM2) and FSB33503 Image Processing. They are offered in semester 2, 3 and 5 respectively. ETM1 and ETM2 are originated from Mathematics Department while Image Processing is served by Industrial Automation Department. They are among the core subjects in Bachelor of Engineering Technology (Hons) in Industrial Automation and Robotics Technology program at UniKL-MFI. Both ETM1 and ETM2 have the purpose to provide adequate and necessary mathematical skills to students. The main topics in ETM1 consist of Linear Algebra, Complex Numbers and Polynomials, Vectors and Vector Applications while ETM2 covers topics namely Pre-Calculus, Partial Derivatives, Integration of hyperbolic, inverse and inverse hyperbolic functions, Multiple Integral and Differential Equations. On the other hand, Image Processing has the purpose to introduce image processing techniques and technology with its topics covering digital image fundamental, image representation, transformation, enhancement, restoration, segmentation and compression.

As mentioned in earlier section, the focus given in this research was to identify and map the related topics in mathematics and image processing. Therefore, the communication between lecturers from different departments was established at the first place. Through detail discussions on main topics, sub-topics, terminologies and application examples in mathematics and image processing, it was found that similarities exist in both subjects. Some topics and sub-topics could have been related easily because they usually represent basic calculations in mathematics and at the same time, represent calculation applications in image processing. An example is the topics of Matrix operations in mathematics and Image operations in image processing. In our case, the overall comparison and identification of highly related topics and sub-topics in ETM1, ETM2 and image processing is shown in Figure 2. It is interesting to discover that there are about 45% of ETM1 topics and 20% of ETM2 topics are directly contributing to about 90% of the basic calculations in image processing's topics and sub-topics. So, this FSB33503 Image Processing can be said as highly dependent on mathematics because almost all of its topics are directly related to topics such as Linear Algebra in ETM1 and Pre-Calculus in ETM2.

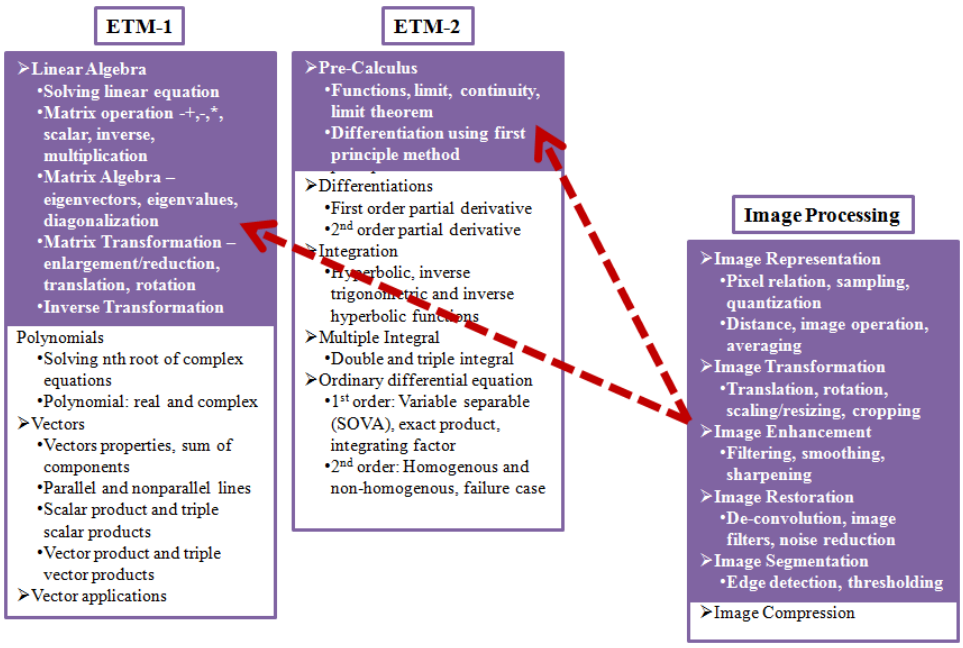


Fig. 2: The topics and sub-topics in ETM1, ETM2 and Image Processing subjects that are identified as having significant relations.

III. Methods Of Integration

Literatures have shown that many engineering or technical educators have proposed changes to the way that mathematics is taught to engineers or technicians. Some of the suggestions are mathematics should be taught by engineering lecturers rather than mathematics lecturers, integrating mathematics and engineering or technical subjects or even a more radical approach is by doing a revamp in engineering or technical curriculum [10]. At the same time, the mathematics community believes that by considering a broader notion of mathematics in developing mathematical thinking will be more advantageous to engineering or technical students [10].

Common needs between these two fields have to be investigated and achieved. Thus, this study aims to propose a new model of teaching mathematics for technical students by integrating the teaching of mathematics and its related counterpart. A teaching method reform will be proposed from teaching mathematics and technical subjects separately to an integrating teaching approach. The main objective of this approach is to find one teaching technique that can cater both, mathematics and technical subject.

The collaboration of mathematics and technical subjects are likely to be an effective approach of teaching any mathematics subjects [11]. This integration method will give students a great opportunity to experience a more encouraging environment in learning mathematics concepts more deeply. The relevant technical activities and examples will help students to think critically about the related mathematical concepts. Furthermore, mathematics should be taught in conditions that lead to its real life applications.

In this study, there are two sub-topics of Linear Algebra involved, namely Matrices and Matrix Transformation. The applications of matrices in technical and engineering fields are very broad, but this study focuses on the application of Matrices and Matrix Transformation in Image Processing.

The current teaching practice of Mathematics and Image Processing will be enhanced through the integration of both subjects (Figure 3). Lecturers from both subjects will involve in teaching both subject where the basic mathematical knowledge will be taught by the mathematics lecturers. The applications of the mathematical knowledge will be explained through the content of Image Processing. This part will be covered by Image Processing lecturers.

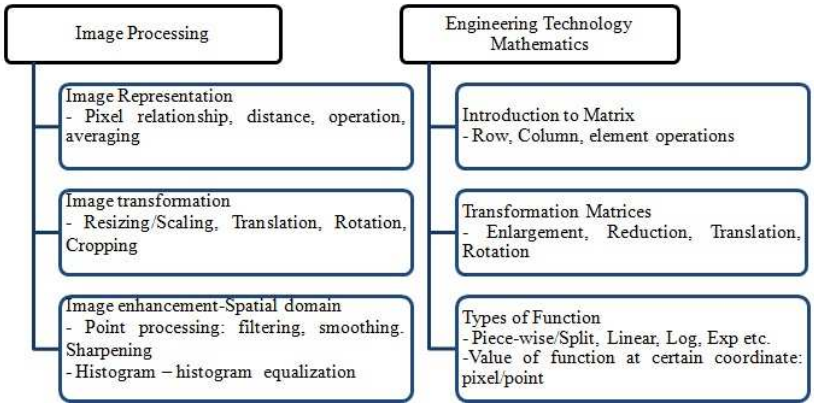
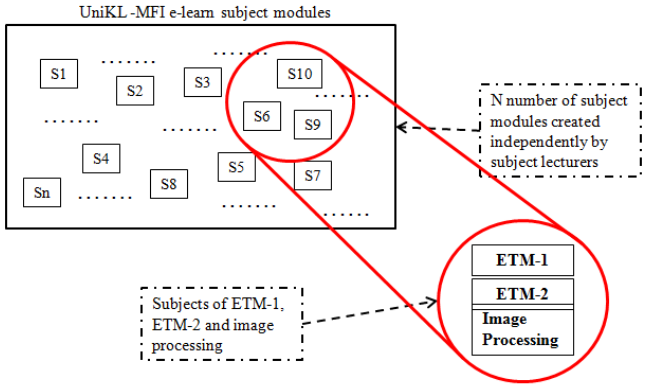
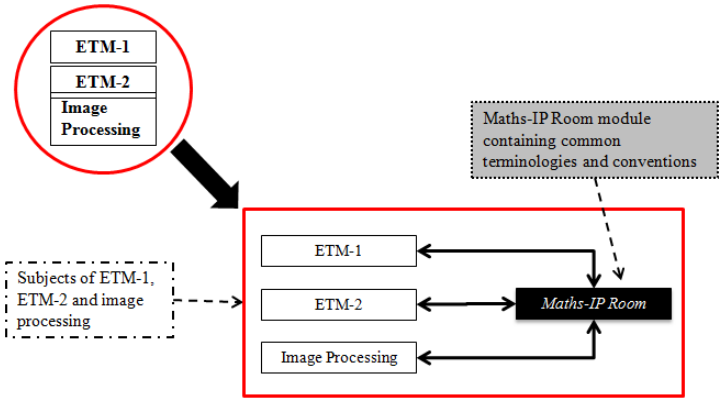


Fig. 3: Identified topics for enhancement in teaching and learning of image processing by integrating mathematics



Current teaching and learning approach

Fig. 4: Current approach for teaching and learning of image processing and mathematics



Proposed approach using Maths-IP Room

Fig. 5: Proposed teaching and learning approach using Maths-IP Room

These two subjects which currently taught separately in different semester (Figure 4) will be brought together in a virtual library called the Maths-IP Room through application and examples as shown in Figure 5. Using the existing e-learn system, developed by our institution, the Maths-IP Room will provide a better learning environment

for BET IART students. In this proposed model, the students will also be able to transfer their mathematical skills into the application of Image Processing.

IV. Conclusions And Recommendations

From the proposed Maths-IP Room teaching and learning model, students should hypothetically be able to assimilate a new concept of teaching and learning. This means that lecturers must disseminate the meaning of the concepts to the students. The dissemination process will be meaningful if students understand the link between the concepts learned and their related applications. This study proposes the integration in the teaching of Mathematics and one of its application subjects that is Image Processing. In this approach, the mathematical operations to the matrices can be applied in manipulating images. In this sense, the teaching of Matrices and Image Representation can be taught simultaneously with the aim for the students in this university to be able to overcome the difficulties in learning Image Processing and Matrices through the real world application. Furthermore, lecturers are also able to teach the contents of Matrices to students in more stimulating and motivating environment.

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