Usefulness and Practicality of Moodle quizzes to enhance the learning process for Foundation Mathematics Courses in Engineering

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Abstract

Mathematics is crucial for Engineering problem solving, analysis and design. However, students are weak in basic mathematics due to lack of interest, practice and their inability to correlate mathematics to real world problem solving and applications in their core discipline. Therefore, this paper aims at addressing the efficacy of MOODLE (an online e-learning platform) in strengthening the foundation in mathematics for engineering students.
The paper aims at designing and presenting foundation lectures supplemented by videos for the students and then subjecting the students to a series of Moodle quizzes, subsequently analyzing these results to correlate to teaching -learning activities. These studies also aim at carrying out a psychometric analysis on the learning activities and use it to adapt to the learner's needs and thus help improve their engagement with topics of mathematics in engineering education.

Keywords- Student engagement, Active Learning, Mathematics for Engineering, Moodle quizzes

1. Introduction

In the present era of globalization and rapid development, higher education plays an important role in providing the right impetus for producing quality engineers, leading to the growth of the nation. Almost all branches of engineering rely on mathematics as a language of description and analysis. Hence, students of engineering programs require a thorough knowledge of mathematical concepts. During the engineering program, students learn and consolidate basic mathematical principles in order to solve mathematical problems in engineering. Engineering Mathematics- Advanced Calculus is once such course and is offered at the entry level, first year of Engineering, a prerequisite course for all engineering disciplines. This course is designed to equip the students with the fundamentals of multivariable calculus leading to problem solving skills and cognitive ability. In every curriculum revision, once in two years, changes are made responding to the requirements of the industry so that the student is prepared to meet the constantly changing needs of the society in terms of the skills acquired. However, student performance in this foundation course in mathematics is a major concern for the mathematics educators. In fact, it is alarming! Poor performance of students in mathematics has been a global issue among stake holders in engineering mathematics teaching and learning.
As a first step to identify these causes, research is conducted to investigate and analyze the causes for the poor performance of the students during the last few years. Literature survey of the current practices in the teaching and learning of mathematics to engineering students, was undertaken. The causes affecting the poor performance have been studied extensively.

Mathematics is not the problem, but the lack of practice in working out the problems, not motivated to learn mathematics for lack of appealing examples and application -oriented problems in these courses is one of the main reasons for the poor student performance. There is therefore a strong need for application-oriented education to counter this. If mathematical topics are taught and followed up with quizzes on the topics and further with linked with interesting examples from engineering, a more realistic impression of the use of mathematics motivates the student and the interest in the topic is sustained.

The paper is organized in three sections. The first section presents a literature review, summarizing some of the causes for poor performance in the mathematics courses. In the next section, an attempt is made to design a pedagogical strategy -using Moodle as an e- learning platform to influence and enhance the student engagement in mathematics, focusing on the challenges of the slow learners. The third section deals with the assessment and psychometric analysis of the results of the quiz. This would help to design the questions better considering the level of difficulty and correlating it with the mathematical abilities. Finally, the conclusions and some implications for future work are presented.

2. Literature Review

The poor performance of students in mathematics courses in engineering education is a major concern among the mathematics educators and is therefore a subject of study in many research papers[6]. In this section, the factors that influence learning of mathematics- anxiety, motivation and learning styles of students are examined to understand and innovate over the traditional styles of teaching and learning.

In the recent literature [11], [12] and [13, Maths anxiety is defined as feelings of concern, tension or nervousness that are experienced in combination with maths. Anxiety for maths has been studied by several of these researchers and it has been revealed that emotions like maths anxiety are a fundamental part of the learning process because they can influence a student's behavior. For instance, if a student is enjoying a lesson he/she will be motivated to invest more effort in that class, and perhaps future classes, and will learn more effectively. High level of anxiety in the classroom has the opposite effect and can lead to students avoiding work and learning things superficially.

Pekrun, a leading researcher in the area of emotions in the classroom, points out that anxiety is an anticipatory emotion that focuses on the uncertainty of achieving a particular outcome [14].

Researchers from a study, *"Exploring Mathematics Anxiety among Engineering Students" in,* [9] concluded that it is not the skill level of the maths anxious individual that leads to performance drop but rather the ability to manage anxiety at this anticipatory stage and devote attention to a task.

Pekrun's theory on emotions in the classroom proposes that emotions have two underlying components: 1. The value that a student attaches to a task and 2. The amount of control a student has over a task.

For instance, an emotion like enjoyment is the product of a student highly valuing what he/she is are doing in conjunction with a feeling of high level control over the task. On the other hand, anxiety is experienced when a student highly values a task but feels that he or she has no control and it is the incongruence of these two things that causes discomfort.

Mathematics anxiety among engineering students is manifested in five dimensions, namely: (a) Feel mathematics is a difficult subject; (b) always fail in mathematics; (c) Always writing down in a mathematics classes; (d) anxious if not understood and (e)loss of interest in mathematics subjects [10].

Students may lack the motivation necessary to obtain a thorough understanding of key mathematical concepts or do not retain key elements of knowledge needed for their engineering courses due to lack of a link between the mathematical concepts and the practical problems from engineering examples. These problems with mathematical concepts can lead to comprehension difficulties during the latter part of their engineering education. The motivation is the driving force behind these actions and affects the needs, desires and ambitions in life. Hence, there must be an effort to stimulate the students' attitudes and motivation towards learning. This will lead them to achieve the best results [9].

Slow learners are learners who are characterized who are functioning at an ability significantly low below grade the grade level and consistently score low on achievement. As part of the strategies to improve these achievement levels, innovative teaching using technologies need to be employed in contrast to face to face learning so that students become responsible for their own learning in their own space and time.

This study highlights the teaching- learning strategies that we embarked on to improve student engagement and measure the academic achievement. Today's students are digital natives, more at ease with technology. They are living in a fast-paced world, where today's technology becomes outdated tomorrow. Hence it is natural that they are bored of the traditional methods of learning and are impatient. What is required is new methods of learning, which can stimulate a deeper learning experience. They can no more be 'passive' subjects, waiting for the professor to deliver a lecture. The modern day student would appreciate an active engagement with the problem at hand. This kind of active learning requires paradigm shift from a teacher centred pedagogy to a 'learner centred' pedagogy, or rather a 'learning centred' pedagogy where the students are 'agents of their own learning' (Kay, Dunne and Hutchinson 2010; Dunne and Zandstra 2011; Greene and Crespi 2012). And all this is possible only when we can yoke active learning methodology with the use of technology. This concept of active learning in higher education is also advocated by Chickering and Gamson (1987) and Chickering and Ehrmann (1996). Cromack (2008) also emphasises on the synergy between 'technology and learner-centred education"

We understand that the use of technology aids teaching and also acts as a catalyst in learning (Pinder-Grover, Green and Millunchick 2011; Yoon and Sneddon 2011; Carrillo et al. 2013).

Thus the use of technology not only facilitates a stimulating learning experience to the student but also provides space for individual learning styles, engaging the student profitably.

This paper deals with evolving some strategies to overcome all the above barriers to help improve and enhance the student performance in mathematics courses in engineering education, reflecting the current thinking of learning.

3. Research study and Methodology

In this research study, the causes of poor performance in mathematics courses in engineering programs having been identified as: students functioning with low ability , lack of knowledge of basic concept, diverse learning styles, attention span of the students and lack of practice among

the students. Innovative teaching- learning strategies using technologies as support mechanisms are designed to take care of these students early, in the first year itself.
A mismatch between the learning styles of engineering students and the teaching styles of their teachers calls for a modification in the teaching style. Once the threshold areas are identified, the traditional auditory method which is generally a direct instruction of facts and using standard methods is to be augmented by including physical concepts showing real-time applications in the relevant discipline. The present generation of students being digital natives and institutions providing more resources, including videos of the relevance of the concept being taught in the class room and providing links to various sites will allow for further exploration of the engineering application. These visual videos and aids would help the student understand the utility of the topic, assisting the student to strengthen the knowledge of the concepts taught in the class room and be able to appreciate and apply it in core engineering areas.

Learning Management Systems (LMS) are the online technologies making serious impact on learning and teaching in higher education and becoming popular across the world. These are being widely used to enhance and improve the learning in almost all subjects. The very fact that they are used to improve the learning is a valid reason to believe that the student engagement is high. Exploiting this, quizzes have been designed using MOODLE (Modular Object Oriented Learning Environment) in an online environment. The students are connected in the college environment through LAN and once their accounts are created, they can participate in the online learning at their convenience using the login ids created and provided. Thus face- to -face is no more a necessity to use the quizzes. An online diagnostic test is conducted at the entry level and the students with low competency levels are identified. These students are then subjected to MOODLE quizzes throughout the course.

Weekly online quizzes were developed for these students in three stages in a blended learning environment. The regular teaching of concepts is done as part of the lectures in a face to face environment. The lectures are further supplemented with quizzes in three stages. The focus of the quizzes was on the critical lower level thinking of the students, and in providing immediate feedback to the answers for further improvement in formative assessment. Learning gaps which are wide can be addressed through the face to face sessions for the benefit of all students. Confidence levels are boosted, and the student is likely to perform better in the class environment.

In the first stage, a short quiz is administered using MOODLE. The quiz is mostly multiple choice and covers the prerequisites for the Advanced Calculus course such as basic calculus-concepts-differentiation and integration. The quiz is designed to assess the level of the student and competency by focusing on the concepts which are difficult to understand. After analysis of the results of this quiz, the students are given more resources as content to remove their deficiencies Students recall the concepts studied with a better understanding.

Stage 2 caters to the visualization of the concepts in the course. Video links are circulated, and a quiz designed based on the visual aspects of the concepts is uploaded on to the LMS- MOODLE
The videos allow students to synthesize and disseminate knowledge from various sources on a given topic. This quiz is repeated every week on the content delivered in the previous week. After thorough analysis of the performance, more remedial measures are suggested.

Topics on which the concepts were tested include:

- Mean Value Theorems
- Sequences and Series
- Multiple Integrals- Double , Triple Integrals
- Vector Calculus- Differential and Integral
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The MOODLE quizzes are convenient tool to inform students of their performance throughout the learning process.

In stage 3, advanced concepts in the course are assessed via a MOODLE quiz, wherein difficult portions related to concepts are tested. The questions are arranged from easy -to- moderately difficult- to difficult and are tested on the conceptual aspects only. This is then supplemented with worksheets on problem solving. Solutions to these problems are worked out collaboratively in groups of two to three with students from diverse learning backgrounds. This helps to promote a deeper learning experience rather than rote learning

The experiment was conducted on a group of 30 students initially. Students login and see the content online. The activity database of MOODLE records the user details.
Usage data and score from the quizzes are analyzed. Evaluation of student performance is carried out using the tools of the Learning Management system
This three-pronged strategy surely helps the student as he is autonomously engaged and learning is enhanced.

In the context of this project designed exclusively for slow learners, the quiz module from MOODLE provided information on the number of questions that the students got wrong, time spent on the quiz and overall quiz results.
The tables below give a brief description of the three online quizzes designed based on the competency levels of the student.

Table1. Number of questions and question type

Quiz Basis	Number of questions	Multiple-Choice	Short-answer/ numerical
Diagnostic	30	20	10
Visualization	20	15	5
Advanced topics	25	20	5

Table2. Topics covered in quiz-1 (Diagnostic)

Quiz Basis and number of questions						
Functions (3)	Graphs (2)	Limits(4)	Continuity (5)	Differentiability (5)	Maxima and minima for one variable (6)	Integration-basics (5)

Table 3. Topics covered in quiz 2 (Visualization)

Quiz topics and number of questions					
Mean value theorems (2)	Sequences and Series (2)	Double Integrals(5)	Triple Integrals(5)	Vector Differential calculus (6)	Vector Integral calculus(5)

Table 3. Topics covered in quiz 3 (Advanced Topics)

Quiz topics and number of questions					
Mean value theorems (2)	Sequences and Series (2)	Double Integrals(3)	Triple Integrals(3)	Vector Differential calculus (4)	Vector Integral calculus(6)

Since assessment is one of the most important activities in education, feedback on performance plays a relevant role in the teaching-learning process. Immediate feedback after the quiz is useful for students to evaluate their own activity and begin to understand where they went wrong. It helps student to be engaged with the task. The student will also able to manage his anxiety as he now values what he is learning and takes control of and devotes his attention to the task assigned. The main purpose was not only to familiarize with the quiz but to revise their lecture notes as part of the formative assessment.

4. Result Analysis

Analysis of results showed that the results of the first two quizzes were good with high or perfect scores. The easy level of quiz 1was intended for learning with fun and to get the student to use the online quiz mode. For the second and third quizzes, more attempts(3) were given to enable the students to repeat the quiz with more learning. The overall results of the second and third quiz were not as high as the first with average scores of 20.33 out of 30.00. out of 30 students who took the quiz, 8 students achieved a perfect score, and 12 students achieved a score of 50%or higher and 4 students did not complete the quiz. The results of the students who participated in the quiz showed a slight improvement during the1 mid exam and the results of the end exam are awaited.

Continuous assessment and feedback of the student on learning by these processes will further enhance their knowledge and instill confidence in them.

Giving students an opportunity to discover and an opportunity to practice what they have learned improves student achievement.

5. Conclusions and Future work

The preliminary results from this ongoing academic research using the Learning Management System- MOODLE(Modular Objected Oriented Developmental Learning Environment) revealed an improvement of student's results in both the continuous and formative assessment conducted on a group of first B.Tech Students for the foundation course of mathematics for engineering- Advanced Calculus. The main limitation of the research was the limited data. This preliminary research is a first step as part of this work- in- progress paper aiming to present a new approach to teaching and learning of mathematics in engineering using technology.
This study shows the impact of using MOODLE quizzes in the learning process, especially among the slow learners. The study clearly indicates that the student participation in an online learning platform is an effective predictor of their academic achievement.

Future work-To begin with the implementation of the methods suggested above was on a small group of 30 students. The accuracy of the results and the efficacy of the method can be improved with a larger group. The range of tools that are available with the LMS- MOODLE can be suitably exploited by creating a strong database and customizing it to the specific needs and addressing the diverse group of students. The students rating on these quizzes can also be taken as an improvement measure. This methodology in this paper is new and will be refined in future with experience, as work progresses.

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