A implementation framework for Tutorial Based Learning (TBL)

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Abstract: - The use of Problem Based Learning (PBL) has proved to be a successful method in improving student knowledge retention and understanding. However, the implementation of PBL puts stress on resources in terms of teaching staff and lab usage which is a hindrance for the participating students. In this paper we present a framework for implementing a Tutorial Based Learning model which can be used in institutions where the number of students is large (>100) and resources are limited which is very much the case in developing countries. Results of an experiment conducted under the proposed model have also been discussed. The experiment involved four modules taught at the undergraduate course in Electronics Engineering at Mehran University of Engineering and Technology, Pakistan. A total of 120 students were divided in to four sections each consisting of 30 students. Each section was further divided in to groups of 6 students each. Two hour Tutorial Based Learning (TBL) sessions were conducted for each section on different courses each week in which a particular problem/topic was discussed. The students were asked to present the deliverables of the problem on the completion of the program. At the end of the experiment which ran for one semester, results showed a marked improvement in the student grades for the courses involved in the experiment and increased student participation in classes.

Key-Words: Electronic Engineering, Problem Based Learning, Tutorial Based Learning.

1 Introduction

Developing countries face the challenging task of providing quality education to students with limited resources in terms of teaching staff and equipment.

After the introduction of PBL in Maastricht University, Maastricht, The Netherlands [1], it has been implemented in several scenarios [2]-[4]. The PBL involves teacher to act in a facilitating role instead of a tutoring role and allow the student to explore some decided aspect of his field of study [5,6].

The authors in [7], [8] and [9] discuss a PBL implementation in which the Problem Based Learning is preceded by course lectures for Electronic Engineering [7]. This approach is said to have provided the student exposure to both conventional style learning as well as solving real problems. However, such practice has the disadvantage of students moving between two very different forms of learning.

The authors in [10] provide their observations on the implementation of a PBL system for the teaching of Wind Energy Conversion Systems for a Masters Degree. First, the theoretical background of wind turbines was provided to the student in taught lectures followed by a PBL section. The PBL involved providing the students with a virtual simulation of a wind turbine and its inherent systems as well as a real physical system. The students were then asked to analyse the two systems to develop an understanding of the two and determine experimental integrity. It was found that the students performed well on the virtual analysis part of the PBL implementation but did not receive well the real time analysis. This method, like [5], [8] has the disadvantage of presenting the student with a dramatic change in the learning method.

The authors in [11] introduced an Integrated Project system for students of Chemical Engineering, which involved teaching courses from various fields in order to develop solution to an open ended project. It was found in a survey that both the teachers and students had positive perceptions of the program in terms of student learning outcomes. The authors in [12] discuss a framework for the implementation of

Integrated Projects for students of Mechanical Engineering and several issues relating to resources, nature of projects to be work on have been discussed. Like [10], the students responded well to the change of methodology from theory based lectures to the more project oriented learning mechanism employed in the program.

The authors in [13] discuss the impacts and the observations from PBL courses in various fields. It was found that the PBL based courses exhibited higher student attendance as compared to conventional lecture style classes. This has been shown to support the theory that PBL provides a practical understanding of the theoretical concepts and thus is a motivating factor for student involvement. It was also found that PBL courses had improved the problem solving skills of the students as determined through exercises. It was concluded that students favoured a PBL based setting because of its learning benefits and understanding of theoretical concepts.

However, the implementation of PBL has encountered problems [14-16] in terms of students behaviour, workload on the students as well as the instructors involved, the behaviour of the instructors as to the extent of help to be provided to the students, the required resources and the number of students involved in the program.

Since the effectiveness of PBL depends greatly on the geological and cultural location of the institution in which it is being used in, it is important to reshape the PBL models to ensure productive results [17], [18]. To try accomplishing this and overcoming some of the mentioned problems in this paper, we present a learning model that incorporates theoretical understanding with practical real world problem solving. The paper is organised as follow, the second section presents a description of the proposed framework, the third section gives the methodology of our implementation and the fourth section presents and discusses the results. The paper is concluded in the fifth section which also presents potential areas of further study.

2 TBL Framework

Engineering students in the modern world need not only be equipped with technical skills but also should be able to communicate their ideas while dealing with a range of people. Our Tutorial Based Learning framework therefore has been designed so as to incorporate both these aspects and combines the cognitive and social learning approaches as described in [19]. TBL system was implemented for four out a total of five courses taught during the second year of the undergraduate program of BEng. Electronics Engineering at Mehran University of Engineering and Technology, Jamshoro, Pakistan. Three courses were related to core Electronics Engineering, namely Measurement and Instrumentation (MI), Amplifier and Oscillators (AO) and Digital Electronics (DE) whereas the fourth course was on engineering mathematics called Differential Equations and Fourier Series (DEFS). All of the courses were previously taught in a traditional lecture/exam setup, however, for the experiment, in addition to theoretical lectures separate TBL sessions were scheduled every week. Apart from the outcomes of the course as a whole, the targeted outcomes of the experiment were to:

a) Enhance student learning
b) Develop interpersonal and discussion skills
c) Trigger cognitive thinking for practical problem solving

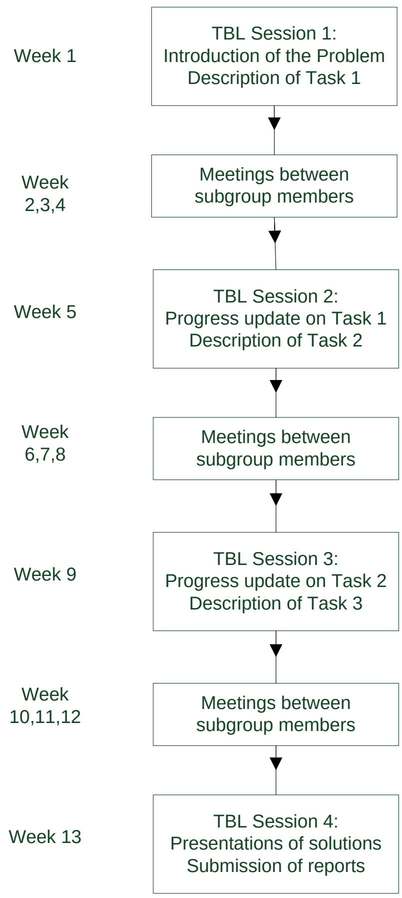

Figure 1: TBL framework (each subject)

The experiment was conducted over the span of one semester (13 weeks) in 2013. A class consisting of 120 students was divided in to four sections of 30 students. Each section was assigned a supervisor. The supervisor was responsible for facilitating the students in matters relating to understanding of the problem and logistical issues**.** Furthermore, 5 subgroups were formed within each section such that each subgroup consisted of 6 students. It was ensured that each subgroup consisted of at least one student from the top six students of the section as determined from previous examination results. A problem comprising of three stages was devised for each course included in the experiment. Every week, a two hour TBL session was organised in each section for one of the four courses in which students were provided a description of a case study. Students were instructed to organise subgroup meetings and submit a report on the work progress during the TBL sessions. At the end of every month, students were introduced to a new aspect of the case study. Finally, students were required to deliver presentations on their understanding of the case study. This framework has been shown in Fig. 1. The educational model used in the semester has been shown in Fig. 2.

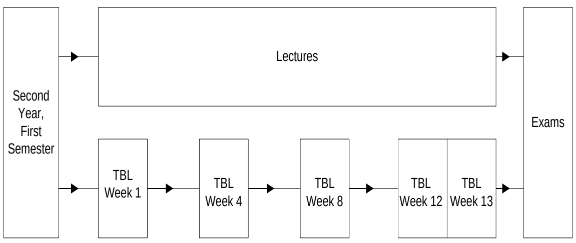

Figure 2: Educational Model

3 Methodology

3.1 Measurement of Instrumentation

The course on Measurement and Instrumentation is designed to introduce the basic principles of instrument operation and measurement systems to the students. It aims to provide the students with the skills required to be able to conduct measurements of physical parameters and interpret them. It also provides the students with an understanding of functionality and principles of commonly used instruments.

3.2 Amplifiers and Oscillators

The course on Amplifier and Oscillators aims to provide the student with skills necessary to develop analogue circuits for tasks such as signal conditioning, communication systems and to gain an insight in to the various methods employed to accomplish certain analogue functions using discrete components.

3.3 Digital Electronics

This course serves as the foundation course for digital system design for applications. It involves the study of the various aspects of digital circuit design and study of the functions of common combinational and sequential digital circuits. It also provides an insight in to the characteristics of the different technologies available in the digital electronic industry.

3.4 Differential Equations and Fourier Series

Differential Equation and Fourier Series is a course designed to introduce the student to the application of differential equations to formalising problem+s in electronic circuit analyses. It also provides the student an understanding of basic Fourier principles and the concept of decomposition using Fourier series.

For each course, the devised problem was broken down in to three stages in increasing order of complexity, each requiring a different set of deliverables to be satisfied. The first stage of the problem for each course related to review of the available literature so that students can familiarise themselves to the case study being considered. The second stage of the case study consisted of a task to describe the dependency and requirements of system components. The third and final stage was a set of specification parameters in a problem scenario for which each subgroup was instructed to produce a solution and provide justifications for their design. Regular theory lectures/Lab sessions were conducted alongside the TBL sessions during the semester.

4 Results

These students were evaluated in written exams conducted at the end of the semester and for the solutions developed for the assigned case studies. Several factors are provided in [20-22] for taking in to consideration when assessing the effectiveness for a problem based learning program. However, there is no agreed gauge on testing the success or failure of a program. In order to incorporate the diverse testing criteria advised by authors and provide a broad insight in to the results from various sides, we used three metrics to examine the efficacy of our model. The first metric was an analysis of the performance of the students in exams and the report on the problem, the second and third was a survey conducted from the students and the staff involved in the program. We present in this paper a summary of our findings.

4.1 Student Performance

Student performance was analysed based on the reports produced in the TBL sessions and the results of the exams appeared in for each of the courses. Three measures have been considered for inspecting student performance. The first indicator we use is the comparison of the average marks for each course with and without TBL. Fig. 3 shows the average marks (rounded to the nearest integer) scored for each course during the year TBL was implemented (2013) and the year prior to TBL implementation (2012).

It can be observed from Fig. 3 that the largest improvement of 19.75% was observed for the course DEFS. This can be possible due to the fact that TBL included mathematical application to practical electronic problems which provided a

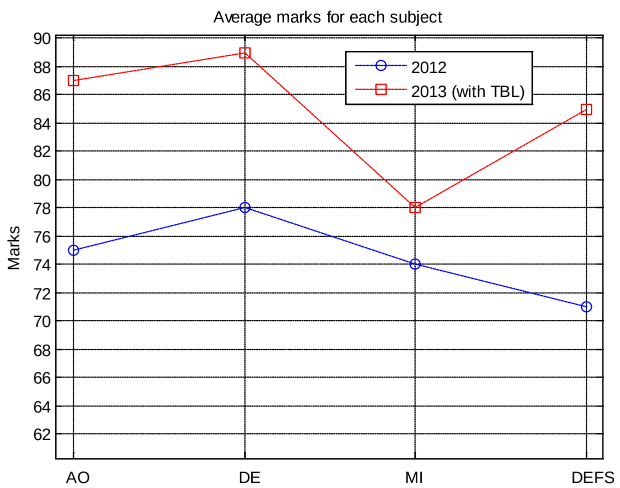

Figure 3: Average marks for each course

direct insight in to application of the mathematical principles rather than an abstract mathematical understanding. It was also observed that the course MI showed the least improvement that is 5.45%. The possibility for this stems from the fact that this course already required a significant amount of laboratory based work in the previous year, since TBL also emphasises on practical understanding, a relatively small improvement was observed.

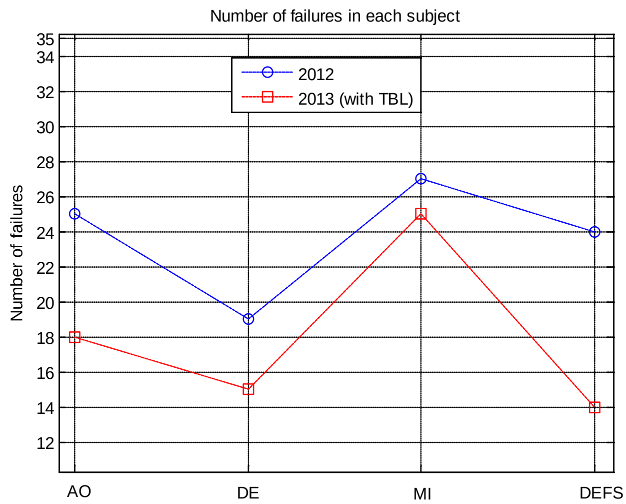

Figure 4: Number of student failures for each course

The second gauge that was used is the number of failures in these courses for the two years. This was chosen so as to ascertain the uniformity of the improvement as average marks can be misleading when considering the performance of individual samples. Fig. 4 shows the number of failures in the courses for the year 2013 and 2012. It can be seen that the number of failures reduced significantly in DEFS which is supported by the average increase in marks. The least reduction is seen to occur in MI which is again corroborated by the fact that the course had a considerable amount of practical work involved in the previous year.

Fig. 5 provides a comparison between the number of students of the same class who failed at least one course in the semester prior to the introduction of TBL. It can be observed that with the implementation of TBL, the number of failures has been reduced by 10.

The quality of the reports submitted for the TBL tasks were found to be more detailed with clear methodologies described for their prescribed solutions as compared to reports produced for previously constructed projects for lecture based courses.

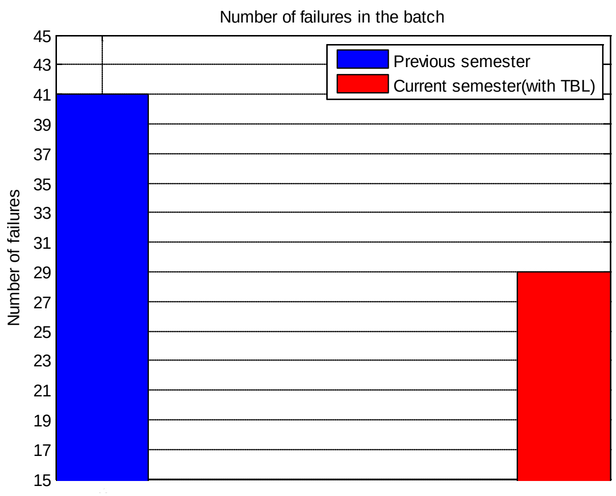

Figure 5: Number of failures in 2013 and 2012

4.2 Student Feedback

Upon the conclusion of the semester, all 120 students were asked to participate in a survey which was used to determine the perspective of the students on the program. The survey consisted of questions relating to various aspects of the TBL implementation. The questionnaire used in the survey and the student response is presented in Table 1.

It can be observed that the TBL program has been well received by the students with a significant majority being satisfied with it. A further area of interest is the student impression on the increased amount of work and the time management involved in the completion of the tasks. Nearly half the students found the increased amount of work to be manageable; however, the time given to the students for completing the tasks was found to be problem with 45% indicating so. The fact that the increased work load was manageable can be explained from the fact that the students were attending classes for the selected modules and thus were getting an insight to the general field of study. This is evident from the fact that 68% of students supported this aspect of the program and found it to be helpful. The problems on the management of time can be mitigated by changing the extent of the problem depth.

Another aspect to look upon is the student perception on the technical content of the program. The problems assigned to students were of open nature so as to enable to students to develop different approaches to the same problem and be able to devise solutions. This was well taken as shown by the high acceptance of the problem context. This is corroborated by the improvement in the performance of students in the module exams. Feedback was also taken on the management of resources and the support provided by teachers. Due to the tight schedule of the class timetable, making the resources available for students was a considerable challenge. However, as seen from Table 1, resource allocation was sufficiently provided for all students. This depends heavily on the nature of the tasks formulated for the courses

Table 1: Student Questionnaire and responses (N=120)

S No.	Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	Overall Satisfaction with course model	33(28)%	53(44%)	30 (25%)	04(3%)	00
2.	The amount of work was manageable	07(6%)	43(36%)	45(38%)	24(20%)	01(<<1%)
3.	Time management was a problem	19(16%)	35(29%)	47(39%)	15(13%)	04(3%)
4.	Context of problem was understandable	27(23%)	61(50%)	24(20%)	08(7%)	00
5.	Like to work in a team	81(68%)	26(21%)	13(11%)	00	00
6.	Studying course material was helpful in providing an insight in to tasks	37(30%)	45(38%)	29(24%)	09(8%)	00
7.	Teacher support was sufficient	40(33%)	58(48%)	21(18%)	01(<<1%)	00
8.	TBL has helped developed practical understanding of subject	37(31%)	65(54%)	18(15%)	00	00
9.	Resources provided were well managed	24(20%)	79(66%)	17(14%)	00	00

involved. The tasks in this program required the use of computers and hardware equipment which was easily available. Teacher support for the tasks was limited to getting updates from students on current progress. As seen from the Table 1, the students were satisfied with the support the teachers provided during the program.

4.3 Teacher Feedback

Along with conducting a student survey, the participating faculty members were also asked to provide details of their experience during the program. Unlike the students, however, the feedback required elaborate answers on two aspects of the program, the design of the curriculum which involved planning the tasks along with the taught modules and the sessions with the students. The other was the increase in workload.

The tasks to be designed for the TBL sessions were meant to provide students with an outlook of problem solving and management skills required in a real world scenario. This involved surveying projects from various sources, breaking them in to tasks, downscaling them to be completed within the given time duration and deciding the deliverables for each part of the task. This increased work load of the teachers significantly and proved to be a tedious task. Ensuring that the problem was open enough to be carried out using different approaches also required careful consideration from the point of teachers. Furthermore the teachers involved in the program also responded that personal interaction with students allowed them to be informal with the students.

4 Conclusion

In this paper, we highlighted the observations from the implementation of a Tutorial Based Learning methodology developed at Mehran University of Engineering and Technology. The methodology provides an opportunity for universities to provide their students with practical as well as theoretical knowledge. Implementation of the model was found to have improved student grades in the respective courses with the most significant improvement being observed in the areas containing significant mathematical content. Student feedback showed that the students were comfortable with such a learning system as it helped them with their courses. Furthermore, since the tasks were of familiar nature due to the support provided by the course study, grade anxiety [23], [24] was not complained by any of the students. Teacher feedback provided an insight in to the challenges that faculty members have to encounter in formulating tasks for such a program.

Finally, the TBL has shown promising results in light of improvement of student performance in our courses. However, more research needs to be carried out in understanding the long term impacts of such a module especially in the area of the skills of teamwork and management that students can potentially develop which are of interest to employers, the effect of increased workload and the formulation of tasks for such as system is also something that needs to be further studied.

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