STRUCTURED ABSTRACT

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Enhancing Motivation for Homework Exercises in Engineering Mathematics Classes

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CONTEXT

Engineering Mathematics is a core course/subject for many engineering programs and is included in the early years of the program in most universities. At Eynesbury Institute of Business and Technology in Adelaide, South Australia, this course is offered in a pathway program. In this course, a combination of factors prevents students from succeeding academically. Lack of motivation creates a failure to transfer appropriate knowledge to the current academic situation. Positive motivational beliefs can lead to increased academic performance through engagement with classroom tasks.

PURPOSE OR GOAL

To improve the students' success rates in this subject/course, it was decided to give more focus to the issues related to homework exercises. Initially, the reasons for poor performance in homework assignments were investigated: a series of strategies was then developed to address these issues. Furthermore, these strategies were implemented and their effectiveness was evaluated.

APPROACH

The strategies adopted comprised making the homework exercises part of the assessment; changing the assessment questions to suit the students by including real-life situations; and conducting discussion on homework exercises at the end of every class. These strategies were implemented and a survey was conducted to obtain feedback from students. The survey results were then analysed to determine the success of the plan.

ACTUAL OR ANTICIPATED OUTCOMES

The survey conducted after the implementation of the new strategies showed significant improvement in the participation rate and student engagement. Moreover, good academic results were achieved by the participating students in their final examination.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The adopted strategies were effective in improving the performance of students in the Engineering Mathematics course. The reflections on these exercises will be analysed to further improve the delivery of the course.

KEYWORDS

Engineering Mathematics, motivation, homework exercise, student engagement

Introduction

Engineering Mathematics is a core course/subject for many engineering programs and is included in the early years of the program in most universities. At Eynesbury Institute of Business and Technology in Adelaide, South Australia, Engineering Mathematics is offered in a pathway program. In this course, a combination of factors prevents students from succeeding academically. Lack of motivation creates a failure to transfer appropriate knowledge to the current academic situation. Positive motivational beliefs can lead to increased academic performance through engagement with classroom tasks.

Engineering Mathematics provides an introduction to the basic concepts and techniques of calculus and linear algebra, emphasising their inter-relationships and applications to engineering, the sciences and financial areas; introduces students to the use of computers in mathematics; and develops problem-solving skills for both theoretical and practical problems. The topics covered are:

- calculus – applications of the derivative;
- functions of two variables;
- the Taylor series;
- differential equations;
- algebra;
- the real vector space;
- eigenvalues and eigenvectors;
- linear transformations; and
- applications of linear algebra.

Students are from diverse backgrounds and include domestic students as well as those who are international students. In this class, a combination of factors prevents students from succeeding academically. They are constantly on the borderline of success and failure. Lack of motivation creates a failure to transfer appropriate knowledge to the current academic situation. When students on a Monday cannot recall aspects of the previous week's lessons, this is due to a combination of cognitive factors and motivation. Engagement with the study material relies on a combination of self-goals and beliefs about the Engineering Mathematics class and their self-perception. Positive motivational beliefs can lead to increased academic performance through engagement with classroom tasks (Hopkins 2002). The implication is that building a supportive class community is an essential aspect of teaching low-track students.

To improve students' success rate in this subject, several strategies were put forward: it was decided to implement these strategies in steps.

The first step was to focus on the issue of completion of homework by students. As indicated earlier in this paper, the authors' intentions were to change students' homework completion patterns as not all students were completing homework and, of the students who were attempting to do so, many were only partially completing exercises. The authors' intention was to observe rates of homework (HW) completion and to adopt appropriate strategies

based on these outcomes. Therefore, action research and reflective practice were applied to address these issues. The scope of the project was limited to the improvement of homework exercises. It was also observed that, as Engineering Mathematics is taken in the first year of the degree program, some students need to adjust their learning style within the new study environment, especially those who are high school leavers.

Problem description

The topic of homework originally received attention in 2013 for Cohort 1 (Feb '13–May '13). The Engineering Mathematics course relied on lectures as the primary delivery mechanism for the study material. The tutorials generally supplemented the lectures by providing exercises and problems to enhance the understanding gained from lectures. At the end of each tutorial, homework exercises were given to reinforce the learning. During this course of study, a sequence of tests provided assessment opportunities for students to gauge their progress and understanding. The assessment tasks consisted of an assignment, two tests and the final examination. It was observed that not all students completed their homework as it was not part of the subject assessment. Only 30% of the students completed their homework. In addition, only 55% of the students were able to achieve pass grades in their final examination.

Students in this class had many barriers for academic success. These included after-study jobs, poor time management and motivational factors that left little time for homework. For some students, grades were not motivational tools. It was realised that student motivation lies at the heart of the homework issue. To improve the pass rates in this course, more focus was given to the issue of homework completion by students and on investigating the issues related to homework (HW). Therefore, action research principles were applied to address these issues (Mills 2011; Hopkins 2002). The scope of this project was limited to improvement in homework exercises.

Literature review

Research has shown that homework is one of the important factors in achieving success in studies. Homework can be defined as any task assigned by teachers or facilitators that is intended for students to carry out during non-school hours (Cooper 1989; Pintrich and Schrauben 1992). Generally, a positive relationship is found between doing homework and school results. In their review of research on the effects of homework, Cooper et al. (2006) demonstrated a positive relationship between the homework of students and their school results in terms of both class grades and standardised test scores. Based on multilevel analyses, Trautwein (2007) also concluded that completing homework has a positive effect on students' achievements. Different strategies are to be adopted to enhance motivation: the selection of strategies depends upon a variety of factors such the nature of the subject, and the level and mode of delivery (Narayanan et al. 2013 and Spuzic et al. 2013).

In addition, research has shown that making coursework relevant to students' lives increases their motivation and potential for success. Bryan and Sullivan-Burstein (1998) found that real-life homework assignments made a difference in assignment completion. By making

classroom topics relevant, students were motivated to do their homework and to prepare for tests.

Ahmad et al. (2010) conducted a study to determine whether there was any difference in student achievement when the educator used the traditional method to teach mathematics compared to greater use of a more interactive approach as tools for teaching. It was found that students who were exposed to teaching which was aided by multimedia achieved higher scores compared to students who were exposed to the traditional method. This showed that teaching students using multimedia can stimulate the students' understanding faster and better compared to the traditional method (Ahmad et al. 2010). As the influence of the internet is rapidly increasing among the younger generation, educators need to slowly change the paradigm of teaching and learning. Tawil et al. (2013) have found that usage of internet technologies like YouTube has a positive impact on teaching and learning progress in mathematics courses (Tawil et al. 2013 and Pundoor et al. 2007).

Data collection method and data analysis

This study was conducted during the first few weeks of the study period of students in Cohort 1 (Feb '13–May '13) to find the reasons for failure to complete homework and non-engagement by students. It was planned to conduct a survey using a questionnaire as detailed in the next section. Responses from this survey were then analysed: a series of action plans was proposed and implemented for the students in Cohort 2 (June '13–Sep '13). Finally, a second survey was conducted to find the effects of the changes implemented: the student grades of the two cohorts were also compared.

Initial survey

In the first survey, the 20 students in Cohort 1 participated by completing a questionnaire in which the following questions were asked: students were asked to tick more than one answer for each question.

Example of question:

Q. What hinders you from doing the homework? (Students were given the following options:)

a. Not interesting
b. No time
c. No credits
d. After-class jobs
e. Too tired in the evening
f. Forgot to do it
g. Extracurricular activities
h. Too much work for other subjects

Figure 1 shows the outcome of the initial survey conducted. The reason "not interesting" received the highest number of responses, followed by the reason "no credits". It was

obvious from this result that students were not very motivated to do the homework exercises. It was concluded that the homework exercises needed to be modified in order to increase the students' participation.

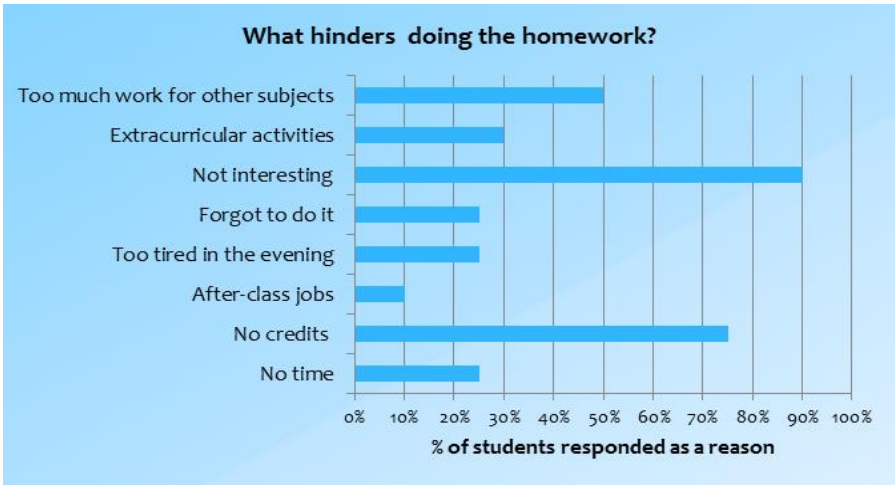

Figure 1: Outcome of initial survey

Using the findings of the initial survey, the following changes were introduced to homework exercises for the students in Cohort 2:

1. Convert the homework exercises into homework assignments.
2. Change the questions to suit the students by including real-life situations and incorporating internet technologies such as YouTube.
3. Include discussion of the forthcoming homework exercises at the end of every class.

There were 12 sets of homework assessments in total: it was decided to provide a weighting of 15% with each one receiving 1.25 marks.

Examples are provided below of the changed questions and the implementation of the above changes for Cohort 2 students:

Cohort 1 students:

Given that the logistic equation, $\frac{dP}{dt} = 45000\,KP(1 - \frac{P}{45000})$, is a first-order separable differential equation, show that the solution is

$P(t) = \frac{CP_0}{P_0 + (C - P_0)e^{-kt}}$ where $P(0) = P_0$. Also, find $P(5)$ when $P_0 = 200$ and $P_3 = 2800$.

Cohort 2 students were asked to answer the same question presented in a different way:

A town of 45,000 people suffers from a swine flu epidemic. If the number of people $f(t)$ at time *t* (in weeks) who have contracted swine flu satisfies

$f'(t) = 45000\,K\left[1 - \frac{f(t)}{45000}\right]f(t)$ and if 200 people have swine flu at the outbreak of the epidemic (*t = 0*) and 2,800 have it after 3 weeks, find the number who have it after 5 weeks.

While discussing and implementing exercises on some topics, students were, for example, asked to identify a quadratic surface in their homework with geometrical figures shown using some video clips and discussion on the different types of quadratic surfaces during class time.

These changes were effected and the new homework exercises were implemented for students in Cohort 2. To improve active participation, at the end of each class, students were asked to discuss in groups the forthcoming week's homework exercises. The problems were highlighted by showing some of the audiovisual resources available for the particular topic such as YouTube clips from various sources. The following link is one example of the YouTube clips shown in class:

http://youtube/x6c2DdOrkQI

Final survey

The effect of the changes in homework exercises was investigated by determining the completion rate of homework exercises and conducting a final survey using another questionnaire for the Cohort 2 students. The following questions were again asked and the answers were analysed to check the validity and reliability of this project.

How do you feel about the homework assignment?

Q1: Was it interesting?

Q2: Does it help you to understand the topic?

Q3: Do you feel confident in this course?

Q4: Was it helpful to you in reaching a good grade?

Q5: Was the discussion at the end of the class useful for your learning?

A column at the end of the questionnaire provided space for students to add their comments and suggestions. The students' response rate for this final survey is given in Figure 2.

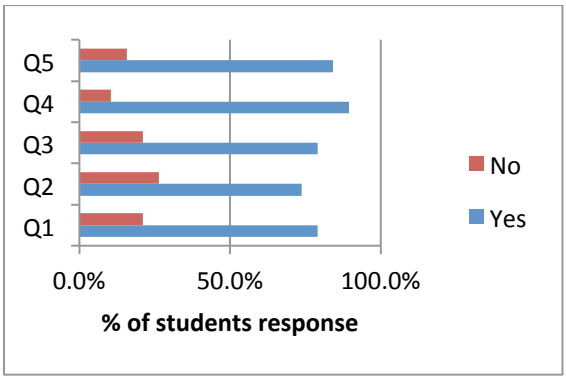

Figure 2: Students' response rate on homework assignment question

Qualitative feedback and comments were also collected through this questionnaire using a comment section. Some useful student comments are included below:

- "… reduce the number of questions in the assignment".
- "… we would like to start the assignments in the class and finish them at home".

Finally, data on student homework completion rates for Cohorts 1 and 2 were collected and compared as shown in Figure 3.

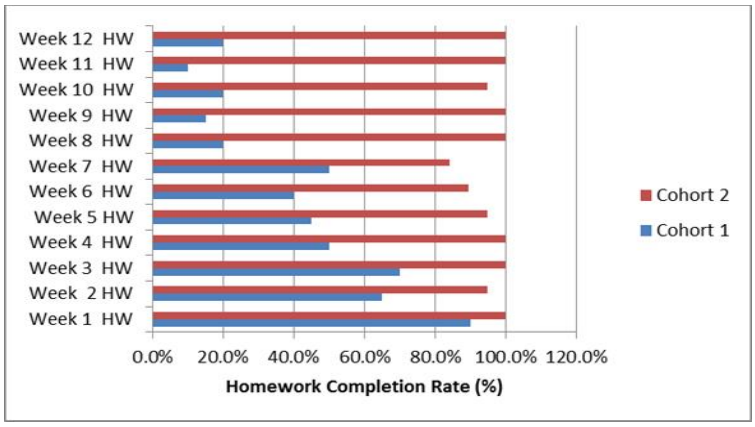

Figure 3: Homework completion rate comparison for both cohorts

It was observed that 80–100% of the Cohort 2 students completed their homework exercises. Also, these students actively participated and showed a significant improvement in their engagement in the classroom. Moreover, as shown below, they achieved a good result in the final exam.

The final examination set for the course for both cohorts was exactly the same and conducted identically. Therefore, it was considered a good tool for comparing the performance of the two cohorts. Figure 4 presents the grade distribution of students in both cohorts in their final examination.

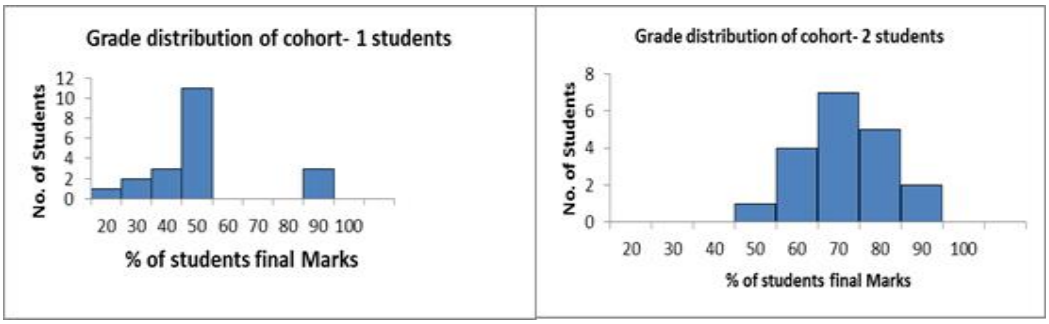

Figure 4: Final examination grade distribution

Conclusion

After investigating the homework component of the Engineering Mathematics course, the reason for the low participation rate was found to be low motivation. The changes carried out to the homework comprised converting homework exercises to become part of the assessment; changing the assessment questions to effectively engage the students by including real-life situations; and including discussion of the forthcoming homework exercises at the end of every class. Finally, these strategies were implemented and a survey was conducted to gain feedback from the students. The final results of the study showed significant improvement in Cohort 2 students' participation rate and engagement. Other minor factors may have contributed, but the improvement in both homework completion rate and the final examination is large enough to substantiate the success of new approach.

This study shows that the strategies adopted in this case were definitely useful and worked. Student motivation towards homework and Engineering Mathematics improved significantly with this result achieved through adopting alternative approaches to homework exercises. Engineering Mathematics is one of the toughest fundamental subjects for engineering students; therefore, more realistic and interactive methods can enhance students' motivation and can increase their confidence in solving Engineering Mathematics problems. The reflections on these exercises will be analysed to further improve the delivery of the course.

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