IDENTIFYING REASONS FOR STUDENTS’ NON-UNIFORM LEARNING OUTCOMES

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ABSTRACT: This paper presents results of an investigation into identifying reasons for students’ non-uniform assignment outcomes in a first year subject in the Civil Engineering discipline and proposes some effective measures to overcome this issue. The subject has been taught for three years since it was introduced in 2007. The assessment of the subject includes three assignments contributing 40% of the final result. In 2007 and 2008 the author observed that students performed well in the first and third assignment, however student performance in Assignment 2 was poor. This observation was confirmed through statistical analysis of the students marks from these two years. In an attempt to rectify the less than satisfactory student results in assignment 2 a change was made to the amount of teaching and tutorial time allocated to preparing for this assignment in 2009. It was found that this increase in teaching time allocated to mathematical calculations produced significant positive outcomes. While student results in Assignment 2 improved to a satisfactory level, assignment 2’ remained the least performing assignment compared to other assignments in the subject. To gain a deeper understanding students were surveyed. The initial hypothesis of this study was that the mathematical calculation focus of Assignment 2 might be the reason for lower student performance, however results of the survey show that the majority of students did not agree with this hypothesis. Students reported that they found Assignment 2 interesting and they understood the concepts and theory that it was testing. It would appear that other factors, perhaps the timing of the assignment mid-semester competing with other subject assessment, may account for the dip in student results. The outcomes from this investigation inform a set of recommendations for future teaching of the subject.

KEYWORDS: Non-uniform; Assignment; Statistical analysis; Problem based learning and Mathematical calculations.

INTRODUCTION

The subject named ‘Sustainable Design’ was introduced in 2007 in the Civil Engineering discipline as a first year compulsory subject at an Australian university. The strategic approach employed in the teaching of the subject is ‘problem based learning’. The assignments in the subject contribute 40% to the students’ final result. Assignments
include a degree of choice and are on the topics require students to work concept designs for infrastructure and utility services with sustainability as the prime objective. Project topics are sourced from Engineers Without Borders (a non-profit organisation) and the final product is submitted to a nation-wide competition. Project work is carried out in small groups and problems relate to real-life issues. During the semester course content informs the group project and is delivered concurrently through lectures, tutorials and consultations. This duration of semester allocated to Assignment 1 six weeks while it requires conceptual knowledge on sustainability and innovative thinking, it is introductory in nature. The objectives are to enhance students’ ability to apply knowledge of basic science and engineering fundamentals; enhance students’ ability to communicate effectively, not only with engineers but also with the wider community; develop an understanding of the social, cultural, global and environmental responsibilities of the professional engineer and to improve the understanding of the principles of sustainable design and development. The objectives of Assignment 2 are more focused and aim to enhance students’ ability to undertake problem identification, formulation and solution as well as demonstrate an ability to utilize a systems approach to design and operational performance. Assignment 2 also requires students’ to perform a set of mathematical calculations to calculate heat gains and losses from a typical house, eventually to minimise cooling load required by the traditional air-conditioning system. It requires accurate calculations using provided mathematical equations and steps. The objectives of the third and final assignment in the subject are to increase student knowledge about sustainability features, increase their understanding of professional and ethical responsibilities as well as their ability to function effectively as an individual in a multi-disciplinary team. The third assignment requires students to demonstrate their knowledge of life cycle analysis of the building or house selected by each group. This assignment also requires detailed calculation of energy and water uses, as well as waste generation for the building’s whole life cycle. Finally, students prepare a comprehensive life cycle assessment for the building at its different phases. The pattern of variable assessment observed over the first two years of the subject showed that most students did well in the 1st assignment, not as well in the 2nd assignment and yet their marks improved again in the 3rd assignment. The objective of this research was to investigate the reason(s) for this fluctuation in student results using a survey as well as an analysis of assignment tasks and content. The final goal was to propose measure(s) to overcome this pattern of variable results to enable more effective and uniform learning of the students.

**SELF-EFFICACY AND STUDENT PERFORMANCE**

The literature shows that self-efficacy is important in student outcomes and is task related. Researchers have been exploring these concepts for over 40 years. For example, Marton, F. and Saljo, R. [4] conducted an experiment with two groups of 20 first year students and studied outcome differences as a function of the learner's conception of the task. Marton, F. and Saljo, R. [5] described functional differences in the process of learning which gave rise to the qualitative differences in outcome. Svensson, L. [10]
studied outcome skills in different situations and related study activity to levels of understanding and academic performance.

Twenty years on, Bandura [1] defined self-efficacy as "one's belief that he/she is able to organize and apply plans in order to achieve a certain task" and described affective variables which were found to play an essential role that influences behaviour and learning. Bandura and Locke [2] commented that construct self-efficacy is tightly connected to motivation and plays a prominent role in human development since it directly influences behaviour. They further mentioned that among the various mechanisms of human agency, none is more central or pervasive than self-efficacy beliefs. According to Bandura's social cognitive theory, every individual possess a system that exerts control on his/her thoughts, emotions and actions.

Pajares and Schunk [8] examined the contribution made by the self-efficacy component of Bandura’s [1] social cognitive theory to the study of self-regulation and motivation in academic settings. He explained the difference between self-efficacy beliefs and other expectancy constructs, followed by a brief overview of problems in self-efficacy research.

Klassen [3] reported that self-efficacy is a task-specific construct and there is a correspondence between self-efficacy beliefs and the criterial task being assessed; in contrast, self-concept is the sense of ability with respect to more global goals, while self-esteem is a measure of feeling proud about a certain trait, in comparison with others. Nicolaou and Philippou [6] found that self-efficacy belief is a strong predictor of mathematical performance while problem posing is considered fundamental in mathematical learning. They examined the relationship that efficacy has in problem posing, problem-posing ability, and mathematics achievement. They reported that a students' perceived efficacy to construct problems is a strong predictor of the respective performance as well as of their general mathematics achievement. A strong correlation was also found between ability in problem posing and general mathematics performance.

In similar studies Pajares [7] posited that children self-beliefs are inextricably tied to their thinking and functioning. These researchers identified reasons why students select some activities and avoid others, why they succeed in some academic pursuits and fail at others, or why they are filled with either anticipation or panic at the thought of doing this or that task. Furthermore, Schunk and Pajares [9] described the development of one type of motivational process: perceived self-efficacy. They concluded that poor perceptions of self-efficacy reduces academic motivation, learning, and achievement. Self-efficacy is grounded in a larger theoretical framework known as social cognitive theory, which postulates that human achievement depends on interactions between one’s behaviors, personal factors (e.g., thoughts, beliefs), and environmental conditions.

This body of literature demonstrates that self-efficacy is an important variable and corresponds to the criterial tasks. It influences the global measures of student
achievement and can inform prediction of related outcomes. These earlier studies informed the hypothesis that underpinned the investigation reported in this paper:

The strong mathematical content of Assignment 2 is related to self-efficacy around the task and self-efficacy in mathematics affects student outcome.

RESEARCH METHOD

As the main focus of this investigation was to determine if students had a particular with the Assignment 2 a survey was constructed with to obtain student feedback on assignments. The survey questions were prepared to extract information on students’ level of understanding, their efforts in terms of total hours spent on the tasks, their self reported interest related to creative thinking, mathematics and learning new concepts. The survey was conducted at the end of the teaching period in 2009 when students had completed and submitted all of their assignments for the semester.

As noted in the introduction, the observation that students performed poorer on Assignment 2 was verified by two years of data. However, to improve students learning outcome related to Assignment 2, a strategic change was made in 2009 in the teaching process and the amount of time devoted to teaching concepts and content applicable to Assignmen 2 . In brief the changes are outlined below:

- An increase in teaching hours (from 1 hour to 2 hours) on explaining the basic theory to strengthen students understanding on basic concepts related to the assignment.
- More tutorials on hands-on calculations (from 2 hours to 4 hours) for the same assignment components to facilitate more practice and to build efficacy as suggested by Nicolaou and Philippou [6].

RESULTS ANALYSIS

This study was initiated with two years (2007 and 2008) of students’ assignments results. With the two years of data a brief statistical analysis was performed to quantify the students’ results anomaly. Table 1 shows the comparison of statistical analysis performed on 2007 and 2008 data. Note that the sample number was not same for both years. It is evident that there are significant differences between student performance on Assignment 1 and 2. Similar differences of performances between Assignment 2 and Assignment 3 are also evident (see Table 1).

In summary the mean values of assignment marks are 83~86.3, 60.2~62.7 and 83.3~84.7 for assignment 1, assignment 2 and assignment 3 respectively. The median values of assignment marks are 80~90, 60~65 and 88~90 for assignment 1, assignment 2 and assignment 3 respectively. Figures 1 and 2 graphically show the ‘Mean Mark’ and ‘10th Percentile Mark’ respectively for all the assignments in 2007 and 2008. It is shown that
the ‘Mean mark’ for ‘Assignment 2’ was around 60, whereas the ‘Mean mark’ for other assignments were above 80. Again, ‘10th Percentile Mark’ for ‘Assignment 2’ was about 45, whereas ‘10th Percentile Mark’ for other assignments was above 65. This statistical analysis proves that there are significant differences in the student results of Assignment 2 compared to other assignments.

Table 1: Summary and Comparison of Statistical Analysis

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<tr>
<td>Mean</td>
<td>86.3</td>
<td>83</td>
<td>60.2</td>
<td>62.7</td>
<td>84.7</td>
<td>83.25</td>
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<td>126</td>
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<tr>
<td>Median</td>
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<td>80.0</td>
<td>60.0</td>
<td>65.0</td>
<td>88.0</td>
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<tr>
<td>10th Percentile Mark</td>
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<td>70.0</td>
<td>45.0</td>
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<td>75.0</td>
<td>80.0</td>
<td>100.0</td>
<td>95.0</td>
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<td>30.00</td>
<td>0.00</td>
<td>40.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
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<td>100.0</td>
<td>100.0</td>
<td>85.0</td>
<td>100.0</td>
<td>100.0</td>
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</tbody>
</table>

Figure 1: Comparison of ‘Mean marks’ among all assignments in 2007 and 2008

**EFFECTS OF STRATEGIC CHANGE**

A further statistical analysis was carried out using the assignment marks for 2009. Keeping in mind that in 2009 there was a strategic change in the teaching of the subject. Table 2 shows the statistical analysis summary for the 2009 assignment marks compared to the average of 2007 and 2008 marks.

It would appear that the effect of the strategic change in teaching and tutorial timing produced significantly positive outcomes. The effects of the strategic change are
presented graphically in the Figures 3 ~ 6. From these figures it is shown that student results in all the assignments increased in 2009 compared to 2007-8. Due to increased teaching and tutorial hours, ‘Mean mark’ for ‘Assignment 2’ increased by 39% in 2009. Moreover the ‘Mean mark’ for Assignment 1 and 3 also increased by 7.5% and 10% respectively.

![10th Percentile](image)

Figure 2 Comparison of ‘10th Percentile’ among all assignments in 2007 and 2008

Table 2 Comparison of Statistical Analysis between 2009 and Previous years

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<tbody>
<tr>
<td>Mean</td>
<td>84.6</td>
<td>91</td>
<td>61.5</td>
<td>85.5</td>
<td>84</td>
<td>92.3</td>
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<td>Sample No.</td>
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<td>166</td>
<td>114.5</td>
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<tr>
<td>Median</td>
<td>85.0</td>
<td>95.0</td>
<td>62.5</td>
<td>90.0</td>
<td>89.0</td>
<td>95.0</td>
</tr>
<tr>
<td>10th Percentile</td>
<td>67.5</td>
<td>80.0</td>
<td>45.0</td>
<td>60.0</td>
<td>67.5</td>
<td>80.0</td>
</tr>
<tr>
<td>90th Percentile</td>
<td>97.5</td>
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<td>77.5</td>
<td>100.0</td>
<td>97.5</td>
<td>100.0</td>
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<tr>
<td>Minimum</td>
<td>35.0</td>
<td>25.0</td>
<td>15.0</td>
<td>50.0</td>
<td>20.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>100.0</td>
<td>100.0</td>
<td>92.5</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
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</table>

Figures 4~6, graphically show that the ‘10th Percentile’ and ‘90th Percentile’ values for 2009 were increased by 33% (45 → 60) and 29% (77.5 → 100) respectively. The ‘10th Percentile’ values for Assignments 1 and 3 were also increased by 18.5%. There was significant increase (233%) in ‘Minimum mark’ for ‘Assignment 2’, which may be attributed to the increased teaching and tutoring on mathematical calculations, ‘Minimum mark’ for ‘Assignment 3’ also increased significantly (150%). However, ‘Minimum mark’ for ‘Assignment 1’ decreased, this may be considered as an outlier.
In summary, it may be concluded that strategic changes (more teaching and tutoring hours for basic theory and hands-on practice on mathematical calculations) have produced significantly positive outcomes for Assignment 2. It may also be concluded that because Assignment 3 also has some mathematical calculations, the strategic changes also had a positive effect on students’ assignment 3 results. This finding is in line with the findings of Marton and Saljo [5], which mentioned that functional difference in the process of learning gives rise in the outcomes. Figure 7 shows the temporal patterns of different statistical patterns for Assignment 2.

![Mean Marks](image)

**Figure 3** Comparison of ‘Mean Marks’ between 2007-8 and 2009

![10th Percentile](image)

**Figure 4** Comparison of ‘10th Percentile’ between 2007-8 and 2009
SURVEY RESULTS

A set of survey questions was prepared and were given to the students towards the end of the semester in 2009. Of the 170 students enrolled in the unit, 122 participated in the survey, a response rate of 72%. The survey questions were prepared to elicit information about the level of student engagement in each assignment; their perception of the level of creativity, interest, and improvement of knowledge applied to Assignment 1; their
perceived reasons for lower performance in Assignment 2 and perceptions about excitement, interest and difficulties associated with Assignment 3. Figure 8 shows the percentage of students who spent less than 5 hours on each assignment. It was found that more than 40% of students spent less than 5 hours on Assignment 2, however for Assignment 1 less than 20% students spent less than 5 hours. This finding supports the conclusion made by Schunk and Pajares [9], that self-efficacy reduces academic motivation, learning and achievement.

Figure 7 Temporal patterns of different statistical parameters for ‘Assignment 2’

It may be concluded from these survey results that Assignment 1 enhanced students learning and knowledge; they reported that they found it both interesting and inspiring. Approximately 75% students agreed that the ‘problem based learning’ style of Assignment 1 enhanced their knowledge and skills, whereas only 3% students disagreed with this. Approximately 80% students agreed that the incorporation of ‘sustainability features’ and the real-life application of the problem made Assignment 1 interesting, whereas only 4% students disagreed with this. Approximately 66% students agreed that Assignment 1 was inspiring because it encouraged creative thinking and had the potential to lead into a national competition, however approximately 12% students disagreed with this. In summary, Assignment 1 appeared to be effective in satisfying the learning objects moreover students’ results were very good.

The initial hypothesis of this study was that the mathematical calculation aspect of Assignment 2 might be the reason behind lower student performance. However, only 22% students agreed with this hypothesis and approximately 58% students dis. In general many students did not realize the magnitude of deeper mathematics required for this
assignment. This supports finding by Nicolaou and Philippou [6], which says strong correlation exists between ability in problem posing and mathematics performance.

![Bar Chart]

Figure 8 Percentages of students spent less than 5 hours for the assignments

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are proposed as a result of this investigation:

- Increased teaching and tutorial time on Assignment 2 contributed to improving student results in this task. The lowest mark of Assignment 1 was increased by 230%.
- Even with the strategic changes, the least performance was still observed in Assignment 2, although most of the students agreed that they understood the theory (concept) and reported that they found the task interesting.
- Mathematical calculation was thought to be the reason for lower performance in Assignment 2, however most of the students did not agree with this reason. Only 22% students reported that they had difficulties with mathematical calculations. It should be noted that in the survey year (2009), approximately 20% students were from non-engineering disciplines, and may therefore have had weaker knowledge and skill related to mathematics.
- Most of the students reported that they understood the theory and concepts of Assignment 2 and that mathematical calculations were not a critical issue for this assignment. However students spent the least amount of hours on this assignment compared to other assignments. Could this mean that a degree of over-confidence (due to good performance in Assignment 1) might have led them to apply less effort to this assignment and be the reason for the poorer performance in Assignment 2
Through the observation of the effect of the strategic change and feedback from the students, the following recommendations are proposed to be implemented:

- More hands-on tutorial time on applied to Assignment 2 because in 2009 there was a significant improvement on students’ outcome for this assignment.
- If a significant number of students are from non-engineering disciplines, it is recommended that the subject to be reorganised in a way that results that in one semester it is offered for engineering students and in the other semester it is offered for non-engineering students.
- During tutorials, a performance summary of previous years student results could be presented to current students to alert them not to become over confident and to regulate student self-efficacy.
- Assignment 2 needs to be modified to make it more feasible for non-engineering students.

REFERENCES