**Development of a multidisciplinary assignment for 1st year engineering students**

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**Abstract**

Multidisciplinary teaching is one of the contemporary education techniques currently introduced by different tertiary institutions to stimulate students’ critical thinking, develop inter-disciplinary understanding, and enhance students’ problem solving skills. This paper analyses the pilot study for the development of a combined assignment between two units of the 1st year of the engineering curriculum “Foundation mathematics” and “Introduction to programming”. The current classical tasks of these two units are basically the application of the perspective, rules and theories in the vicinity of each unit experience, however students’ satisfaction is of concern when it comes to many real life applications of the mathematics or programming rules. In some industrial contexts, engineers are required to develop programming codes or work closely with the software designers to solve or analyse critical designs. The proposed assignment aimed to help students understand the link between these two disciplines. The proposed multidisciplinary task integrates a mathematical element into programming subroutine, giving mathematical concepts a context and relevance. Case studies from the mechanical and civil engineering industry were selected to develop the pilot assignments. The mathematical rules applied in this assignment were introduced in brief in the assignment sheet, which was provided to students as a guideline to help them undertake further investigation by online research. To measure students’ satisfaction, pre- and post-assignment surveys were conducted and analysed. The preliminary statistical results show improvement in students’ multi-disciplinary knowledge in the different units and enhancement in their industrial experience.

**Introduction**

The main goal of tertiary education is to develop knowledge about a certain discipline that can engender in the students the capacity to analyse information and apply it to real life cases. To make the learning process more enjoyable and productive, students need to experience the connection between different subjects of the respective curriculum. The International Bureau of Education specified three major types of contemporary approach to curriculum integration: multidisciplinary, interdisciplinary and transdisciplinary. Multidisciplinary curriculum is based on studying a topic from the viewpoint of more than one discipline, such as solving a problem using the approaches of different disciplines. Interdisciplinary curriculum involves the understanding of theories that cut across disciplines, which normally involves highlighting the process and meaning, rather than combining different disciplinary contents. A good example of this is a design of a medical device requiring engineering skills as well as knowledge of the function of a specific human part. Transdisciplinary curriculum is aimed at removing the boundaries between the core disciplines and integrating them to construct a new context with a real-world theme.

In multidisciplinary study, each discipline contributes to the solution individually to produce a parallel vision of a particular problem from different disciplinary perspectives (Klaassen, 2018). The design of multi to transdisciplinary tasks depends on the learning outcomes of a specific course and its respective tasks. Through identifying these outcomes and concurrent tasks, the level of knowledge and theories for integration can be decided during the curriculum design.

In this paper, the results of an experimental multidisciplinary task are presented. These tasks were developed to write a combined assignment for two units; “Introduction to Programming” and “Foundation Mathematics”. Both of these units are part of a first year engineering curriculum of the Sydney Institute of Business and Technology (SIBT). The combined assignments provide practice in programming principles to solve real life mathematical problems. Students’ satisfaction and cognitive progress were investigated by conducting surveys before and after each assignment.

**Related work**

Many pieces of work have been conducted to investigate the impact of interdisciplinary and multidisciplinary education on engineering student outcomes. Interdisciplinary education techniques challenge students to integrate multiple sources of knowledge and methodology to understand the designated problem.

Woods (2007) discussed the effect of the process of splitting a foundational field of expertise, into smaller and more technical segments, on the creation of knowledge boundaries between students of the same major. Woods (2007) further showed the way in which this stratification of expertise may lead to communication problems between professions such as the use of different basic vocabulary. She proposed the addition of collaborative work to the curriculum to improve students’ negotiation skills using different vocabularies and methodologies.

Biswas (2012) developed an engineering curriculum by incorporating industrial ecology into undergraduate and postgraduate programs. Passive and active learning techniques were applied, as well as case studies related to industrial ecology, to provide the graduates with sustainable engineering solutions.

Whitney (2014) demonstrated interdisciplinary collaboration using a real world project to encourage students to value the knowledge of other professions. The assignments in this project helped the students cross the boundaries between different disciplines by adopting new vocabularies and methodologies through self-guided learning. The project allowed the students to formulate their own learning approach, which also empowered their personal sense of responsibility and improved their decision-making skills.

Another type of interdisciplinary curriculum work is that of combining intercultural architectural designs with classical engineering lectures in under- and post-graduate courses (Ebert et al., 2016). The study showed that at the end of their engineering program, students were able to apply and combine their knowledge and practical skills in a very realistic design that could accommodate certain cultural and environmental requirements.

A first year capstone unit was developed to apply physical, mechanical and electrical principles to a real life design project (Odeh et al., 2016). Three engineering design modules were developed for the following engineering disciplines: civil, electrical, and mechanical engineering. Student feedback indicated that they had a clearer understanding of the work involved in the different engineering disciplines which would give them more confidence when choosing their final major.

A multidisciplinary course was also developed by Doyle and Bozzone (2018) with the intention of providing undergraduates with skills to integrate knowledge by interconnecting topics from different disciplines (social science and life science) organised around a “BIG” question task.

**Background of the higher education provider involved in this study**

This research work was conducted at the Sydney Institute of Business and Technology (SIBT), which is a private higher education provider in Sydney, Australia. The Institute has been in operation since 1996 offering enabling programs in many disciplines such as: information technology, engineering, accounting and business.

Curriculum development was undertaken during 2015 as a major initiative to re-establish SIBT as a progressive provider that employed contemporary learning and teaching principles such as (McRae et al., 2017):

* A modern, innovative curriculum
* Technology-enabled learning using various applications, online tasks, and provision of access to laptops and tablets in the class room
* Authentic learning by embedding case studies, field trips and guest speakers
* Increasing interactivity to change the learning experience to increase student engagement
* Small classes, personalised learning and a high level of learning support.

The development of a new curriculum for SIBT provided the opportunity to explore learning and teaching frameworks that could be applied to future programs. SIBT’s focus is on preparing students to have a successful transition to the second year program at their partner institution, Western Sydney University (WSU).

**Programming and mathematics**

Mathematics has always had inherent characteristics of programming, even before programming became a subject of its own (Ziegenbalg, 2014). However, programming is absent in many introductory mathematics units nowadays, except for the use of some advanced tools like calculators or spreadsheets. Learning a programming language can be tedious for students as well as limiting the time the teachers have to complete the set topics in the units they are teaching. A common perception about programming is that it should be restricted to computer science classes. However, programming has inherent advantages for teaching and solving advanced mathematical problems such as in numerical analysis. Many topics that are common in both subjects can be taught more practically using programming tools such as variables and functions, thus enabling the students to generalize problems. Similar to functions, a program performs a transformation from an input (argument) to an output (value). Setting students a task to write a program can be compared to asking them to develop a constructive proof.

Adding programming into the mathematics curriculum is not a new idea, for example (Wallace & Seymour, 2011) introduced an “integrated course in algebra.” (Vöcking et al., 2011) used a more widespread approach for efficient problem-solution of selected algorithms used in the modern world applications. In practice however, limited time is an obstacle regarding the usage of programming in the mathematics class, otherwise a number of new topics and techniques could be included or extended in the classroom.

We have avoided this problem of time limitation by introducing combined assignments for both mathematics and programming units in which first year engineering students were enrolled. Some students were studying both units concurrently and were having assessments in each unit. One of the assessments was introduced as a combined assessment in both units, with students having to solve a mathematical problem by developing their own approach (algorithm) as well as writing a computer program to demonstrate the correctness of their solution. This approach resulted in a noticeable improvement in terms of their understanding of the mathematical problem and their satisfaction in gaining this understanding.

**The methodology of the developed combined assignment**

Three types of real life multidisciplinary assignments were developed to allow the practice of theories in mathematics (principles of differentiation and integration) and programming (variables, functions, and arrays) delivered in the first year of the engineering and information technology degree. The aim of such practice was to achieve the following outcomes**:**

* Apply self-teaching: this was achieved by guiding the students to the source of information they needed to investigate and understand principles in mathematics and computer programming.
* Develop practical skills: students learnt how to apply theoretical mathematical skills on actual engineering cases and use computer programming as a solution tool for gaining high accuracy in their results.
* Introduce students to problem solving skills: this was achieved by analysing the assignment problem and comparing the results achieved by hand calculation method and the developed computer code.
* Interaction and collaboration between academics of different disciplines to improve students’ performance.

The combined task between the programming and mathematics units was designed to allow students to search for and develop the skills they needed in solving real world problems. Students had to write a program in ‘processing’ language to solve a real-life mathematical problem. The information given about the method of solution was very limited, however, students were given guidance through one on one consultation and online support.

**Combined assignments – case study**

In this assignment, students were given a section of a lake in New South Wales called “Jindabyne Reservoir” (see Figure 1 below). They were asked to use Simpson’s Rule in mathematics to estimate the surface area of the lake. Simpson’s Rule is a method used to calculate a surface area of irregular shape with high accuracy. The order of accuracy depends on the number of subdivisions (see “Δx” in Figure 2 below) used in the calculation.



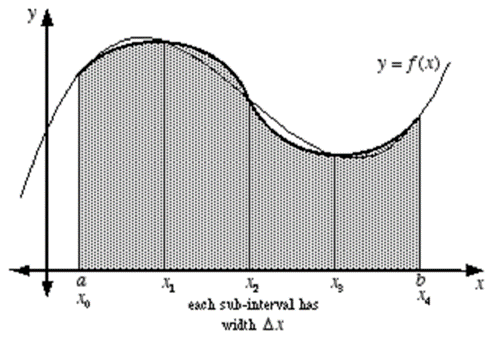
*Figure 1*: A section of Jindabyne Reservoir

Δx

Δx

Δx

Δx



Δx

Δx

Δx

Δx

*Figure 2*: Evaluation the area of the lake using Simpson’s Rule

Students were asked to solve this problem manually and then to write a program using processing programming language to solve the problem. The lengths of the area mentioned in Figure 1 were approximated to the nearest km unit.

More than 70 students, enrolled in both programming and mathematics units, were asked to solve this problem. Students were expected to apply the concepts of variables, functions and arrays in processing programming language. One of the intentions was to highlight how mathematical rules can be applied in the real world, and how those rules can be automated using a programming language.

Results showed that students gained a deep understanding of the process that is required for any such problem to be programmed. This experiment also helped students to learn using self-learning principles by exploring various sources of information. This pilot study has shown encouraging results with this type of assessment in terms of task completion and student satisfaction. This satisfaction was analysed using two feedback surveys designed to ask students their opinion of this approach to conducting an assignment. One survey was conducted before students were given the assignment (pre-assignment) and the other was asked about the same topic after completing the assignment (post-assignment). The types of questions asked in these surveys and their results are analysed in the following section.

**Students’ survey and feedback**

Two surveys were conducted before and after each assignment to get feedback on students’ satisfaction from both student cohorts (IT unit and mathematics unit). These two units are part of the first year units in engineering and information technology degree in SIBT. The impact of this type of interdisciplinary work on students’ learning processes was identified and different types of student skill backgrounds were considered in the survey:

* Students have already studied the math unit and now are studying programming, or,
* Students are studying programming in conjunction with a maths unit, or,
* Students have already studied programming and are now studying maths,
* Students are studying maths without a programming background.

*Pre-Assignment Survey*

Before releasing the assignment, the online questionnaire below was given to students. The possible rating for each question was on a scale of 1-5 (1 being the least and 5 being the highest score)

1. Are you able to apply the skills or knowledge of Mathematics to Programming or real life problems?
2. Are both of these units, Mathematics and Programming, related to your field of study?
3. Would you like to do combined assignments between units in your current study?
4. Have you used computer software or programming successfully in the past to estimate the area under a curve?
5. What is your level of understanding of the respective Mathematics rules?
6. What is your level of understanding of using programming in real life problems?
7. How often do you do online research on topics studied in class?
8. How would you rate the introduction to the assignment given to you in class?

*Post-Assignment Survey*

After they had submitted the assignment, the following online questionnaire was released to students. The possible rating for each question was on a scale of 1-5 (1 being the least and 5 being the highest score).

1. Were you able to apply the skills or knowledge of Mathematics to Programming for the real life problems in this assignment?
2. Was the assignment related to your field of study?
3. Did you find this combined assignment useful for improving your knowledge?
4. What is your level of understanding in using computer programming technology or software to calculate a close approximation to the area under a given curve?
5. Did the assignment improve your level of understanding of the respective Mathematics rule?
6. What is your level of understanding of using programming in real life problems?
7. Did you search online about the topic studied in this assignment?
8. How would you rate the support provided by your lecturer/tutor in this assignment?

The results for these surveys for Session 1, 2018 are shown below in Figure 3.

*Figure. 3:* Combined assignment survey results

The results exhibited in Figure 3 clearly show that there is an improvement in many aspects of the learning outcomes represented by the increase in the post-assignment scores. This pilot study has improved the ability of students to apply the skills or knowledge of mathematics to programming for real life problems (Question 1). Also, students have shown their belief that this assignment has helped them to improve their knowledge (Question 3). Moreover, students have shown considerable improvement in terms of their understanding of using a programming language to calculate the area under a curve (Question 4 and 5). Students have also appreciated how programming language can be used to solve real world problems (Question 6). The results show that this assignment has not only inspired students to learn at their own pace and develop self-guided learning techniques (Question 7) but they also wanted to have more assessments of this type in different units of study (Question 8). The survey results expressed by Question 2 show that the majority of students believe that the work they did is related to their field of study despite the fact that the case studies they worked on were not addressed in their lecture content. The score for Question 2 indicates that the combined assignment achieved one of the major outcomes mentioned in section 5 “apply self-teaching” where students conducted their own reading to find out how to apply some principles in maths and programming to real life cases.

**Conclusion**

Multidisciplinary or interdisciplinary teaching is considered by many institutions to be an effective technique to help students understand a problem better and to be able to contextualise it in the real world, while also enhancing problem solving skills and nurturing critical thinking. In this paper we have presented a pilot study that developed a combined assignment between two units in the first year of the engineering curriculum, Foundation Mathematics and Introduction to Programming. The combined assignment helped students to adopt self-learning principles by requiring them to explore various sources of information for the related units and solve a mathematical problem by developing their own approach (algorithm) as well as writing a computer program to demonstrate the correctness of their solution. The paper has demonstrated that the results from student evaluations for this combined assignment showed that students believed that they gained an increased level of understanding about how to write a program in processing language that can solve a real life mathematical problem.

The future plan is to expand this experiment for more than one assessment and to use the results in restructuring the content of both units so that these units can be taught in a more collaborative and effective manner. Other contemporary teaching techniques such as online support and illustration videos will be introduced to motivate the self-teaching approach on a wider scale.

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