EXPERIENCES OF USING A SINGLE ASSESSMENT FOR BOTH PRACTICAL PROTOTYPING SKILLS AND INTRODUCTION TO ENERGY ENGINEERING

Jorrel Bisnath[1*], Aneil Ramkhalawan[2], Edward Cumberbatch[3], Prakash Persad[4], Aatma Maharajh[5], Natalie Persadie[6], Ronnie Bickramdass[7] and Dinesh Soodeen[8]

[1,2,3,4,5,6,7,8] Design & Manufacturing Systems, The University of Trinidad and Tobago, Trinidad
[1]Email: jorrel.bisnath@utt.edu.tt *(Corresponding author)
[2]Email: aneil.ramkhalawan@utt.edu.tt
[3]Email: edward.cumberbatch@utt.edu.tt
[4]Email: prakash.persad@utt.edu.tt
[5]Email: aatma.maharajh@utt.edu.tt
[6]Email: natalie.persadie@utt.edu.tt
[7]Email: ronnie.bickramdass@utt.edu.tt
[8]Email: dinesh.soodeen@utt.edu.tt

Abstract: Engineering students are often faced with many assessment points during a semester. One of the more common assessments in an engineering programme are group-based, design and build projects. These projects often require a disproportionate amount of time due to coordination between members and resources for acquiring materials. This study relates an attempt to reduce this burden by utilising a common project as an assessment point for two separate courses: Practical Prototyping Skills and Introduction to Energy Engineering. The challenges faced by instructors in creating a project that would adequately address their individual learning outcomes are presented, along with the students' perspective on this approach. Student surveys indicated that there was a clear understanding of how the project related to both courses and that they had sufficient support for the project, while lecturers highlighted several positive outcomes such as more student emphasis on the project, a higher standard of project and collegial support in the design and administration of the project.

Keywords: *Engineering education, project-based assessment, student assessment.*

https://doi.org/10.47412/ZIAI9517

1. Introduction

Engineering is a very practical profession as it involves the application of scientific knowledge to the solution of real-world problems. It is for this reason that engineering education often involves projects that require the design and construction of a physical device that would form part of, or act as the solution to, a particular challenge [1]. To simulate the workplace and the nuances that arise from having colleagues, projects such as these, tend to be assigned to groups of students

rather than individuals. This adds the complexity of having to coordinate tasks between team members to the initial difficulty of having to design, build and test a device.

As a result of this approach to engineering education, it is not uncommon for an engineering student during the course of the semester to have multiple projects due at the same time. This leads to a stressful educational environment with which some students may find it difficult to cope [2][3]. While there is an argument that this would be the reality that students would face in the workplace, such a system leads to inefficiencies on the part of the administering institute [4][5]. From the perspective of the lecturer, time has to be spent both during and outside of class hours guiding students, addressing concerns and providing clarification. This carries over to technical support staff that may need to assist with fabrication of components or provide access to laboratory facilities as well as the monitoring of tools and equipment. There is also the question of the cost of materials for construction of devices and space that must be allocated for the storage of inventory for separate projects.

A proposed solution to help create a more streamlined approach to design and build group projects is described in this paper. Two courses were identified that both had, as an assessment, a design and build group project for the same cohort of students during the same semester. The projects were both analysed to identify what crossovers potentially existed with the aim defining one common project that would be able to meet the specific learning outcomes outlined in both courses. This paper describes the approach that was taken in developing the common assessment and provides feedback from the students and lecturers on the experience.

2. Background

The University of Trinidad and Tobago was established in 2004 by the Government of Trinidad and Tobago with its mission listed as, "To contribute to the sustainable and entrepreneurial development of society through the advancement and application of research, dissemination of knowledge and public engagement in our pursuit to produce work-ready graduates, innovators and critical thinkers" [6]. A major part of the University's offerings are engineering degrees, among which is the Bachelor of Applied Science in Manufacturing and Design. This programme was established to support the local manufacturing sector of the country by providing graduates that had good practical training in relevant areas of the industry. The programme is offered as both a three-year full-time and five-and-a-half-year part-time degree.

To ensure that students gain confidence in their ability to design and create products, this degree, in particular, has a heavy emphasis on project-based work which involves the creation of devices. Students are given such projects throughout the course of their study, starting from the first semester in the first year to the final year of the programme. For the purposes of this study, two courses in the first semester of year one were used; Practical Prototyping Skills (PHOT 1001) and Introduction to Energy Engineering (EGYA 1001).

2.1 Practical Prototyping Skills

Practical Prototyping Skills (PHOT 1001) is a year one undergraduate course with a six (6)-credit point rating. This course is offered only within the Bachelor of Applied Science in Manufacturing and Design Engineering. This course introduces students to knowledge and practical skills in workshop technology, safety practices, electrical basics and labs, instrumentation and errors,

prototyping and ways of communicating these skills through presentations, drawings, graphs and reports. Students become knowledgeable in the designing and prototyping of products/projects. They are able to analyse and develop the necessary procedure and processes to build a prototype, apply these processes and practical skills to develop their own projects and apply safety measures during building of prototypes or development of projects. The course serves to develop practical and professional skills such as the ability to work individually and in teams with some supervision, meet deadlines and standards and present work individually or in groups to an audience as well as the ability to communicate effectively through the use of technical reports, drawings, animation and presentations. The course is separated into six modules, with each module having an assessment that would contribute 10% towards the final grade. There is also a group project that contributes the remaining 40%.

The modules in the course are as follows:

Module 1: Communication

The communications module is run over a three-week period. These sessions are used to assess and enhance the oral and written technical communication skills of the students using engineering and workplace scenarios as contexts. The students are required to host a job interview in the roles of employer and prospective employee (interviewee) at an engineering firm to understand their oral skills (language, voice projection, fluency, ability to speak in front of groups) as well as write a personal mission statement for having chosen this particular programme of study. Students often have challenges in articulating themselves in writing, and this carries on over the course of the programme. It is therefore essential to identify writing difficulties early on. Importantly, as engineers-to-be, technical communication is equally important. Students are given a data set for which they are to produce a single graph, justifying their graph choice. Seemingly simple matters, such as axis labels, legends, and captions, are often omitted, highlighting items that can adversely affect report writing later on. The written justification allows for assessing research and referencing skills.

Module 2: Health and Safety

The health and safety component sensitises students to the importance for setting health and safety policies as it relates to the University and the general workplace environment. Students are exposed to the laws governing occupational health and safety within Trinidad and Tobago and the roles, rights and responsibilities of employers and employees. Students are further exposed towards designing and operating in a safe work environment

Module 3: Errors and Instrumentation

This module introduces students to the basic units of measurements and concepts such as dimensional consistency. The concept of errors involved with measurement systems is presented and students are taught how errors are treated in calculations and methods of reducing errors. Students are also exposed to basic metrology equipment such as Vernier callipers and micrometres.

Module 4: Electronic Prototyping

The goal of this module is to show students an intuitive way to understand how electricity in electrical and electronic circuits work. The module does not assume prior knowledge of circuit theory, but at the end of the module, students should be able to build and test prototype circuits using various electronic components, such as resistors, capacitors and ICs, use electrical measuring instruments and effectively follow wiring diagrams to construct a circuit.

Module 5: Mechanical Workshop

This module takes students into the workshop environment to expose them to bench fitting, basic machining and welding/joining processes. The module is run over the course of eight weeks, within which the students have to fabricate a specific artefact. The sessions are divided as follows: one classroom session, three practical sessions on welding/joining and four sessions on machining and bench fitting.

Module 6: Prototyping

Students are introduced to the engineering design process and are shown the role that prototyping plays within this process. They are given knowledge of approaches and considerations in the creation of a prototype and are educated on rapid prototyping and the different technologies available.

2.2 Introduction to Energy Engineering

Introduction to Energy Engineering (EGYA 1001) is a year one undergraduate course with a three (3) credit point rating. This course is offered only within the Bachelor of Applied Science in Manufacturing and Design Engineering. It introduces students to the principles and technologies involved in energy conversion, transformation, utilisation and conservation. Both non-renewable and renewable sources of energy are discussed in the course. Students become knowledgeable on the sources and applications of energy sources and are able to evaluate the energy requirements and technology required for manufacturing applications. Cognitive skills are developed through using necessary analytic skills and techniques to evaluate energy needs requirements. Some transferable and key skills are supported via effective communication through written reports, multimedia and oral presentations for assignments.

The areas of study and expected learning outcomes at the end of the course include:

- to understand the concept of energy, work and power
- to understand the types and forms of energy
- to understand energy conversion and transformation
- to understand the principles of energy conversion
- to introduce renewable energy sources, technologies and applications
- to introduce heat and mass transfer

The learning and teaching strategy includes lectures, demonstrations, videos, labs, projects and independent research. This enables the students to acquire and be able to apply their knowledge to

relevant issues in analysing and designing the energy requirements of equipment and systems. The assessments are broken up into labs, weighted at 15%, a group project, weighted at 35%, and a final exam, weighted at 50%.

3. Design of the Combined Project

Both of the courses described previously had a design and build group project as a major part of their assessment. The weighting assigned to the project in the EGYA 1001 course was 35% while PHOT 1001 assigned 40% towards the project. For EGYA 1001, the student project involved the creation of a test platform to be able to measure the transfer of heat across several sample materials which would simulate the effect of heat transfer though ceiling materials. The students were required to work in groups of three to four persons to design the test bed, which involved the creation of a physical structure to support the sample materials as well as the use of power to apply a variable heat source to the system and the installation of instrumentation to measure the temperatures at different points within the system. The students also needed to determine the experimental procedure that would be used for testing the materials and then present the data in a clear and logical manner.

The PHOT 1001 project gave the students the freedom to choose a problem that they felt could be solved with an electromechanical solution.

The students then had to work in groups of three to four persons to go through the process of designing and fabricating such a prototype and then validate the effectiveness of their designs. The students had to illustrate the technique that they used to design the prototype while being cognisant of the use of proper safety in the creation of the device. They had to demonstrate their competence in the creation of a mechanical component and provide the electrical schematics of for any electrical/electronic components used and, at the end, present their device and submit a report documenting its development. Both classes contained seven persons so there were two groups for each project.

It became clear looking at the scope of both projects that there were several areas of repetition, where the same techniques would have to be applied by the students. Both projects involved the design of a physical prototype with an electrical and mechanical component and resulted in the generation of a report at the end of the process to report on methods and findings. These two projects therefore seemed to readily lend themselves to some degree of collaboration among the lecturers.

3.1 Project Outline

After discussions were held with the lecturers responsible for the project aspect of both courses, it was decided that separate project briefs would be developed to provide the students with the specific deliverables for each of the courses.

The students were however guided by both sets of lecturers in the creation of a prototype test bed as shown in Fig. [1] for thermal conductivity that would meet the requirements of both projects.

Figure 1 An example of the device created

For PHOT 1001, project marks were allocated for:

- Background
- Alternative Designs
- Circuit Diagrams
- Safety Considerations
- Details of Final Prototype
- The Construction of the Prototype
- Testing and Validation.

While for EGYA 1001, project marks were allocated for:

- Introduction
- Literature Review
- Alternatives
- Method- Experimental procedure
- Theoretical Analysis
- Results
- Discussion
- Conclusion

The students were told that they had to produce one report that would be submitted to both sets of lecturers and that they would have to do a single presentation to both sets of lecturers.

4. Method

This study explored the attempt at combining an assessment point for two individual courses. What was therefore administered in this work was to be treated as a pilot study to help refine this approach and potentially identify areas of concern and benefit. To this end, a mixed method approach was employed to obtain the most relevant understanding of the experience. While quantitative data did allow for subjective analysis of the study, a large part of the experience would have to be documented qualitatively. After the projects were completed and the submissions were made by the students, a questionnaire was administered to the students to ascertain their view of this approach to project-based assessment. Due to the nature of the study and small number of students that registered jointly for both course, a targeted sampling method was preferred.

Seven (7) of the students registered jointly for PHOT 1001 and EGYA 1001 and were administered the survey. Students were asked to consider eight (8) key areas in the survey and rank each area under five categories: strongly agree, agree, neutral, disagree, and strongly disagree. The eight (8) areas considered in the survey were:

1. Clarity of the relationship of a common project between two separate courses.
2. Helpfulness of the project to illustrate techniques and methods taught in both courses.
3. Whether it was a good idea to combine the project for these courses.
4. Whether students would like to have more common projects between separate courses.
5. Whether students felt pressured into preparing submissions for a combined assessment.
6. Student feelings towards having separate projects for courses rather than combined course projects.
7. Student feelings toward clarity of guidance and support provided by lecturers.
8. Whether Students were confused while doing the project because of conflicting information from lecturers.

Additionally, a section was provided for students to relate any thoughts or feedback that they may have experienced of having a project used as a combined assessment for two courses. The lecturers that facilitated the projects from both courses were also interviewed and their views recorded.

5. Results

5.1 Student responses

Table 1 displays a summary of the responses to that were obtained from the structured section of the survey.

Table 1 Responses of Students to Survey

Areas	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No response
It was clear to me how the course project related to both PHOT1001 and EGYA1001	3	3	1	0	0	0
The project helped to illustrate techniques and methods taught in both courses.	5	2	0	0	0	0
I think it was a good idea to combine the project for these courses.	2	3	2	0	0	0
I would like to see more courses to use combined projects for assessments	1	3	2	0	0	1
I felt that it was harder to prepare a submission for a combined assessment.	0	2	4	1	0	1
I think it is better to have separate course projects.	1	1	4	1	0	0
I felt that I received clear guidance on this project and sufficient support from both sets of lecturers.	3	3	0	1	0	0

I found myself confused while doing the project because of conflicting information from lecturers.	1	1	1	2	2	0

From Table 1, it can be seen that six out of seven students indicated that they saw the relevance of the project to both courses and all seven agreed that it helped to highlight the techniques taught. Five out of the seven indicated that they would like to see this approach used in other courses. Responses were more neutral on the topic of difficulty in preparing the submission for the combined assessment, indicating an indifference. A similar result occurred for the question asking if separate course projects are preferred. Six out of seven students indicated that they received sufficient support from the lecturers. This response was reinforced with four of seven students stating that they were not confused as a result of conflicting information from the lecturers. Of the seven students surveyed, four responded in the open-ended section. Two respondents wanted the project to be offered earlier in the semester. One of these respondents reported that as a result there were some "slight misconceptions". One student indicated that there was clarity of guidance and support provided by lecturers. The other respondents stated that they wanted "to have more time to prepare for exams". One student reported "it was bit confusing at first, then a chat with both lecturers made it easier to understand". The final student identified that there may not be equity in the allocation of work within the groups and suggested that log sheets be introduced to monitor work done by each individual member of the group.

5.2 Lecturer Response

Coming out of the interviews with the lecturers from both of the courses, the following themes were identified. During this experience, it was observed that:

- Students had more time to allocate to their project rather than having two separate projects.
- Students focused more because they knew that the project was being marked via separate criteria for both courses, hence it was worth more.
- The quality of the project was of a higher standard as compared to other projects done separately for other courses.
- The learning outcomes from the project seemed to be better understood as more time would have been spent on these criteria for one project versus two projects having separate or different learning outcomes.
- The students had more guidance for the same project by having the instructors from both courses providing support.
- It was easier to design and supervise the project as there was additional collegial support.

6. Discussion

From the student responses, it can be seen that they had an overall positive view of the attempt at combining the assessments for both of these courses. It could be observed that although combined, the students were able to still clearly relate the project to the individual courses and understand how the classroom skills they had learnt should be applied practically. There was a general trend

in the responses towards the application of this approach to more courses, showing that they felt that this approach is something that they would like to have repeated in future courses.

Respondents were largely neutral on the topic of the combined assessment being harder to prepare for and if they felt it was better to have separate assessments indicating that they did not feel that they were at a disadvantage with the combined assessment and it was not much more difficult than a normal design and build group project.

On the topic of guidance, it seemed that the students appreciated having the lecturers from both courses being able to lend support. This may have aided in their ability to complete the project successfully and, while there was a spread of responses on the question of additional confusion from conflicting information from lecturers, the responses tended away from additional confusion and were largely positive.

From the perspective of the lecturers, it was clear that they felt that this approach to assessment was of merit, with no negative views being recorded whatsoever. The areas highlighted showed that the lecturers felt that the standards of the projects were higher as a result of the combined approach and the students were able to better focus their efforts.

It may be difficult to say conclusively that this combined approach to assessments is something that should be attempted whenever there are such projects within the same semester due to the small size of the classes and the fact that it was only used within these two courses. In future, this experimental approach could maybe be applied between two additional courses to see if the reflections of participants are similar. The responses from the study do, however, show that this assessment technique is of value and is definitely worthy of further study.

7. Conclusion

This experience indicated that a combined project between courses, especially theoretical and practical ones, can improve staff collaboration and the students' overall understanding and preparedness to take on future challenges. Students indicated that they viewed this approach as being beneficial to them and teaching staff were able to provide several positive outcomes from the study.

References

1. Mills, J. E., Treagust, D. F. (2003) 'ENGINEERING EDUCATION – IS PROBLEMBASED OR PROJECT-BASED LEARNING THE ANSWER?', AUSTRALASIAN JOURNAL OF ENGINEERING EDUCATION, 3(2), pp. 2–16.
2. Behere, S. P., Yadav, R., Behere, P. B. (2011) 'A comparative study of stress among students of medicine, engineering, and nursing.', Indian journal of psychological medicine. Wolters Kluwer -- Medknow Publications, 33(2), pp. 145–8. doi: 10.4103/0253-7176.92064.
3. Talib, N., Zia-ur-Rehman, M. (2012) 'Academic performance and perceived stress among university students Title', Educational Research and Reviews, 7(5), pp. 127–132.
4. American Institutes for Research (2013) How Much Does It Cost Institutions to Produce STEM Degrees? Available at: https://files.eric.ed.gov/fulltext/ED558229.pdf (Accessed: 21 December 2019).