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Development of and reflection on introducing a pass/fail course for first-year engineering students

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ABSTRACT

CONTEXT

The first-year courses for all College of Sciences programmes at Massey University were redesigned and a new set of courses were introduced in 2020. One of the new first year courses was 247.114 Science and Sustainability for Engineering and Technology. In this project-based learning course, groups of students take a component of a consumer product and examine its lifecycle. They then propose ways for the component to be more sustainable. It was decided that this course would be a pass/fail course rather than a graded course. This new course replaced a graded project-based learning course, and it is the only pass/fail course in the Bachelor of Engineering with Honours and Bachelor of Food Technology with Honours programmes.

PURPOSE OR GOAL

This paper provides an overview of the drivers for introducing a pass/fail course; how it was developed and implemented; reflection after the first offering of the course; and discussion on proposed strategies to improve the next offering.

APPROACH OR METHODOLOGY/METHODS

During the delivery of the course and at the end of the semester staff reflected on the overall course and the approach used for the assessments. Areas for improvement for the next offering were identified and discussed.

ACTUAL OR ANTICIPATED OUTCOMES

Key lessons learnt during the implementation of this pass/fail course are discussed along with areas for improvement and the approach which will be taken for the next offering of the course. It was found that this style of course aligns with competency-based learning very well and this helps guide the future direction for the course.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Pass/fail courses allow the focus to be on achieving a certain level of competency for each learning outcome rather than achieving 50% overall in a course. The assessments and marking rubrics need to be developed with this in mind and designed to minimise 'game playing'. This will be one of the key changes for the next offering.

The style of assessments including quizzes, team gate meetings and individual written assignments suited the pass/fail approach very well.

This course is moving towards a competency-based learning approach, however there are challenges which still need to be addressed. How to maintain motivation within the course when more effort is not rewarded by higher grades requires more consideration.

KEYWORDS

Competency-based learning; first-year; pass/fail

Introduction

In 2019 the College of Sciences reviewed and redeveloped all the courses which were offered in first year. As a result of this process there were two new project-based learning courses developed for first year which were first offered in 2020. This paper focuses on the development and delivery of the first offering of the course 247.114 Science and Sustainability for Engineering and Technology. This course is compulsory for all students studying the Bachelor of Engineering with Honours and the Bachelor of Food Technology with Honours.

In order to develop professional skills including communication, teamwork, project management and problem solving, a project-based spine was established within the Bachelor of Engineering with Honours and the Bachelor of Food Technology with Honours at Massey University. This is a series of project-based learning courses with one course each semester taught in this way and is common to all students in Years 1 and 2. The students work in teams to solve problems. The context changes with each project and the projects progressively get more complex throughout the programmes. Different aspects of these project-based courses have been published in other studies (e.g. Goodyer & Anderson, 2011; Shekar, 2014; Gupta & Bailey, 2014; Brown, 2017; Tunnicliffe & Brown, 2017; Brown & Tunnicliffe, 2017; Konings & Legg, 2020; Brown, 2020; Brown 2021).

Science and Sustainability for Engineering and Technology is a pass/fail course. All other courses in the programmes use a graded system for their assessment (A+/A/A-/B+/B/B-/C+/C/C-/D/E). A student's overall GPA, to determine the level of honours that students graduate with, is calculated from year 2-4 grades so first year has no influence.

Pass/fail courses are not new and have been applied to many different fields including medicine (e.g. Gold et al., 1971; Bloodgood et al., 2009) and engineering (e.g. Stanton & Siller, 2011). There have however been varying degrees of success. Gold et al., (1971) found that students who had taken pass/fail courses had a lower GPA than those who took graded courses and there was an effect even if the student had taken only one pass/fail course. However, Bloodgood et al. (2009) reported that pass/fail did not result in any reduction in performance in courses, test scores or residency placements for medical students.

Our drivers for pass/fail

In traditional graded courses students can achieve a pass grade overall without passing all the elements of the course. One of the advantages of pass/fail is that it ensures all students pass all elements of a course. This can be particularly useful in first year as it makes sure that everyone has a baseline of knowledge which can then be built on in future courses.

Some of the topics in this particular course can be challenging for certain groups of students. An example is the content where we ensure students take cultural considerations into account when developing their solutions. As this project is based on an Aotearoa New Zealand context, that involves the students gaining an understanding of te ao Māori (Māori word view) and Mātauranga Māori (Māori knowledge). While domestic students typically find this straight forward due to their prior knowledge, it can be very challenging for international students who may have no prior knowledge. The course was set up to allow students to fail individual assessments but with further learning achieve these learning outcomes in later assessments. This helps to take the pressure off.

When the course was being developed the potential to lower staff workload was also seen as an advantage. This course is taught over two campuses and in all courses, we ensure that both offerings are equivalent. This involves checking that all assessments are marked to the same standards and some assessments are marked by both campuses to ensure this. At the end of the course both offerings are also compared to ensure the final grades are equivalent and the same grade point cuts are used. In a pass/fail course, equivalence is more straight

forward as it is only the pass/fail point which needs to be calibrated. The end of semester is also much more simplified as determining pass and fail is straight forward and no grade cut points are needed.

One of the challenges of project-based learning courses which involve team-based assessment is that there is a reduced spread of grades and students tend to be clustered together. This means that these courses essentially already act as pass/fail because there is little separation between students. In cases where there is a spread of marks there tends to be teams which contain high performing individuals, and their ability helps to lift the performance of the weaker students. This means that a student's mark can be highly influenced by the team that they happen to be in, rather than the effort that the students put in.

It is often reported that pass/fail courses are implemented to reduce stress for students (e.g. Bloodgood et al., 2009; Stanton and Siller, 2011;). While this was not the primary reason for the pass/fail approach, a reduction in stress would be advantageous for our students.

Course design and assessment

This course was designed to provide an introduction to many important concepts which will be built on further in later courses. Many students associate sustainability with environmental sustainability, however, in this course the importance of social, cultural and economic aspects is introduced. In an Aotearoa New Zealand context, the importance of Tikanga Māori (including culture, ethics and knowledge systems) is discussed in relation to sustainability. The key skills developed include finding information, evaluating information, written communication to different audiences, working in teams, basic project planning and communication in a meeting setting.

The learning outcomes for the course are:

1. Critically appraise information.
2. Use scientific information to communicate issues of sustainability to a range of audiences.
3. Discuss the impact of mātauranga Māori for advancing sustainability.
4. Work collaboratively to explore society- through to individual-level solutions to sustainability challenges.
5. Reflect on the concept of sustainability.

The student projects

For this course students are placed in 3-5 member teams. In 2020 each major was given a different consumer product to focus on. Food Technology students looked at a block of milk chocolate, Chemical and Bioprocess Engineering students looked at a takeaway cup of coffee and Mechatronics, Electronics & Computer Engineering and Engineering & Innovation Management students focused on a toaster. Each group took one component of the product and looked at its lifecycle. For example, the takeaway cup of coffee was split into the cup, milk and coffee beans.

Students conducted research to understand the lifecycle of their component and produced a process flow diagram. They then mapped relevant UN Sustainable Development Goals (SDGs) to their process flow diagram. This information was used to narrow down the scope of their work to areas where they thought there was the highest potential to have an impact on the sustainability of the product with respect to chosen SDGs.

Once their problem/opportunity was identified the students used idea generation methods to develop a list of potential solutions. Screening tools were introduced to allow the students to narrow these down and justify their decisions. Each member of the team then developed one

idea further and evaluated the potential solution in terms of its technical feasibility, environmental sustainability, social and cultural aspects, and its economic viability (at a basic level). Students give a recommendation for whether the potential solution should be developed further in a written report. Finally, the students write a reflective report on the skills they have learnt and the skills they feel they need to work on in future courses.

A Stage-Gate® process is used to monitor progress and there are three Gate meetings where progress within the team was assessed. Material was delivered through online pre-workshop books, followed up by a lecture and two workshop tutorials providing activities related to the pre-workshop books and supervisory meetings.

Assessments

The learning outcomes of the course are assessed in several ways. A description of the assessments is given in Table 1.

Table 1: Description of assessments

Assessment	Description	Links to Learning Outcomes
Online quizzes	The content of the course is split into 5 units. At the end of each unit there is an online quiz which is then used to open the content of the next unit.	1, 3, 5
Assignment 1 – Evaluating information	Students select one source of information that they have used and write a brief summary of the source and then evaluate the information source using the CRAAP framework (currency, relevance, accuracy, authority, purpose).	1, 2
Assignment 2 – Blog	Students select one company out of a list of five. They write a blog (350-500 words) which explains the sustainability initiatives the company is implementing. They also discuss the links between sustainability and Mātauranga Māori.	1, 2, 3, 5
Assignment 3 – Technical report	The final report covers the development of their solution and an analysis of its feasibility. They also write a reflective report on what they have learnt and what they feel they need to work on in future project courses.	1, 2, 3, 4, 5
Gate meetings	There are three gate meetings which monitor the progress of the teams. A list of tasks needs to be completed before they can move onto the next stage of the project.	1, 2, 4

The gate meetings are assessed as a group, but all other assessments are individual. A rubric was developed for each of the written assignments. The rubric described each of the learning outcomes covered by the assessment. To pass the course all quizzes and Gate meetings needed to be passed and each of the learning outcomes needed to be achieved in the written assessments. If a learning outcome was not achieved, then it could be picked up in a subsequent assessment.

Reflection on the first offering

The process of introducing the first pass/fail course into these programmes has been a steep learning curve for all involved. It is quite a different approach to assessment previously used, and it took a while for staff to understand the implications of this.

One of the challenges was to try to anticipate how students would respond to this approach without having any experience of pass/fail grading. The students are strongly motivated by grades and staff did see this as a challenge when designing the course. Based on informal feedback students seem to fall into two groups:

- Those who treated the course the same as a graded course and tried to do their best in all assessments. Some of these students however became frustrated when their effort was not rewarded by a higher grade.
- Those who determined the minimum that needed to be done to pass and did no more than was required. These students were very strategic in the way they approached the course and the assessments.

Those who were strategic realised that many of the learning outcomes were assessed multiple times and that they only needed to pass those learning outcomes once to pass the course. Assessments did have unique learning outcomes, but they could ignore the ones they had already passed. This opened the course up for 'game playing' where students could ignore the areas of the assessments where they had already passed the associated learning outcomes. Students who were strategic missed some important aspects of the course and could instead spend less time on the course and put their effort into their other courses where their grades could be improved.

During the first offering of this course the pass/fail grading system was interpretated by some to mean that they needed to achieve what is equivalent to 50% in a graded course. This may have contributed to some students looking for the minimum they needed to complete in order to pass. Going forward it will be very important to explain that this course measures competency and explain to the students our expectations. This clarification will be very important at the start of the course.

Staff felt as if there was a lack of motivation within the class. Many engineering and food technology students are driven by their grades and there can be a healthy level of competition within the class which motivates everyone to do well. However, in this course more work did not change their grades. Some students were frustrated by this and therefore prioritised their other courses where they would be rewarded by higher grades. It is recognised that for engineers lifelong learning is very important (International Engineering Alliance, 2013) but to truly engage in self-regulated learning there needs to be intrinsic motivation to learn. It has been recognised in some medical schools that a pass/fail system can reinforce the need to have intrinsic motivation as the external motivation of higher grades does not exist (Spring et al., 2011). It has also been reported that students taking pass/fail courses have more freedom and can lower their priority of getting good grades which means that they can prioritise other things in their lives (Stanton & Siller, 2012). In our case there is only one course which is pass/fail so the students prioritised their other graded courses.

Changes for the next offering

There are two key changes which are being implemented for the next offering. The first is to ensure that the students understand that the course is about demonstrating competency for a range of tasks. It is hoped that this will lead them away from thinking it is equivalent to getting 50% in another course and get them focused on achieving a certain standard which may be equivalent to a higher 'pass' mark in other courses. It is important for students to perceive that the bar is high (Stromme, 2019).

The second key change is to modify how the written assignments are assessed. In the next offering each learning outcome will be broken down into a series of achievement criteria. In order to pass the assignment each of the achievement criteria will need to be achieved and these will be unique for each assessment. If one or more achievement criteria is not met, then the students can resubmit that component. This will avoid 'game playing' and ensure that strategic students still complete all aspects of the course.

This course would suit a competency-based learning approach as discussed by Johnstone & Soares (2014). Competency-based learning sets strict standards for what is required in order to demonstrate mastery and can be applied to both theory and knowledge gained in practical settings (Hendri et al., 2017). Johnstone and Soares (2014) give five key principles which are needed for this approach. These are reviewed in the sections below with notes on where improvements could be made.

1 Robust and valid competencies

Being a professional programme there are key skills and knowledge needed to achieve the graduate outcomes which are defined according to the Washington and Sydney Accords (International Engineering Alliance, 2013). While staff are aware of the graduate attributes and the importance of the skills being developed the students probably aren't aware of this. Additional information needs to be presented to explain where this course fits within their programme of study.

2 Students able to learn at their own pace and with support

The majority of the content is available online for students to access in their own time. There are however limits to how quickly students can progress through this course due to the group nature of the project. The role of staff is to make sure that students are progressing at a reasonable rate and that struggling students are offered support. The quizzes are a useful monitoring tool for this purpose.

3 Effective learning resources available at any time

Some of the learning resources were developed with the help of a Learning Designer and the rest of the content was designed with similar principles in mind. All online material is available for students to access at any time. The content is split into units and at the end of each unit there is an online quiz to ensure that they have understood key concepts. There are in-person sessions each week where activities are used to reinforce the online material and these activities are related to their group project. There will be ongoing review of the learning resources to continually improve them.

4 Mapping of competencies to courses, learning outcome and assessments is explicit

This is one of the key areas where the course needed improvement. One of the key changes will be making the connection between learning outcomes and the assessments stronger. As already discussed, each written assessment will have a unique set of achievement criteria which are linked to the learning outcomes. This should clarify expectations and avoid 'game playing'.

5 Assessments are secure and reliable

The assessments consist of online quizzes, written assessments and group Gate meetings. The students receive immediate feedback for their online quizzes. Written assessments are submitted online and are automatically submitted to Turnitin to check the originality of their work. The gate meetings are typically conducted in person although some were conducted online due to Covid-19 restrictions and feedback is given in the meeting immediately.

The use of a competency-based learning approach may be particularly useful in first year where students come from a diverse set of backgrounds and may be starting at different levels of knowledge as discussed by Henri et al., (2017). The way that the students need to master one unit of material and complete an online quiz before continuing to the next unit is

already following this model. The Stage-Gate® process used for evaluating the progress of the team also requires a set of tasks to be completed before they move on to the next stage of the project. The only parts of the course that did not follow a competency-based learning approach were the written assessments, which can be adapted to this approach. The final aspect currently missing is the students being able to progress at their own pace. The group nature of the project restricts the degree to which this can be done. It could certainly be adapted to some extent in the written assessments.

Another challenge is how to increase the motivation of the students within the course. It is possible that some of the proposed changes will help with this, but the course would still lack the reward of receiving higher grades present in their other courses.

Conclusions

One of the most important things which we have learnt during the implementation of a pass/fail course is the importance of explaining that the course is measuring competencies. Some had thought that passing the course was equivalent to gaining 50% in a graded course, which probably contributed to low levels of motivation in the class.

On reflection the course is progressing towards a competency-based learning style, which would be particularly appropriate for a first-year course where students have a wide range of backgrounds. More explicit links between learning outcomes, achievement criteria and assessments will help to strengthen this.

The style of assessments suited the pass/fail system well. The use of gate meetings as group assessments were very effective and having the written components as individual assessments ensured that all students focussed on developing their written communication skills.

There are other challenges needing to be addressed and more research is required. How to maintain motivation within the course when more effort is not rewarded by higher grades requires more consideration.

References

Bloodgood, R. A., Short, J. G., Jackson, J. M., & Martindale, J. R. (2009). A change to pass/fail grading in the first two years at one medical school results in improved psychological well-being. *Academic Medicine, 84*(5), 655-62.

Brown, N. (2017). Updating assessment styles: Website development rather than report writing for project based learning courses, *Advances in Engineering Education, 6*(2). https://advances.asee.org/wp-content/uploads/vol06/issue02/Papers/AEE-21-Brown.pdf

Brown, N. (2020). Practical solutions to manage staff and student workloads in project-based learning courses. *Global Journal of Engineering Education*, *22*(1), 20-25.

Brown, N. (2021). *Assessing individuals within teams in project-based learning courses – Strategies, evaluation and lessons learnt.* Paper presented at the 2021 IEEE Global Engineering Education Conference (EDUCON), Vienna, Austria.

Brown, N., & Tunnicliffe, M. (2017). *Staff competencies/capabilities required and challenges faced when delivering project based learning courses.* Paper presented at the 28th Annual Conference of the Australasian Association for Engineering Education (AAEE 2017), Sydney, Australia.

Gold, R. M., Reilly, A., Silberman, R., Lehr, R. (1971). Academic achievement declines under pass-fail grading. *The Journal of Experimental Education, 39*(3), 17-21.

Goodyer, J., & Anderson, A. (2011). *Professional practice and design: key components in curriculum design*. Paper presented at the 7th International CDIO Conference, Technical University of Denmark, Copenhagen.

Gupta, G. S., & Bailey, D. G. (2014). *Complex Engineering Design: Project Based Learning Incorporating Sustainability and Other Constraints*. Presented at the AAEE2014 Conference, Wellington, New Zealand.

Henri, M., Johnson, M. D., & Nepal, B., (2017). A review of competency-based learning: Tools, assessments, and recommendations, *Journal of Engineering Education*, 106(4), 607-638.

International Engineering Alliance (2013). Graduate attributes and professional competencies, https://www.ieagreements.org/assets/Uploads/Documents/Policy/Graduate-Attributes-and-Professional-Competencies.pdf

Johnstone, S. M. & Soares, L. (2014) Principles for developing competency-based education programs. *Change: The Magazine of Higher Learning,* 46(2), 12-19.

Konings, D. & Legg, M. (2020). *Delivering an effective balance of soft and technical skills within project-based engineering courses.* Presented at the *2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, Online.

Shekar, A. (2014). *Project-based learning in engineering design education: Sharing best practices*. Presented at the 2014 ASEE Annual Conference & Exposition, Indianapolis, IN.

Spring, L., Robillard, D., Gehlbach, L., & Simas, T.T.M. (2011). Impact of pass/fail grading on medical students' well-being and academic outcomes, *Medial Education in Review*, 45, 867-877.

Stanton, K. & Siller, T. (2011). *A pass/fail option for first-semester engineering students: A critical evaluation*. Presented at the 41st ASEE/IEEE Frontiers in Education Conference, Rapid City, SD.

Stanton, K.C. & Siller, T. (2012) *A first look at student motivation resulting from a pass/fail program for first-semester engineering students*. Presented at the 2012 Frontiers in Education Conference, Seattle, WA.

Stromme, T.J. (2019). *Pass/fail grading and educational practices in computer science.* Paper presented at the Norwegian Informatics Conference, Narvik, Norway.

Tunnicliffe, M., & Brown, N. (2017). *Evaluation of a redesigned engineering degree founded on project based learning.* Presented at the *28th Annual Conference of the Australasian Association for Engineering Education (AAEE 2017),* Sydney, Australia.

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