

# Assessment of Self-Management Skills in a Project-Based Learning Paper

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## SESSION C2: Interdisciplinary and cross-disciplinary engineering programs...

**CONTEXT** Assessing student learning outcomes as evidenced through their technical skill development and grades in project-based courses is well-described in the literature. However, most work to date concentrates on students' learning achievement rather than their learning process, leaving students to learn how to manage the projects that they are assigned largely on their own. Students therefore consider their technical achievements to be the desired outcomes, even though staff may list non-technical skills such as "time management" or "self-organisation" (self-management skills) as formal learning outcomes, working on the theory that the student must have managed themselves to have achieved their technical outcomes. However, in order to meet the imperatives for quality engineering graduate attributes and professional competencies, educators need to attend to and make explicit the ways important non-technical skills can be facilitated and valued in project-based courses.

**PURPOSE** This study aimed to investigate the effectiveness of implementing a management-based assessment structure to promote engineering students' self-management skills as part of learning to organise their work in a final year entirely project-based course.

**APPROACH** In a final-year, entirely project-based (students working solely on several prescribed projects), mechatronics paper, we employed a postgraduate student with a business degree to take up the role of a "demonstrator manager". Technical assistance was provided to students through lectures and lab work but organisational assistance and reporting was provided by the "demonstrator manager". About one-third of the marks for the paper were to be awarded by the "demonstrator manager" based on how well she perceived each student to be planning and executing their projects. Key to the process is the fact that the manager did not know much about the technical details of the projects, forcing the students to plan their work, explain milestones in consultation with her, and explain their progress to an "outsider". Data were collected from end of the course survey and interviews with staff and students as well as students' progressive achievement in the course.

**RESULTS** Preliminary observations indicate that students were at first unsure and rather casual in their response to this new assessment process. After evaluative feedback was given justifying marks they received (or did not receive), students responded by taking the need to report much more seriously. The most positive feedback was received from students whose first language was not English. This new assessment process coupled with the role of the "demonstrator manager" have value in helping students make explicit the learning process (i.e. learning of important self-management skills in this study) pivotal to the successful conduct of their projects.

**CONCLUSIONS** This initial study revealed the potential of having management-specific assessment and business-related demonstrating staff in undergraduate engineering project-based classes. This will offer students valuable insights in preparing for engineering industries that are increasingly incorporating interdisciplinary expertise and ideas to solve complex issues.

**KEYWORDS** Problem-based learning, assessment, non-technical competencies

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## Introduction

Assessing student learning outcomes as evidenced through their technical skill development and grades in project-based courses is well-described in the literature. Common assessment approaches used include peer- and self-evaluation (van den Bogaard & Saunders-Smiths, 2007), prescriptive processes (dos Santos, 2016), and learning rubrics (Szarka & Brestenská, 2012). Most work to date concentrates on learning achievement rather than learning process, leaving students to learn how to manage the projects that they are assigned largely on their own. The students consider their technical achievements to be the desired outcomes, even though staff may list non-technical skills such as “time management” or “self-organisation” (self-management skills) as formal learning outcomes, working on the theory that the student must have managed themselves to have achieved their technical outcomes. However, in order to meet the imperatives for quality engineering graduate attributes and professional competencies detailed in the Washington Accord (2013), educators need to attend to and make explicit the ways important non-technical skills can be facilitated and valued in project-based courses. This is pivotal if graduates are to develop the capacity for self-directed lifelong learning and to function effectively in ever changing and increasingly complex engineering work contexts.

## Research Context and Design

### The Course

This study is based at a New Zealand university within its School of Engineering. The Mechatronics paper/course ENEL417 is offered to final year electronic engineering (EE) students and is intended for advanced students to integrate their learning of concepts from earlier three years of coursework and apply them in a series of three projects, each increasing in complexity and building on the learning of earlier projects. The course is entirely project-based. Students work mostly independently on their projects and are allocated lab workspaces and equipment simulating environments in real-world engineering workplaces/industries. Classes in the paper are scheduled for two hours each day of the week for an entire semester but students have the flexibility of accessing their workspaces and equipment in the laboratory (lab) whenever they need them, and most do. The course typically has an enrolment of between eight and 16 students each year. Students are required at various stages to program microcontrollers, design and build interface circuits, process sensor inputs, drive actuators, transmit or receive data, parse data packets, etc.

Traditionally the course is convened by a single lecturer (Lecturer 1) who offers technical assistance through lectures and lab work to facilitate students' developing and successful construction of their projects. The lectures highlight the theoretical understanding and technical ideas students will need to apply in their projects. The lecturer would also run short mini-lectures during labs as and when needed to support students if students persistently face an issue in their project work; examples might include the application of sub-sampling or best-practice in coding delays. As the lecturer is an expert in the area and had been teaching the course for quite some time, he is able to quickly pick up students' assumptions and misconceptions and address these early in the course to guide their thinking. The lecturer felt this may not be benefitting students' learning of important non-technical skills (i.e., planning, self-management and problem-solving skills). Students had difficulty planning milestones and articulating their thinking. As Glaser (1987) pointed out, experts differ from novice learners in terms of “knowing what one knows and doesn't know, planning ahead, efficiently

apportioning one's time and attentional resources, and monitoring and editing one's efforts to solve a problem" (p. 13). The lecturer was thus keen to investigate strategies that would enhance students becoming aware of, and articulating their own planning, managing and problem-solving aspects of their project. The lecturer's idea was to enhance the course assessment structure to include a component requiring students to report on their planning and progress to staff (demonstrator) from a management background (the assessment innovation) rather than technical, as occurs in industry.

## **The Intervention**

This study focuses on the assessment innovation implemented in ENEL417 Mechatronics. When the study was conducted, the course was co-taught by two lecturers (Lecturer 1 and Lecturer 2). A science student with a previous commerce degree was employed as a course tutor to take up the role of a "demonstrator manager" throughout the course. The lecturers took turns to offer technical assistance to students through lectures and lab work but organisational assistance and reporting was provided by the "demonstrator manager". About one-third of the marks for the paper was awarded by the "demonstrator manager" based on how well she perceived each student to be planning and executing their projects, and the timeliness and comprehensibility of their reports. Key to the process was the fact that the demonstrator manager did not know much about the technical details of the projects, forcing the students to plan their work, explain milestones in consultation with her, and explain their progress to an "outsider" (see Appendix 1 for the sample questions that the demonstrator manager used to probe students to be more explicit in thinking through their project and the marks allocated). Students reported their progress to the demonstrator manager on a weekly basis. The demonstrator manager would drop in several times a week or every other week during students' lab hours. In these reporting sessions, students meet individually with the demonstrator manager to provide a quick update of their work, go through issues they have encountered and provide an outline/plan for troubleshooting and achieving their next milestone. Students could email their progress if they missed seeing the demonstrator manager. The paper organisation strategy is based on Packard's (1985) Management by Walking Around.

This demand for milestones and progress reporting forces students to break down the process of managing their project into small steps with specific goals that they will need to achieve within the week/a timeframe to develop their project. This strategy shares characteristics with the notion of setting *subgoals* in situations where one is required to take small functional steps to solve a complex problem. Teaching learners to identify and achieve subgoals have been evidenced to increase their success at solving novel problems (Margulieux & Catrambone, 2016). The assessment innovation in our study was therefore intended to be authentic and to function as a learning tool in itself.

## **Research Design**

This exploratory qualitative study therefore aimed to investigate the effectiveness of implementing a management-based assessment structure to promote students' self-management skills as part of learning to organise their work in their project-based course. It case studies staff and students' experiences in the final year Mechatronics paper to obtain their views on the new assessment strategy and highlight any suggestion for enhancing the assessment innovation.

## **Participants**

Nine out of 11 EE students who enrolled in the course consented to participating in the study. They completed the end of the course survey. Of these nine, seven students attended the focus group interview. The study received ethical approval from the University's Human Ethics Committee and all participants participated in the study on a voluntary basis.

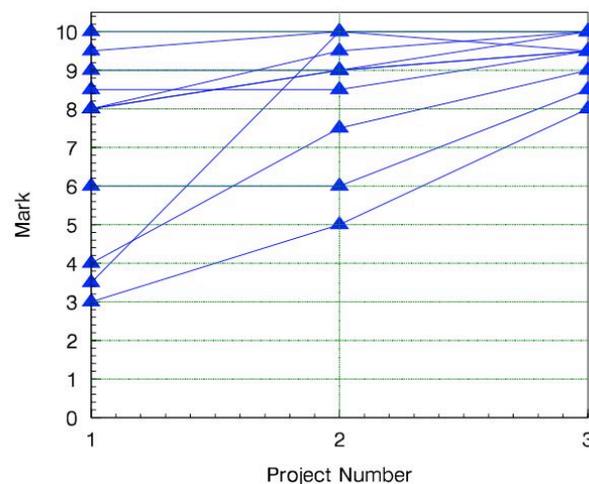
Data were collected through lecturer and demonstrator manager interviews, students' progress achievement in each project, demonstrator manager's feedback to students, student focus group interview, and students' survey evaluation of the course. The survey was conducted online via Google Forms and was collated and analysed using Microsoft Excel software while the focus group interview data was thematically analysed to identify emerging themes (Braun & Clarke, 2006). Each form of data was analysed separately and then triangulated to address the research aim.

## Findings

We report the findings from the student achievement first, followed by the themes emerging from the survey and interviews. Themes regarding the value of the assessment innovation will be highlighted first followed by challenges and suggestions for enhancing student learning. Each theme will be evidenced by student data and corroborated with data gathered from lecturers and tutor.

### Student achievement

Figure 1 illustrates the marks awarded by the demonstrator manager for each student for the three projects, based on the assessment innovation.



**Figure 1: Individual student marks for the assessment innovation based on the three projects**

The marks in Figure 1 summarise the outcomes: The figure shows a clear overall improvement in student ability to explain and report on their project over the duration of the course. Every student improved from project to project, with the single exception of one student who scored 100% in the second and 95% in the third project. Three of the cohort went from failing in their ability to explain what they were doing in the first 3 weeks to A grades. The lecturers consider this simple quantitative summary to reflect the success of the intervention in improving students' non-technical performance.

Lecturer 2 commented on the benefits for especially the average achieving students including those for whom English was not the first language:

*It worked really best for the average students. The good ones already had it under control. It's the ones that were in the middle range who benefited most. The weak ones probably benefited but still struggled a bit.... There's a definite trend of improvement, most had got it by the second one [project] but by the third one they've all pretty much got it. The non-technical skills, they [students] are starting to get more organised, aiming for the deadline. The students struggling to achieve the midway assessment in the third project by the end had caught up. They all passed that last bit comfortably (Lecturer 2).*

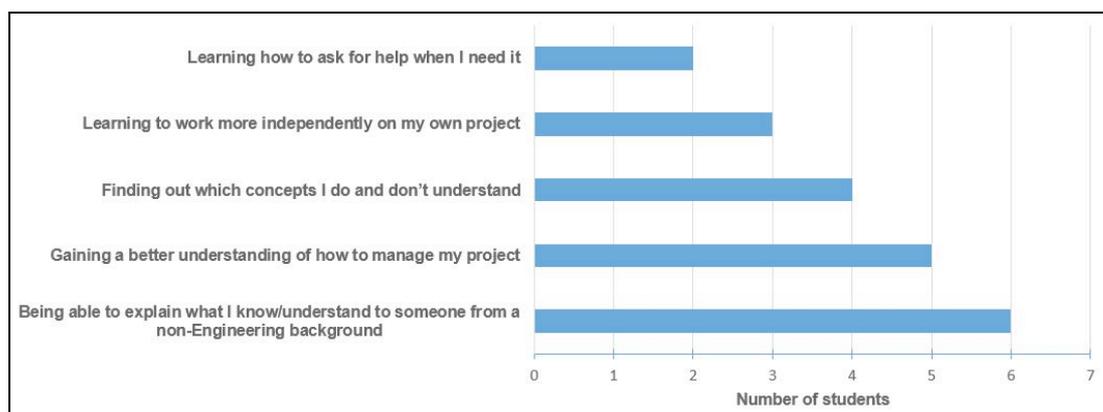
The demonstrator manager affirmed students' progress over time and the fact students had time to consider the process of working through their project:

*In the first project, it was 2 or 3 students who did a very good job, majority did an average job and 2 students did really poorly. But then the second project, this increased to 4 students who did a very very good job who got full marks, 3 to 4 students did a reasonably good job, no one failed. And for the last one everyone did a really good job of explaining. I think the [last] project was longer as well and hardest and they had a lot of time to think about it. They had time to think about the process thoroughly so they were able to explain better, it's not just my involvement. I hadn't expected such a great improvement over a short period of time (Tutor).*

## Benefits to Learning

### *Students perception of the assessment innovation*

In the student survey, all students reported that the assessment innovation was helpful to varying degrees in developing their project. Three students reported it was 'Very Helpful', four reported 'Helpful' while one reported it was 'Somewhat Helpful' to their learning. When asked about the skills they think they have developed as result of the assessment innovation, a majority of students reported that it was 'Being able to explain what I know/understand to someone from a non-Engineering background' (6 students), followed by 'Gaining a better understanding of how to manage my project' (5 students), and, 'Finding out which concepts I do and don't understand' (4 students) (see Figure 2).



**Figure 2: Skills students reported developing due to the assessment innovation**

Four key themes emerged from the findings. These show the value of the assessment innovation.

### *Becoming an engineer*

All participants considered the identified skills integral to becoming a professional engineer and thought the assessment innovation went some way towards supporting students' developing these. Lecturer 1 valued students being able to communicate and demonstrating their thinking to others:

*Many papers in engineering ask students to do some lab work and write up a report. This hardly happens in real EE companies. You keep a lab book and you convey the outcome of some measurement to your colleagues in a meeting. You don't write a report and send a memo around. It just doesn't happen. One of the key skills you need is the ability to come up with some lab measurement and go 'We have been doing this wrong and we need to [whatever]... or you say that, I did this and it worked quite well'. So the way students communicate is not by writing report to people. It's by telling them what is going on and showing them here is the proof (Lecturer 1).*

Lecturer 2 highlighted skills such as self-learning, collaborating with others and communicating ideas clearly:

*This project-based work is quite good. We are preparing students for a professional degree for the workplace and therefore it is appropriate to start them to think about 'how do I practice the art of the workplace in the industry, to get a feel for it. If they can't organise themselves they can't make progress. As an engineer you should be able to self-learn, work out what you don't know, what you need to learn for the project and why. You should be able to work together with others, team effort, put together a whole product. So they need to be able to communicate and understand others. When they start off they may not be able to manage others but they should be able to organise themselves (Lecturer 2).*

The demonstrator manager added that key skills in becoming an engineer was problem solving, communication and being customer-focused:

*If you are going to invest your time, money and training for an engineer, he/she should be able to set milestone, be able to solve problems, or give a time frame to the supervisor about the problem they have encountered. Because the customer wants the product in a certain timeframe. It's a very important skill to be able to communicate to the customer where you are at in the project making process. Why would they [customer] choose your company if they can get the same product but with better communication from another company who is keeping in touch with the customer, taking the customer's needs into account (Tutor).*

### **Simulating a real-life workplace environment**

In the survey and focus group, students affirmed the assessment innovation offered them a realistic experience typical in the engineering workplace. They highlighted advantages such as having to communicate ideas to a non-technical person and setting milestones. Two student responses from the open-ended survey were:

*It was helpful to have a person that has a tangential understanding of what is happening but requires updates on what we were doing, this is a good comparison to what we will expect in the workplace.*

A condition to ease the process of communicating their ideas was that despite the demonstrator manager having minimal technical knowledge, she at least needed to have some basic technical understanding. Students in the focus group made this clear:

*It made it easier to explain things, we didn't need to go really basic, we could talk about our components and she'd understand. There are certain things you can take for granted that she knew; how components work, for instance using capacitors to filter things out. I don't have to stop and explain [otherwise] it will slow us down as well. You do need a certain degree of technical knowledge (Student, Focus group).*

### **Maintaining regular planning and progress in project work**

Students appreciated having to plan and maintain regular progress on their project work through the new assessment structure. Student quotes highlighted their becoming aware of developing time management, planning and goal setting/milestones and problem solving skills:

*It [Talking] helps realise it [project] rather than it being just an idea, what you actually need to do, your plan...also the scale of the project, it's actually a lot of parts to it. So you can appropriately plan for it (Student, Focus group).*

*The management component to this course was helpful for me in managing the timeline of the my project in the way of providing milestones to the manager also help to keep my progress on track as I would aim to achieve those milestone by the next meeting (Student, survey).*

*I was so focused on what I was doing and not thinking about what it [part of the project] will be building onto but ...when you talk to the tutor and she asks 'What's next?' then you actually stop and think, 'Ok this is still what I have got to do'. Initially I didn't really set up milestones but when I started talking to her then I can tell her what it is going to look like. Milestones help to put the whole project in perspective, explaining to her [tutor], it quickly became apparent whether you are ahead or behind schedule (Student, focus group).*

The demonstrator manager confirmed that all students' developed skills in self-setting of milestones, time management and written and oral communication (e.g., setting up checklists) towards the end of the paper:

*By the end, a majority of students had small self-set milestones as opposed to the lecturer's general milestones. For them to break it down into small goals for themselves, this improved significantly for everyone (Tutor).*

*Their [Students] time management improved - when they said, 'I could fix this problem in 3 days', I'd come back in 3 days and it was fixed and they are on to the next problem [for the final project]. The first project, time management was lacking (Tutor).*

*The best result I saw was their checklist through email. They would send me a checklist and they would print off the checklist or keep it up on the screen and show me each time I came in, [explaining] 'This is where I am at, I am doing this for this particular reason, for example, I am soldering this circuit because I want to read data off the tracks...' Every student did this towards the end (Tutor).*

### **Deeper understanding of technical concepts and communicating these clearly**

All students thought the assessment innovation supported their thinking more deeply about their technical ideas. Having to communicate to a non-engineer forced students to explain their ideas explicitly and clearly without using 'geek speak', in doing so students realised potential flaws in their own thinking and began to plan ways to problem solve their project work. Students in the focus group alluded to these ideas:

*As electronics students we spend a lot of time on our own in our work, communicating with one another, it was good to have someone to practice communicating with someone a bit more 'real'. Our communication is mostly what we hand in...assignments, reports. It's [the assessment innovation] not something we normally deal with so it's great because when we get into the workplace, we'll be having to report to quite a few people (Student).*

*You are trying to change the language, you are not thinking of specifically coding language. It's a separate thing, so you are thinking of slightly different perspectives. You don't need to consider how to build it on the schematic, it's just that thinking in simple language, 'What I need to do to get the motor driving is...' It does change the way you think in the language you won't normally use (Student).*

*Explaining how you are going to do something to someone early in the project can help outline flaws in your thinking (Student).*

The demonstrator manager reported students communicating more succinctly towards the end of the paper in terms of time and quality of communication:

*Being able to communicate succinctly about their project. It would start off with 20 minutes per person in the first project but over time this would go down to 5 to 10 minutes because they would just tell me what I needed to know about their project (Tutor).*

### **Challenges and recommendations for improvement**

Students raised three aspects that could be improved when implementing the assessment innovation: clarifying expectations about the innovation, flexibility in reporting to the demonstrator manager, and obtaining regular feedback about progress.

#### **Clarifying expectations**

A key challenge in the introduction of the assessment innovation was the unclear expectations about how it was going to be played out and clarification of the demonstrator manager's role and responsibilities. It was unclear whether her role extended to offering technical guidance.

*Be more clear about what is needed or have a handout/guideline, this will be helpful for future cohorts. The lecturer could prepare a doc that can be uploaded to Moodle [class website] explaining what is needed/criteria for marking/what needs to be in the discussion content with the tutor, etc. (Student Focus Group)*

### *Flexibility in reporting*

In the focus group, students mentioned wanting more flexibility in being able to do more reporting via email to the demonstrator manager as they could not always meet with her on a face-to-face basis:

*Being able to email their progress to the tutor apart from the face-to-face discussions as coding is a hard work and you don't always get it right, sometimes you fall back two steps behind and it appears as if we have not progressed from the previous meeting with the tutor when she comes into the lab. We felt this affected our marks.*

If a face-to-face meeting was to be held, students thought they could get better organised if they had a pre-arranged fixed time/day of reporting to the demonstrator manager:

*She could let us know (have a fixed time to see each person) so we know to prep for her coming. Otherwise her coming in was a bit random and we are at times scrambling for what to say to her. You never know when she was coming from the 5 lab times but we may not fit into those times, some of us work away from home or late night.*

### *Obtaining regular feedback about progress*

Although students appreciated their regular reporting to the demonstrator manager on their progress, they had hoped that she would provide them with how they were progressing including her grading of their progress. A sample student survey quote was:

*It would have been good to get some feedback of how well we were communicating with the tutor throughout the projects instead of just at the end. This would be so that we could work at improving during the current project instead of the next project.*

## **Discussion and Conclusion**

Science and engineering graduates are expected to have strong communication skills, practical ingenuity, and good written and oral communication skills (Coll & Zegwaard, 2012), as well as an understanding of business practices and a sense of social, ethical, political, and human responsibility (Campbell & Zegwaard, 2015). Tertiary institutions have been tasked with the need to offer relevant and authentic curricula to enable students to develop these competencies. The authors consider this innovation to have been very successful. We have presented quantitative and qualitative evidence showing that the innovation of separating the technical and reporting assessments, and having the reporting handled by a “demonstrator manager” worked surprisingly well.

Although this small study may not necessarily generalise to other contexts, it is hoped that the insights gained can inform other educators interested in pursuing the assessment innovation to consider ways of implementing it in their practice. We hope to extend this study with the aim of characterising what is required in the “demonstrator manager” role, and testing it in larger classes.

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## Appendix 1. Sample tutor/demonstrator manager questions

At the beginning of a project:

1. Tell me about the project.
2. What is your primary plan to handle the project?
3. What milestones have you set for the project?

Middle of the project:

1. What milestone have you achieved thus far?
2. How did you achieve it? Can you show me some demonstration of your device when you achieve an actionable milestone?
3. (Usually they'll run into a problem) What is the problem? Do you know why it is occurring? and what actions are you going to take to resolve the issue and within what time-frame?
4. If you cannot resolve it within that time frame, do you have contingency plans?

End of the project:

1. How did you fix your problem?
2. Can you show me a working demonstration of the device?

### Marking criteria

1. Student understanding of their project [1 mark]
2. Student ability in planning and organising (i.e. milestones with time frames) [4 marks]

3. Student ability in explaining issues that they ran into [2 mark]
4. Student ability in resolving project issues [2 mark]
5. Student providing evidence of their progress [1 mark]