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Assignment to Engagement to Employability

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ABSTRACT

CONTEXT

Teaching courses for the Engineering Degree programme at a polytechnic, or technical institute, requires emphasis on academic writing, whilst ensuring the learning outcomes match the industry requirements. One challenge for students is that a significant amount of the practical work completed by the student is not necessarily identifiable by employers. A challenge for academic staff is that teaching such courses is frequently seen as reducing research time. In this paper, the authors demonstrate how assignments, or mini-projects, undertaken in courses by students in the third year of their degree, can be converted into research outcomes, co-authored by the student and supervisor, using the example of an applied computational modelling course.

PURPOSE OR GOAL

This work presents the process of converting a level 6 mini project assignment within the Bachelor for Engineering Technology in Mechanical Engineering (Sydney Accord) to a research project published at prestigious conferences such as the International Sports Engineering Association (ISEA), and Q2 and Q1 journals. The main research work involves showing the students how to generate a comprehensive report covering all requirements, with such examples as modelling using the one-way fluid-structure interaction for a go-kart spoiler. This is an ongoing iterative process, continually improving, where the work is suitable for submission in Q2 and Q1 journals to seek international reviews.

APPROACH OR METHODOLOGY/METHODS

The methodology used in this study is autoethnographic reflection by the author, describing how undergraduate coursework-based papers can still generate publishable research outcomes.

ACTUAL OR ANTICIPATED OUTCOMES

The work that this study reports on is the successful publication of six research articles and one conference proceeding since this process began in 2018.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

In conclusion, to improve the perceived tradeoff between teaching and research, this study shows how even assignment-based papers can still generate research outcomes. Furthermore, the benefit of those research outcomes accrue to the student, in terms of employability, because they have a peer-reviewed and internationally recognised record of their achievement(s) during their studies.

KEYWORDS

Applied computational modelling; teaching; research; industry engagement; employability.

Introduction

One of the requirements for teaching in the Bachelor of Engineering Technology (BEngTech) program is to perform research to maintain the tutor's industry and research relevance while teaching level 7 courses. The mechanical BEngTech specialization offers the following courses at level 7, which require some research components such as Energy Engineering, Fluid Power and Advanced Fluid Mechanics, Advanced Thermodynamics and at level 6, Applied Computational Modelling. The BEngTech is an accredited program based on the Sydney Accord, which differs significantly from the Bachelor of Engineering (BE) and the Bachelor of Applied Science in Mechanical Engineering (BSc), which are based on the Washington Accord. The focus, in the BEngTech, is to provide students with comprehensive training the students on existing technologies related to the engineering strand.

Burleson et al. (2023) presented a comprehensive study to identify emerging technologies in advancing engineering for sustainable development. They surveyed 20 academic and 36 industry participants from the American Society of Mechanical Engineering (ASME) 2022 Engineering Global Development (EGD) Stakeholder Summit using the Adapted Delphi study design approach. Their results showed that innovation and creativity were the foremost desired skills for the Engineering for Sustainable Development (ESD) workforce. In China, Chen et al. (2022) discussed the actions required to demonstrate the role of engineering education in the progress towards training engineering graduates to achieve the Sustainable Development Goals (SDGs) using qualitative methods based on a case study. Their results suggested that there is a different range of typologies of global engineering education governance for SDG, but it is required to develop a comprehensive understanding of the country's participation in this global governance. In the United States, MacDonald et al. (2022) reviewed the global engineering education in North American universities of engineering degrees to address the importance of undergraduate education and research using a workshop approach. Their review identified 15 priority learning objectives, with technical skills being central to preparing the next generation of global engineers.

Previous research described the process used to align research objectives with student learning outcomes to meet sustainability objectives at two different institutes to address the graduate profile and Engineering New Zealand (Al-Rawi et al., 2016 & Al-Rawi et al., 2021). The project discussed within those papers led to publication of the following articles (Chand et al., 2021; Al-Rawi et al., 2022a & Al-Rawi et al., 2022b) co-authored with students and incorporating results obtained during their final-year project. This final year project, called the Engineering Development Project, Level 7, comprises 30 credits (out of 360) taken across two consecutive semesters in the final year of the three-year degree. This represents 30 weeks of study, for a total of 300 hours.

The Engineering students' results were also incorporated into broader fields of study: what was prototyped by these graduates was tested by another student from applied science to perform mould and pathogen assays in campus classrooms (Williams et al., 2023), the results of which were of great interest to students learning in those classrooms. This aligns with the approach described by Rodriguez et al. (2023) who identified that human-centred design and equity-centred engineering in the medical device industry provided a rationale for the need to incorporate meaningful stakeholder analysis. Students and academics are generally strongly motivated by the health, safety and wellbeing applications of their research. Askarinejad et al. (2017) noted that a shift from traditional transmission-based teacher-focused pedagogy to a modern student-centred learning approach, combined with strong industry linkages, fostered high-quality student projects that generated peer-reviewed publications. Student feedback acknowledged the value of this experience as part of their learning and motivating them to excel in their project work.

The main objective of this study is to describe the method by which: (1) research objectives may be embedded into final-year student projects; and (2) the outcomes of those projects may be converted into peer-reviewed journal articles. These research outcomes benefit both the supervisor/institutional research performance, and the undergraduate student who retains coauthorship in this research which supports their employment applications in research and development jobs.

Methodology

The engineering development project paper is based on the Sydney Accord, and aims to make the BEngTech students work-ready as technologists. Additionally, the BEngTech program requires all the staff teaching level 7 papers (third-year papers) to be actively engaged with applied research to maintain currency with the industry advancements. The learning outcomes for the final year project paper are: (i) synthesis of a solution for an engineering problem; (ii) complete a project to a specified standard; (iii) design, project management, and evaluate a concept/model/product; (iv) Use software application packages as an engineering tool, if required; and (v) communicate effectively with customers, peers, technicians and engineers. These learning outcomes should enable students to demonstrate their ability to apply of theoretical knowledge and use practical skills in creating an effective product.

In addition to that, the supervisors should be research active with a 0.2 FTE (Full-time Equivalent) research allocation and with the job description of senior and principal lecturers. Also, all universities and vocational institutions, until recently, required their academic staff to submit portfolios to the Performance-Based Research Fund (PBRF), which is provided by the New Zealand government. The PBRF is currently going through reform. However, its main aim is to increase the quality of research to ensure excellence in the tertiary education sector in Aotearoa, New Zealand. Additionally, one of the main objectives of the PBRF is to lift the university's and vocational institutes' rankings relative to their international peers. One of the categories is to assess the publication for each academic staff with research requirements in relation to the quality and quantity of publications produced, as well as their impact on Māori and Pacific communities.

The final year Project

In the last six years at Waikato Institute of Technology (Wintec), there have been several different student projects related to a main, overarching research project on designing and prototyping air purification devices for improving indoor air quality (IAQ). Several of these student projects have been described in publications. The following projects related to IAQ for students in either the Mechanical or the Electrical Engineering strands have been published (Al-Rawi et al., 2022a; Al-Rawi et al., 2022b & Al-Rawi et al., 2021):

1. Prototyping a low-cost residential air quality device using ultraviolet germicidal irradiation (UVGI) light
2. Cost-Effective Customizable Indoor Environmental Quality Monitoring System.
3. Assessing Indoor Environmental Quality in a Crowded Low-Quality Built Environment: A Case Study.

Another project relates to designing helmets for e-scooters or polo sports is also one of the common projects picked by students, resulting in the publishing of the following articles.

1. Designing Foldable Helmets for Micro-mobility using Sustainable Materials.
2. Explicit and Computational Fluid Dynamics Analysis of a Novel Polo Helmet Design: A Parametric Study.

After supervisors expanded their research projects to include different centres within Wintec and across other universities such as Auckland University of Technology (AUT) with the following title: Pilot Study Investigating Effects of Changing Process Variables on Elastic and Energy-Absorbing Characteristics in Polyurethane/Agglomerated Cork Mix for Use in Micro-Transport Helmet, which also attracted other researchers within Wintec to publish their final year applied student project in the following articles (Hwang et al., 2023: Kim and Kim, 2023) Particulate Matter ($PM_{2.5}$) and Mould Characteristics in Selected Classrooms Located in Waikato, New Zealand: Preliminary Results which will benefit both centre for Engineering and Industrial design and the Centre for

Applied Science and Primary Industries towards achieving good score in the PBRF or what will be equivalent. These projects required funding, which will be discussed in the next section.

Project Funding

The concept started with prototyping the air purifier using the circular economy concept by converting an existing dehumidifier and adding HEPA filters with UV lights. This project cost NZD$213.76 with many donated materials as shown in Figure 1. The BEngTech student completed the processes for the applied work, and then supervisors tested the device with minor changes to enhance the research capabilities. This was one of the first articles published within a Q2 journal called HardwareX, which supervisors found suitable in relation to the level of work undertaken for these undergraduate student projects. Furthermore, this prototyped device was then able to be used in different research for further testing and improvement. These tests were funded with approximately NZD $19k for the relevant ANSYS research license and purchase of testing equipment, such as the Testo Thermal Comfort Kit and other sensors.

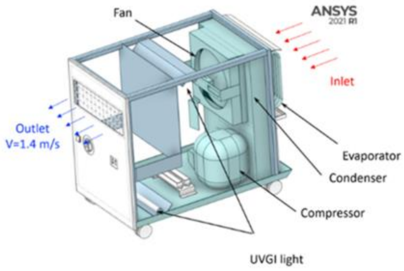

Figure 1: Polyester Filter and UV Light (PFUV) Dehumidifier.

The same concept was applied to the Helmet project, which started with an assignment in the applied Computational modelling as a mini project to design a new polo helmet and then the concept was further developed to extend to micro-mobility devices. The motivation for this work was the existing problem, seen in New Zealand and many other countries that have adopted micro-mobility devices: that many e-scooter riders do not use helmets due to hygiene, discomfort or inconvenience. Therefore, supervisors started applying for contestable funds to create helmets from organic and sustainable materials like cork. This project was extended to develop a relationship with Auckland University of Technology (AUT) in New Zealand, and Hanbat National University in Daejeon, Korea. The concept was to design a fordable helmet that was easy to carry and made of cork and a few materials. The first step of the design is to perform the finite element analysis (FEA), as shown in Figure 2, before 3D printing the helmet and moulding it.

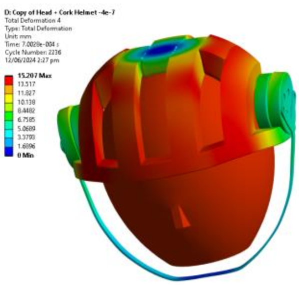

Figure 2: The Cork helmet with transient explicit dynamic analysis during the impact

Both projects are ongoing and have resulted in many productive additions to the researchers' networks, including more students from New Zealand and Korea to work on the helmet project and from different departments, such as creative design.

Supervision Process of User Experience (UX) Concept Design Components

Industrial design, a convergent discipline, is driven by the integrated practical problem-solving process between consumers (or users) and engineers. Figure 3 shows a pivotal Double Diamond Diagram (DDD) concept introduced by the UK Design Council (Design Council UK, 2007).

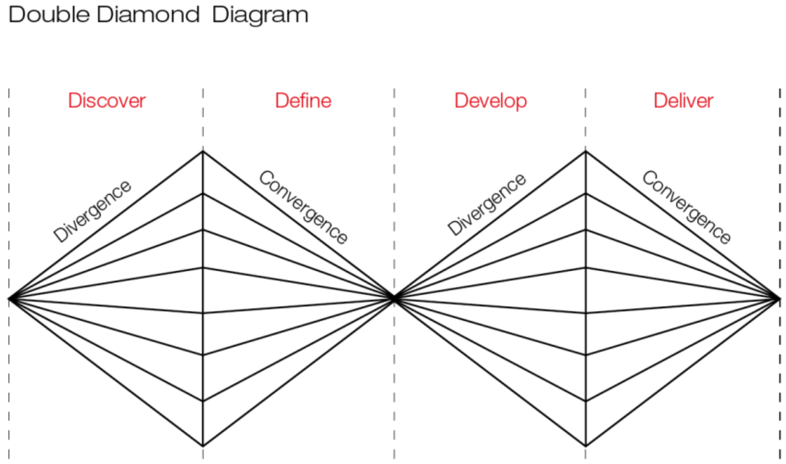

Figure 3: Visualization of the Four Stages of the Double Diamond model for the design thinking process (adapted from the British Design Council)

Supervising a student project using the DDD is a great approach to ensure a structured and thorough design process. The DDD framework consists of four phases:

- **Discover**: This phase focuses on understanding the problem or opportunity. It involves researching, gathering insights, and identifying user needs.
- **Define**: In this phase, students clarify their design process. Students carefully analyse the information gathered during the Discover phase to define a clear and actionable problem statement or brief. This step is critical to help students narrow their focus and set a clear direction for their design work.
- **Develop**: The focus shifts to brainstorming and generating ideas and potential solutions. It is about exploring possibilities and prototyping.
- **Deliver**: This final phase involves refining and finalising the chosen solution. It includes testing, iteration, and implementation.

The supervision process of the project design is divided into the following stages. In the Discover Phase, clear objectives were set, which ensured the students defined what they needed to learn or understand about the problem or users. Research guidance enabled the establishment of the research method, such as interviews, surveys, or observations, selected, whilst analysis involved organising and analysing the data collected to uncover critical insights. In the Define Phase, findings were synthesised, guiding students in synthesising their research findings into a coherent problem statement, such as user personas or scenarios were created to clarify the end users' identities and potential needs, whilst attention to the scope and focus ensured the problem statement is specific, actionable, and addresses the core issues identified. The Develop Phase involved idea generation, such as brainstorming sessions to generate various ideas, encouraging creativity and divergent thinking. While prototyping occurred with the creation of prototypes or sketches, ensuring iterative development and testing of ideas and feedback loops were set up with regular reviews to provide constructive feedback and guide improvements. Finally, the Deliver Phase involved refinement, based on testing and feedback, to refine the prototypes, final testing to ensure the solution works as intended and meets user needs. Students were given guidance in preparing a final presentation or report to showcase their work, process, and findings.

Ensuring the production of high-quality UX design required adequate supervision at every phase. To achieve this, the supervisory team organised and scheduled regular meetings to review progress, address challenges, and plan the next steps. Furthermore, the team fostered collaboration and open communication among students. Facilitating access to essential resources, tools, and expertise was also crucial to their responsibilities. Throughout the project period, the supervisory team consistently encouraged students to assess their work critically, seek feedback from peers and stakeholders, and celebrate milestones and successes to maintain high motivation.

Supervision Process of Engineering Components

Several points should be considered when supervising final-year project students with a view to publishing the outcomes of this work in Q1 and Q2 journals. The following points describe the process used in the approach:

Project scope adjustment and prior planning

First, project brief is prepared and mapped to my research plan by simplifying the task to be suitable for undergraduate work and of an appropriate workload for the level 7 requirements. Part of this task includes ensuring that the project work will be within the scope of the course's learning outcomes. This task also results in estimates of the timeline, resources, and milestones to be achieved at the end of the project.

Assignment of project, including teams and roles

Secondly, depending on the project’s goals, students may be selected to work individually, or in a team of two to three students. At this stage, the supervisors meet with the students, explain the project's requirements, and identify their prior training or experience with relevant software, for example, if they have taken an Applied Computational Modelling paper. Also, the supervisors outline their responsibility and my responsibility as a supervisor, to give them a clear idea of the nature of the project and the supervision process. Within the project, my role is as the project manager, and the students’ roles are as the engineers working on it.

Project training, planning and proposal development

Thirdly, after they confirm they are interested in taking on a project, the supervisors start training them to work on developing their initial plan and how to organize their project, including keeping records and weekly meeting presentations to show their progress. Also, they will start developing the proposal, which will set the final objectives, timeline for the deliverables and budget.

Running the project and technical challenges

Whilst working on the project, students frequently identify technical challenges, or skills they want to develop during their project. One frequent challenge occurs during the applied work, such as difficulties effectively prototyping items, even if they have a sound design concept. Another challenge arises when the student’s technical drawings do not meet the requirements of the technical team in the workshop, such as missing essential information. The technician will reject the work as their time is in high demand. These are important components of the student’s learning process and best to occur when they are still a student. Exemplars can be helpful to improve their technical communication skills, but sometimes the trial-and-error process reinforces the need for appropriate technical drawings.

Team dynamics, collaboration and communication

Given their role as project manager, supervisors will discuss, with the student/s, communication styles, addressing any conflicts that may arise, and how to work in a team, where necessary. For example, supervisors have a WhatsApp group in which supervisors can update each other on the tasks and address any urgent problems that need resolving. Also, supervisors set the boundaries for communication to keep it very professional. Of course, some students like different approaches, and the supervisors are happy to accommodate their preferences where it is appropriate. This approach is very important to develop their professional and personal team communication skills.

Development of graduate attributes and continuous improvement

In this process, the supervisors are trying to address the lifelong learning graduate attributes to ensure the students develop a good understanding of managing the project and address the many challenges that will arise during the project. For example, as students experience regular issues, such as sourcing the right parts, waiting for the parts from overseas, modifications of the project, including negotiations for changing a non-achievable objective and replacing it with another objective, they improve their understanding of project management and self-management during a project. Every year, this process also enhances my supervision experience, and the supervisors share their experience with the students and other supervisors, as well as adjusting my approach in line with what they have learnt. Additionally, the supervisors shared the projects which supervisors successfully published with students, and the new supervisors who joined me in this process.

Project outcome mapping and impact

This is the part of the process in which the students and supervisors check the progress of the project mapped to the Gantt chart and address the outcomes of the main objectives. Also, supervisors assess the impacts and benefits of the results for the communities. This process sometimes requires the students to retest the results to prove the concept and validity.

One of the good things about the projects is that, where students have come up with an innovative and unique approach to achieving their final projects, supervisors have frequently managed to publish these results, with the students as co-authors, after converting them into research articles. This means the outcome of the students' work, and the novel solutions adapted, are recorded in the form of research articles, thereby extending their impact.

Industry feedback and improvements

Supervisors invite industry and stakeholders to provide us with feedback. Also, supervisors get feedback from reviewers when supervisors submit the work to journals. Some projects required supervisors to extend the testing method for a device the students designed and prototyped, which was conducted after the students had already finished and graduated. This ongoing work has provided project work for students from other fields, such as applied science.

Personal reflection

Here, supervisors reflect on my experience and how to manage students with different backgrounds and knowledge of the topics they study for a year. The supervisors attached to these project ideas; that attachment has frequently moved to the students over time. So, it important to have a firm affinity for the work supervisors do, a curiosity to extend and further develop the work, because this enthusiasm is passed on to the students. The supervisors focus on ensuring that what supervisors do is also relevant to the student's experience to be work-ready, so that they can use the time spent on their projects as a good example to share during their job interview. One rewarding thing is hearing that the project process helped the students get a job in research and development. The supervisors learned many lessons during these years, such as converting an undergraduate project into a research article, which requires more experience and time to be more efficient. Also, the supervisors thank the unknown reviewers who considered the work relevant and at the level of applied research articles.

Converting student project work into a research article

The first attempt to convert the work done during a student's final project into a research article took two years of development. In the first year, supervisors published a proceeding paper at the International Conference on Engineering Sports, and then supervisors started to advance the idea of approaching journals. Top journals in the field rejected the first manuscript supervisors compiled, but fortunately the reviewers gave us incredibly helpful comments and recommendations, comprising about three pages of comprehensive feedback, which resulted in completely redoing all the testing to a suitable level and then successfully publishing the work in two articles: one focusing on the prototyping process for the device made by the student; and the other about the advancement of the testing method for indoor air quality. This process helped, as a project supervisor, to more effectively identify the gap in the application related to the research field, and to work with limited resources and funding, in order to publish peer reviewed research articles. Also, this process helped us to expand the concept to apply to different projects, such as sports and micromobility helmets, and to secure internal funding to start creating special research laboratories at the polytechnic level of funding. Also, the number of publications improved supervisors' networks with other researchers at the university level, resulting in co-authoring articles and securing external funding.

Conclusion

To convert final year projects into research articles requires careful design *ex ante*, to ensure that the student's project is: aligned with the graduate attributes for the research project; of a suitable size and scope for the level of the undergraduate project; and aligned with the over-arching body of research, and therefore able to contribute towards this work. Regular meetings with students ensure that they stay on track, as well as giving a feeling of typical project manager / project engineer interactions. This paper described two examples of the process and methods for supervising final year projects and converting these into research articles, for the fields of indoor air quality and using sustainable materials for designing e-scooter helmets. These projects aligned with the United Nations Sustainable Development Goals (UN SDGs) and addressed issues related to New Zealand. Supervisors identified that the following elements were critical to the success of this process:

1. Provide the "right" project, such that the student is keen to learn and is likely to become highly engaged in the project. This is more important to success than other elements typically considered, such as their grades in previous courses
2. Conduct weekly meetings with the students. These are crucial to keep them on track, and also help prepare them for the workplace.
3. Supervisors must provide the equipment and the financial resources to ensure the student can produce an outcome.
4. Since supervisors are limited to their budget, CFD modelling analysis was the main aim of many projects conducted so the work could be published.
5. The applied prototype projects attract students more than the testing project; therefore, they do the initial testing, and the supervisor does the rest.
6. Many projects are planned to be completed in two years (due to budgetary restrictions) and students' abilities, so supervisors introduced the commissioning of the project to the next group. This usually requires recruiting students before they start on the project. Also, this should be approached if the student is keen to commission both sides.
7. Be patient with students as supervisors manage many aspects of the project, working with the project coordinator, research office, the students (within Wintec and other Universities in New Zealand or South Korea), industry partners and other researchers involved in the project. Therefore, this point is applied at the project development stage and to the journal submission. There are many aspects which do not involve the students as they are outside their requirements for the degree.

Overall, the process could be different for other students and supervisors. Still, this method works for students studying at the degree level compared to universities with master's and PhD students to work on research projects. The efforts made by the supervisors and students have resulted in successful publications in peer-reviewed international journals.

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