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Design and Evaluation of an Introductory Engineering Ethics Module

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ABSTRACT

We report on the design, delivery and evaluation of a short but dialogue-rich first-year Introduction to Engineering Ethics module at UNSW Canberra at the Australian Defence Force Academy. The trigger for the design of this new module was an accreditation review by Engineers Australia that recommended we teach more engineering ethics, rather than rely on our students' military ethics training. The goals of the module were to stimulate intellectual and emotional engagement with engineering ethics, and encourage the development of ethical imagination. The learning outcomes included knowledge of the Engineers Australia Code of Ethics and application of ethical reasoning. This module was designed using a social constructivist approach consistent with the goals of the module, by a fourth-year engineering student as his honours project, as part of a students-as-partners approach to educational development. The student-staff partnership provided valuable outcomes for all parties – the student researcher, the academic staff, and the cohort of students taking the module. The module used frequent group discussion of hypothetical ethical conundrums, including some with a military context, and direct instruction on the Engineers Australia Code of Ethics. Apart from this contextualisation, the module was separate and distinct from the students' military ethics training. Evaluation of the module using classroom observation, pre- and post-module surveys and students' assessment results showed that the module was intellectually and emotionally engaging for the students and the learning outcomes were met. However, we also found that students tended to revert to deontological "follow orders" reasoning consistent with their military training. So while engineering ethics does need to be taught in addition to military ethics, it cannot be taught in a way that ignores the existing ethical frameworks held by students. While the military context is novel, any student entering an engineering degree will already hold an existing, although possibly implicit, ethical framework which may complement or compete with the engineering ethics we are teaching. These existing ethical frameworks should not be ignored.

KEYWORDS

Engineering ethics, Engineering education, Military education.

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Introduction

Context

This study was triggered by an accreditation recommendation from Engineers Australia (EA) that UNSW Canberra include engineering ethics in its undergraduate engineering programs.

Before this, UNSW Canberra, which is located at the Australian Defence Force Academy and provides tertiary education to defence force personnel, primarily trainee officers, relied on military ethics courses and training to provide ethics education.

UNSW Canberra is unique in the world in that it is a campus of a large research-intensive civilian university located on a defence force base, providing tertiary education equivalent to that at the main campus, and conferring university degrees. The vast majority of students at UNSW Canberra are concurrently undertaking three years of military training, at the conclusion of which they are commissioned as officers in the Australian Defence Force (ADF). The tertiary education and military training are parallel but separate; the former is delivered by civilian academics, the latter by ADF staff. There is little day to day contact between military and academic staff, and what communication there is typically has to ascend the hierarchy on one side before it is passed across the divide and then descend the hierarchy on the other side.

The military ethics education and training that all students/trainee officers take is taught partly through a compulsory military ethics course delivered by civilian humanities academics and partly through the ongoing military training delivered by ADF staff. The military ethics course delivered by the School of Humanities and Social Sciences is taken by all trainee officers in their second or third year of studies, in a single cohort (no streaming by discipline). So it was not feasible for engineering ethics to be integrated into this course, as it is not relevant to half the cohort, and is taken later than desirable for an introductory module. The military ethics training provided by Australian Defence Force staff is also taken by a mixed cohort of engineering and other students, and has a strong focus on the rules of war (laws of armed conflict) and is based on a deontological ethical framework.

Content that is specifically relevant to the engineering degree is, justifiably, seen as content that should be taught within the engineering degree rather than outside of it. It is also worth noting that at the time of writing (although not from 2026 onwards) there was a small annual intake of civilian engineering students, typically defence sponsored, who did not take military courses or training, so integrating engineering ethics into the engineering degree, rather than into military ethics training, was necessary. The question then was whether to create a single course on engineering ethics or to distribute it throughout the curriculum.

Colby and Sullivan (2008) found that engineering ethics education in the US is provided in three different ways: stand-alone courses; modules within courses, typically design or "Introduction to" courses; and just-in-time brief discussions as it arises naturally. Each approach has both advantages and disadvantages. Johnston et al, (2000) and Herkert (2000) describe the use of a single mandatory ethics course in engineering, which has the advantage of affording a greater depth of understanding of ethics. This is also the approach favoured by McGinn (2018). However, the single-course approach may mean students do not continue to think about ethics after completing that single course. Shorter modules distributed throughout the curriculum, as supported by Johnston et al (2000) and Hess and Fore (2018), may better support ongoing engagement with engineering ethics, and encourage reinforcement of learning. However, it may result in disjointed instruction, and the ethics education may be lost within the technical aspects of engineering and promptly forgotten. Both approaches have been in use in Australia for decades (Johnston et al, 2000), but so far, there is no consensus on the best way to incorporate engineering ethics into the curriculum, and local factors such as timetabling, degree structure and staff availability are likely to determine the approach taken. Degree structure was an important factor in the UNSW Canberra/ADFA context. Like all engineering degrees, there are many core courses, and our students also have compulsory academic courses related to their military training including leadership and military ethics. So there was little space in the degree program to insert an additional compulsory course. So to address the EA recommendation that we teach engineering ethics, a large project is in progress to develop four engineering ethics modules: Introduction to Engineering Ethics for first year; Design Ethics for second year; Engineering Workplace Ethics for third year; and Research Integrity for fourth year. The first two of these are face-to-face modules placed within core courses, the second two are online modules to be completed as part of engineering work experience and the engineering honours project respectively (Pawar et al, 2024).

This distributed structure also better mirrors the way that they receive their military ethics training by ADF personnel. Apart from the course taught by the School of Humanities and Social Science, this ethics training is distributed throughout their three years of military training, allowing staged reinforcement. We hope to match this pattern of teaching and reinforcement by dividing the engineering ethics instruction into modules taken each year. We also hope that integrating the modules into courses and having them taught by the same staff that teach the technical content makes it evident to students that this is an integral part of engineering, and ethical decision-making skills are as core to engineering as technical skills.

In this article we describe the design, delivery and evaluation of the first of these new modules, Introduction to Engineering Ethics. The design and evaluation of this module was a collaboration between staff and students, and much of it formed the honours research project (final year project) for one of the authors (AA) in 2024. That initial work is described in Abdullah et al (2024).

The research questions, as formulated by the research student to inform the design and evaluation of the module, were:

1. What should be taught in an introductory engineering module in Australia, and what teaching methods are appropriate?
2. How well is the designed module received by students, and how effectively do they meet the module learning outcomes?
3. How can the module be improved?

The first question was answered by (1) a literature review conducted by the student, and subsequently expanded for this article and (2) the design of the module.

The second and third questions were answered by the evaluation of the module in its pilot implementation.

The module was presented in Introduction to Electrical Engineering by the course convener in 2024. Based on the results of this study, a slightly modified version is being presented in every introduction-to-discipline course at UNSW Canberra in 2025.

Literature review

As engineers play key roles in the development of technology, they must be considered in some measure responsible for the results of that technology (Zandvoort et al, 2000). In the quarter century since Zandvoort (2000) wrote about the need for ethics in the engineering curriculum, the benefits but also the risk to society and individual humans has grown as technology has advanced, as has the teaching of engineering ethics. But many engineering educators still see a need for further ethics education (Polmear et al, 2019), and better ethics education (for example Bucciarelli, 2008) for engineering students. This engineering ethics education would help shape their professional identity as engineers and make everyday decisions in the field of engineering (Chance et al, 2025).

The status of engineering ethics education within an institution is largely determined by two groups of factors: internal (school, faculty and university) and external (accrediting bodies, etc) (Martin et al., 2021B). Either of these may hinder or promote engineering ethics education. A dedicated accreditation criterion on ethics education can provide explicit motivation that may override internal factors that would otherwise hinder the inclusion of ethics education (Martin et al., 2021B). Accreditation bodies worldwide have responded to the need to improve the status of engineering ethics education and highlighted the importance of engineering ethics in their accreditation documents (Junaid et al., 2022). The US Accreditation Board for Engineering and Technology (ABET), Engineers Australia and the Engineering Council (UK) all require an integration of engineering ethics education in undergraduate engineering programs. This development of accreditation criteria has been important in driving curriculum change to incorporate engineering ethics (Zandvoort et al, 2000).

At UNSW Canberra, the status of engineering ethics education was very low prior to the Engineers Australia accreditation recommendation that we teach engineering ethics, due to both internal and external factors. The main internal factor was the prioritisation of technical content. The main external factor was the military/academic context, in which students are primarily being trained for careers in the defence force, for which their existing military ethics training is crucial. To overcome these two factors, it was necessary for there to be a strong external driver – the Engineers Australia accreditation recommendation. This requirement drove the development of the engineering ethics module presented here, and the other modules being developed, where previously military ethics training was allowed to stand in for engineering ethics education.

Both Engineering and military ethics are types of professional ethics, defined by Harris et al. (1996) as special morally permissible standards of conduct that, ideally, every member of the profession will follow. But the profession of arms and the profession of engineering are quite different, and so the professional ethics associated with each are also likely to be different.

Military ethics typically focuses on character and moral decision-making in a military environment (Robinson et al., 2008) – for example, rules of war, collateral damage and discussion of permitted and prohibited weapons. There is overlap with engineering ethics, for example humanitarian work. However, Davis and Butkus (2008) state that a robust military ethics program, even with many elements similar to that of an engineering code of ethics, may not be sufficient to prepare engineering graduates for stakeholder relationships and engineering roles, a deficiency that was also noted by Robinson et al (2008). Military ethics emphasises the role of the chain of command: following orders is seen as the primary duty of a member. However, engineering ethics involves reflecting on the way workplace practices shape routine engineering decisions while mitigating the risks to public safety (Lynch and Kline, 2000).

At the Australian Defence Force Academy, the military ethics training is informed by the ADF Philosophical Doctrine document ADF-P-0- Military Ethics (ADF Doctrine, 2021). The focus of this doctrine is ethical decision making as it is required for the moral authority to exercise force. It explicitly states which ethical frameworks are consistent with ADF ethics (deontology, virtue ethics) and which are not (consequentialism, utilitarianism). The doctrine describes the four key ethical principles of the

ADF: discrimination (to whom acts of violence should be directed), proportionality (appropriate degree of force), military necessity (acts of violence should be for the purpose of achieving military objectives) and humanity (protecting the humanity of people involved in conflict). The doctrine was written to be consistent with the international Laws of Armed Conflict. Training also aims to inculcate the trainee officers with the ADF values: Courage, Respect, Integrity, Service and Excellence.

These principles and values are not necessarily incompatible with the Engineers Australia Code of Ethics and Guidelines on Professional Conduct (Engineers Australia, 2022), the four pillars of which are Integrity, Competence, Leadership and Sustainability, but nor are they inclusive of them. And, obviously, the contexts for which the two sets of ethical guidelines were written are very different. So the accreditation recommendation from Engineers Australia that we teach engineering ethics was clearly justified.

Having established the need for the modules, and taking a design approach consistent with constructive alignment (Biggs, 1996), we needed to determine appropriate learning outcomes for the module.

Graduate engineers need to be familiar with the codes and professional standards they must comply with. These professional standards are formulated formally in various codes of practice, and following them is an essential part of being an engineer (Harris et al., 1996). Hence, Colby and Sullivan (2008) suggest that these be the framework for deciding learning outcomes for engineering ethics courses. In Australia, the relevant code is the Engineers Australia Code of Ethics and Guidelines on Professional Conduct (CEGPC) (Engineers Australia, 2022). Engineers Europe provides a statement on ethics and conduct of professional engineers (Engineers Europe, 2022), and individual nations have their own specific codes, for example the Statement of Ethical Principles by the Royal Academy of Engineering and Engineering Council in the UK (Engineering Council, 2017).

While our graduates may find themselves working almost anywhere in the world, as a minimum they need to be familiar with the relevant Australian code, as described in the Engineers Australia CEGPC. Hence the first two learning outcomes for the module directly reference the Australian context and EA CEGPC:

1. Develop baseline knowledge of the ethical and professional responsibilities that are required to practice engineering in Australia
2. Describe the Engineers Australia "Code of Ethics and Guidelines on Professional Conduct"

In addition to content knowledge goals, most teaching, whether of technical or other content, also aims to develop skills. In the case of engineering ethics education, these are the skills required to make good ethical decisions. Our students are concurrently undergoing training in military ethics with a focus on deontology and virtue ethics (Robinson, 2008; ADF Doctrine, 2021). But we wanted to ensure that they had as many ethical frameworks as possible in their ethical problem solving "mental toolboxes". Hence we formulated the second two learning outcomes as:

3. Explain ethical theories and their applicability to the engineering workplace
4. Apply ethical reasoning in line with the Engineers Australia "Code of Ethics and Guidelines on Professional Conduct"

These learning outcomes partly answer the first research question: *what* should be taught.

While in formal course documents it is the Learning Outcomes that define the explicit measurable goals for a course, there are typically other, less measurable, goals that a course designer or instructor has. These goals are often related to the affective rather than cognitive domain, for example, we may want to stimulate our students' curiosity, develop their self-efficacy or give them a sense of belonging. Such goals are common, but rarely articulated in learning outcomes.

Various goals for engineering ethics education, both cognitive and affective, have been suggested. Haws (2001) gives the goals of engineering ethics education as "enhanced divergent thinking; assessing the outcomes of engineering from the perspective of non-engineers; and gaining access to the common vocabulary of ethical discourse". Newberry (2004) suggests three goals: to stimulate students' interest in engineering ethics (intellectual engagement), encourage them to care about behaving ethically (emotional engagement) and give them some basic tools for making ethical decisions (particular knowledge). The same principles have been suggested to be important for ethics education in the Routledge International Handbook of Engineering Ethics Education (Chance et al., 2025b). Huff and Frey (2005) are more specific in their suggested goals: a) mastering and applying basic and intermediate ethical concepts and principles; b) practicing moral imagination; c) learning moral sensitivity; d) adoption of professional standards; and e) building an ethical community. Variations on these are common in the literature. For example, Kotluk and Tormey (2025) expand on the idea of emotional engagement to include the development of compassion, as compassion is linked to pro-social behaviour.

The goals described above are all worthy, and we would hope that all are met by the time our students have completed all four engineering ethics modules, and their military ethics training. For the first year Introduction to Engineering Ethics module, we drew on the work of Newberry (2004) and Huff and Frey (2005), to define additional goals for the Introduction to Engineering Ethics module as intellectual and emotional engagement with engineering ethics, and the practicing of moral imagination, leading to improved ethical reasoning and moral sensitivity. These goals, along with the learning outcomes, extend the answer to the first research question beyond assessable learning outcomes.

Once learning outcomes and goals are defined, the appropriate learning activities can then be designed, to answer the second part of research question one: what teaching methods are appropriate. Or, *how* should the content be taught.

Haws (2001) in a metanalysis of engineering ethics education categorised teaching approaches in undergraduate courses into six categories: instruction on Professional Engineer's Code of Ethics, humanist readings, grounding in theoretical ethics, ethical problem-solving heuristics, case studies, and service learning. These approaches are not exclusive, and Haws (2001) found that typically multiple approaches are taken in a single course or unit. As our learning outcomes specify knowledge of the EA CEGPC, a focus on that code is appropriate for our module. Including ethical reasoning heuristics to support ethical problem solving is also appropriate to support our third and fourth learning outcomes. Haws (2001) states that "helping our students to formulate, articulate and defend their ethical resolutions to the broader community, can only be achieved with theoretical grounding." However, given the limited time and the reluctance of our students to engage with readings, we chose not to use humanist readings, as our students will be exposed to these in their later military ethics course taught by humanities academics. Instead, we began with a brief introduction to theories of ethics to establish a common vocabulary for describing ethical reasoning (Haws, 2001) and then focussed on the EA CEGPC.

Direct instruction in ethical frameworks and the EA CEGPC, followed by testing on these alone, could be sufficient to meet the first three learning outcomes. However, it is unlikely to be sufficient to meet the final learning outcome, or contribute to the goals of emotional engagement and development of moral imagination. To achieve these goals, learning activities that promote student motivation and engagement are needed. This is particularly true in engineering ethics, as students may not perceive ethics as important compared to their technical studies, and may take a "frivolous" attitude (Sethy, 2017) towards it.

The most popular tool to promote engagement in ethics education is real (Harris et al, 1996) or fictional (for example, Hitt et al 2022) case studies. A case study can provide motivation and stimulate emotional engagement and "encourages students to adopt the deliberative perspective" (McAninch 2023), while also highlighting the potentially disastrous consequences of a failure of ethics. Case studies can also support the increase of compassion (Kotluk and Tormey, 2025), and even seemingly "emotionally neutral" case studies generally trigger some emotion for students. Martin et al (2018) describe the benefits of case studies as including verisimilitude, opportunities for interaction and for students to be challenged by ill-structured problems where they need to consider multiple perspectives, and grapple with ambiguity. This can lead to improved reasoning and problem-solving skills.

Case studies can be used in various ways, from traditional, passive readings or videos to highly interactive activities. For example, case studies can be used to create roles for students to play (Wareham et al 2006; Martin et al, 2018). Wareham et al (2006) describe "structured controversies" in which students role play various stakeholders, and the ethical issues and frameworks naturally emerge as a consequence of the different perspectives, rather than being a starting point. Case studies can also form the central problem in a Problem Based Learning approach (see, for example, Chang and Wang, 2011).

However, Harris et al (1996) suggest that ethics instruction should not rely on the types of case studies they refer to as "tragedies, disasters and scandals", a perspective echoed by Bucciarelli (2008). Herkert (2000) further argues that the use of high-profile disaster-type cases may not prepare engineers to tackle the smaller decisions they might face in their everyday professional lives. He suggests the use of smaller case studies or hypotheticals based on day-to-day interactions in the workplace that graduate engineers are likely to encounter. Colby and Sullivan (2008), while highlighting the advantage of using case studies formulated as moral dilemmas to engage students in ethical reasoning to decide on a course of action, point out that reading about an already resolved historical case study may not support development of ethical reasoning effectively. Martin et al (2018) are also critical of the case-study based approach, pointing out that there is a lack of evidence for their effectiveness, and describing various ontological and epistemological deficits of the case study based approach. Further, while being proponents of the use of case studies to promote emotional engagement, Kotluk and Tormey (2025) warn that increased engagement can "flip over into overarousal and distraction". Finally, Lawlor (2021) argues that "ethics teaching – like teaching in any other discipline – ought to have substance", and not rely purely on case studies. So, although case studies are popular and can have an important role to play in engineering ethics education, their use should be carefully planned, and they should not be the only means of instruction.

Hence, we opted for the use of frequent small hypotheticals, as recommended by Herkert (2000), presented as ethical dilemmas for students to determine an ethical response to (Colby and Sullivan, 2008), in the hope that these would stimulate intellectual and emotional engagement and support the development of ethical reasoning. Limited use of historical case studies was made.

In summary, for our particular context, we conclude that an appropriate teaching strategy is a combination of direct instruction, activities that stimulate engagement including hypotheticals and no more than one or two case studies. The design for the module that follows from this conclusion is described in the next section.

Finally, Colby and Sullivan (2008) point out that lack of assessment of engineering ethics is a common weakness in engineering ethics instruction. Without assessment, such courses or modules are devalued by students. Hence, we include assessment that is aligned with the learning outcomes in the module, and is broadly consistent with the existing assessment practices in the course the module is situated in.

Design of the module

The guiding teaching philosophy for developing the module structure and teaching/learning activities (how it would be taught) was social constructivism. The academic supervisors of the Honours student who designed the pilot module both have a philosophy of education that is strongly constructivist (Jones, 2002), and social constructivist (Adams, 2006). This teaching philosophy is consistent with the approach taken by the convener of the Introduction to Electrical Engineering course in which the module was first taught. In this course, there is a strong focus on active student engagement, group work and experiential learning in laboratories including productive failure (Kapur & Bielaczyc, 2012; Kapur, 2015) and reflective practice (Machost & Stains, 2023). While there are differences in the details of how ethics versus technical content in the course is taught, the overarching strategies are similar. The student who designed the module was influenced by these philosophies and explicitly advised to include approaches consistent with social constructivism (Adams, 2006), in particular extensive group discussion to ensure consistency with the rest of the course.

The main difference in approach in the ethics module compared to the technical content that preceded it was that worked examples primarily done by the lecturers with student suggestions, were replaced with class or group discussions of ethical problems with suggestions from the lecturer and Socratic dialogue to encourage reflection and consideration of alternative viewpoints (Altorf, 2016).

Hence the epistemological view that knowledge is constructed, and then tested and refined in dialogue with others, is evident in the design of the module, with many opportunities for students to grapple with ethical questions, and then compare their views to others. However, balancing this underlying philosophy is the accreditation requirement that certain content be taught, in particular the EA CEGPC (Engineers Australia, 2022), and so direct instruction was included for this material. This is also consistent with Lawlor's (2021) statement that engineering ethics needs to have substance.

The choice of the module content (*what* would be taught) started from the premise that the guiding document would be the EA CEGPC (Engineers Australia, 2022), to meet accreditation requirements. In addition, to give students an introduction to the language of ethics and a theoretical grounding for their reasoning (Haws, 2001), instruction on theoretical ethical frameworks was included.

The choice of module learning outcomes is described above. The form of the learning outcomes was informed by Bloom's taxonomy (Forehand, 2010), to stretch from lowest to mid-level outcomes, and to be measurable using assessment tasks, consistent with the principles of constructive alignment (Biggs 1996).

As this is the first of four ethics modules that students will complete throughout their degree, and students are in their first year, the learning outcomes focus on lower levels in Bloom's taxonomy. Later modules address higher-level learning outcomes.

As already described, in addition to the learning outcomes, which provide assessable outcomes in the cognitive domain, we also had less easily measurable goals including affective domain goals: intellectual and emotional engagement (Newberry, 2004), and development of ethical imagination (Huff and Frey, 2005).

At the time the students took the module, they had had only a few months military training but had already been introduced to the military ethics doctrine described in the introduction (ADF Doctrine, 2021). We wanted to stimulate their interest in *engineering* ethics (intellectual and emotional engagement) and give them another set of decision-making tools, ones particularly designed for engineering workplaces rather than the battlefield. We also want to support their future decision making as engineers (whether in military or civilian life) by practicing using their moral imagination *before* they are faced with difficult decisions. While our students are generally of the belief that their future is with the ADF, and they strongly identify with this future imagined self as an ADF officer much more so than with their imagined future self as an engineer (Wilson et al, 2015), the reality is that many will leave the ADF either immediately after their return of service obligation, or in the 10 years following that. Hence giving them tools and knowledge to make ethical decisions in a civilian context is likely to be important for them in the future.

The design of the module was informed by the literature review undertaken by the project student, and the answer to research question one is embodied in the design presented here, as constrained by our specific military context. The design was also logistically constrained. The class time made available for the module by the Introduction to Electrical Engineering convener was five 50-minute lectures and two 50-minute tutorials. The module was designed to fit into four lectures and two tutorials, to allow a margin of error in timing and for pre- and post-instruction surveys to be completed (see Evaluation section below).

The content for the module drew on an existing two-lecture introduction to engineering ethics in Introduction to Aeronautical and Mechanical Engineering, but was substantially expanded using the EA CEGPC, McGinn's (2018) text *The Ethical Engineer*, Rachels' (2023) *Elements of Moral Philosophy,* and hypotheticals created by the student researcher. These hypotheticals were informed by his experience in the ADF, and by discussions with academics and ADF members. Case studies were sourced from McGinn (2018).

The first lecture gave the module learning outcomes, then began with a discussion question. This was followed by a general introduction to ethical frameworks; deontology, utilitarianism and virtue ethics. This provides the beginning of the theoretical grounding recommended by Haws (2001), which will be reinforced and elaborated in later engineering ethics modules, and military ethics education and training.

Students were then presented with a short hypothetical taken from Baggini (2006), and asked for their choice of action, and their reasoning behind that choice. They were then presented with the R I G H T framework (Steare, 2006) as a heuristic for ethical reasoning and decision making (Haws, 2001). This was followed with class discussion. Note that by "hypothetical" we mean short first-person scenarios that are generally fictional, or based on common experience, such as sexism in the workplace. These hypotheticals fill the role of case studies framed as moral dilemmas, as described by Colby and Sullivan (2008). As identified by Sivaraman (2021), students may be able to identify the issue and the ethical principle that should be applied, but may be unable to determine the correct course of action. The hypotheticals were all formulated to ask the students "what do you do?", thus requiring them to outline a course of action.

The hypotheticals were intended to stimulate intellectual and emotional engagement (Newberry 2004) and provide an opportunity for "practicing moral imagination" (Huff and Frey 2004). Harris et al (1996) point out that discussion stimulates the growth of "ethical will power" and that if "students [have] a chance to make ethical judgements, explain them, and compare them with those other students make, the student is more likely to judge well".

Comparisons with other students', as well as the lecturers', viewpoints also encourages students to think from different perspectives (Huff and Frey, 2005). Hence student discussion was a central part of the module design, to support both intellectual and emotional engagement.

The use of hypotheticals as learning activities thus aligns with the second two learning outcomes, by scaffolding the application of theories of ethics and frameworks for ethical decision making, and providing an opportunity to practice ethical reasoning in an engineering context. Figure 1, reproduced from Abdullah et al (2024), shows the first engineering specific hypothetical. This hypothetical was designed to be realistic for an early career engineer, and interesting to ADF trainee officers. The hypotheticals used a mix of civilian and military-related contexts. The hypothetical shown in Figure 1 asks students to imagine themselves as a civilian engineer working for a defence contractor, so has a military-related context although students are being asked to think from the point of view of a civilian. When ADF personnel separate from defence, especially engineers, a common career path is into defence related industries and to defence contractors. Other hypotheticals used purely civilian contexts.

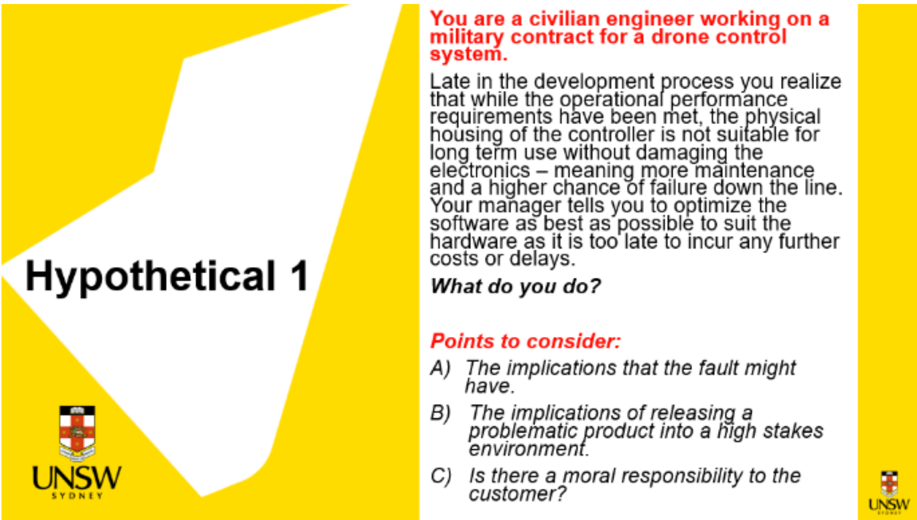

Figure 1. Example hypothetical from the module

Each subsequent lecture followed a pattern of a stimulus hypothetical, which students discussed in groups, followed by direct instruction on the EA CEGPC, and then a discussion question. The final lecture concluded with a case study. By case study we mean a real example of a complex situation in which one or more people had to make decisions, and which may have resulted in ethical failings leading to catastrophic engineering failures; what Harris et al (1996) describes as disasters.

The direct instruction following the hypotheticals introduced the specific pillar of the EA Code relevant to the hypothetical. For example, the hypothetical shown in Figure 1 was followed by instruction on the Demonstrate Integrity pillar of the EA CEGPC. The hypothetical to support instruction on the Sustainability pillar asked about displacing an Indigenous community to build a hydroelectric dam. The hypotheticals acted to "prime" the students for the direct instruction that followed.

The discussion questions that followed the direct instruction were intended to help students clarify and summarise the immediately preceding content. For example, at the end of the section on the "Integrity" pillar of the CEGPC, the discussion questions were:

"Why is integrity a desirable quality for an engineer to have? What responsibilities do engineering professionals have that are unique to our profession?".

The wording here is intended to reinforce to the students that they are (becoming) part of the engineering profession, *in addition to the profession of arms*, and that there are ethical responsibilities in engineering also.

As with the hypotheticals, students discussed these questions in groups, then shared their answers with the rest of the class. In this way students could check their understanding of the content and support each other's learning.

The combination of direct instruction and follow up discussion questions aligns with the first two learning outcomes, which are about specific content including the EA Code of Ethics.

In the two tutorials, students worked in small groups (the usual tutorial mode for this course) to revise their knowledge of the EA CEGPC (aligning with learning outcomes 1 and 2), and apply it to a real case study (learning outcomes 3 and 4). The case study chosen was the Strategic Defence Initiative – Computing Support for Battle Management (McGinn, 2018), and David Parnas's resignation as an advisor on that project (Parnas, 1985). This case study was chosen because it illustrates a (software) engineer taking a moral stance, even at risk of their own reputation, and is within a military context.

Additional readings were supplied to students on the course website, including further case studies from McGinn (2018), but these were not compulsory.

Assessment for the module was consistent with assessment practices throughout the course, and the assessment tasks were aligned with the learning outcomes (Biggs, 1996). Tutorial work in Introduction to Electrical Engineering is assessed by weekly online submissions to a discussion board of 1. a solution to a tutorial question nominated by the lecturer and 2. the review of a solution submitted by another student. To further encourage students to use their "moral imagination" (Huff and Frey, 2004), the tutorial assessment tasks for the ethics module were to write and post to the tutorial discussion board their own hypothetical (tutorial 1) and either respond to someone else's hypothetical, or to feed the hypothetical into ChatGPT or another AI/LLM and then copy its response and write a critique of it (tutorial 2). These tutorial assessment tasks align with learning outcomes 3 and 4. The second class quiz, held approximately 5 weeks after the conclusion of the ethics module, included simple questions on the theories of ethics presented in lectures and the EA CEGPC. This assessment aligns with learning outcomes 1 and 2.

Delivery of the module

Introduction to Electrical Engineering is team-taught by two staff, the convener and the supervisor of the student researcher, and it is normal for both teaching staff to be present for all classes. The class size is small (39 students in 2024), mainly young ADF Trainee Officers. In all classes students sit in table groups to facilitate group discussion.

In all lectures there is some direct instruction but a focus on active engagement, and the course convener has been previously recognised with a teaching award as an exceptionally engaging teacher who encourages students to speak in lectures. Hence the presentation of this module, with its focus on discussion, was not substantially different in style or format from the rest of the course.

The first 15 minutes of the module's first lecture were given to the student researcher to introduce his project and hand out pre-instruction surveys and consent forms, and the last 10 minutes of the last lecture was given to completing the post-instruction survey.

Although the lecture slides were designed to be delivered in only 4 lectures, the degree of engagement in discussions was such that all five lectures were fully used. The tutorials ran as usual for the course, with students working in small groups. The convener departed from the usual tutorial format of uninterrupted small group work to have students report back on their discussions of the SDI battle management case study (McGinn, 2018).

Evaluation methodology

The evaluation methodology was designed to answer research questions 2 and 3:

2. How well is the designed module received by students, and how effectively do they meet the module learning outcomes?
3. How can the module be improved?

In question 2, when we say "effectively" we mean both in terms of the affective-domain aims of the module to stimulate intellectual and emotional engagement (Newberry 2004), and the cognitive domain aims as stated in the form of assessable learning outcomes. Similarly for question 3, we want to know how to improve both *how* the module is taught and *what* is taught, to improve student experience and learning.

A mixed methods approach was taken using both quantitative and qualitative data from surveys, classroom observations and assessment tasks.

Surveys provided primarily quantitative data via the use of Likert scale questions, and some qualitative data from open questions. The surveys address question 2 in terms of the affective domain – students' self-reported feelings about the module, their confidence and their learning.

Assessment data contributes both qualitative and quantitative data, and addresses the cognitive domain aspect of question 2, in particular the module learning outcomes.

However, a significant challenge to the reliability of data from studies on ethics education is the students' knowledge that they are being assessed on the application of ethical principles, which may result in them defaulting to the 'right' answer rather than genuinely considering alternatives (Thoo & Strong, 2022). To address this concern, classroom observations were also used. Classroom observations of the students' discussions are less subject to this potential bias than is the use of assessment tasks. Such observations also provide an indication of student engagement that is not subject to potential bias due to self-reporting on surveys. Classroom observations of lectures and tutorials contributed qualitative data to the evaluation.

Thus, the evaluation of the module draws on a variety of data sources, which enables triangulation and better rigour than relying on a single data source.

Ethics approval was obtained from the Human Research Ethics Committee of UNSW Canberra for the research student to administer surveys and undertake classroom observations (UNSW iRECS5920), and following his graduation, a modification was approved to allow his supervisor to use assessment data. Ethics approval for use of assessment data by the student researcher was not possible, and conditions on the project were strict because of the nature of the student cohort as primarily defence personnel, with an existing hierarchy making coercion, perceived or real, a significant risk. Data collection was also limited by the time available for the module within the course, and the limited time that could be required of students outside class time.

Surveys

There are a small number of existing survey instruments designed to evaluate ethical reasoning in an engineering or science context (Kim & Bairaktarova 2023). For example, there are the Engineering and Science Ethics Test (ESIT) (Borenstein et al 2010), and the Engineering Professional Responsibility Assessment (EPRA) (Canney & Bielefeldt, 2016). The former of these consists of a series of scenarios each followed by 12 questions, the latter is a 50 item survey. Other existing instruments are similarly lengthy, and hence time consuming to administer. Given the total time allowed for the module was approximately six hours, it was not logistically feasible to use one of these lengthy instruments, particularly as both pre- and post-instruction data sets for comparison are desirable. In principle, students could have been asked to complete these out of class time, but unless such a task is assessed, our students are unlikely to do it. Obtaining ethics approval to use assessment tasks for research purposes is at best challenging, and given the time limits for thesis submission on the honours student, we decided to instead use a pair of short surveys designed specifically for the module, and triangulate the survey data with assessment data that we were able to obtain ethics approval to use after the honours student had graduated.

The pre-instruction survey consisted of eight Likert scale questions on a six-point Strongly Disagree (1) to Strongly Agree (6) scale (no centre neutral). The first six questions were repeated on the post-instruction survey, so that gains in (self-reported) familiarity with, and confidence in, applying ethics knowledge and ethical reasoning could be measured. The aim of these questions is primarily to explore the affective responses of the students to the module – how they feel, rather than what they know. The cognitive domain, linked to the explicit learning outcomes of the module framed using Bloom's verbs (Krathwohl, 2002) is explored by examining the assessment tasks completed by the students, and by observing their discussions in class. Hence the survey questions do not use verbs compatible with Bloom's taxonomy, but rather address students' subjective sense of their own confidence and their experience of the module.

The normalised gain was calculated by analogy with normalised learning gains for multiple choice questions, as introduced by Hake (1998). Here we calculate the normalised gain as the actual gain divided by the maximum possible gain:

$$Normalised\ gain = \frac{< post - module\ score > \ - < pre - module\ score >}{6 - < pre - module\ score >}$$

The normalised gain gives a measure of how much the average response improved (assuming moving from lower to higher agreement is an improvement) as a fraction of how much it was possible for the score to improve.

The post-instruction survey also included student experience questions, and the "overall satisfaction" question as used on the UNSW student experience surveys. This allows comparison of results for the module to results for the course, and the faculty average. The Likert scale questions from the two surveys were:

Pre-instruction:

1. I am familiar with the EA code of ethics
2. I am confident that I understand the EA code of ethics
3. I am familiar with theories of ethics
4. I am confident in my ability to apply ethical reasoning in an engineering context
5. I believe ethics is an important aspect of the engineering profession
6. I can name the four pillars of engineering ethics
7. I have previously studied ethics at school
8. I have previously studied ethics (not at school)

Post-instruction:

The post-instruction survey began with questions 1 to 6 above, then continued with the following Likert scale questions:

7. Overall, I was satisfied with the quality of this module
8. The assessment tasks were appropriate
9. I enjoyed this module
10. This module was relevant to me as an engineer
11. I learned something useful in this module

Followed by three open questions:

"1. The best thing about this module was:", "2. This module could be improved by:" and "3. Any other comments?".

The responses to these open questions were analysed using thematic analysis (see, for example, Castleberry and Nolen, 2018). Given the explicit nature of the questions, we looked for semantic rather than latent themes (Braun and Clark, 2006), taking the students' responses at face value. The process used was as described by Maguire and Delahunt (2017), following the six steps proposed by Braun and Clark (2006): 1. Familiarisation with data; 2. Code the text; 3. Search for themes; 4. Review the themes; 5. Define the themes; and 6. Report.

To improve reliability, two researchers independently looked at the data (step 1) and coded the responses to find themes (steps 2 and 3). The two researchers then reviewed the themes together, and compared the themes they had identified to check for consistency (step 4). This enabled a set of themes to be clearly defined (step 5), and reported in the results section below (step 6).

Classroom observations

Given that the underlying teaching philosophy informing the design of this module was social constructivism (Adams, 2006), including classroom observations in the evaluation methodology is appropriate, as it provides information on how active students are, and how much they are interacting with each other. The classroom observations contributed to evaluating whether the module was effective in meeting the aims of stimulating intellectual and emotional engagement (Newberry 2004) and providing an opportunity for "practicing moral imagination" (Huff and Frey 2004) (research question 2). They can also contribute to answering research 3, by providing data on which activities in the module were effective at stimulating engagement, and hence should be retained, and which are less useful.

There are many protocols for classroom observations, as described in the extensive systematic literature review by Guimarães et al (2021). Most of these protocols are for the purpose of teacher evaluation. For this research, it was not the teacher that was being evaluated, but rather the design of the module, including how effectively it stimulated engagement. Hence a protocol that focused on student engagement with the content, rather than on the teacher, was required. To this end, although it scored poorly in the ranking by Guimarães et al (2021), the Active Learning Classroom Observation Tool (ALCOT) (Bidwell *et al.,* 2016) was adopted because it "is intended for development rather than for evaluation". As the main purpose of the evaluation was to improve the module before wider implementation in 2025, this protocol was selected as most appropriate. ALCOT (Bidwell *et al.,* 2016) was also chosen in preference over COPUS (Smith *et al.,* 2013), even though COPUS is already in use at UNSW Canberra, as we wanted to know *what* the students were discussing, not just *whether* they were discussing.

Unobtrusive classroom observations were carried out by the student researcher and his supervisor. During the observations, notes were kept of what students were doing throughout the class, including how long was spent on discussions, whether groups quickly came to consensus or whether there was deeper discussion, and whether during reporting back to the whole class there was generally consensus across groups or variations in opinions.

Assessment results

Assessment results contribute to answering research question 2, in terms of the stated learning outcomes. The learning outcomes of the module were assessed, as described, in tutorials and in a class quiz five weeks after the module. The two assessable tutorial submissions were marked using a binary grading system as either complete, satisfactory and on-time (100%) or not (0%) and contributed 4% of the total course mark. The same binary system is used for all tutorial submissions in this course. The class quiz included five multiple-choice questions and two short-answer questions, which required recall of the EA CEGPC and other material from the lecture notes. The ethics component of the quiz contributed approximately 3% of the course mark. Figure 2 gives an example quiz question.

Question 4 [1 mark]

According to the EA code of ethics, to act with integrity means to:

(a) Follow instructions faithfully;

(b) Act on the basis of a well-informed conscience;

(c) Put a client's interests above all others;

(d) Promote diversity in the workplace;

(e) Act on the basis of adequate knowledge.

Figure 2 Example quiz question

The total weighting (7%) of the ethics module assessment was intentionally kept low, and predominantly formative. While Colby and Sullivan (2008) advocate for higher stakes and more challenging assessment in engineering ethics to ensure students take it seriously, as this was the first pilot of the module we wanted it to be low risk for the students. The difficulty and weighting of the module's assessment can be increased in later iterations.

Results and discussion

Survey data: quantitative

Of the 39 students in the class, 35 completed the pre-instruction survey and 32 completed the post-instruction survey, giving response rates of 90% and 82% respectively. The lower response rate post-instruction is due to lower attendance due to illness among the student cohort.

All six repeated Likert scale questions showed large and significant gains. The average response, taking 1 = Strongly Disagree to 6 = Strongly Agree, is shown in Table 1, along with *p*-values calculated using a two-tailed *t*-test (Sullivan & Artino, 2013) and the normalised gain (defined above) for each repeated question.

Table 1. Average response (1 = Strongly Disagree to 6 = Strongly Agree) to each of the six repeated survey questions (see Figure 3)

Question number (question summary)	1 (familiar with EA code)	2 (confident understand EA code)	3 (familiar with theories of ethics)	4 (confident can apply ethical reasoning in engineering)	5 (ethics is important in engineering)	6 (can name 4 pillars of EA code)
Pre-instruction average (% agree)	1.9 (11)	1.8 (9)	3.6 (49)	4.1 (74)	5.1 (94)	1.6 (3)
Post-instruction average (% agree)	5.1 (100)	5.1 (100)	5.0 (100)	5.0 (100)	5.5 (100)	5.0 (97)
Normalised gain	0.78	0.78	0.60	0.49	0.38	0.77
p-value	1×10^{-12}	6×10^{-13}	2×10^{-5}	2×10^{-5}	0.001	3×10^{-12}

We found a significant gain with $p < 0.01$ on all questions. Hence, we can confidently say that the students believed that they learned from the module, and that their confidence in applying ethical reasoning increased. Unsurprisingly, the largest gains were on the questions about the EA code, which the students were unlikely to be familiar with prior to the module.

Encouragingly, on both the pre- and post-instruction surveys the question that students agreed most strongly with was "5. I believe ethics is an important aspect of the engineering profession". This result contrasts with the findings of other researchers. Balakrishnan and Tarlochan (2015) found that their final year engineering students' "attitude towards socio-ethical issues related to engineering is poor", with responses to similar questions scoring below 3 on a 5-point Likert scale (disagreement). Sethy (2017) describes Indian undergraduates attitude to engineering ethics instruction as "frivolous and ornamental", and they consider it not relevant to engineering jobs. Our results are strikingly different, but we do not know whether the difference is due to culture, stage in degree, the influence of defence force recruitment selection processes or military training, or some combination. This opens an avenue for future research in tracking students' attitudes to engineering ethics as they progress through their degree, or for comparing students across institutions and cultures.

Figure 3 gives the pre- and post-instruction distributions for questions 1– 6.

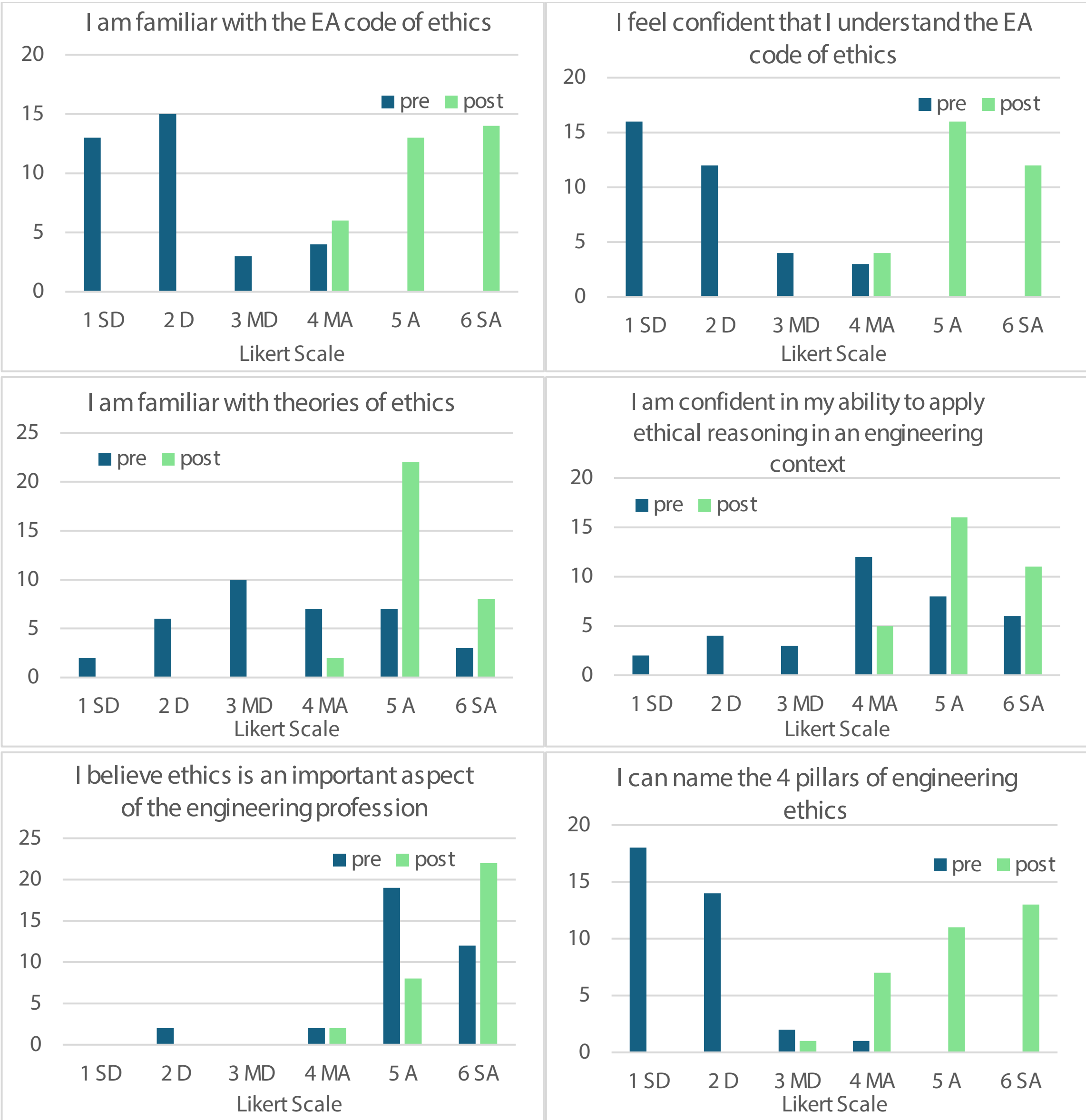

Figure 3. Pre- and post-instruction response distributions for repeated survey questions (1 SD: Strongly disagree, 2 D: Disagree, 3 MD: Moderately disagree, 4 MA: Moderately agree, 5 A: Agree, and 6 SA: Strongly agree)

The other two questions on the pre-module survey asked students whether they had studied ethics before, either at school or elsewhere; 60% of students agreed with at least one of these questions, which explains why many were already familiar with theories of ethics.

The responses to the post-instruction survey questions designed to measure student experience were almost uniformly positive, as shown in Table 2.

Table 2. Average response (1 = Strongly Disagree to 6 = Strongly Agree) and % responses at any level of agreement in the post-module survey

Question	7 Overall satisfied	8 Assessment appropriate	9 Enjoyed	10 Relevant	11 Useful
Average	5.4	5.4	5.2	5.5	5.6
% Agree	100	100	97	100	100

Figure 6 gives the response distributions for the two questions with the lowest (Q.9) and highest (Q.11) average scores.

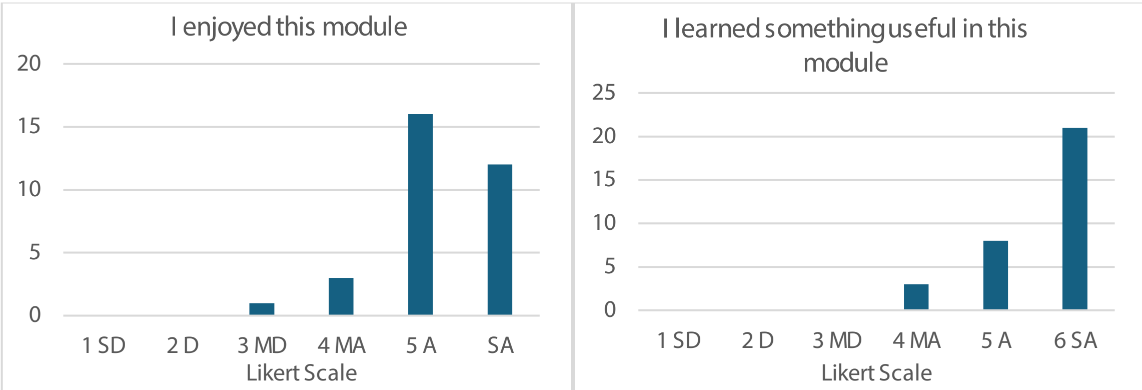

Figure 4. Response distributions for questions 9 and 11(1 SD: Strongly disagree, 2 D: Disagree, 3 MD: Moderately disagree, 4 MA: Moderately agree, 5 A: Agree, and 6 SA: Strongly agree)

The question with the highest overall score was "11. I learned something useful from this module.", with an average of 5.6 (100% agree). While self-reported learning should be taken with a grain of salt, this at least indicates that students believed their learning from the module was useful. Students also believed it to be relevant (question 10).

Question 7, "Overall, I was satisfied with the quality of this [module/course]" is the standard UNSW student experience survey summary question. For comparison, the ethics module scored 5.4 (100% agree) on this question, which is lower than the Introduction to Electrical Engineering course score of 5.6 (100% agree) but well above the school and faculty averages of 4.6 (84% agree) and 4.7 (86% agree) respectively, for the same semester.

Survey data: qualitative

The first open question, "The best thing about this module was:" was answered by 30 of the 32 survey respondents, or 77% of the class. There was good agreement between the two reviewers in identifying themes and both found that the most strongly emerging themes were 1. The in-class discussions, 2. The hypotheticals and 3. Group work. Other minor themes emerged, but had far fewer mentions and/or were not identified independently by both reviewers.

In-class discussions were mentioned explicitly by 16 students, and in some cases linked to critical thinking or considering multiple perspectives. For example:

> *Lots of discussion with peers, and everyone getting a say, critical thinking as opposed to copying a powerpoint*

These types of responses provide evidence that the module met the goals of supporting emotional and intellectual engagement (Newberry, 2004)

Other comments about the hypotheticals pointed at the development of ethical imagination and ethical reasoning:

> *Hearing others ethical opinions and solutions to tackling ethical conundrums was very interesting and increased my ethical problem solving skills*

Martin et al (2018) and other proponents of case studies claim that they can enhance critical thinking skills and the feedback from our students on the value of hypotheticals, which in effect are mini-case studies, supports this. This response and others like it indicate that students were being encouraged to consider different viewpoints, an important part of ethical reasoning (Haws, 2001; Huff and Frey, 2005).

Group work is generally popular at UNSW Canberra, likely due to the concurrent military training and selection processes, and this was true in the ethics module, with comments including:

> *The ability for us to discuss what our personal opinions were, where there was no 'right' answer, we could collaborate and be active in the class*

These responses tell us what aspects of the module students valued, and hence which aspects we should retain for 2025. In particular, the group discussions and the use of hypotheticals were very popular, and supported student engagement and (self-reported) ethical thinking.

The second question, "This module could be improved by" was answered by 26 students, but four responses were "nothing"/"I don't know" or equivalent, leaving 22 responses. These responses were extremely varied, and neither reviewer was able to identify any recurring themes other than "more discussions/hypotheticals/case studies". There were some suggestions from the students for additional elements that could be incorporated into the module, including short videos, guest speakers and links to military ethics. Overall, the lack of emerging themes for this question indicates that there were no major problems with the module, from the point of view of the students. This question also yielded some valuable suggestions for improvement, which speaks to research question 3, on how to improve the module.

Thirteen students responded to the final question: "any other comments?", and most responses were affirmations, for example:

> *I really enjoyed this module and it was really useful for me as an engineer. I loved how [convener] and [lecturer] conduct the class by letting us work and discuss as a group*

Classroom observations

The discussions of the hypotheticals and discussion questions were expected to take approximately ten minutes each; five for discussion and five for reporting back. However, it was observed that even after ten minutes, most groups were still actively discussing the hypotheticals, with students playing devil's advocate to each other and posing "what if" follow up questions without being instructed to do so. Mature age (serving officer) students made connections to their defence force experiences, for example with “command over-ride", and raised possible conflicts between engineering and military ethics. We also found that every group was keen to contribute, in detail, in the reporting-back stage. The liveliness of the discussions (and indeed the difficulty in getting students to stop discussing) is evidence of strong intellectual and emotional engagement (Newberry, 2004). Their spontaneous extensions of the hypotheticals with “what ifs” indicates they there were exercising their moral imaginations (Huff and Frey, 2005).

However, despite the strong engagement and willingness to consider and even argue for a range of possible responses to the hypotheticals, when pushed for a response the students almost invariably converged to a deontological model: report up, but follow orders. This was noted on multiple occasions, and when explicitly asked, one student said that this is what they were told in the small amount of military ethics they had so far met. It is important to note that these students were yet to take the military ethics course taught by civilian academic staff, and had only taken a very small fraction of the ethics taught in their military training, as they had only had approximately 10 weeks of military training at the time the module was taught. Interestingly, the students sometimes argued for an answer that was rationalised using ethical relativism. Yet the ADF doctrine states its opposition to ethical relativism clearly and explicitly: “The ADF is not relativist or subjectivist about ethics.” (ADF Doctrine, 2021). So while our students have been inculcated with a deontological approach to ethics very early in their military training, they have not yet discarded ethical relativism at this point.

Whether they would still converge to a “follow orders” response later in their degrees, and discard ethical relativism, is not known. But considering the finding by Balakrishnan et al (2021) that cultural beliefs play an important role in ethical decision making, this seems likely as they become even more strongly enculturated into the military.

In tutorials, students were generally less engaged than in lectures but still on task. The case study on the SDI (McGinn, 2018) prompted lively discussion with some students criticising Parnas’s actions, particularly for making his objections public. This response is consistent with military ethics.

We conclude from these observations that while the current version of the module is successful in stimulating engagement, it is less successful in providing students with engineering ethics as an additional, equally valid, framework along with military ethics for ethical decision making. While promoting divergent thinking (Haws, 2001) was not one of our initial goals, it became apparent that this needs to be a goal of the module if students are to be able to draw on both their professional ethics frameworks. This contributes to answering research questions two and three. The module needs to be more effective for developing ethical reasoning, and could be improved by providing instruction and activities that promote divergent thinking.

Assessment results

The assessment results contribute to answering research question 2, and speak to both student engagement and learning.

The quiz questions assess the first two learning outcomes:

1. Develop baseline knowledge of the ethical and professional responsibilities that are required to practice engineering in Australia
2. Describe the Engineers Australia “Code of Ethics and Guidelines on Professional Conduct”

The average mark for the ethics component of the quiz was 83%, which is substantially higher than the average mark on the technical components of the same quiz. While the questions were very simple, this does indicate some basic familiarisation with the EA CEGPC following instruction, and agrees with students' self-reporting on the surveys that their familiarity with the EA CEGPC had increased.

The second two learning outcomes were assessed via the tutorial submissions, particularly the second task. These learning outcomes were:

3. Explain ethical theories and their applicability to the workplace
4. Apply ethical reasoning in line with the Engineers Australia "Code of Ethics and Guidelines on Professional Conduct"

The first tutorial task, creating an ethical hypothetical, was not specifically aligned with the learning outcomes but did give students an opportunity to practice their "ethical imagination" (Huff and Frey, 2005). Student intellectual engagement with this task was strong. Students must make 10 out of 13 (or 77%) possible submissions to earn 100% tutorial marks. 37 students (95%) submitted a unique hypothetical, most of which were of a good enough quality that they could have been included within the module. Many drew on students' own interests and had a military context, indicating emotional and intellectual engagement. Scenarios included: whether a questionable contractor should be used even if cheaper; sacrifice of few for the good of many; short-term military advantage vs long-term health problems and ethical use of AI in an unregulated environment. Engagement with the second task was even higher, despite tutorial task completion rates usually dropping as semester progresses. This was particularly notable because the task was due the day the mid-semester break starts, when submission rates are typically low.

The second task, responding to one of the hypotheticals, is directly aligned with the second two learning outcomes. The task requires students to demonstrate ethical reasoning and justify their reasoning using ethical theories and/or the EA code, or to critique a response by an AI against these criteria. Half of the submissions were written by the student, half by ChatGPT and critiqued by the student. The students' responses were generally substantial (100 to 350 words) and well considered, often giving multiple possible courses of action and referring explicitly to the EA CEGPC pillars. We did note that while none referred directly to ADF ethics doctrine, there was again a tendency to give solutions that ended with reporting up, but following orders. Again, in contrast to ADF ethics doctrine, ethical relativism was implied in some of the solutions. Students' critiques of the ChatGPT responses were typically shorter (100 to 250 words), and agreed with the AI responses (which were thorough and consistent with general ethical standards), but added to it. There was variation in the quality of responses and critiques, and not all clearly demonstrated the third learning outcome. But, as the marking on these tasks was binary satisfactory/unsatisfactory, and all students demonstrated ethical reasoning, all were marked as satisfactory. In future iterations of this module, as well as in ethics modules taken later in the degree by the same students, we intend to use more fine-grained marking and more difficult quiz questions to ensure grading reflects more closely whether learning outcomes were met, and to what extent, consistent with the suggestion by Colby and Sullivan (2008) that assessment for engineering ethics needs to be substantive.

Implications and Limitations

Implications for Curriculum

The development of this module demonstrates a successful students-as-partners project, in which an undergraduate student contributed to curriculum development. The student researcher gained insight into the curriculum development process, and the intentions and reasoning behind the decisions that academics make about their teaching both in planning and day to day delivery of courses. The civilian academic supervisors benefitted from being required to explain and thus clarify their teaching philosophies, and by having a student collaborator who is immersed in the two cultures, academic and military, while they themselves are embedded only in the academic culture. The first-year students were presented with a module designed by a senior peer, who had recent lived experience of their situation, and was able to make the module more relevant to them. All stakeholders (including the school more broadly, as accreditation requirements are now met) benefitted from this students-as-partners method of curriculum development. Including students in curriculum design can deliver better curricula outcomes. This finding is relevant in any higher education context.

Military ethics education is not a substitute for engineering ethics; codes, responsibilities, stakeholder relationships, goals and contexts differ (Robinson et al, 2008). The EA CEGPC (Engineers Australia, 2022) provides the profession-specific foundation students need to apply ethical reasoning about public safety, sustainability, professional integrity, and competence in civilian settings. The military ethics training and education that our students receive do not do this. The results here validate EA's accreditation recommendation and support keeping engineering ethics within the engineering curriculum.

However, contextualisation is important. Interestingly, the research student who designed the module, although a member of the ADF, did not incorporate comparison to ADF ethics doctrine or references to military ethics, although he did include hypotheticals of relevance to defence. It was noted that students tended to take a military point of view rather than a civilian one regardless of the hypothetical context. Even when a hypothetical started with "You are a civilian engineer...", they still generally argued from the point of view of a military officer. For these students, even so early in their military careers, they identify strongly as military officers-to-be. As educators, we need to support them to develop a dual professional identity (Wilson et al, 2015), which includes being an engineer, particularly as many will not spend their entire careers in the ADF. We have a responsibility both to them, and to society, to ensure that they are able to make ethical decisions in a civilian engineering context, informed by civilian engineering ethical guidelines. While Haws (2001) states that engineers need to be able to consider outcomes from the perspective of non-engineers, we need our students to be able to consider outcomes from a non-military perspective. Balakrishnan et al (2021) argue that cultural and religious contexts cannot be ignored in the teaching of engineering ethics. In our context, military ethics cannot be ignored. So in future we intend to make explicit links to ADF doctrine, and ask students to argue from the perspectives of different stakeholders including civilian and military, and compare the decisions they would make depending on whether they were applying military ethics or engineering ethics so that any differences can be made explicit. Feedback from students also showed that they wanted more connection with the ADF context and ADF ethics doctrine.

These findings, that engineering ethics needs to be explicitly taught separately from military ethics, but that it needs to be contextualised, apply to any engineering degree at a military college or academy. At other such institutions, education and training are delivered by military staff. We encourage such academies to consider including civilian engineers and civilian engineering contexts in their teaching programs, particularly for engineering ethics.

While we have focussed on the military/engineering context, these implications will likely apply for other contexts where students are part of a culture with strong ethical norms and values (Balakrishnan et al, 2021). This culture may be religious, political, or even industry based for mature age students. The ethical norms and values of engineering ethics may be consistent, complementary or competing with those of their other, pre-existing, culture. In any of these cases, contextualisation balanced with explicit teaching of engineering ethics as distinct from their other ethical frameworks is important, so students can distinguish whether they are making ethical decisions based on engineering ethics codes and guidelines, or another ethical framework which may not even be explicit to them.

There are different views on when engineering ethics should be taught within the degree, and whether it should be integrated into technical courses or be contained in a stand-alone course (Colby and Sullivan, 2008). We chose to distribute the engineering ethics education across all four years of the degree. While we cannot as yet say that this model is preferable to a single ethics course, we have demonstrated that first-year instruction can establish baseline knowledge, shared language, and strong engagement with the material. We hope that this will prepare students for progressively higher-order learning outcomes in later years, and that they will be willing to engage in future modules, however further work is required to determine if this is the case.

Finally, as described in the Introduction, the development of this module was triggered by the Engineers Australia accreditation recommendation that the school explicitly teach engineering ethics, rather than relying on military ethics. Without that prompt, it is doubtful whether this module would have been developed at all, yet our findings clearly indicate that military ethics training is not a complete substitute for engineering ethics education. This demonstrates the important role of accrediting bodies in education development, and promoting engineering ethics education.

Implications for pedagogy

Dialogue can effectively drive engagement and learning. We observed students applying "devil's advocate" reasoning and unsolicited "what if" elaborations, indicating use of a "moral imagination" (Huff and Frey, 2005). The students' feedback on the post-instruction survey not only expressed how much they enjoyed the discussions, but linked them to critical reflection and recognition of multiple perspectives, showing that while we had not included "divergent thinking" (Haws, 2001) as one of our goals, it was observed and was valued by the students. Student feedback, and our own observations, indicated that discussion of hypotheticals was engaging for students, and drove learning, particularly in relation to the second two learning outcomes.

However, as noted already, we also observed that even when open to discussing different perspectives and different possible decisions, our students tended to choose a final decision consistent with ADF doctrine and a deontological framework. This underscores the need to encourage our students to explicitly practise reasoning beyond deontology, so that processes for dissent, escalation, and conscientious refusal can be explored. We need to encourage divergent thinking during discussions (Haws, 2001), to push students to question their own tendency towards convergence to a "follow orders" solution to ethical dilemmas. Further, explicit critique of ethical relativism, and when it might be appropriate, is also important, given its recurring presence in student reasoning despite ADF doctrine.

Again, although this research is situated in a military/engineering context, this implication is likely to be relevant in any context where students have strong cultural or religious ethical beliefs.

The direct instruction provided the substance needed (Lawlor, 2021) to meet accreditation requirements that students were familiar with the EA CEGPC. While in principle we take a constructivist approach, we do not expect students to construct their own code of engineering ethics, particularly when they are required to abide by an existing code. Some direct instruction is necessary, but it is complemented by discussions which drive engagement and critical thinking. The first two learning outcomes were supported by the direct instruction, and the study students did for the quiz.

In summary, we intend to maintain the structure of the module, while updating some hypotheticals and the case study. As the module moves from being a pilot to a normal part of the course, we will also make the assessment more challenging to bring it into line with expectations for the technical components of the courses and to ensure it has the same status as the technical parts (Colby and Sullivan, 2008).

We are also responding to student feedback suggesting various possible additions to the module, including guest speakers from industry and the military and short videos.

Limitations:

So far, only one iteration of the module has been studied. Ideally, education development is done iteratively, using cycles of development, implementation, evaluation and refinement. We intend to address this limitation by evaluating the effectiveness of the module once it has been rolled out to the larger engineering cohort.

Second, this module was delivered to a single small cohort, at an unusual institution and by an unusually engaging lecturer, with whom the students had already built trust. Delivering non-technical content to engineering students can be challenging, and would have been more so if the lecturer had not already built a relationship with the class.

Running a version of the module elsewhere, with different constraints and affordances, would likely require some modifications. For example, whether the module is scalable to much larger classes is an open question at this point.

Conclusions

The Introduction to Engineering Ethics module that was developed in partnership with an honours (fourth year) student was well-received by our first-year students and assessment data provides evidence of learning consistent with the learning outcomes for the module. In addition to the formal measurable learning outcomes, the goals of the module were to stimulate intellectual and emotional engagement and encourage the development of ethical imagination. Classroom observations of student discussions in which they engaged deeply with ethical hypotheticals, and student survey responses, indicate that these goals were met. Distributing ethics learning across the degree, aligning content with accreditation requirements, and using social-constructivist methods that make ethical reasoning visible appears to be a promising model.

However, classroom observations revealed a reliance on deontological “follow orders” reasoning, arising from the students’ military training and possibly also defence force selection processes. Students tended to approach hypotheticals from the point of view of a military officer even when the hypothetical explicitly began “You are a civilian...”. The existing ethical frameworks – cultural, religious, or military - held by students, and previous or concurrent ethical training, cannot be ignored when designing engineering ethics curriculum. Our students wanted explicit links to military ethics, and in the absence of these, applied the military ethics doctrine to their decision making without generally comparing it to the engineering code of ethics. By providing connections and comparisons between military and engineering ethics in subsequent iterations we hope to give our students a robust and integrated framework for making ethical decisions in their career as military officers, and potentially later as civilian engineers.

Declaration of interests

The authors have no conflicts of interests to be declared for this article.

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