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ARTICLE

Using case studies in engineering ethics education: the case for immersive scenarios through stakeholder engagement and real life data

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ABSTRACT

Our contribution is part of a broader study conducted in cooperation with the national accreditation body Engineers Ireland that examined the conceptualisation and education of ethics in engineering programmes in Ireland. The paper is a qualitative examination of the use of case studies in engineering ethics education and includes 23 engineering programmes from 6 higher education institutions in Ireland. The qualitative study aims to determine (RQ1) how cases are selected, (RQ2) the goals envisioned for engineering ethics case instruction, (RQ3) the characteristics of the scenarios employed and (RQ4) the preferred application by instructors. A first finding notes the diverse set of goals and application of ethics case studies. The focus is more on decision-making in professional contexts and less on power relations, equity and the broader societal mission of engineering. The second finding highlights the discrepancy between how instructors employ cases and their preferred application. Engineering ethics cases typically include individualistic, hypothetical and historical scenarios. Nevertheless, instructors favour immersive cases set in real or realistic contexts of practice, containing factual or real-time data, which can provoke students to reflect on broader ethical issues. Considering this aspirational discrepancy, we conclude with recommendations that can guide the development of engineering ethics case instruction.

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1. Introduction

Case studies are considered to be the most popular method to teach engineering ethics (Herkert, 2000; Haws 2001; Colby and Sullivan 2008; Fotheringham 2008; Freyne and Hale 2009; Bairaktarova and Woodcock 2017). Nevertheless, there is little known on how cases are presented and the type of cases used (Yadav et al. 2007), how they should be taught (Davis and Yadav 2014, 172), and what approach serves the achievement of which learning goals (Romkey 2015). Empirical research on the use of case studies in engineering ethics education has preponderantly focused on students' reception and engagement with case content, as well as their own perception in regard to the method's effectiveness (Lundeberg 2008; Yadav *et al.*, 2010; Davis and Yadav 2014). Moreover, the unit of analysis was found to target one course or student group (Lundeberg 2008, 6). As such, as Dolmans et al. (1997, 185) point out, principles of effective case design cannot be deduced from existing studies. This highlights the importance of designing and using cases that are evidence based rather than building on the instructor's experience or intuitive guidelines.

In light of the 'paucity of clear documentation regarding what and how ethics is taught' (Fore and Hess 2020, 1357), our contribution aims to respond to the need for scholarship in the area of engineering ethics case instruction highlighted by Yadav *et al.* (2010) and Davis and Yadav (2014), as to determine how this teaching method is employed and what support might be needed to foster its development. This examination is prompted by the preference for teaching engineering ethics with case studies recorded in the literature, as well as by the calls for the development and adoption of case instruction issued by the Royal Academy of Engineering in the United Kingdom (Fotheringham 2008) and the National Academy of Engineering (2005) in the United States. Our study is thus envisioned to contribute to engineering ethics research and instruction by revealing patterns in the application and goals of engineering ethics case instruction. It is also the first study in Ireland examining the use of case studies in engineering ethics education.

2. Background

There is a diverse set of goals envisioned for engineering ethics education (Hess and Fore 2018), but also a lack of clarity as to how to ensure the alignment between goals and teaching methods (Romkey 2015, p.25; Keefer et al. 2014, 250). A coherent curricular strategy implies that learning goals inform decisions

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about assessment (Borrego and Cutler 2010, 366), and are congruent with the delivery and pedagogical methods employed (Li and Fu 2012, 343). As Li and Fu (2012) warn, lack of clarity might lead to missed educational opportunities.

In what follows, we aim to explore how case studies have been conceptualised in the literature in terms of their goals and the nature of the scenario employed.

2.1. Goals of engineering ethics case studies

Case studies are described as scenarios meant to closely reflect features of a profession (Herreid, 1994). They are expected to contain authentic professional problems, thus raising students' awareness of the type of situations and problems they might encounter in the workplace (Merseth 1994; Davis 1997; Davis and Yadav 2014; Martin et al 2019). While there is no empirical study exploring the goals of engineering ethics education specifically in connection to the use of case studies, the literature mentions a broad and diverse set of goals.

2.1.1. Goals related to professional conduct

A major goal set for cases is to provide opportunities for students to focus on standards of conduct for the members of the engineering profession, as well as increasing students' ethical sensitivity to professional standards (Davis 1999). Case studies can also strengthen the voice of engineers within large organisations (Herkert, Borenstein, and Miller 2020).

2.1.2. Goals oriented towards stakeholders

Another goal is raising awareness of the perspectives of different stakeholders (Haws 2001; Beever & Hess, 2016; Dempsey, Stamets, and Eggleson 2017; Martin, Conlon, and Bowe 2018, 2019; Børsen et al. 2021; Herkert, Borenstein, and Miller 2020). According to Haws (2001, 227), case instruction needs to facilitate students' understanding of engineering outcomes from the perspective of the larger community. Cases inviting students to reflect on the nature of their own and others' engineered and technologically mediated lived-experiences could enhance their social responsibility (Morrison 2020, 1397). To ensure a strong social justice component, cases need to connect ethics with equity concerns (Rottmann and Reeve 2020). Scenarios that interrogate systemic patterns of privilege can encourage students to ensure just decisions and outcomes for the users and beneficiaries of engineering artefacts and technologies (Rottmann and Reeve 2020).

2.1.3.Goals related to global practice

Broadening the focus from the local community to the global aspects of engineering practice, case studies can raise awareness of the multinational and cultural differences enacted in engineering practice and how engineers from different backgrounds might define and solve problems differently (Jesiek et al., 2014; Zhu et al., 2020)

2.1.4.Goals focused on decision-making

Cases are also used to develop students' decision-making skills when confronted with ill-structured and fractious problems (Jonassen et al. 2009). Ill-structured problems are described as unanticipated problems that possess conflicting goals, multiple forms of representation and solution paths, as well as non-engineering success standards and constraints, making use of distributed knowledge and collaborative activity systems and placing a high importance on experience (Jonassen, Strobel, and Lee 2006). Fractious problems are characterised as novel, complex, ethically fraught, unavoidably public and divisive, and could lead to policy dysfunction (Berry 2007).

2.2. Nature of scenario

There are considerable variations in the content and implementation of engineering ethics case studies, marked by a lack of consensus as to which approach is more effective and towards which goals (Davis 1999; Gorman, Mehalik, and Werhane 2000; Herkert, 2000; Haws 2001; Harris, Pritchard, and Rabins 2009; Jonassen and Hernandez-Serrano 2002; Herreid, C. F. 2007a, Herreid, C. F. 2007b; Abaté 2011; Romkey 2015; Martin, Conlon, and Bowe 2019).

Based on the description of the case studies reported in the literature, we identified several dimensions that can be considered in the analysis of case scenarios (Table 1).

2.2.1. Scale of case studies

In terms of scale, cases can present *micro contexts* or *macro contexts*. While the former focus on a specific subset of a larger problem or domain to help understand and apply theoretical concepts, the latter are context-rich as to allow the exploration of a problem from multiple perspectives and the development of environments for cooperative learning and teacher-directed mediation (The Cognition and Technology Group at Vanderbilt 1990, 3). Micro contexts are focused on specific examples formulated in a limited amount of detail targeting a clearly delimited problem that students have to solve (Latcha and Jordan 1996; Shallcross 2013; Andrews 2013). A macro contextual scenario is rich in details that convey the physical, organisational and sociocultural context of the problem, among which

> the nature of the business, agency, or institution in which the problem occurs, what is produced, annual

Table 1. Taxonomy for engineering ethics case studies.

Scale	Micro context vs. Macro context
Sphere	Individual vs. Societal
Veracity	Hypothetical vs. Factual
Timeframe	Historical vs. Real-time
Duration	Brief vs. Lengthy
Student role	Predefined vs. Open

> reports, mission statements, balance sheets, and profit-and-loss statements, the values, beliefs, socio-cultural expectations, and customs of the people involved, who sets policy, what sense of social or political efficacy do the members of the setting or organization feel, what are the skills, backgrounds and hobbies of key players (Jonassen 1999, 220).

Lynch and Kline (2000) argue for cases that include more actions and agents. More contextual details can convey a more realistic understanding of engineering practice, considerate of the constraints encountered by engineers and the need for persuasion.

2.2.2. Sphere of case studies

The sphere of reflection encouraged by case instruction can be directed at the *individual* or *societal* level. According to existing literature, the prevalent use of cases is centred on the perspective of the individual engineer facing a dilemma (Haws 2001). The individualistic approach has an overriding focus on ethical heuristics and resolutions rooted in the precepts of professional codes and ethical theories (Martin, Conlon, and Bowe 2019). Societal cases foster reflection on the collective responsibility of the engineering profession and societal decisions about technology (Herkert 2001, 404). Case studies appear to include in a lesser extent the societal sphere, as researchers highlight the diminished focus on considerations related to public policy, power relations, equity and the broader societal mission of engineering (Colby and Sullivan 2008; Conlon and Zandvoort 2011; Bielefeldt et al. 2016; Verrax 2017; Morrison 2020; Martin, Conlon, and Bowe 2019; Rottmann and Reeve 2020).

2.2.3. Veracity of case studies

Considering the veracity of the cases reported in the literature, we could distinguish between *factual* scenarios based on real and accurate data sources or *hypothetical* cases drawing on realistic features of engineering practice transposed in a fictional account. Factual cases rely on publicly available data, directives, policy documents and news features that students can consult (Newberry, 2010; Byrne and Svanström 2012; Doorn & Kroesen, 2013; Shallcross 2013). Hypothetical cases simulate or mimic situations that require ethical decision making, be it at the design stage of a technological artefact, in its routine operation, or in mundane engineering practice. Such cases provide flexibility in examining a desired professional environment, by adapting the elements of the scenario and teaching approach based on instructional goals, resources, and the details of the student group (Watkins 2017). The most common hypothetical workplace scenarios encountered in the literature are conflict of interest, integrity of test data, trade secrets and gift giving (Herkert 2001; 2005; Colby and Sullivan 2008; Smith, Harper, and Burgess 2008; Barry and Herkert 2015; Dempsey, Stamets, and Eggleson 2017; Watkins 2017).

2.2.4. Timeframe of case studies

The timeframe employed in case instruction can be rooted in *historical* events and data or *real-time* data. A common source for *historical* scenarios are major engineering disasters, such as the Challenger shuttle explosion, nuclear accidents, plane crashes or building collapses (Haws 2001; Herkert 2005; Van De Poel and Verbeek 2006; Verbeek 2008; Freyne and Hale 2009; Harris, Pritchard, and Rabins 2009; Ozaktas 2013; Beever & Hess, 2016; Morrison 2020; Herkert, Borenstein, and Miller 2020). There is a tendency to focus on scenarios presenting a bad outcome which is the result of poor decisions or decision-making practices (Huff and Frey 2005). There are also historical cases that celebrate the figure of moral exemplars and notable figures in engineering, such as the General Electric engineers who developed the sealed-beam headlight in their spare time, Albert Rich, who developed a consumer friendly solar water heater, Frederick Cuny, who provided disaster relief assistance, or the engineers who reported in the 1920s the illegal actions of a contractor working for the Los Angeles Water (Pritchard, 1992; Gorman 2001; Gorman and Mehalik 2002; Harris 2008; Harris, Pritchard, and Rabins 2009; Mitcham, 2009). Real-time scenarios, on the other hand, are open-ended and forward looking in nature, as they are informed by current affairs and challenges, or linked to ongoing projects. Students receive the case study in the form of a brief, whose formulation or tasks might involve the cooperation of an external partner such as a private company, local government body or NGO (Kalamas Hedden et al. 2017; Membrillo-Hernández et al. 2018; Holgaard and Kolmos 2018).

2.2.5. Duration of case studies

In terms of duration, *brief* case studies can be implemented during one course unit, while *lengthy* cases can take place throughout the semester during several course units (Davis and Yadav 2014, 162).

2.2.6. Student role in case studies

The students' role when engaging with the case content can be *predefined* or *open*. In a *predefined* case study, the instructor has control over the unfolding of the scenario, by identifying the problems it raises, leading the discussion and formulating questions for students. In *open* cases, students have to identify or generate themselves the problems to be solved (The Cognition and Technology Group at Vanderbilt 1990, p.5; Reid 2012; Kalamas Hedden et al. 2017). As such, the instructor's role changes 'from sage to guide' (Hedden et al. 2017, 14). Student generated problems recently became a mark of Challenge-Based Learning approaches (Gaskins et al. 2015).

Determining the type of content employed in case instruction is important given that cases are uneven in terms of their pedagogical value (Bagdasarov et al. 2013, 1305) and that the value of case-based learning is considered to be contingent on the design and features of the cases themselves (Thiel *et al.*, 2011, p.266). While there are various strategies for applying case studies, Li and Fu (2012, 346) warn that not all of them would be suitable to meet a specific learning goal, which might lead to missed educational opportunities. Thus, a prerequisite for examining the effectiveness of engineering ethics case instruction is to first identify how cases are employed in terms of content and goals.

3. Methods

Our present contribution is part of a larger study conducted in cooperation with the accrediting body Engineers Ireland that examined the conceptualisation, implementation and teaching of ethics in engineering programmes in Ireland (Martin 2020). In regard to the latter issue, the paper has four main research questions:

(RQ1) how are case studies selected?

(RQ2) what are the goals envisioned for engineering ethics case instruction?

(RQ3) what are the characteristics of the scenarios employed in case instruction?

(RQ4) what is the preferred application of cases in engineering ethics instruction according to instructors?

While the larger study employs mixed methods, our contribution is based on qualitative methods, such as interviews with instructors and document analysis of course descriptors.

Following the guidelines provided by Lincoln and Guba (1985), we first identified the population of the main research study that the present contribution is part. The population consists of the degree programmes in Ireland that offer the title of engineer. At the start of our study, there were 58 programmes offered by 14 institutions listed by the national accreditation body for engineering programmes for the academic year 2017–2018.

After identifying these programmes, we then undertook purposive sampling (Creswell 2013), and decided to include in the sample group the programmes undergoing accreditation during the period autumn 2017-spring 2019, comprising two academic years. Upon the completion of the sampling stage, our study identified 23 programmes granting the Chartered Engineer title, offered by 6 institutions (Table 2). At the time the study was initiated, two institutions were classified as institutes of technology and four as universities. While institutes of technology and universities still foster a different ethos, with the former placing a higher emphasis on practical skills and vocational studies and the latter on research and theoretical knowledge, both type of institutions are subject to the same accreditation process and entry paths (Walsh, 2018, pp.143–9).

While the scope of the first part of our study targeted the implementation of ethics and curricular content purporting to ethics in programmes offered by both institution types, the second part of the study focused on individual teaching practices. As such, the research process for examining how engineering ethics is taught through case studies developed over the following stages:

3.1. Stage 1: participant selection

For our examination of ethics instruction, the chosen sample population consists of courses of professionals formation offered by the programmes participating in the study. We consider these to be courses which, based on their descriptions, aim to introduce students to the role of the professional engineer and to the nontechnical specifications of the engineering profession. Inspired by the definition provided by Riley (2014), professional formation courses address the development of students' engineering identity, their acculturation to the profession and its norms, knowledge of professional practice, as well as the development of professional skills and perspectives. The participant programmes offer 1–3 mandatory courses of this type, under names such as 'Professional Practice', 'Professional Skills', 'Professional Development' 'Professional Engineering', 'Fundamentals of Engineering', 'The Engineer in Society', 'Introduction' to the profession or a specific discipline. Typically, these are first year courses that are part of the common syllabus for the entire student cohort, and are positively highlighted during accreditation visits and in accreditation reports as having a strong contribution to ethics. As such, professional formation courses serve as a gateway for familiarising engineering students with the ethical dimension of their profession. Based on the goals, content description and title of the courses offered by the 23 participant programmes, we identified 12 courses falling under the category of professional formation courses.

Table 2. Sample vs. total population of the research study.

	Institutes of Technology	University
Total population	17 programmes/7 HEIs	41 programmes/7 HEIs
Sample population	8 programmes/2 HEIs	15 programmes/4 HEIs

The next step was to contact all instructors from the participant programmes who were identified either (a) on the institutional website as currently teaching courses of professional formation, or (b) in the documentation submitted by the programmes for accreditation, even if they were not teaching in the academic year 2019/2020. Sixteen of the 19 instructors contacted confirmed their participation. For eight courses of professional formation included in the study we interviewed only the current instructor, while for four courses we interviewed both a former and current instructor.

The demographic overview of the participants' age range, gender, specialisation, previous professional experience and class size is available in Table 3. What is significant to note is the high number of instructors with a private sector background. The work experience outside academia was highlighted by instructors as a personal motivation for opting to teach a course of professional formation, or as the reason why such a course was assigned to them. Only one instructor had a solely academic background.

3.2. Stage 2: determining interview format and questions

We opted for semi-structured interviews (Adams 2015), which included a set of open-ended and probing questions. The open-ended questions explored the instructor's methods for teaching ethics, whether they use case studies, the goals they envision, their criteria for choosing a case study and their process for selection, their preparation to teach, the resources they consulted, challenges they encountered, the supports they considered beneficial, and their preferred application of cases. Based on the responses received, probing questions were asked to help participants offer a more detailed response. Such questions invited participants to reflect why some of the aspects and practices described are perceived as challenging or beneficial, why they consider that their current teaching practices are different from their preferred way of teaching, and also if they could say more about the content of the cases employed and their overall role in the course.

Table 3. Main demographic characteristics of participant instructors.

Demographic Category	Interview participants (n = 16)
Gender	F: 6 M: 10 non-binary/other 0
Age (in years)	<30: 0 30–39: 3 40–49: 7 50–59: 4 > 60: 2
Specialisation	Engineering: 13 Philosophy: 3
Professional Experience	Private sector: 11 Policymaking: 2 Non-governmental sector: 2 Healthcare: 1 Solely academia: 1
Class size (students)	<50: 2 50–100: 5 100–150: 4 150–200: 3 200–300: 2
Affiliation	University: 13 Institute of Technology: 3

3.3. Stage 3: conducting the interview

The interviews were conducted by the first author between October and December 2019. The protocol respected the guidelines suggested by Jacob and Furgerson (2012), and was agreed by the three authors. Sixteen interviews were conducted, 2 online and 14 in person, and recorded. Procedures in relation to consent, confidentiality and data storage, as laid down by the institutional Research Ethics Committee, were adhered to.

3.4. Stage 4: transcription

The interviews were transcribed using an online software, whose output was verified and corrected by the first author while listening to the recording. The protocol of transcription followed a denaturalised method suggested by Mero-Jaffe (2011), according to which the transcript eliminated interview 'noises', such as pauses in speech, coughs, laughs, involuntary sounds, stutters, grammatical errors. A naturalised transcription approach that renders speech verbatim is considered to carry the risk of insulting the interviewees, who might feel that their speech was unrefined, given that the representation of speech as written text is evaluated according to the conventions of written text, despite their differences (Mero-Jaffe 2011). To ensure transparency and consent, the transcript was made available to the participants, who could suggest corrections, clarifications or additions. Three participants asked for edits, which either targeted the fluency and syntax structure of their speech in order to align it with the standards of written speech, or added further information about their teaching practice.

3.5. Stage 5: data analysis

To facilitate the interview analysis, we followed the advice of Lofland (2009, 201), who suggested sorting the available data into meaningful categories following two coding iterations. While the first coding iteration inspected the interview transcript line by line, enquiring what each item represents and what is an example of, the second coding iteration led to a more analytical organisation of the previously identified meanings and examples into themes. The first author then created a codebook based on three components rendered in Table 4: the code theme, its definition that specifies inclusion and exclusion criteria, and examples (Decuir-Gunby, Marshall, and Mcculloch 2011). The examples in the codebook rendered verbatim the participants' answers.

Table 4. Example of a code definition.

Code Theme	Definition	Example
Challenge	Difficulty experienced by the instructor when applying or preparing to use case studies (excludes challenges experienced with other teaching methods)	'From a practical point of view, I think the challenge is actually finding good case studies of where it has gone very well or where it has not, and the behaviour of people when it has not, as well as finding the documentation to support it.' (Eoin)
Selection	How instructors describe choosing or obtaining the case studies employed in their course (excludes resources obtained for the course unrelated to case instruction)	'when I inherited the course, I received a slide pack from the previous course coordinator and this had lots of wonderful case studies in it, that I used as they were.' (Saoirse)

Table 5. Example of theme saturation.

Code theme	Information (interview when code first occurred/ saturated)
Challenge	Student cohort size (2/11) Classroom space and design (2/12) Finding case examples and materials (4/6) Crowded curriculum (8/11) Timetabling (9/9) Finding external contacts (9/12) Institutional resources (11/11) Course format (14/14)

A well-documented audit trail of materials was maintained to ensure the reliability of the data analysis. To ensure inter-rater reliability higher than 75% (Saldaña 2009), the first two authors discussed the thematic categories before coding separately the first four interviews. We then identified the discrepancies in coding and the rationale for opting for different codes, before rechecking for consistency by coding separately a fifth interview. The remaining interviews were coded by the first author.

Although the number of participants to be interviewed was predetermined based on meeting the criteria of teaching or having taught a professional formation course, the study also met the criteria for code saturation and theme saturation suggested by Hennink, Kaiser, and Marconi (2017). As such, code saturation, by which further interviews did not yield any new themes, was reached at the eighth interview, and theme saturation, by which no further insights were identified, was reached at the fourteenth interview. Inspired by Guest, Bunce, and Johnson (2006)'s approach to documenting saturation by code, we tracked the development of themes in a dedicated codebook that included each new theme as it emerged and the interview number, based on series of two interviews. The codebook structure became stable at the eighth interview. In addition to counting the occurrence of code themes, we delved deeper into their meaning, as to ascertain the number of interviews needed to have a comprehensive understanding of the emerging issues (Kerr, Nixon, and Wild 2010). We noted the information gained about all code themes from each successive interview, and these reached saturation at different points in the process (Table 5 for an example). The last two interviews analysed (15 and 16) did not yield any novel code themes or insights.

4. Case studies in engineering ethics education

As in the case of the research conducted in the United States (Herkert, 2000; Colby and Sullivan 2008; Haws 2001), the instructors interviewed expressed a preference for teaching ethics through case studies. Of the 16 instructors interviewed, only one instructor did not employ case studies for conveying ethical content. The 15 instructors who use cases describe including between one and 'half a dozen' (Rian) different cases in their course. One advantage is that the method facilitates the inclusion of ethical considerations into technical content. According to Saoirse, 'the easiest way to integrate ethics into a program is through case studies, through picking something that is large enough to have different components within it that will link to the technical aspects of the course'. This view is shared by Erin, who considers that 'it is the only way to teach ethics for engineers, by putting it in a scenario. Then they have to do their calculations based on some ethical decision as well'.

4.1. Case study selection

As seen in Table 6, engineering ethics case instruction shows a close balance of (1) the use of existing case studies in the form the instructor has received or found them, (2) cases that are adapted by the instructor based on newspaper reports or existing cases and (3) the instructor designing an original case or asking students to design a case.

The use of imported case studies received 10 mentions from 9 instructors. Two popular sources for case studies stand out. Online sources, such as repositories of case studies and university websites, received five mentions. More specifically, the repository of case studies developed by the Online Ethics Center received three mentions. Case studies obtained from colleagues or peers met during academic events received four mentions. This highlights the importance of online resources and dedicated events in supporting engineering ethics instructors with

Table 6. Types of sources employed in engineering ethics case instruction (number of mentions).

Type	Source	Example	Description
Imported case studies	Online repositories, i.e. the Online Ethics Center (4) University websites (1) Colleagues (3) Conference events (1)	Cutting roadside trees Killer robots	'I attended a workshop in London some years ago, and they made presentations there and gave me the contact into their content there. So I use their cases too, because it's relevant to engineering students.' (Aoife) 'It was from Engineers Ireland that I was notified to go to someone within here [. . .]. So I went up to him, and he had case studies, and we went through them and he helped me' (Kaitriona)
Adapted case studies	News features (9) Online repositories (1)	Challenger shuttle explosion (3) Volkswagen emissions scandal (3) The wall between US and Mexico (1) Hurricane Katrina (1) The Christchurch Earthquake (1)	'Basically, I would have done some research, on the Internet in particular, and there are websites that give sample case studies. So I would have taken some case studies that would refer to engineering, and then would have adapted some of those slightly to the context of our students here' (Rian)
Original case studies	Developed by the instructor (6) Developed by students (1)	Workplace situations (2) Using governmental data such as policy reports, environmental impact assessment, court case reports (2) Inspired by local issues (1) Inspired by technical issues (1 mention)	'I make these based on past experience. Not direct experience of my own work, but from looking at what's been reported in newspapers or in the academic journals as issues that are arising.' (Eoin)

information, examples of best practice and teaching materials. As one instructor admits, peer dialogue helped him improve the way he teaches ethics through case studies:

> I was teaching this 10–20 years ago, but I wasn't really happy with it. I just felt that the case studies were very shallow. And then I came across [n.m. peer's name] work, and it made more sense to me. I think networks can help people who are interested in these things to see that there's a link between ethics and the environment and society, and then put that into our programmes (Liam).

The use of case studies adapted from news reports received 10 mentions by 7 instructors. High-profile cases such as the Challenger shuttle explosion (Cara, Fiona, Sean, Aidan) or the Volkswagen emissions scandal (Erin, Darragh, Aidan) appear to be the most popular scenarios. Natural disasters were included by one instructor, with Saoirse mentioning case studies about the Hurricane Katrina and the Christchurch Earthquake. One justification given for adapting rather than importing case studies is to better fit 'the context of our students' (Rian).

Four instructors responded that they include original case studies, either developed by them (Saoirse, Eoin) or by asking students to create a scenario (Sean, Oisin). The instructors developing their own scenario rely on their professional experience, academic expertise or local concerns. To achieve this, Saoirse and Eoin either draw up hypothetical workplace situations, or expose students to local or contemporary issues by integrating factual data, such as policy reports, environmental impact assessments or public court case reports.

4.2. Goals of case instruction

The study found several goals linked to the use of case studies. Nine instructors have highlighted the epistemic character of ethical decision-making that students are exposed to. Five instructors emphasised how case instruction helps convey certain values that engineers need to cultivate. A fewer number of instructors focused on exposing students to the broader context of engineering practice (three instructors) and on conveying to students various problematic issues related to individual engineers exercising their agency (two instructors).

4.2.1. Epistemic

The majority of the instructors interviewed employed case studies presenting ethical dilemmas. By being exposed to 'wicked problems' and 'grey areas' (Sean, Oisin, Cillian, Liam, Cara), students are expected to become acquainted with scenarios that lack a win-win outcome similar to those they might encounter in the workplace. Ambiguity is seen as an important feature of ethics that comes into play in engineering decision-making. As explained by Oisin, 'when you work as an engineer, you're exposed to grey areas far more than most'. Conor reinforces the importance of case studies that render wicked problems. He considers that

> in the ethics of all engineering decisions, a lot of it is compromise, and a lot of it is about how do I weigh the different things. There's nothing easy about that, and I want to get students used to that, that ethics isn't about a simple 'this is right, this is wrong', it's about the things that are complicated. If it's a simple question, if it's a case of something that's obvious, it's not really an ethical question.

Other instructors opt for wicked problems due to their lack of a predetermined approach, which allows students 'to look at different framings of the problem' (Liam) and analyse an ethical issue 'from multiple perspectives' (Fiona). This view is shared by Cara, who considers that such cases show students the 'complex grey areas and the sense that there are different values that people hold.'

4.2.2. Value and virtue driven

The five instructors who employed high-profile cases such as the Volkswagen emissions scandal or the Challenger shuttle explosion aimed to highlight to students the importance of fostering virtues such as 'moral responsibility', 'care' or 'conscientiousness'. The focus is on reflection about the effects that an engineering decision might have, as well as on the decision-making process preceding it, highlighting the responsibilities and virtues needed of an engineer.

4.2.3. Awareness of the broader context

The interviews showed a concern for making students aware of the broader societal context of engineering practice and the 'satellite effects' (Oisin) of their decisions. Saoirse described the role of case studies in allowing students to 'think about those wider contexts, which might mean that a technically sound solution is not the best solution. That is where the ethical responsibility is'. Another instructor shared a similar goal of making students aware that addressing an immediate problem 'might not solve the broader problem' (Liam).

4.2.4. Encouraging agency

Two instructors mentioned agency-related aspects as one of the goals of case instruction. One instructor achieved this by focusing on junior level engineering roles, aiming to make students aware that 'regardless of how junior they are in an organization, they have moral responsibility within that level' (Aoife). Another instructor aims to develop 'awareness that it's not all black and white, and you have agency and responsibility in those spaces in between' (Cara). According to instructors, raising awareness about the engineer's responsibilities should be taught alongside legal mechanisms of protection for whistleblowers, such as protective disclosures. The rationale offered is that 'a lot of the ethical questions are around the edges of the legal questions' (Cara).

4.3. The nature of the scenarios employed in engineering ethics case instruction

Upon analysing case instruction through the theoretical lens rendered in Table 1, the study found a diverse application of case studies.

4.3.1. Scale: micro context vs macro context

Fifteen participants described the use of scenarios placed in a micro context, while three participants rendered macro-contextual details in their scenario. The micro context scenarios employed by participants present particular examples of engineering situations which require students to reflect on the consequences of their actions. As Erin notes, 'ethical questions are usually done by example', as they allow students to discuss 'what they would do' in a particular situation and 'understand the different uses of things and when they're appropriate or not'. Similarly, Darragh includes 'examples of poor ethical behaviour and good ethical behaviour, and students talk about the consequences of not behaving ethically versus behaving ethically'. More specifically, Darragh used a scenario inspired by

> the Volkswagen emissions scandal, which was presented to students as an engineering problem faced by an engineer that had the opportunity to fool the testing system to make the cars look cleaner than they actually were. And to discuss what's the thought process that an engineer goes through in doing something like that.

In light of the minimal contextual detail contained, micro cases have the advantage of incorporating ethical questions into technical exercises. As Erin explains,

> for a more technical course, you can do it as a case where instead of giving somebody some math calculations with numbers, you write out a scenario where they have to do the calculations, and embed ethics in there somehow [. . .] For example, 'if I had a budget for this, budget is limited, how would I spend it?'. And you could reflect on 'ethically I should do it this way, but I'll make more money if I do it that way'.

Micro contextual scenarios have an overriding focus on goals related to the values and virtues that engineers need to uphold, and the ethical reasoning process for recognising the correct line of action based on these values. Aidan notes that such examples convey to students the message that 'the first ethical imperative for engineers is to do your job properly, carefully and conscientiously'.

Scenarios featuring macro-contexts are described in connection with aims related to helping students develop an awareness of the broader context of engineering practice and the different stakeholder perspectives. In this regard, Saoirse notes that the inclusion of contextual details

> ties together how things can go wrong and how that can have implications for public well-being and the safety of individuals, but also for the environment and the sustainability of resources within that environment, based on understanding the technical knowledge, but the context around that as well.

Liam also emphasises having rich contextual data to make students 'realize that our problem can be framed in different ways, and hence the framing actually sometimes guides the way one addresses it, and also that addressing it might not solve the broader problem.'

4.3.2. Sphere: individualistic vs societal

Twelve instructors employed only individualistic cases, two instructors included only societal cases, and two instructors used both types.

Based on the description of the case studies employed, we notice a strong focus on the individual engineer facing a moral dilemma encountered in day-to-day practice, with 14 instructors describing such scenarios. The dilemmas mentioned during interviews and in the course descriptors include conflict of interest, reacting to either improper practices or crisis situations. The instructors note that case studies promoting an individualist perspective are often 'expanded through various ethical theories' (Oisin) or 'referred back to' professional codes (Aoife, Sean), by asking students to propose how an individual engineers should act according to the precepts of professional codes, the deontological or utilitarian theories.

Societal scenarios also cultivate questions about the collective responsibility of the engineering profession and societal decisions about technology (Herkert 2001, 404). Our study found that four instructors employed case studies with a societal outlook, as suggested by the examples given by Eoin, Liam, Cara and Saoirse. These cases are preponderantly developed by the instructors themselves, and include policy aspects, local and global issues and the perspectives of different stakeholders.

Two main aims were mentioned for the use of societal scenarios. The first aim is to foster reflection on the broader context of engineering practice. This includes the social dimension of engineering and the structural issues affecting an engineer's agency. Liam and Cara emphasised the importance of scenarios that require students to consider different perspectives. To achieve this, Cara integrated role-play in a case of killer robots for

> a unit on responsibility. Each person in the group had to fulfil one role and they had to come to a decision on who was actually responsible for the death of a person when a robot malfunctioned, such that there were all kinds of distributed responsibility. [. . .] I love the killer robot case because it made them think about 'how do I think about responsibility?' There's so many different levels of responsibility [. . .] but there's also the interpretations I make and the public-facing interaction issues. [. . .] It's really the vocabulary and complexity and the sense that there are different values that people hold, and just because I believe in one thing doesn't mean everybody needs to agree with it.

Cara also mentioned the goal of making students aware of the tension between recognising a morally right action and the organisational constraints that might impede pursuing it. For this, she incorporates whistleblowing in the context of a high profile scenario:

> whistleblowing has been an example in the Challenger disaster, and everybody said 'I would not have done it'. But then, to think of the dynamics, to see how the reality of doing things in practice can be much more difficult than thinking 'Yes, I know what's right'. To see how ethical practice is part of social dynamics to some extent, and to make that a little bit more experiential, that they have a little bit of the question 'what would I have done? Probably not what I should have done' (Cara).

The second aim for using societal scenarios is to expose students to the broader mission of engineering. Societal case studies are considered more engaging and effective in prompting students to reflect on their responsibilities towards local communities or underprivileged groups. Liam switched from 'case studies of right or wrong things to do' to societal scenarios due to the former 'washing over' and not being engaging enough. Cases addressing local or global problems are seen by Liam to help 'create more fit for purpose engineers, who can productively engage with society'.

4.3.3. Veracity: hypothetical vs factual

Hypothetical scenarios are used by all 15 instructors who declared they used case studies. The hypothetical scenarios used by the participants interviewed are set either in mundane workplace situations or in crisis situations.

Among the more mundane workplace dilemmas, the ones most often mentioned refer to prioritising conflicting values, roles or potential outcomes, loyalty and conflict of interest, tendering procedures, issues around safety and design, quality control and whistleblowing. To exemplify, one instructor explored the dilemmas faced by an engineer tasked with building a wall between the United States and Mexico. He describes students' 'internal conflict between wanting to retain a sense of professional propriety and all the existential concerns that go with having a job and loving your job, looking after your family, looking after your career, and then you come up against something which is very rewarding from a financial perspective' (Oisin). Similarly, an instructor who employs a case of an engineering development that can be weaponised, asks students to consider 'if you were given that problem how would you approach it? Have you thought of this effect? Would you do it again?' (Erin). The 'problem of wearing two hats at once, a managerial hat and the engineering hat' (Fiona) was also mentioned by one of the instructors

interviewed. Dilemmas surrounding tendering procedures and quality control were incorporated by one instructor via case studies 'on reporting observations where practices aren't what they should be in an engineering environment' (Aoife).

Factual scenarios were employed by ten instructors. Among these, three instructors (Eoin, Liam, Saoirse) rely on publicly available data from court cases, open data or policy data issued by the Environmental Protection Agency, meteorological institutes, the European Commission, local councils or smart city initiatives. Also, all ten instructors using factual scenarios included data obtained from news reports on scandal and disasters featured in the news. As Saoirse notes, 'sometimes I use something that might have been a huge story in the international news [. . .] things that might have been more widely reported in the global press'. Eoin also notes that 'if something has disastrous consequences, there might be court cases or reports by external people on the situation', which could inform case study design.

4.3.4. Timeframe: historical vs real-time

Historical cases used by the instructors interviewed focus on high-profile events, with the Volkswagen emissions scandal and the Challenger Disaster being the events most frequently mentioned. The study finds a similar thematic focus to the use of case studies in the United States (Haws 2001, p.226; Herkert, 2005, pp.306–7; Freyne and Hale 2009, p.8; Harris, Pritchard, and Rabins 2009, 12–3).

Instructors describe the role of disaster scenarios rooted in real-life events as precautionary. Cases featuring high-profile failings can make students aware of the negative and often catastrophic outcomes of unethical decision-making, as they actually occurred. According to one instructor, 'it's important that some of the case studies discussed with students are real world case studies, that show that when people ignore the ethics, things can go horribly wrong' (Eoin).

The majority of historical case scenarios put forward an individualist perspective. For example, an instructor relies on high-profile historical scenarios to prompt students' reflection on

> "the thought process that an engineer goes through. Students have to think about what they would do in that situation: How would they behave, was the observed behaviour correct, how would they modify their behaviour if it's not correct, what did they expect the outcome to be if they had behaved differently, would they hold on to their job, would they lose their job?" (Darragh)

One instructor described the application of scenarios that use real-time data. Saoirse mentioned two case studies that ask students to reflect on the development of wastewater solutions benefitting the wider community. She hopes to familiarise students with their 'responsibility towards the environment' by consulting real-time data:

> In some of the case studies I used this semester, we were looking at the Greater Dublin Strategic Drainage Study, where you access online all the data and the entire environmental impact assessment, which allows a discussion around that. Another thing I incorporated is the applications of physical processes, which is where you're looking at how material contaminant pollutants might be transported, so looking at air quality based on Dublin's urban publicly available sensor data. [. . .] This is an example in which you've got a technology that is treating the wastewater to a certain standard and being discharged to the environment, but maybe it's not meeting the legal concerns that it needs to. Students need to then understand many different elements to see whether this technology is functioning to a certain level, but maybe a different technology could be better.

4.3.5. Duration: brief vs lengthy

Thirteen of the 15 participants that use case studies opt for brief studies, which can be explored in one teaching unit. Two participants, who are teaching the same course, rely on lengthy case studies that require students to develop and film their own case scenario across several weeks.

4.3.6. Student role: predefined vs open

All fifteen instructors who employ case studies included scenarios in which the students' role is predefined, by guiding the discussion based on explicit problems and specific questions. Five of the instructors interviewed, representing three different courses, also described an open role given to students in the application of case studies. This was achieved either by asking students to develop their own scenarios based on problems they identified themselves, or by exposing students to several pieces of factual data as to create an ill-structured scenario characterised by epistemic uncertainty that would require students to untangle different problem formulations.

4.4. Immersive case studies: a preferred way of using case studies

During interviews, instructors were asked about the preferred features and application of ethics case studies, revealing a set of desirable characteristics. Instructors consider that case studies should be realistic, experiential, relevant, engaging, provocative, facilitated properly, including various stakeholders, integrating ethical alongside technical or legal considerations, based on real or real-time data and documentation.

4.4.1. Preferred case format

Reflecting on the preferred format of case studies, eight instructors would opt for cases exposing students to real contexts of practice through the inclusion of scenarios with a *factual* or *real-time* component that give students an *open-ended* role. These are considered to immerse engineering students in contexts of practice. The rationale in support of the use of case scenarios is their perceived relevance (Aoife, Cara, Saoirse, Rian). Four instructors argued for the superiority of case studies that are 'realistic', anchored in 'real life' (Kaitriona, Eoin, Cillian), 'close to practice' or 'experiential' (Cara). Kaitriona considers that 'having real scenarios where students can see the actual real-life dilemma' is 'the best approach', while Cillian notes that dilemmas about health and safety work best when the theoretical aspects are combined with practice and 'fused in real life situations'. Cara explains that she would like to use more 'experiential' cases, as these would better allow students 'to see how ethical practice is part of social dynamics to some extent'.

All eight instructors who expressed their preference for an immersive application of case studies have professional experience outside academia, generally in the private sector, but also in policy-making or healthcare. Saoirse notes her involvement in 'a very collaborative [. . .] multi stakeholder project, which involved the university, a local authority, the Environment Agency and a water company', as an explanation for why she prefers immersive ethics case studies in her current teaching. According to Saoirse, 'I've always worked in that space where you're working with lots of different organisations and bringing them into different aspects of what you're delivering. So I would love to do that here in this program.' Kaitriona also notes the role of industry experience in shaping her teaching approach, noting that

> I focused on a lot of stories about what I've heard or seen in the industry and on site, to try to make it a bit more real. And then I had contacts from outside that I could get in touch with and kind of go 'what's the latest on this, has this changed?'

One way of anchoring case studies in real contexts of practice is through the involvement of external stakeholders. Saoirse states that she 'hopes that in future years I can bring in different stakeholders, [. . .] to bring in a more practical element', and 'at the minute I've been trying to build up contacts in the area'. A second way is through inviting stakeholders to the classroom (Kaitriona, Sean), and a third way is through employing actual data and documentation (Saoirse, Eoin, Liam).

4.4.2. Preferred case study content

A second group of desirable case characteristics points to their content. Several instructors mentioned combining ethical concerns alongside technical issues (Erin, Saoirse, Aidan) or legal matters (Cara, Oisin). This approach is best explained by Saoirse, who emphasises the role of addressing technical questions alongside ethical questions in order to make students aware of the wider context and implications of their work:

> a really important part of students' decision making is to understand the implications of the technical content they've learnt [. . .] and to think about the downstream impact of one solution over another solution. Thinking about those wider contexts might mean that a good technical solution is not the best solution. [. . .] I think the best way to teach that is through understanding different case studies.

4.4.3. Student experience facilitated by case instruction

Thirdly, the instructors' preferred case characteristics is about student experience. According to them, case studies should be 'provocative' as to give rise to debates and discussions that allow students to 'think about the deeper ethical issues that might be in play in a certain circumstance or certain context that you as an engineer might face' (Fiona). It is important for students to 'resonate' and 'engage' with the scenarios presented by case studies (Aoife, Cara, Sean).

4.4.4. Barriers and support for the preferred application of case studies

Instructors encounter several obstacles for employing case studies in a manner that more closely aligns to their preferred application. These challenges include the impact of big student cohorts on interactive and experiential teaching interventions (Aoife, Liam, Aidan), a crowded syllabus (Erin, Aidan), available classroom space and classroom design, such as the allocation of tiered-seating rooms (Kaitriona, Aoife), involving or developing stakeholder contacts (Kaitriona, Saoirse), lack of best practice case study examples (Eoin, Liam), timetabling issues (Saoirse), the course format, such as the online delivery of the course (Fiona), or insufficient resources (Aidan).

These opinions suggest the need for, on one hand, a greater institutional or departmental support for courses of professional formation, and on the other hand, for guidance on improving ethics instruction through case studies.

Institutional support can be translated either as an investment of financial resources, appointment of additional instructors or support staff, changes to timetabling or room repartition. Institutional effort is not sufficient by itself. Three instructors (Kaitriona, Liam, Aidan) highlighted the role of accreditation bodies in supporting the liaising with external contacts or

providing expertise about best educational practices. Kaitriona 'initially went to Engineers Ireland, because they have the code of ethics, to ask if they have anyone who would come and [...] give some examples that they've dealt with in practice, maybe litigation'. A representative of the accreditation body gave Kaitriona the contact details of an instructor within her own institution, who 'had case studies, and we went through them and he helped me'. The need for the accreditation body to offer informational support is also highlighted by Aidan, who 'would like to see Engineers Ireland providing support and really help deliver an ethics program outcome and how to embed it, and to provide some case studies or best practice examples'. Furthermore, Liam suggests that 'an evolution of the accreditation requirement could be helpful to explain what's required and then people would have to go look up the literature on case studies, and so on, to see what does this actually mean'. These opinions suggest a growing need of guidance and the development of repositories where cases can be consulted. As Eoin states,

> I think the challenge is actually finding good case studies [...] as well as finding the documentation to support it, because very often some of the information is not made publicly available.

There are ample online repositories of engineering ethics case studies developed in the United States, such as The Online Ethics Center. Several higher education institutions also host examples of case studies on their website. Nevertheless, instructors noted the lack of cases rooted in the national context and of a national platform presenting their content and application.

5. Limitations

A limitation of our examination lies with the choice of research methods we used. Our reliance on qualitative methods highlights the subjective perspectives of instructors, based on their own descriptions of how they teach ethics via case studies, rather than their actual teaching practice. Conducting additional research by observing teaching practices could offer additional insights about how ethics case studies are taught *in situ*. Nevertheless, the subjective element would still have been present, this time not at the level of the participants' stance towards their teaching practice, but represented by the observant researcher's perspective and judgement about how ethics is taught. The document analysis of course descriptors, combined with interviews, revealed how instructors perceive and articulate the practice of teaching engineering ethics, as well as the scope and goals of their practice.

Another limitation of the method used was the relatively small number of participants in a qualitative study. This resulted in a study, which unlike quantitative research, does not facilitate generalisation. Using quantitative methods such as questionnaires was considered to miss the level of detail about the use of case studies that an interview would achieve. Nevertheless, the findings are transferable and adequate context has been provided to help readers assess transferability. More so, it was not the intention of the study to include data that is representative of all engineering programmes in Ireland. Instead, the project aimed to identify patterns of content and application of engineering ethics cases which would highlight the main features of this teaching method, as it is adopted in a category of courses that is recurrently identified in accreditation events and in the engineering programme structure as having a strong contribution to ethics.

6. Conclusion

Findings of this qualitative study reveal that case studies are a highly popular method for teaching engineering ethics in the Irish engineering education context. This is consistent with prior literature (Colby and Sullivan 2008; Haws 2001; Herkert, 2000). The fact that our findings echo those in the US setting suggests the appeal of the method, which would warrant additional research in other geographical contexts about the nature of the cases used and whether such applications align with the instructors' preferred use.

In terms of the nature of the scenarios employed, we uncovered a diversity of approaches. There is a wider use of individualistic cases, exploring either hypothetical scenarios framed around mundane workplace dilemmas or historical scenarios focused on disasters that require decision-making in crisis situations. Such dilemmas are often addressed through appeal to ethical theories and professional codes. To a lesser extent, we encountered societal scenarios exploring power relations, equity and the broader mission of the engineering profession.

Data collected for this study indicates that the instructors' use of case studies does not always align with their preferred application. Instructors highlighted the need to switch from hypothetical scenarios towards more immersive case studies set in real or realistic settings and using factual or real-time data. Immersive cases can engage and provoke students to reflect on broader ethical issues affecting engineers and to acknowledge the prevalence of ethical considerations in contemporary engineering practice. This closely reflects Perlman & Varma's (2001) observation that a major shortcoming of case instruction is the problem of professional distance, achieved by historical cases which emphasise individualism and are removed from students' experience. Similarly,

Valentine et al. (2020) note the need for cases that familiarise students with real-world features of engineering practice, by recounting the experience of graduates and interns.

Educators are concerned that just taking an ethics class is not sufficient for students to enhance their ethical reasoning or awareness (Tormey et al. 2015; Bairaktarova and Woodcock 2017). *How* engineering ethics is taught is of crucial importance for this aim, and instructors need to enquire how to design impactful educational experiences. Building a deep understanding of practice has the potential to strengthen engineering ethics instruction (Trevelyan 2010). This might be achieved by developing and using teaching approaches with more real-life scenarios and open-ended questions, that would offer students 'a more complete exposure to engineering ethics' (Bairaktarova and Woodcock 2017).

One approach for implementing immersive scenarios suggested by engineering ethics instructors was to involve external stakeholders and guest speakers. This preference mirrors emerging Challenge-Based Learning initiatives for developing and employing case studies that would closely replicate the context of engineering practice (Kalamas Hedden et al. 2017; Holgaard and Kolmos 2018; Bombaerts & Spahn, 2021; Mattasoglio Neto, Lima, and Mesquita 2019). A second approach makes use of real data and documentation, such as environmental data and recordings, policy documents or court reports made publicly available by governmental organisations or community initiatives (Newberry, 2010; Byrne and Svanström 2012; Doorn & Kroesen, 2013; Shallcross 2013).

An important aspect highlighted in the interviews was the need for institutional support, teaching resources and the development of communities of research and practice to assist and enhance engineering ethics instruction. There is a need for cases rooted in various geographical and cultural contexts and of an internationally oriented online platform for presenting their content and application that can serve as inspiration for instructors. Although there are ample online repositories of engineering ethics case studies developed in the United States, such as The Online Ethics Center, functioning under the leadership of Rosalyn Berne, these are underdeveloped in other national settings as to reflect their specificity.

There is a growing number of voices calling for the revision of engineering ethics case instruction (Martin et al. 2019; Morrison 2020; Rottmann and Reeve 2020). Such changes cannot be achieved without the support of institutions, in the form of additional resources and instructors, as well as adequate room repartitioning. Having the support of accrediting and professional bodies is needed to provide expertise and facilitate stakeholder engagement. The development of online platforms and communities is necessary for practitioners to share best practices.

Finally, these supportive measures need to be backed up by further empirical research. We identify three research lines that can continue the work conducted in the present study.

First, given the ambiguity and scarce empirical evidence as to what counts as an effective implementation of case studies in engineering ethics instruction, we recommend that educators analyse in their class-room setting the application of the different case formats put forward in our study in connection to specific learning goals and student characteristics. Of particular concern is the impact of different case formats on students' engagement with ethics. To ensure curricular alignment, the contribution of different case formats to the achievement of learning goals set at course level should be further enriched by an examination of how these fit into the broader programme. The use of case studies should thus reflect a systematic concern, manifest in the approach to implementing ethics at programme level and the overall educational vision of the programme and desired graduate attributes.

Second, such efforts in ensuring alignment between the format of case studies and learning goals or graduate attributes needs to be complemented by the development of metrics for measuring the effectiveness of various case formats and applications.

Thirdly, the aspirational discrepancy between the instructors' use of case studies and their preference for a more immersive application prompts us to recommend additional research about the resources and institutional support required for the development of ethics case studies that involve external stakeholders and real-life data. Given that these are two barriers to the development and use of immersive case studies identified in our study, it is important to examine the cost involved by such teaching initiatives and ways to make them operational.

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