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# Embedding sustainability in IT degree programs: Stakeholder perspectives and curriculum strategies

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## Abstract

Despite the importance of the Information Technology (IT) sector for sustainability, there is a lack of guidance for including Education for Sustainable Development (ESD) in IT degree programs. This research investigates perspectives of staff, students and industry, and contextual factors, to develop strategies for embedding sustainability in IT curricula. We conducted a case study at an IT department in a major Australian university, through semi-structured interviews and workshops with academic staff (n=10), students (n=28), and industry professionals (n=5), and by analysing documentation such as university plans, handbooks and company reports. A thematic analysis was used to synthesise perspectives, and sustainability topics were mapped to IT knowledge areas. While IT professionals have increasingly important roles in addressing sustainability challenges, many IT staff and students are unaware of, or uncertain about, sustainability's relevance to their field. Additional barriers to integrating sustainability into IT programs include lack of educator expertise, overcrowded curricula, and the lack of tailored resources and support. We provide an empirical account of stakeholder perspectives on integrating sustainability into IT curricula in Australia. We offer a framework and recommendations to address these issues through loose, program-level coordination, training and resources to empower educators, paving the way for more profound change. This case study offers valuable insights for integrating sustainability into IT curricula, along with a framework and strategies that can serve as useful starting points for universities to take practical, educator-led steps towards ESD.

## CCS Concepts

• **Social and professional topics** → **Computing education**; **Sustainability**.

## Keywords

IT sustainability competences, IT curriculum, IT sustainability, Education for sustainable development


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## 1 Introduction

Information technology (IT) occupies a central role in contemporary sustainability challenges, acting as both a driver of environmental pressures and an enabler of sustainable futures. Deeply concerning impacts of IT include rapidly rising energy consumption and carbon dioxide emissions from data centres and artificial intelligence systems [11], worsening wealth inequality [36], and accelerating production of e-waste [53] At the same time, data and information systems are seen as integral to achieving and measuring progress on sustainability [5, 22, 35].

IT and Information Systems (IS) are distinct yet closely aligned fields within the broader realm of computing. In contrast to computer science and software engineering, they focus on the application of digital technology in organisational contexts; IT addresses implementation and management of computing resources, and IS emphasises strategic use for business objectives. These degree programs include subjects that span technical foundations, IT professional practice and business analysis, to prepare graduates for roles in IT management, IT consulting, and project management. (For brevity, we hereafter use "IT" as an overarching term encompassing both IS and IT fields). Graduates take on roles such as IT managers, analysts, consultants and Chief Information Officers. These positions, and organisations' technology strategies, are being reshaped by sustainability priorities, including Environmental, Social, and Governance (ESG) reporting requirements [33, 43]. Growing corporate demand for sustainability-literate IT graduates [33, 47] underscores the responsibility of higher education institutions (HEIs) to adapt IT curricula to prepare future IT professionals to navigate and shape sociotechnical responses to sustainability challenges.

Influential international initiatives for computing education, such as the Seoul Accord [44] and the Computer Science Curricula jointly published by the Association for Computing Machinery (ACM) and IEEE [26], recognise the importance of sustainability in IT and computing education. However, IT educational leaders

lack practical guidance for designing curricula and identifying sustainability topics that should be included. This gap is compounded by the relatively "immature" state of research into sustainability in the wider field of computing education [38], and some perceptions that sustainability is peripheral or irrelevant to computing and IT curricula [28, 37]. While Australian universities are addressing sustainability in, for example, engineering programs [4], evidence of its inclusion in computing and IT remains scarce, and this is also the case globally [33, 51].

Embedding Education for Sustainable Development (ESD) in universities faces several barriers, including lack of understanding or resistance among staff and students, and conflicting institutional values [1, 14, 34, 45]. These barriers can be context-specific, varying across disciplines and institutions. Consequently, there is a critical need for targeted case studies to better understand the local factors involved [7], as a foundation for context-sensitive tailoring of ESD integration strategies [41, 54]. This paper addresses this gap by investigating the challenges of integrating sustainability teaching in IT programs, through a case study conducted at an IT department of a major Australian university. Focusing on a single institution, we explore in depth how contemporary contextual factors, including barriers and enablers, affect sustainability integration in IT degrees. We draw on these findings to develop recommendations that respond to the sectoral and institutional landscapes, as well as the needs, expectations and concerns of the IT industry, students and IT educators.

In this study, we addressed two intertwined research questions:

- RQ1. What are the perspectives of staff, students and industry on embedding sustainability in IT degree programs?
- RQ2. What strategies can support integration of sustainability into IT degree programs?

We addressed these questions through interviews and focus groups with students, staff and industry representatives, and conducted thematic analysis of transcripts alongside relevant documents such as university reports and curricula handbooks. We present findings from our research, addressing the first research question; and subsequently discuss insights, responding to the second research question. We conclude by summarising how the practical strategies we propose support ESD inclusion at other institutions.

This paper contributes to research at the intersection of computing, sustainability and education by providing an in-depth, empirical account of how sustainability is understood, valued and enacted by IT educators, students and industry in a major Australian university. It addresses a persistent gap between sustainability discourse and practical curriculum design in IT programs by contributing a three-tier framework, comprising Disciplinary, Generic and Specialist sustainability topics. Finally, the paper offers actionable, educator-led strategies for embedding sustainability in IT education through program-level coordination, shared resources and light-touch staff capacity building, demonstrating how sustainability can be meaningfully integrated into IT curricula in ways that are aligned with industry and societal sustainability challenges, and sensitive to context, institutional constraints and educator capacity.

## 2 Literature Review

### 2.1 Challenges of including sustainability in IT curriculum

The integration of sustainability teaching into computing and IT education has gained increasing recognition in recent years, as evidenced by its inclusion in international curriculum specifications [26, 44]. However, studies have highlighted the underrepresentation of sustainability topics in computing degree programs [33, 42, 51] in contrast to closely related fields such as engineering [4]. Holgaard [24] notes that accreditation of engineering degrees in Australia requires inclusion of sustainability [15], but this is not the case for computing and IT degrees accredited by the Australian Computer Society. While several academic initiatives and scholarly communities have addressed ESD in computing [2, 10, 13, 19, 20, 28, 30, 33, 37, 39, 40], research in this area remains relatively "scattered" [38]. Furthermore, the majority of this body of work focuses on computing, with relatively few studies considering IT or IS education [3, 25, 32].

A significant barrier to ESD in computing and IT degree programs is that educators are often unclear about the relevance of sustainability to their discipline. There has been a persistent perception that sustainability is peripheral or irrelevant to these programs, despite growing evidence of the crucial roles digital technologies and IT professionals play in achieving sustainable futures [28, 37]. This underscores the need for clearer guidance for IT educational leaders and curriculum designers on which sustainability topics should be included in IT degree programs and when and how they should be taught. For example, while Ligozat et al. [28] provide valuable insights into integrating environmental issues into individual subjects, their focus does not encompass the broader scope of ESD (i.e., societal sustainability) and does not address questions of program-level integration [16]. Recent work proposing a framework for sustainability in computer science curricula [2] focuses topics such as software engineering, coding and machine learning, but does not address the competencies required of IT and IS professionals - such as aligning technology decisions with organisational strategy, enterprise systems strategy and decision-making, and information management in institutions. This present study sought to address a significant gap by identifying sustainability topics that should be included in IT programs and exploring how they can be meaningfully embedded in curricula at the program level.

### 2.2 ESD in Australian Higher Education

Australia has made significant progress in addressing sustainability within its higher education sector, although this progress has been halting and characterised by persistent challenges [4, 14, 24]. ESD was actively promoted in Australian higher education curricula during the UN Decade of Education for Sustainable Development (2005-2014), for example through the Australian Government's 2009 "National Action Plan for Education for Sustainability" [21] and Universities Australia's call for members to embed sustainability into academic programs [27].

More recently, the Australian Universities Accord Final Report [6] specifies that the objective of tertiary education is to both "underpin a strong, equitable and resilient democracy" and "drive national

economic and social development and environmental sustainability". However, the Universities Accord Final Report provides little guidance on the curricular changes required to achieve this objective. The report also identifies a broad set of additional, complex goals and challenges for tertiary education related to, for example, technological advances, affordability and equity, international dynamics, the student experience and industry engagement. More broadly, modern higher education curriculum development involves complex challenges and requires educators and institutions to balance multiple, often competing demands.

A 2011 survey of Australian higher education educators identified the top three reasons for not including ESD as: 1) a perceived lack of relevance to their subject; 2) an overcrowded curriculum, and 3) perceived resistance from students [14]. Notably, the survey also found that science educators were less likely to support ESD in universities than arts educators [14]. A separate study identified a lack of funding, resources and training as key barriers to ESD integration in Australia [24].

Effectively introducing ESD requires close attention to the differences between disciplines [14] and to institutional context [41, 54]. The present study focuses on fields that have received relatively little attention to date: IT and IS. We engage with discipline-specific contexts, challenges and perspectives to develop practical strategies for embedded sustainability into degree programs – an approach that has been largely overlooked in the Australian context.

## 3 Methods

This project investigates the perspectives of IT industry, teaching staff and students, to understand contextual factors, barriers and enablers associated with including sustainability in the University of Melbourne's IT and IS programs (hereafter referred to collectively as "IT programs"). Given the identified gaps in practical strategies for implementing sustainability in IT curricula, and the recognised importance of context-specific approaches, a case study focused on understanding contemporary perspectives and challenges within a single institution is both timely and necessary [8, 58].

A case study approach enables an in-depth, qualitative examination of the complex issues involved, allowing for a holistic understanding of diverse stakeholder perspectives (RQ1), and facilitating analysis of the underlying reasons and contextual processes that influence curriculum integration, with the aim of developing effective strategies for including sustainability in degree programs (RQ2). By examining the perspectives, motivations, perceived barriers, and enablers within one institution, we aim to identify practical strategies for embedding ESD into programs in a way that is responsive to the institution's unique culture, resources, and constraints. We investigate the experiences at the University of Melbourne – a major player in Australian higher education, with strong reputation in computing and IT education [50] – in efforts to implement its institutional objective of integrating sustainability into curricula. This exploratory case study is designed to provide empirical insight into the challenges and strategies involved in preparing IT graduates to address complex sustainability-related challenges.

The research team engaged in reflexive practice in study design, data collection and analysis. Three authors are academics teaching IT, digital ethics, digital design and software engineering in the institution under study, and brought perspectives shaped by their pedagogical and research engagements. Their backgrounds encompass professional and non-profit IT, ethics and digital ethics education, and ethics in games and virtual worlds. The other two authors have held teaching assistant roles within the institution, and brought expertise in sustainability-focused risk communication, and gender equity in online communities and digital games. These backgrounds informed the team's engagement with sustainability topics and shaped underlying assumptions and priorities, which were continually negotiated and reassessed through reflexive engagement with the literature and the data.

### 3.1 Data collection

The research team gathered qualitative data from three main groups: representatives of companies that typically recruit our IT graduates (n=5), teaching staff (n=10), and students (n=28). Data were collected through semi-structured interviews, focus groups and a demographic questionnaire. In these, we explored participants' sustainability knowledge and skills, and their perspectives on the role of IT education in addressing sustainability and related opportunities and challenges.

After gauging participants' initial responses to the topic and their awareness of sustainability frameworks and initiatives, we provided baseline definitions of sustainability that included social impacts as well as environmental considerations. These provided a foundation to probe more deeply their prior knowledge and perspectives on sustainability topics' relevance to IT education.

In interviews with industry representatives and teaching staff we showed participants a figure representing the 17 UN Sustainable Development Goals (SDGs), a framework referred to in the University of Melbourne's Sustainability Plan [49].

In focus groups with students, we showed slides that represented the 17 UN SDGs, briefly introduced examples of technology impacts relating to SDGs 3, 4, 10 and 12, and discussed the issue of fresh water use for data centre cooling. Focus groups were conducted by research assistants with no involvement in teaching the students who participated, and focus group transcripts were anonymised prior to analysis. Three focus group sessions were conducted, with 8-12 participants each.

Additional materials, such as curriculum handbooks, teaching materials, university strategy documents, corporate sustainability statements and reports, were collected and analysed to provide contextual information on existing teaching content and industry practices. Development of curriculum improvement strategies was also supported by review of scholarly literature, grey literature, prospectuses and online materials of other HEIs, as well as professional bodies and accrediting bodies. This study had the approval of the institutional ethics committee.

### 3.2 Data analysis

The research team conducted a thematic analysis [12, 48] of the interview and focus group transcripts, researcher memos and relevant supporting documents such as university reports and curricula handbooks. The aim was to identify common themes, highlight points of tension and explore opportunities to strengthen sustainability education in IT curricula. The analysis focused on comparing

the expectations and experiences of industry representatives, staff, and students, with particular attention to how these perspectives aligned or diverged. The findings also provide insights into current curriculum coverage of sustainability topics and perceived gaps, and suggest ways to adapt existing teaching to enhance graduates' readiness to address sustainability challenges.

## 3.3 Recruitment

Participant recruitment approaches were designed to ensure broad representation from relevant stakeholder groups. We recruited IT sustainability industry representatives from companies that regularly hire IT graduates from the University, through LinkedIn and researchers' networks. Teaching staff involved in IT curriculum design and delivery were recruited through internal email (identified through handbook contact information). Students from relevant programs were invited through the student portal and advertisements in lectures. Recruitment strategies ensured coverage of different sectors and role types, as well as a balance between technical and business-focused areas of study. This approach helped capture diverse viewpoints on sustainability within the IT graduate education context.

We interviewed 5 industry representatives from large (n=3), mid-size (n=1) and small (n=1) companies that regularly recruit the University's IT graduates. These included male (n=2) and female (n=3) respondents. Educators interviewed comprised coordinators and principal lecturers of IS (n=5) and IT (n=5) subjects, across computing, Artificial Intelligence, cybersecurity and human-computer interaction specialisation areas, and included male (n=5) and female (n=5) participants. Student participants were enrolled in the University's IS program (n=16) or IT program (n= 12) and included male (n=16) and female (n=12) respondents, as well as international and domestic students.

# 4 Findings

## 4.1 Findings from interviews with IT sustainability leaders

*4.1.1 Industry's sustainability priorities and initiatives.* Interviews with industry representatives confirmed that sustainability, or ESG, is increasingly embedded in the sector's strategy and operations, amongst large and small companies. Drivers most notably include Australian requirements for reporting greenhouse gas (GHG) emissions, demands from customers and graduates, and expectations of younger employees. Additional ESG topics mentioned included renewable energy, electricity use, carbon emissions across the product chain, transitioning to "net zero", risk assessment, management of end-of-life technology, modern slavery supply chain assessment and reporting requirements, duty of care in relation to suppliers and gender inequality.

For some companies, sustainability is about far more than compliance, with one respondent explaining it is "*becoming less and less a kind of corporate social responsibility issue and more of a fundamental* [requirement] *... this is how a company has to operate for its social licence*". Examples of sustainability initiatives included long-term sustainability strategies, hackathons, development of software for carbon accounting, and investments in technologies for e.g. climate risk management and reducing the digital divide. This indicates both breadth and depth in the IT sector's involvement in sustainability initiatives.

*4.1.2 Industry sustainability challenges require IT capabilities.* IT sustainability leaders emphasised the need to deliver "*technology solutions to sustainability problems*". Specifically, respondents mentioned that GHG emissions reporting requires new IT capabilities and rigorous data management, noting the challenge of "*getting ... data systems up to scratch and assurable*". Capabilities for "*green coding*" and driving technology efficiency were noted to have multiple benefits in terms of hosting space, cost and emissions. Amongst technology companies there is "*a lot of anxiety*" around consumption of energy and water by Large Language Models (LLMs) and other forms of Artificial Intelligence (AI), presenting technical challenges and IT governance dilemmas.

IT capabilities were noted as relevant to many other sustainability challenges, including monitoring bushfires, species conservation, developing more effective battery materials, and increasing the capacity of wind generators. Some technology companies will seek future employees, including university graduates, who can develop and drive an ESG agenda. For example, the video games industry was seen to lack sustainability awareness, particularly among smaller companies, highlighting a need for graduates who can contribute to games companies' capacity in this area.

*4.1.3 Industry perspectives on the role of HEI in IT Sustainability.* Industry respondents saw missed potential for sustainability learning in university. It was noted that some interested graduates have undertaken relevant extra-curricular learning on sustainability issues, but to integrate it with their IT responsibilities "*they've got to kind of make it up as they go along because no one's ever taught them this.*"

Several types of sustainability education were mentioned. Firstly, foundational sustainability literacy that would prepare graduates to "*speak the same language*" in discussing ESG with colleagues. Secondly, technical knowledge related to, e.g., data for emissions reporting, technology life-cycles and circular economies. And thirdly, ways of thinking such as problem-solving skills, creativity, "*mental flexibility and dexterity*" and "*systems thinking*", to foster a view that sustainability problems are systems problems that can be solved. IT sustainability leaders welcomed the formation of partnerships between HEI and sustainability industry professionals, with one interviewee stating that "*one of the biggest challenges we face in Australia is a real lack of permeability between academia, public, and private sectors*".

## 4.2 Findings from student focus groups

*4.2.1 Students' sustainability orientations and awareness.* The focus groups revealed IT students hold varied orientations and exposure to sustainability. Many had not previously considered its connection to IT. Some students associate sustainability with particular lifestyles and ways of thinking, for example as a "*mindset*", a "*philosophical way of thinking*" or as a "*trendy*" topic. These indicate that it is not seen as a substantial topic in relation to IT professional learning. Some students had encountered sustainability through specific subjects, whereas for others the focus group was a first exposure to the topic in an academic context. Most who had learned

about the topic had done so through clubs, events or independent learning.

Students had minimal in-depth awareness of sustainability's relevance to the IT discipline and careers. One student thought sustainability to be "*far away from*" IT, and two others pointed out that it is probably more relevant to other domains. Many students struggled to identify ways in which sustainability relates to the IT discipline. Interestingly, the focus group discussion and case studies had a noticeable impact on a few participants' perspectives. Some students explicitly commented that the workshop changed their understanding of sustainability and its relevance to IT. Overall, this indicates that even brief sustainability exposure and education can help students build awareness of the issues.

*4.2.2 Uncertainty about relationship between sustainability and job readiness.* Students' responses indicated uncertainty about the relevance of sustainability to IT careers, and low baseline awareness of ESG issues and expected contributions of IT professionals. Generally, students were concerned about building career readiness, and some supported sustainability learning if it aligned with emerging industry needs. One felt that sustainability would be the domain of specialists, so would not generally be an important skill for IT professionals. Overall, these responses indicate a need for explicit teaching about contemporary impacts of ESG on IT strategy and professional practice, and the importance of digital systems in addressing sustainability challenges.

*4.2.3 Including sustainability in higher education.* Students generally connected sustainability education with the University's aim to produce "*change-makers*" and build broad sustainability "*awareness*." Some felt it the University's responsibility to demonstrate the relevance of sustainability to IT, for example to take steps to "*open* [students'] *minds to how important sustainability is*". One noted that including sustainability in the curriculum could boost the University's competitive advantage and suggested that the University needs to "*catch the* [sustainability] *train*".

Opinions were, however, mixed on embedding sustainability into the core IT curriculum. Some preferred that it be optional or self-directed study, citing concerns about increased workload and the potential detriment to learning essential technical skills. Students emphasised that sustainability topics, if included, should be directly relevant to IT and should complement core technical learning.

In terms of teaching approaches, students favoured real-world learning integrated with industry expertise, such as projects, case studies, workshops, hackathons, field trips, mentorship and internships. Many emphasised that expert industry professionals could bring credibility to the teaching of these professional and societal topics. While opinions varied on whether sustainability should be a standalone subject or integrated into existing ones, many were open to its inclusion in compulsory subjects.

## 4.3 Findings from interviews with teaching staff

*4.3.1 Staff sustainability awareness and orientations.* Staff expressed highly varied levels of awareness of sustainability in general. Only a minority of staff had strong awareness of the definitions of "sustainability", "sustainable development" and frameworks such as the UN's SDGs referred to in the University's sustainability plan [49]. Many staff understood the term to relate primarily to resource use (predominantly energy use), efficiency and (to a lesser extent) other environmental impacts. One respondent saw the term "sustainability" as a potential "*turn off*" because it is, they believed, poorly understood and overused. On the other hand, some staff had well developed understandings of sustainability initiatives, and several expressed considerable personal commitment to sustainability in their daily lives, and efforts to integrate related concepts into their teaching.

Generally, staff exhibited low awareness of the sustainability issues affecting industry and the relevant IT skills needed. Several staff mentioned that for organisations, sustainability is driven primarily by compliance, or that it has appeal for industry only if there is a clear business benefit. Some staff also expressed concerns about "*greenwashing*" and hollow promotion of sustainability to gain competitive advantage. Some staff expressed an expectation that, over time, growing pressures would prompt more businesses to integrate sustainability into their strategies.

Several staff identified examples of sustainability-related topics relevant to their teaching that they already teach or could introduce with adequate support. Examples they gave were varied, and included for instance, software development that promotes reuse and modularity; challenging techno-solutionism in discussions of digital ethical; cases of gender bias in AI models; simulation of disease spread; modelling social network effects relating to wealth inequalities; and coding challenges that pertain to management of the commons.

*4.3.2 Growing importance of sustainability in academia.* Some staff, especially those in leadership positions, were broadly aware that the Faculty and the University seek to include sustainability in education. A small number expressed some scepticism about sustainability initiatives and mandates from governments and the University. Several staff who had spent time in northern Europe thought that sustainability understanding and engagement are "*lagging*" in Australia and that pressures to address sustainability would increase in coming years. There were suggestions that upcoming generations of academics would need to grapple with the issues, and some mentions that sustainability was not part of older generations' foundational education, with one respondent commenting that "*the younger generations are much, much more switched on about these topics than [...] older generations are*".

*4.3.3 IT has an increasingly important role to play in sustainability.* Many staff identified meaningful roles for IT education in addressing sustainability issues, with some already including relevant issues in their teaching. A few expressed deep and urgent concern about IT's impacts, such as contributing to reaching a "*point of no return*" on global warming.

However, a few staff were uncertain about the relevance of sustainability to IT education, worrying about superficial engagement or "*box ticking*". When shown the University's sustainability objectives and SDGs, some staff commented that attempting to include them in their IT teaching would involve very tenuous links. Others highlighted tensions between sustainability perspectives and the discipline's technical drive, focus on productivity, "*techno-solutionist*" orientation and impetus to involve resource-intensive technologies.

Despite these concerns, there was a broad agreement that sustainability will "*grow in importance*", that technology education should "*keep up with the concerns of the world*" and that it would be "*irresponsible just to ignore*" the topic. There was some optimism that IT graduates with sustainability competencies could influence employers' environmental and social goals, improve institutional governance and develop technologies with better outcomes.

*4.3.4 Pathways to integrate sustainability into curricula.* Staff expressed interest in better including sustainability in IT curricula and gave thoughtful suggestions on how this could be achieved. For some it was important to "*plant a seed*" of awareness, and ensure that students can "*reflect on the impacts of what they're doing and the choices they're making; and raise these issues [with] their future employers and companies as well*". Most favoured integrating sustainability into several subjects, as this would allow for closely integrating the topics with IT knowledge areas. It was felt on the other hand that creating a standalone elective would run the risk that it would only reach students who "*self-select*".

Proposed pedagogical approaches generally involved a real-world orientation, including case studies, projects and teaching examples. Suggestions included more attention to NGOs and civic applications of technology; involving industry representatives to connect sustainability to employers' priorities; addressing productive as well as negative impacts of IT on sustainability issues; and assessing IT sustainability knowledge and competencies, for example through project topics and sustainability impact analyses.

*4.3.5 Concerns about introducing sustainability into curricula.* A primary concern for staff was the challenge of making room for sustainability in the syllabus, especially in subjects with substantial technical content or accreditation requirements. Staff noted pressures to include varied professional topics and skills (e.g. internationalisation, Indigenous knowledges, teamwork skills, and now also sustainability) alongside core content. Some, however, felt sustainability could be included without increasing overall content, through judicious selection of teaching examples and making explicit the real-world impacts of digital tools and techniques. The notion that sustainability might be "*mandated*" was worrying to a couple of respondents, especially for one who feared topics being "*artificially added*". Others were concerned about a lack of student interest, given students' prioritisation of technical skills, career readiness and assessments. For example, two staff respondents commented that students are reluctant to deliberate on difficult and complex issues. This indicates a need for teaching and assessment that builds students' competencies for dealing with uncertainty, managing complexity and incorporating diverse ways of thinking to address complex problems.

*4.3.6 Support needed to include sustainability in curricula.* Staff indicated that program-level coordination, resources, training and leadership could play an essential role in enabling them to include sustainability in their subjects. Most staff noted that they had not themselves received education on IT sustainability, and so were uncertain as to what topics they should include. Many were wary about teaching on issues such as climate change, outside of their area of expertise. A program-level approach was seen as essential for identifying critical topics, coherent integration, building collective commitment and providing practical guidance. A bank of educational resources, such as statistics, case studies and expert interviews, was seen as essential to help staff introduce sustainability issues and related techniques within the constraints of their teaching workload.

One respondent suggested that training would ideally enthuse staff to introduce sustainability in the classroom, but acknowledged that would be difficult to achieve. Expert guidance from someone with IT and sustainability knowledge was recommended to build awareness and for inspiration. Some staff mentioned the importance of a "*cultural*" focus on environmental and social impacts of technology, including visible championing from departmental and University leaders.

## 5 Discussion

Embedding sustainability teaching into IT curricula presents several challenges, principally due to low levels of awareness about sustainability among students and staff. Many students lack exposure to sustainability's relevance to IT practice, so we anticipate relatively few would choose elective subjects focusing on sustainability. Educators are often expected by HEIs to lead the inclusion of new topics such as sustainability into curriculum. However, many lack the foundational knowledge to identify how sustainability intersects with their areas of expertise. Some staff had little awareness of sustainability frameworks and definitions adopted by their University (such as the UN SDGs), and had a narrow conception of the topic constrained to e.g. climate change and energy emissions. Other staff had stronger understandings of sustainability and related frameworks, but struggled to include it in their teaching in structured, assessable format. Staff expect structured guidance from the institution or curriculum experts, but at the same time fear broad mandates to include sustainability.

To address these challenges, we propose strategies that provide program-level coherence, empower educators and accommodate varied levels of staff readiness. The aims of these recommendations are to make evident the relevance of sustainability topics to IT education and professional practice, provide a foundation for coordination across degree curricula, and build staff capacity and awareness. This proposed approach allows for immediate steps towards better inclusion of sustainability in curriculum and lays the foundation for more profound shifts towards values-centred teaching in the long term.

### 5.1 A framework for IT sustainability curricula

We start by outlining a framework for integrating sustainability into IT curricula comprising three tiers of knowledge: *Disciplinary*, *Generic*, and *Specialist* (see Figure 1). This framework and its components were generated by first developing an extensive list of sustainability topics and approaches relevant to the technology sector, IT practice and disciplines, drawing insights from our interviews, scholarly and industry literature, and mainstream media. We then assessed these topics for their relevance to knowledge areas and competencies targeted by the IT programs, and through affinity mapping clustered them to create six topic areas.

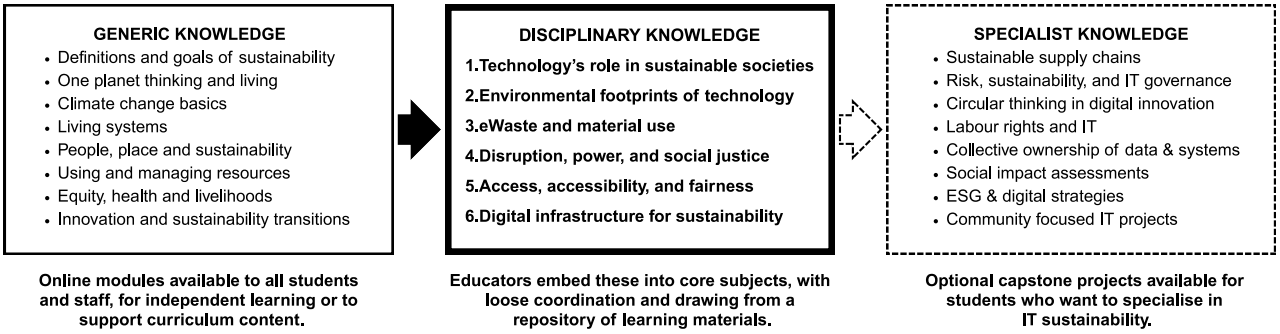


**Figure 1: A three-part framework for integrating sustainability into IT curricula, comprising Disciplinary, Generic and Specialist knowledge tiers**

*Disciplinary* sustainability knowledge encompasses six broad topics directly relevant to IT education and career pathways. These are described in greater detail in Table 1. We recommend these should be embedded into core subjects and tied closely to IT education, supported by explicit learning outcomes and assessments. *Generic* sustainability knowledge covers foundational concepts, such as definitions and goals of sustainability, climate change foundations, and planetary boundaries. We propose that these should be covered by offering supporting educational resources and breadth options, rather than taught directly by IT staff. *Specialist* sustainability knowledge, intended for students seeking deeper expertise, might cover specific topics such as sustainable supply chains, circular thinking in digital innovation, labour rights and IT. These topic areas could be addressed through capstone projects and electives. This tiered approach aims to establish a manageable, shared vocabulary for sustainability in IT education that may also be adapted to computer science and other related fields.

*5.1.1 Disciplinary: IT Sustainability topic areas.* We sought to address the lack of clarity as to sustainability topics that should be taught in our IT programs. We first developed a list of IT curriculum topics taught in of the University of Melbourne's IT and IS degree programs, to understand the broad sets of competencies and responsibilities expected of IT graduates. We next created an extensive list of sustainability issues, competencies and professional responsibilities relevant to the technology sector and IT practice. This list was informed by our interviews with industry representatives and educators, and our review of materials: mainstream media reports, academic literature, grey literature, recommendations of relevant curriculum bodies, publicly available industry reports and literature produced by management consultancies. The sustainability issues and competencies were mapped to IT curriculum topics, and the items were synthesised and into coherent categories. In Table 1, we present the resulting list of IT sustainability issues that graduates should be familiar with and techniques they should learn about to build their capacity to address complex sustainability challenges. We found that many of these items could be mapped to multiple targets (for readability, we show only two per item). This approach results in a manageable list of six categories of IT sustainability topics, providing a discipline-centred foundation for meaningfully integrating sustainability. We demonstrate how the issues and techniques relate to sustainability goals by mapping them to corresponding SDG targets (see Table 1), but note that this method offers a discipline-centric approach, contrasting with curriculum redesign efforts that take SDGs as a starting point.

*5.1.2 Generic: Foundational sustainability knowledge.* Many staff expressed a lack of knowledge or confidence for teaching sustainability topics, and held concerns about teaching subjects outside their expertise. Students also have diverse backgrounds and varied levels of prior learning in sustainability, which cannot all be addressed in IT subject teaching. To address these challenges, we propose to create foundational sustainability modules on topics such as sustainability definitions and goals, climate change basics, and planetary boundaries. These modules will be designed to be engaging and relevant to IT and computing students, drawing links to their areas of interest and future careers, and will be published on the institution's learning management system, freely available to all faculty staff and students. They will be promoted for independent use and for staff to include in their teaching or prior homework, as an introduction to an IT sustainability topic. These modules will be designed for self-service learning, aiming to promote engagement and overcome scepticism. They will comprise short videos, lightweight readings, quizzes and reflective questions which students can complete independently or as part of in-class activities.

*5.1.3 Specialised: Sustainability-focused IT projects.* It is important that students who are interested in sustainability have opportunities to deepen this knowledge in ways that relate to the discipline. We recommend identifying opportunities to integrate specialised sustainability knowledge areas into project-based and capstone subjects. For example, our review of scholarly research and mainstream media identified many IT-related sustainability issues and debates that could provide a foundation for such topics, such as sustainable IT supply chains [57], the impacts of digital technologies on labour rights [55, 59] and collective or community ownership of data and systems [17, 23, 46]. Given lack of confidence amongst many staff for addressing sustainability, we propose that specialist support may

**Table 1: Proposed Disciplinary knowledge topics for an IT curriculum mapped to Sustainable Development Goals Targets (Part 1)**

| Topic Area | Issues and *techniques (in italics)* relevant to IT programs | SDG Targets |
|---|---|---|
| 1. Technology's role in sustainable societies | Technologies' roles in industrial advances, economies and standards of living | 9.5, 9.c |
| | Discourse on helpful and harmful impacts of digital technology | 4.7, 3.9 |
| | UN and governments' perspectives on the role of ICTs in sustainability | 3.9, 17.8 |
| | Business perspectives on the role of ICTs in ESG | 4.7, 9.4 |
| | Proposed roles for technologies in social and environmental sustainability | 4.7, 9.4 |
| | Impacts of ICTs on the growing use of resources by human societies | 9.4, 11.b |
| | *Systems thinking about technologies, societies, and natural systems* | 14.2, 15.9 |
| | *Integrating multiple ways of knowing, including Indigenous perspectives* | 4.7, 16.7 |
| | *Triple bottom line thinking* | 4.7, 9.4 |
| 2. Environmental footprints of technology | Energy consumption and emissions from data centres | 7.3, 9.4 |
| | Water use and pollution associated with data centres | 6.3, 12.4 |
| | Impacts of mining and conflict minerals for hardware | 8.7, 12.2 |
| | Resource demands of training AI models | 7.3, 12.2 |
| | Greenwashing and challenges of environmental sustainability | 12.6, 12.7 |
| | *Software engineering for efficiency* | 9.4, 7.3 |
| | *Critically evaluating suppliers' sustainability claims* | 12.6, 13.b |
| | *Configuring hardware and services for efficiency* | 9.4, 7.3 |
| | *Tools and techniques to monitor technology energy usage* | 9.4, 7.3 |
| | *Planet-centred design and post-growth innovation* | 12.2, 8.4 |
| 3. eWaste and materials | Materiality and eWaste associated with hardware | 12.4, 12.2 |
| | Design and business models that increase eWaste | 12.5, 8.4 |
| | Challenges of eWaste processing and resource recovery | 12.4, 8.4 |
| | Technology design practices that hinder repair and reuse | 12.5, 9.4 |
| | *Modular thinking and right to repair* | 12.5, 12.2 |
| | *Circular design and supporting circular economies* | 12.5, 12.2 |
| | *Lifecycle thinking* | 12.5, 12.2 |
| | *Selecting technologies for low environmental impact* | 12.7, 9.4 |
| 4. Disruption, power and social justice | Effects of technology innovation and disruption on social inequalities | 10.2, 10.3 |
| | Social costs and risks of high-tech solutions and techno-solutionism | 10.2, 8.8 |
| | Corporate dominance of technology spheres: implications for society | 16.6, 16.7 |
| | Power, policy and accountability in technology deployment | 16.6, 10.2 |
| | People's right to control, ownership and access of the data about them | 16.10, 8.8 |
| | *Ethical regulation and frameworks for responsible technology* | 8.2, 9.5 |
| | *Protections and right-of-reply for technology users and citizens* | 8.8, 10.3 |
| | *Participatory, emancipatory and community-led technologies* | 10.2, 5.5 |
| | *Systems thinking to address complexity and unintended consequences* | 8.2, 16.3 |
| | *Systemic design and responsible design of technologies* | 16.10, 8.8 |
| | *Design and policy for data sovereignty and community control* | 16.10, 9.c |

be needed to guide identification of sustainability-related projects, development of grading rubrics and marking guides.

## 5.2 Resources and program-level coordination

To support the integration of sustainability into the IT curriculum, we propose to provide a mechanism for loose co-ordination, a shared repository of teaching materials including case studies, articles, facts, figures, and example lesson plans, and light-touch staff training to build confidence in teaching IT sustainability topics. We recommend program-level coordination should encourage inclusion of sustainability early in the curriculum (for example in first semester subjects), and repeatedly through the program, so that students encounter the six disciplinary IT sustainability topic areas multiple times through their learning journey. By embedding sustainability into specific, predetermined core subjects, we aim to ensure all graduates engage with sustainability knowledge and to reinforce the view that these topics are central to IT practice.

**Table 1 (continued): Proposed Disciplinary knowledge topics for an IT curriculum mapped to Sustainable Development Goals Targets**

| Topic Area | Issues and *techniques (in italics)* relevant to IT programs | SDG Targets |
|---|---|---|
| 5. Access, accessibility and fairness | Impacts of digital divide and unequal access to technology | 9.c, 10.2 |
| | Impacts of poor accessibility for people with disabilities or situational impairments | 10.2, 11.7 |
| | Algorithmic bias and discrimination risks associated with automation | 10.3, 16.b |
| | Underrepresentation of marginalised groups in technology industry and training data | 5.5, 10.2 |
| | *Accessible and inclusive design for all users, including people with disabilities* | 10.2, 11.7 |
| | *Fairness in AI: Measuring and mitigating bias in machine learning* | 10.3, 16.b |
| | *Diversity and inclusion of underrepresented groups in technology design and industry* | 5.5, 10.2 |
| | *Designing respectful automated systems for transparency, agency, and explainability* | 16.10, 9.b |
| 6. Digital infrastructure for sustainability | Challenges of mandatory corporate reporting | 13.2, 15.1 |
| | Societal impacts of security and privacy breaches | 16.3, 16.6 |
| | Data and information challenges of SDG monitoring and reporting | 13.2, 17.7 |
| | Data and information challenges of corporate social responsibility and ESG issues | 9.4, 9.5 |
| | Challenges to the IT profession: energy transitions, changing economies | 7.1, 13.2 |
| | *Secure and resilient infrastructure for critical systems* | 9.1, 11.5 |
| | *Cybersecurity governance to protect individuals and civic goods* | 9.1, 16.3 |
| | *Platforms and skills for civic technology and participatory governance* | 16.6, 16.7 |
| | *Emerging technologies for sustainability monitoring and reporting* | 13.2, 17.7 |
| | *Technologies for optimising energy and resource use, waste, transport, cities* | 7.3, 11.6 |
| | *Change management and design to support transitions* | 7.2, 11b |
| | *Technologies to facilitate new economies, e.g. peer economies* | 8.3, 9.5 |

As part of degree-level co-ordination, we recommend that staff are given guidance as to the IT sustainability topics that could be meaningfully included in the subjects they teach, along with indicators of relevant materials in the shared repository. This approach will reduce duplication of work, provide expert guidance on sustainability issues and techniques to be taught, and ensure broad topic coverage, avoiding repeated exposure to the same prominent cases across the curriculum. We recommend light-touch training through facilitated orientation to the materials and discussion, enabling staff to reflect on the relevance of the IT sustainability topics to different components of the IS and IT degree programs, and to plan collaboratively. This approach will allow staff to include sustainability in subjects at their own pace and in a form appropriate to the subject.

## 5.3 Sustainability values, ethics and ways of thinking

ESD advocates emphasise the importance of values, attitudes, and worldviews in embedding sustainability in education [13, 19, 41, 52]. While we agree that these are important and even vital for long-term success, our findings reveal challenges in prioritising them. Firstly, framing sustainability as a perspective or set of values can diminish its perceived relevance to careers and disciplinary concerns, for some students and educators. Secondly, debates about sustainability definitions, orientations and frameworks, within the institution and beyond, can lead to confusion that prevents curriculum changes [18]. Although structural shifts and cultural change are necessary [18, 29], the urgency of addressing sustainability compels immediate action in strategic ways. Therefore, our approach focuses on identifying strategies for small, coordinated steps at the program level. We envision these steps can build awareness, shift norms and expand thinking about sustainability. Concurrently, there is a need to develop educators' engagement with the diverse ways of thinking and approaches to solving complex sustainability challenges that already exist within academic institutions - such as systems thinking, design thinking, futures thinking and circular thinking [9, 31, 56] - and to demonstrate how these can be integrated into IT curricula. Such broader initiatives will ultimately pave the way for more holistic transformations in the long term.

## 5.4 Limitations and future research

This study is subject to several limitations. First, as a single-case study, the findings are not intended for statistical generalisation but rather for analytic generalisation [58], whereby insights are

transferable to theory and similar contexts rather than populations. Second, there is a possibility of selection bias in the participant sample, as staff, students, and industry professionals with pre-existing interest or commitment to sustainability may have been more likely to participate. Third, the relatively small sample of industry representatives (n = 5) limits the extent to which the full diversity of perspectives within the IT sector is captured. These limitations are acknowledged while recognising the depth of insight that the case-based, multi-stakeholder design enables.

We outline proposed next steps and future work, positioning our recommendations as early stages in a broader set of initiatives to address ESD in our computing and IT curriculum. We envision several key activities to validate and build on the recommendations above.

Firstly, there is a need to evaluate the effectiveness and impacts of the proposed initiatives, including the repository of teaching resources, light-touch training, and sustainability foundation modules.

Secondly, guidance for program-level and subject-level learning outcomes should be developed, along with suggested assessment methods to evaluate students' sustainability learning.

Thirdly, sustainability-focused curriculum planning should be integrated with broader initiatives related to digital ethics, Indigenous knowledge, accessibility and internationalisation, creating a more holistic approach to IT education. In conjunction with these initiatives, there is a need to explore the incorporation of diverse ways thinking and interdisciplinary perspectives into IT curricula.

These future steps are designed to build capacity and institutional momentum towards deeper transformation to address ESD in IT education, foregrounding sustainability alongside other values and ethics-based orientations.

## 6 Conclusion

This paper addresses important knowledge gaps regarding the barriers to integrating ESD into IT curricula. In response to our first research question, our case study reveals that many IT educators lack awareness and capacity for embedding sustainability, amidst various competing priorities impacting on their pedagogy and syllabus. We found that not all staff and students understand the relevance of sustainability to technology sector and professions, despite industry's strong need for graduates equipped to tackle ESG priorities.

Addressing our second research question, we argue for tailored strategies to support ESD in IT degree programs. Our approach focuses on knowledge building and empowerment of staff to meaningfully include sustainability topics in curriculum. We identify Disciplinary IT sustainability topic areas to be embedded in programs, propose self-service online modules to cover Generic sustainability knowledge, and suggest loose program-level coordination, to thread sustainability concepts throughout the curriculum. Additionally, we recommend offering Specialist sustainability knowledge through project options in capstone subjects.

This case study, while focused on a single institution, offers broader insights valuable to HEIs seeking to embed sustainability into IT curricula in a manner that well integrated with the discipline, meaningful and feasible for educators and students, and demonstrates relevance of the topics to graduates' future careers. The framework and recommendations developed here can serve as a useful starting point for other institutions facing similar issues. Our findings and recommendations have implications for institutions seeking practical, educator-led steps towards embedding sustainability, either as a standalone initiative or alongside more comprehensive changes.

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