CASE STUDY

Reflections on developing a collaborative multi-disciplinary approach to embedding education for sustainable development into higher education curricula [version 1; peer review: 2 approved with reservations]

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Abstract

As higher education institutions (HEIs) have increasingly turned to consider sustainability over the last decade, education for sustainable development (ESD) has emerged as a way of imbuing students with the skills, values, knowledge, and attributes to live, work, and create change in societies facing complex and cross-cutting sustainability challenges. However, the question of how HEIs can actively embed ESD more broadly in and across curricula is one that continues to challenge institutions and the HE sector as a whole. While traditional teaching practices and methods associated with subject-based learning may be suitable for educating students *about* sustainable development, a re-orientation towards more transformational, experiential and action-oriented methods is required to educate *for s* ustainable development. The need for educators to share their practices and learn lessons from each other is essential in this transformation.

This paper presents a selection of practical examples of how to embed a range of interactive, exploratory, action-oriented, problem-based, experiential and transformative ESD offerings into HE teaching practice and curricula. Presented by a group of academics and professional services staff at the University of Strathclyde who lead key modules and programmes in the institution's ESD provision, this paper reflects on five approaches taken across the four faculties at

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Any reports and responses or comments on the article can be found at the end of the article.

Strathclyde (Humanities and Social Sciences, Science, Engineering and the Strathclyde Business School) and examines the challenges, practicalities and opportunities involved in establishing a collaborative programme of ESD.

Keywords
Education for Sustainable Development; Higher Education, experiential learning, interdisciplinarity, whole institution approach, skills development, competencies

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Introduction

In recent years, higher education institutions (HEIs) across the United Kingdom (UK) have made pledges to reduce their carbon footprints, with initiatives involving high investment in estates conversion and transitioning to plastic-free campuses and meat-free canteens. Alongside these sustainability promises, commitments to achieving net zero carbon emissions are now an expectation for institutions across the UK. These interventions are rightly seen as vital responses to sustainability problems including climate change, biodiversity depletion, dwindling natural resources, and inequality (Raworth, 2017; Steffen *et al*., 2015). However, the last decade has seen a re-defining of what it means to be a 'sustainable institution', with a realisation that in addition to what institutions install or sell on their campuses, it is the values they instil and skills they develop in their students that will ultimately prove to be the most impactful contribution they can make to the sustainability agenda. In short, all across higher education (HE), sustainability has gone from being considered almost exclusively as an operational challenge to a pedagogical one.

As such, new pedagogies have emerged based on notions of learning for sustainability, aiming to give students the skills and knowledge to live, work, and seek change in societies facing these complex and cross-cutting sustainability problems (QAA/AHE, 2021; Wiek *et al.,* 2011). However, the question of how HEIs can actively embed education for sustainable development (ESD) more broadly within curricula is one that continues to challenge institutions and the HE sector as a whole. While traditional teaching practices and methods associated with subject-based learning may be suitable for educating students *about* sustainable development, a re-orientation towards more transformational, experiential and action-oriented methods is required to educate *for* sustainable development. This will ensure that graduates are equipped with the knowledge, skills, values and attributes needed to contribute to a fair and sustainable future for all. From this perspective, HEIs are seen as change-agents who are themselves creating the change-agents for a sustainable future (Peer & Stoeglehner, 2013; QAA/AHE, 2021).

The broad range of challenges represented by the Sustainable Development Goals (SDGs) mean that every discipline can proactively engage students in addressing these issues (Jones *et al*., 2010; QAA/AHE, 2021; Sterling *et al*., 2013; Sachs, 2015). However, there are significant challenges associated with adopting a whole institution approach to embedding ESD in HE. The main challenges exist around institutional promotion and buy-in; initial and ongoing mapping of ESD; awareness raising and capacity building; promoting activism; identifying priorities, barriers, opportunities and gaps for ESD; integrating it within (regional and institutional) governance mechanisms, educational policy and strategy; staff development, and critically, addressing the "how to" practices and pedagogies educators should adopt and follow when educating *for* sustainable development. All the challenges listed here are key to achieving a whole institution approach to fully integrate ESD across curricula in a way that enables inter and transdisciplinary engagement of staff and students. However, without appropriate teaching and educational tools, practices and methods in place, the front-line delivery at the all-important student/staff interface could undermine and compromise the effectiveness and ongoing integration of ESD. UNESCO's Global Action Programme on ESD Advancing ESD Policy makes explicit the need to "[bring] in new approaches that stimulate pupils to ask questions, analyse, think critically and make decisions; that are cooperative rather than competitive; that offer opportunities for more interactive, exploratory, action oriented, problem-based, experiential and transformative learning". The urgency of Agenda 2030 and pedagogical shift required to fully integrate ESD as a truly transformational learning opportunity across HE will need educators to share their practices and learn lessons from each other; the importance of which is evidenced in the recent calls for examples of practice from the Sustainable Development Solutions Network and to accompany the 2021 QAA/AHE Guidance for ESD.

This paper presents one of many reflective case studies we would argue are urgently required from across the HE sector, providing a practical and transparent summary of a range of approaches to embedding ESD in curricula currently in place at the University of Strathclyde, including an insight into the key challenges and benefits associated with their use. This is by no means exhaustive nor immutable but is intended to contribute a critical insight to a still evolving approach to embedding ESD in HE curricula being undertaken at the University of Strathclyde, and which contributes to the accrescent knowledge base of the ESD community. The paper does so by presenting a selection of practical examples of how to embed more interactive, exploratory, action-oriented, problem-based, experiential and transformative learning for sustainable development into HE teaching practice and curricula. The paper presents five approaches taken across the four faculties at Strathclyde (Humanities and Social Sciences, Science, Engineering and the Strathclyde Business School) and examines the challenges and opportunities involved in establishing a "collaborative programme" of ESD: a coordinated and complementary ESD provision that is accessible to students at all levels of study and across all disciplines. The paper will outline and compare the structure, design and implementation methods of each initiative and discuss the benefits observed and opportunities for progression. Finally, the paper will consider the key lessons learned from the implementation of these initiatives and how they will inform the future integration and delivery of ESD at Strathclyde, which may be translatable to other like-minded institutions.

The ESD initiatives embedded in Strathclyde's curricula are wide-ranging in scope and student participation. This paper will consider five of these: two cross-faculty, multi-level programmes, one Business School module, and two Engineering modules. These are:

1. **Vertically Integrated Projects for Sustainable Development**, a programme of 21 research-based, student-centred, credit-bearing projects which address the SDGs. Students work in multidisciplinary and multi-level teams alongside research staff on these

long-term projects, which they can return to year on year.

2. **Multidisciplinary Perspectives of Sustainable Development**, a credit-bearing blended learning elective module available to all Strathclyde students in all disciplines and at all levels, that aims to develop students' understanding of how various disciplines can and do contribute to the challenges outlined by the SDGs.

3. **Social Responsibility Pathway,** a credit-bearing option for year 3 students participating in the Strathclyde Business School's Management Development Programme. The pathway supports project-based working in partnership with external organisations in real-life contexts while engaging in initiatives and activities with a positive social dimension.

4. **Infrastructure and Environment**, an interdisciplinary year 1 elective module aimed at Engineering and Science students which provides an introduction to the principles of sustainable development and examines modern global challenges through the lens of the SDGs. The module explores the role of engineers and engineering in providing solutions to these challenges while emphasising the importance of interdisciplinarity in problem solving.

5. **Engineering for Global Development**, a credit-bearing core module for year 3 Civil and Environmental Engineering students that engages students in problem-based learning framed around the Engineers Without Borders (EWB) Engineering for People Design Challenge, focusing on sustainable engineering design.

Each of these offerings has integrated ESD to varying degrees. Many of these examples are centred around the UN SDGs, which feature prominently as a core element of the initiative, with sustainable development principles and competencies featuring explicitly in learning outcomes. However, a key challenge for any HEI seeking to offer an institution-wide provision of ESD is to understand the range and blend of that provision. ESD may not necessarily be front and centre in the design of all modules, but it should always be a key consideration in delivery; in many cases, ESD includes a broadening of the key skills that students must be supported to develop through their HE experience. This can range from contextualising subject matter through case studies or storytelling, to explicit inclusion in the development of learning objectives. Therefore, it is important to acknowledge that embedding ESD in curricula is not exclusively about developing new and entirely immersive ESD-centric modules; rather, the goal is to understand where it is relevant and complementary to introduce ESD in the context of a programme or module's broader learning objectives. By understanding the extent to which ESD offers a context for the subject matter and opportunities for more transformational learning of the subject content, educators can arrive at a position where ESD and subject-based teaching mutually reinforce students' understanding of each. In what follows, this paper will examine the approaches taken to embed the ESD initiatives outlined above, the challenges involved in making them scalable, and how the institution is working to connect them to exploit any complementarity that exists in their design and methods of delivery. We will also critically reflect on these programmes, their rationale, and improvements that we aim to make in future years.

Rationale for embedding ESD across faculties

Like many HEIs, Strathclyde has become increasingly invested in embedding a wide-ranging programme of ESD in recent years. The momentum for ESD is more pronounced than ever, as the need for transformative changes in lifestyles, and therefore education, becomes an accepted viewpoint across the sector and society. To achieve this change, students need to be equipped with new skills, and education systems must respond by introducing pedagogies that empower and engage both students and staff.

ESD describes the pedagogies and practices which have emerged in recent years, aligned with the new field of sustainability-oriented research, innovation, and policy development, and responding to the global grand challenges facing society that include (*inter alia*) climate change, biodiversity depletion, dwindling natural resources, growing inequalities and injustices within and between nations, generations, and other societal groupings (Sterling, 1996; Sterling, 2001; Wiek *et al*., 2011). Key moments in that emergence include Wiek and colleagues' (2011) articulation of previously-identified lists of competencies into a conceptually-robust integrated competencies framework. Others added to this, resulting not least in UNESCO's own, slightly different framework, revisions by members of the Wiek team (Brundiers *et al*., 2021), and the recent QAA/AdvanceHE Guidance on Education for Sustainable Development (2021). Strathclyde's ESD provision has hitherto been broadly in line with the UNESCO framework and will increasingly adopt the revised QAA/AdvanceHE guidance.

Both the ESD literature and the SDGs encourage recognition of sustainability challenges as systemic problems which impact (albeit unevenly) the planetary environment, all countries around the globe, segments of their societies, and sectors of their economies. Hence, from a sustainability perspective the SDGs see *all* countries as developing (e.g. if the UK is a high carbon emitting country, then it cannot be sustainable); for this reason, the SDGs are a universal agenda (Sachs, 2015). Sustainability problems understood in this systemic way demand multi, inter, and transdisciplinary responses which can be interrogated within disciplinary curricula, while aiming to give students the tools they need to understand these problems' complexity and potential intervention points as well as the emotional, intellectual, and practical skills they will need to intervene in these problems as the problem solvers, transition managers, and changemakers of the future.

In light of this universal relevance of sustainability problems and the SDGs, it follows that ESD principles can and should be given the urgency of the biogeophysical situation (Steffen *et al*., 2015) and integrated in the curricula across HEIs, whether by modifying existing disciplinary approaches or, perhaps more radically, by introducing cross-faculty modules. The competencies framework is extremely helpful here in that it helps negate concerns from colleagues in traditional disciplines that sustainability is intellectual content which risks diluting their existing curricula (Jones *et al*., 2008). However, embedding ESD has not proven straightforward. Other institutions have faced challenges of seeking to embed ESD across a diverse curriculum (e.g. Finnveden *et al*., 2017; Finnveden *et al*., 2019; Finnveden *et al*., 2020; Jones *et al*., 2008), including management interest, staff time and resource (for mapping a baseline, reporting, running staff development sessions, evaluating successes and failures and identifying/ communicating best practice, etc.), as well as negotiating potential resistance from already over-loaded staff. However, sustainability is a central plank of Strathclyde's new Vision 2025 strategic plan, alongside a related commitment to report progress across all areas of university activity aimed at advancing the UN SDGs. As such, there is a clear rationale to justify embedding ESD right across the curriculum. Moreover, the recently-published ESD Guidance (QAA/AHE, 2021) offers a promisingly useful and clear route to support staff integrating sustainability issues and competencies into their teaching materials for the first time.

The inclusion of ESD in Strathclyde's Vision 2025 strategic plan was influenced by the popularity and success of already established ESD-focused initiatives.

Summary of prominent Strathclyde ESD case studies

The Vertically Integrated Projects for Sustainable Development (VIP4SD) programme was the first ESD programme to become embedded across Strathclyde curricula. The Vertically Integrated Project (VIP) model originated at the Georgia Institute of Technology in 2008 under the leadership of Professor Edward Coyle and was introduced as a mechanism for student-led research projects, which at the time were largely based in the Engineering faculty (Coyle *et al*., 2006). Strathclyde launched its VIP programme in 2012, becoming the first UK institution to do so. The VIP model exploits the nexus between student education and research, and seeks opportunities for connection and partnership across the institution to enable Research-Based Education (RBE) to be embedded and mainstreamed across curricula.

As well as "vertical integration" (students working together across levels of study), the Strathclyde programme further offered "horizontal integration", whereby students from different disciplines could collaborate on these projects. In 2015, in response to Agenda 2030, the programme aligned with the SDGs to form VIP4SD; where each VIP4SD project must address targets of one primary SDG (though they inevitably address the targets of additional SDGs). For example, the Energy for Development project – one of the Strathclyde programme's founding VIP4SD projects – addresses SDG 7 (Affordable and Clean Energy) and involves students from Electronic and Electrical Engineering developing sustainable off-grid solar energy solutions alongside students from Computer and Information Sciences in the Science faculty and students in the Strathclyde Business School. Student teams engage with researchers and communities in India, Malawi and The Gambia to elicit and empathise with user needs to inform design solutions and their research direction, and to deliver practical off-grid systems that have successfully increased access rates across village clusters. The project has completed 12 solar PV installations in remote schools and in nursing colleges in The Gambia and India respectively. Another example involves Politics and International Relations students working on the "Can Democracy Deliver?" VIP4SD project, through which they analyse data from the Afrobarometer to examine the linkages between the quality of democracy, citizenship, service delivery, and quality of life in countries across the continent. The project primarily addresses SDG 16 (Peace, Justice, and Strong Institutions) as well as a number of secondary goals. A third example is Drug Discovery, a collaborative project between students from Engineering and the Strathclyde Institute of Pharmacy and Biomedical Sciences. The project involves student teams using hyper-spectral imaging to identify new antibiotics, addressing SDG 3 (Good Health and Wellbeing). For the academic year 2020/21, there were a total of 21 VIP4SD projects involving a total of around 150 students of varying degree disciplines from across all four Faculties at Strathclyde, many of whom worked collaboratively. The VIP4SD programme largely engages students from year 2 and 3, with most students coming from Engineering disciplines; mainly due to the programme originating as an Engineering-specific programme; however, following the mainstreaming of the programme over the last 2 years and its subsequent framing as a platform to support interdisciplinary, SDG-related project opportunities for students there is increasing uptake from non-engineering faculties.

The initial rationale for the VIP programme was to create a new opportunity for students to engage in practical work and enhance their research skills. Now, the VIP4SD operates as a vehicle for inquiry or research-based ESD and seeks to develop students' ESD skills and competencies, whilst enabling them to tackle the SDGs through their subject-specific learning. The SDGs present a framework of "wicked problems" (Rittel & Webber, 1973) that form a basis for embedding research-based education for sustainable development (RBESD) in HE curricula. Bringing these student-centred research projects under the same programme goes beyond facilitating the administration of the programme and established a common sense of purpose and community amongst the participating students; one that acts as a potent incentive for students to develop a deeper understanding of difficult subject matters (Strachan *et al*., 2019). Healey and Jenkins made the distinction between research-based education and other methods, including research-led education, as the extent to which students were encouraged to become "knowledge producers" as

opposed to "consumers" in tackling real-world problems, and the VIP4SD approach seeks to move students over this tipping point from one category into the other (Healey & Jenkins, 2019). VIP4SD presents an RBESD approach to collaborative working and high-impact learning between staff and students, and a mechanism for embedding this in undergraduate curricula that not only seeks to develops the students' world-view, life experience, skills and competencies, but also tangibly and positively impact the target communities and stakeholders their research centres on and services.

While VIP4SD "teaches" ESD, or exposes students to the sustainable development agenda through focused SDG-related research projects, the University-wide **Multidisciplinary Perspectives of Sustainable Development module** allows students to take a broad view of the issue from the first year of their degree. The module was designed specifically to engage and enthuse students about sustainable development early on in their studies (although it is available to students at all levels) and to help them see the role that they can play in their respective disciplines in realising the aims of sustainable development. The module was developed in response to a Joint Board of Moderators call to embed climate emergency and sustainable development in teaching from the outset of students' University education. Additionally, research from the NUS Sustainability Skills Survey indicates that 83% of students would like to see ESD more actively incorporated in their teaching.

The Multidisciplinary Perspectives of Sustainable Development module includes both a multidisciplinary range of tutors from across Strathclyde, together with industry and practitioner guest perspectives to showcase the range of pathways available to students interested in working in sustainable development after graduation. The aim was to create a module on sustainability which would give wider access to the subject for all students studying at Strathclyde, whilst supporting cross pollination of skills development by bringing together different disciplines. The module was implemented online to avoid timetable clashes and also delivered twice per year (in the first and second semesters) to provide maximum flexibility for students. Students are arranged into multidisciplinary groups so that they can start to understand the complexities of the SDGs and to learn through practice how only working together can we find solutions.

The Social Responsibility Pathway is available to year 3 students on the Strathclyde Business School's Management Development Programme and builds on this aim by giving students experiential learning opportunities related to sustainable development, with a particular focus on local initiatives. Students develop graduate employability skills in real-world contexts and are required to demonstrate knowledge of a specific area of disadvantage, with an understanding of how this relates more widely to socio-economic, educational and public policy contexts. The Social Responsibility Pathway therefore responds to the need to give students discipline-specific learning while also developing the skills associated with ESD.

The Infrastructure and Environment module is the first of two modules from Strathclyde's Civil and Environmental Engineering (CEE) department presented in this paper. This module, open to students from all disciplines and levels (thus far largely taken by students from Engineering and Science programmes), introduces sustainable development and the SDGs in the context of multiple disciplines and dimensions. The module begins by focusing on the SDGs – specifically SDG 13 (Climate Action), SDG 6 (Clean Water and Sanitation), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities) and how they link with the other Goals – before moving to examine sustainability in practice by exploring insights from case study projects and developments shared by industry and third sector practitioners. The class is designed to support key competencies for sustainable development early in the curriculum, in order to challenge common assumptions around sustainable development and to inspire students to see a role for them in tackling global challenges.

The Engineering for Global Development module is the second CEE module and is a project-based year 3 class that involves students working in small groups to design context-appropriate solutions to design areas outlined by EWB their Engineering for People Design Challenge. The module supports students to gain the discipline-specific knowledge required for an accredited degree while ensuring they understand and appreciate the social, economic, and environmental implications of engineering decisions at a local and global level, and thus the importance of globally responsible and sustainable engineering development. In this way, since the Engineering for People Design Challenge launched in 2011, EWB has been supporting ESD objectives amongst the 30+ HEIs that now participate in the Challenge, centred around a particular common structure. Each year EWB partner with a community to develop a detailed design brief for the students (acting as a proxy for initial stakeholder engagement), provide competition launch materials for each HEI, manage an interactive forum where community representatives can respond to student enquiries, and run the resulting competition. In recent years to further support the HE staff involved in running the Design Challenge, EWB have also developed a problem-based learning toolkit with suggested activities that align to the design process and aim to develop key insights that will support their progress in the Design Challenge task. Strathclyde has developed a training partnership with EWB to develop tailored staff training and guidance for incorporating ESD-based Problem-based Learning (PBL) in their curriculum – and, critically, this is being designed as guidance for all disciplines, not only Engineering. There is also a forum and events to build community amongst HE staff.

It is important to note that each of these options can carry different credit weightings to ensure there is flexibility to accommodate them as complete modules in degree programmes already congested with credits and offering limited space for additional modules, often in the form of electives.

Modes of learning and skills and competency development

Each of the initiatives outlined take different approaches to ESD. VIP4SD uses inquiry-based learning, Engineering for Global Development requires students to engage with

problem-based learning, the Social Responsibility Pathway has a strong experiential element and Multidisciplinary Perspectives of Sustainable Development involves blended and jigsaw learning (Aronson & Bridgeman, 1979). Each of these student-centred approaches further encourage co-curricular activities to develop impact (for example, VIP4SD is linked with the Gambia Solar Project, and the Social Responsibility Pathway involve fundraising with local charities and organisations). They encourage varied forms of engagement with communities, stakeholders, and across disciplines. These varied modes of learning and engagement necessarily lead to different sets of learning outcomes in each, particularly in relation to skills development.

ESD can enable students to develop key competencies associated with sustainability. However, a consistent, institution-wide approach to competency definition, development and evaluation – where staff and students are clear on what competencies are to be developed (and how these are defined), why these competencies are considered, how they may be developed and measured – has proved challenging. More entrenched approaches to module assessment tend to focus primarily on assessment of students' subject learning (perhaps with some modest, formative portion set aside for self-reflection) rather than placing any significant focus on the development of the meta-competencies applied in their learning.

The focus on subject learning and assessment is also responsible for focusing students' attention on the credit bearing content and away from self or group (360) reflections on competencies and skills development. As such, buy-in to competency development and evaluation from students should not be presumed. ESD is fertile ground for contextualising subject-learning in terms of the better understood and more prescient real-world challenges that will set 21st century business and industrial strategy, and so it offers an opportunity for educators to frame and promote competency development as a critical graduate attribute.

Graduates will need to be equipped with a set of 21st century competencies that are universally understood and agreed upon by educators, students, employers and employees as those required to develop and implement such sustainable business strategies. And so a shift in focus by staff and students towards competency development and, critically, competency articulation (i.e. understanding and evidencing how, when and where these competencies have been and can be developed in order to understand gaps and opportunities for further and future development) is essential to developing the types of graduates, employees, business leaders, innovators and global citizens required to achieve sustainable development globally. Making students aware of these career opportunities and engaging employers and accreditation bodies in the development, approval and inclusion of such competency frameworks in curricula is essential.

Despite the need for a consistent competency evaluation framework, there is still some debate in relation to how competencies are defined and articulated, how they are prioritised and how they are distinguished from skills associated with other pedagogies and fields, as outlined by Wiek *et al*. (2011) in their previously mentioned paper which marked a key intervention in the identification of conceptually-robust, interlinking, ESD competencies. The five key competencies they identify are Systems Thinking, Anticipatory Competence, Strategic Thinking, Interpersonal Competence and Normative Competence, and their interlinked model of sustainability competencies resists what they call 'laundry lists' which lack clear selection criteria. For example, they highlight the relationship between Systems Thinking and Anticipatory Competencies when they note that 'an intimate understanding of the inner fabric and dynamics of complex social-ecological systems is a prerequisite for identifying intervention points, anticipating future trajectories and staging transition processes.' They further emphasise the need to enable students to not only develop these individual competencies, but to 'combine these competencies in a meaningful and effective way.' However, the ways in which we can evaluate and evidence competency development, particularly competency development within credit-bearing and assessed programmes of study, remain challenging. Others have since added to Wiek *et al*'s competency framework, most notably UNESCO, which is the framework Strathclyde's programmes most prominently align with. UNESCO's eight cross-cutting competencies for sustainability are Systems Thinking, Anticipatory Competence, Normative Competence, Strategic Thinking, Collaboration, Critical Thinking, Self-awareness, and Integrated Problem-solving.

The Multidisciplinary Perspectives of Sustainable Development elective module was developed using the UNESCO framework for skills development, and participating students are expected to develop the eight skills and competencies outlined. They are expected to demonstrate a critical understanding of the SDG agenda, and the role their respective disciplines can play in advancing this, and how it interacts with others. The decision was made to frame the module around a reduced set of SDGs to allow students to take a deeper dive into them, and so this module focused on four specific SDGs where researchers and academics across various faculties were particularly active and could support the development of material. This material was primarily based on their own disciplinary expertise and experience of conducting research aimed at advancing the SDGs, specifically Good Health and Wellbeing (SDG 3), Clean Water and Sanitation (SDG 6), Reduced Inequalities (SDG 10), and Climate Action (SDG 13).

Key to the learning outcomes of the module is that students gain an understanding of how the SDGs can be addressed in the context of other disciplines as well as their own, and opportunities for interaction between them. This is further enabled by collaborative group working with students from other disciplines, therefore enabling the development of both self-awareness and collaborative competencies. Group activity is present throughout the module, reflecting the understanding that multidisciplinary perspectives are needed to tackle complex global challenges. Through multidisciplinary group work on this module, students are expected to problem-solve and

action plan across disciplines, be sensitive to competing viewpoints, and gain self-awareness. The group assessment output of this collaboration is an educational resource focusing on a chosen aspect of sustainable development.

All students who have responded to the evaluation survey for this module have indicated an increase in their understanding/knowledge of sustainable development and the role of interdisciplinary collaboration (including those who felt they had a good understanding in the first place). A number of staff members from across the institution were involved in creating video clips for the module itself, while others were involved in the delivery of the module in their role as group tutors. An aim of the module had also been to encourage multidisciplinary collaboration with staff, but this has not yet materialised – although the module is only in its second year of running. However, the process of developing the module was a smooth and successful collaboration involving around 30 staff members from across the University. Institutionally the module has given a focus on sustainability and has been welcomed due to its unique design as the only module to be delivered with contributions from all four faculties and professional services, and currently the only module on offer to Strathclyde students at all levels.

When creating the module, weekly planners to ensure all contributors kept to schedule were vital. At the start of the module students are introduced to the SDGs through a conversation with a colleague from the third sector. The idea here was to link activity being undertaken at Strathclyde to address SDG challenges to a wider global view. This worked well, and though it had been planned to have more external input, time constraints meant this was not possible; this is a feature that will be added in future years. The use of specially created video content as well as open access web content such as articles and Ted Talks worked well and encouraged students to recognise how their discipline can contribute to solving these complex problems. Another objective was to stimulate activism and provide a platform that encouraged students to be empathetic when forming opinions that can be critical of the SDGs or approaches to achieving them. The module was designed to encourage students to make changes to their lifestyles, think about influencing others to do so, and to remain engaged with ESD by participating in one of the other action-oriented modules or programmes outlined (for example, VIP4SD). Offering a range of education provisions, developed and delivered in different ways, offers a graduated approach to developing activism in our students. They start out as novices, progress to activists, and have the potential to become educators themselves. In this sense, they grow from knowledge consumers to knowledge conveyers, and even producers. The assessment of the module is based on the creation of an educational resource. This has worked well in general, with students using their creativity to produce podcasts and games. However, some student groups struggled with the open-endedness of this assignment, and clearer guidelines are being created to support them.

The Infrastructure and Environment module is another introductory and theory-based module that takes a multidisciplinary approach, though one more focused towards Engineering and Science disciplines. The module is structured around short talks or perspectives (lecture-style) interspersed with workshop-style group tasks designed to develop student engagement and understanding around a particular concept, topic or skill (and, in doing so, develop a range of key competencies, including anticipatory, interpersonal and normative competencies). The workshops use a range of facilitation approaches and techniques to support collective working and to capture group outputs, and many are designed to be dialogic, and so aim to support thinking from different perspectives and drive empathy. Other workshop themes require students to reflect upon their own values, attitudes and behaviours in relation to sustainable development, the relevance and interrelationships of the SDGs, and to support critique of what sustainability looks like in practice. Further, the workshops support student collaboration and enhance satisfaction by helping students develop a peer network, which is crucial to a successful learning experience. Each week the class includes perspectives from an industry specialist or practitioner, and time is always allocated for class-wide discussion about career steps, skills, personal experiences, as well as opportunities and challenges for sustainable development for the sector, and advice that they give to support students aspiring to drive positive change. Some of the contributors are recent graduates. This aspect of the class aims to establish a foundation for personal activism, as well as to drive deeper appreciation of the value of skills or key competencies for sustainable development.

At the end of the module, students are expected to be able to define the principles of sustainable development, describe the SDGs, and appraise sustainability principles in practice. They are also expected to have developed or advanced particular key competencies required to address sustainable development challenges. To support these learning objectives, the module employs a mix of individual and group assessments. The former includes a reflective diary assignment to be updated after each week, where students can also share open access web content. Interim feedback on the diaries is provided to support reflective thinking skills development, and there was demonstrable improvement in this task over the course of the semester. However, it should be noted that the initial primary driver for the reflective diary was to support continued student engagement over the course of the class. With retrospect, it also provides useful feedback on what aspects the students engage with most across the module and assignments and aids the development of students' reflective thinking skills. In fact, many students share resources in their diaries and so there is potential to use the assignment for students to convey knowledge to each other – and with course tutors. In addition, a common observation is that initially the students only reflect on what is shared in the lecture-style content each week, indicating the need for more groundwork around different forms of learning, and what learning comprises. For the group assignment, students must prepare a policy brief centred around an SDG of their choosing. The brief aims to make the case for (and critique) the role of engineering in tackling sustainable development. As well as supporting group working and the development of presentation and communication skills, the students must evidence the ability to critique a project or

policy's sustainability objectives and the interconnectedness of the SDGs. In addition, students have a degree of choice over the topics of their assessment, allowing them to explore their own interests. There is a peer-assessment element to the group working also.

The project and research-based experiential learning that underpins VIP4SD, the Social Responsibility Pathway, and Engineering for Global Development presents further opportunities for skills development. **The Vertically Integrated Projects for Sustainable Development (VIP4SD) programme** consists of a portfolio of undergraduate research projects, where each individual project has its own set of learning outcomes. For example, students participating in Smart Voice gain the technical programming skills involved in app development through their project, which comprises students from Electronic and Electrical Engineering, Computer and Information Sciences, and Speech and Language Therapy. Additionally, given the 'Good Health and Wellbeing' (SDG 3) focus of the project – to develop an app that can detect Recurrent Respiratory Papillomatosis (RRP) through vocalisations, rather than the invasive testing currently required - students must also demonstrate how their project aligns with and advances the targets of SDG3. Comparatively, the Primary Education students participating in the STEM Education and Public Engagement project work with schoolchildren in socially deprived areas of Glasgow with low levels of young people participating in HE, and must demonstrate their ability to make STEM learning interesting and accessible to a wide audience (SDG 4: Quality Education).

The majority of projects operate over two semesters in one academic year, and students have the opportunity to continue developing their work on the projects over a number of academic years, offering a longevity associated with project work not usually available to undergraduates. Additionally, internships aligned with these programmes offer further continuity in project output and progress, and student skills development, out with teaching semesters. From a student perspective, this long-term investment enables them to develop their research skills and ESD competencies over a sustained period; and from a project perspective, this brings a level of continuity and succession planning that enables more ambitious, longer-term research and project objectives to be set and achieved. The assessment of VIP4SD students varies between projects due to the wide range of disciplines represented. The most common forms of assessment are written reports which include background research, methodologies employed, findings and recommendations associated with research, but also reflections on the project and the students' own performance and skills development.

The Social Responsibility Pathway similarly engages students in experiential learning by enabling them to undertake placements with local initiatives and external organisations with a positive social dimension. Since 2014-15, 1,158 students have participated on the pathway. They have worked with 24 external organisations and charities; tackling issues such as poverty, homelessness and support for the newly-arrived refugee community; and, with pupils from 62 secondary schools from 13 local authorities, contributing thousands of hours to access and outreach projects, including tutoring care-experienced young people and mentoring young people with learning disabilities on the Breaking Barriers programme. Students also have the opportunity to design and manage an event for pupils interested in studying in the Strathclyde Business School, mentor school pupils through a sustainability innovation challenge and work as classroom assistants in primary schools in disadvantaged areas. Social Responsibility students also work on various projects with the Sustainable Strathclyde team, including running the Sustainable Strathclyde Student Society and the Strathclyde Christmas Toy Appeal. The programme aims to develop students' employability and interpersonal skills, principally their communication skills and confidence, as well as leadership, organisation, teamworking and time management skills through collaborative working. In the past academic year, students have been further required to reflect on the relevance of the SDGs to their social responsibility work as part of their two written assignments. This is an example of how existing programmes can be realigned with the SDGs, and how the SDG framework can be used to bring (or reinforce) a social, economic, environmental and/or global perspective to a module or programme.

Engineering for Global Development engages students with the EWB Engineering for People Design challenge, which is explicitly orientated towards human-centred design and problem-based learning. As such, students are enabled to develop a number of ESD-related skills. They are engaged most obviously in integrated problem-solving through project work that tasks them with developing viable, inclusive and equitable solutions to complex, real-world problems. These solutions must also promote sustainable development, and so students are challenged to understand and evaluate the linkages between different design areas and sustainability objectives, as well as following the precautionary principle of understanding any potential harm they might cause through the effects of unconscious bias on their design decisions. This enhances their systems thinking competency, and is a key aspect of the learning outcomes, as is questioning their own assumptions, and the influence of their cultural, social, political and economic backgrounds on their own behaviour. Their critical thinking, normative and self-awareness competencies are therefore key to the success of their project, rather than being a secondary learning outcome. The collaborative aspect of the project presents further opportunity for skills development and overcoming challenges. The module is assessed entirely through group work, which includes two group presentations and a design report. The two presentations at the intermediate and final stages of the project allow students to gain feedback from tutors and peers and improve their presentation skills, and the design report further involves both peer review and peer assessment. The peer assessment element is in part to understand how the group worked together but also is designed to invite student refection on different roles in group working. We found that anonymity is important in the peer review element (without it, students find it challenging to be critical, even constructively)

and that students find it valuable to receive feedback on the peer assessment that they provide. These findings were not expected, and so this has been a process of learn-by-doing and co-creation through engagement with class participants to find out what works well and less well for the class.

Practicalities, challenges and connections – the 'nuts and bolts'

Each of these programmes require innovative teaching methods, and the practicalities of running them can be challenging, particularly when asking educators to systemically embrace new environments, subject matters, ways of thinking and teaching practice that remove them from the comfort zone of more conventional and entrenched approaches.

Staff resource, buy-in and support

One of the main challenges associated with embedding ESD in curricular is the staff time necessary to develop, implement, administrate, and maintain these programmes – often in ways that are less familiar to them. This can present a significant barrier to uptake beyond the "coalition of the willing", which is undoubtedly key and useful in overcoming inertia, building momentum and proving the concept. However, this is ultimately an unsustainable resource planning strategy, where constant recruitment and retention of teaching staff for such programmes on this voluntary basis for the long-term is simply not practicable or feasible. This highlights the importance of ensuring staff involvement in such programmes is acknowledged in workload models, development plans and training offerings, annual reviews, and promotion criteria. Installing all of these measures works towards the building and fostering of a culture of confidence within and amongst teaching staff, where they feel empowered and incentivised to innovate and engage with staff and students from outside their own departments.

In addition to supporting staff time, there is also the issue of attracting buy-in and the commitment of academic staff in the first place, which requires appropriate support and training for both teaching and professional services. Rather than asking staff to develop new ESD programmes and modules, appropriate training can empower educators to identify connections to sustainable development in their existing syllabi and draw out these themes to make ESD a more deliberate and integral aspect of their teaching - in practice this may entail a slight pivot, or substituting content or case studies to re-contextualise aspects of the syllabus around particular SDGs. It is important to offer a range of training offerings around Sustainable Development and ESD. At Strathclyde we are developing a portfolio of different offerings for staff, relevant to different stages of their ESD integration journey. Formal staff development courses, coordinated and promoted through our Organisational and Staff Development Unit (OSDU), will offer staff graduated levels of training around Sustainable Development more generally. This will range from awareness raising to identifying opportunities for integration within research, teaching and knowledge exchange, to providing more focused and practical 'how to' guidance on approaches to integrate SD in research, education and knowledge exchange. Other offerings will encourage staff to share experiences and practices through purposely short knowledge exchange sessions, as part of our "ESD, Me and a Cup of Tea" seminar programme. Here, the inviting title is deliberately intended to attract staff contributors to share their examples of practice in embedding ESD in their teaching with their peers in a 'safe and non-judgemental space'.

Another formal training programme we have established is in conjunction with EWB, who, despite their obvious association with the engineering discipline, are keen advocates of interdisciplinary collaboration in ESD, particularly through PBL. Strathclyde are partnering with EWB to co-create a cross-faculty training programme to support staff embed interdisciplinary PBL, related to the SDGS, in their curriculum. To operate these programmes effectively requires the investment of staff time in training (time to develop and deliver material as well as undertake training), and the development and integration of new content, or the re-thinking and re-working of existing content. Where programmes require cross-faculty and inter-faculty academic and professional services support to deliver them, it is necessary to ensure faculty buy-in to ensure a sustainable and scalable model of programme design and delivery. In the case of VIP4SD, this was achieved by demonstrating to academics and researchers, the benefit in utilising undergraduate research teams as an additional research resource, and the opportunities for these projects to nurture and develop undergraduate students to become potential PhD candidates.

Engagement with external stakeholders and third parties (with high quality content) can also alleviate pressures on internal resources, although often sourcing panellists or contributors from outside the institution often still relies primarily on goodwill and still requires careful planning.

The Social Responsibility Pathway relies on staff to foster effective working relationships with external organisations in order to design, implement and run 'in-house' initiatives such as tutoring and mentoring programmes, in addition to the staff time needed to oversee student work and support their placements. While Engineering for Global Development benefits from the ready-prepared nature of the Engineers without Borders Engineering for People Design Challenge, the class organiser needs to be reflexive to actively respond to the needs and progress of different groups and individuals. Similarly, for the Infrastructure & Environment module, the class organiser works closely with guest contributors to design activities and content that support the learning objectives, but is careful to ensure this is not simply a 'wheeling in and wheeling out' of external speakers by following an engaged, dialogic workshop approach.

What is clear is that a firm resource commitment is essential when moving from pilot to mainstreaming and that "resourcing reaps rewards". Both the VIP4SD programme and Multidisciplinary Perspectives of Sustainable Development module aim to attract more students, which requires more awareness of both as well as the space in curricula for these options.

They additionally require further and ongoing resources to scale and continually evaluate these programmes, as well as to administer growing numbers of students and staff involved in each. The VIP4SD programme is one example of an ESD initiative that has received staff investment in the form the appointment of a dedicated Programme Coordinator, which has seen demonstrable scale-up and further programme development in return, with the number of active projects rising from 8 to 12 in the first year since the appointment, and from 12 to 21 in the second.

As ESD becomes more integrated and mainstream, we also hope to see modules and programmes more directly feeding into one another, offering ESD pathways; for example, students joining a VIP4SD project following their involvement in another one semester ESD module. However, there are challenges around curriculum design to accommodate interdisciplinary, multi-level, project-based and vertically integrated learning, which will have to be overcome and which have been discussed previously.

Interdisciplinary collaboration

Global collaboration in every sense will be key to achieving climate change adaptation and mitigation in a way that is socio-economically progressive. At the heart of this collaboration is equality and inclusion, leading to greater diversity, which ultimately serves to enhance this global effort.

This is well-acknowledged in SDG 17 – "Partnership for the Goals" – where just like the married couple that sits atop the (Stockholm Resilience Centre's) 'wedding cake', it symbolises a union or collaborative partnership that is vital to achieving each and all of these goals. It is unfathomable to imagine successfully meeting any of the SDG targets without this. Given this, it would seem manifestly obvious that collaboration, and in particular, interdisciplinary collaboration (and the associated competencies and skills required for this) should be front and centre of how students engage with ESD.

It is for this reason that ESD programmes should, wherever possible, offer a platform for interdisciplinary engagement and collaboration between staff and students, of different disciplines, and with a wide range of stakeholders. However, the main issues and barriers within universities in enabling such engagement often lie in the administration and coordination of such programme across faculties with different course accreditation processes and criteria, timetables, curriculum structures, elective constraints, finance and resource allocation, assessment approaches, and perhaps even cultures of teaching and learning. However, without careful attention, there is potential for these aspects of course administration and management, partitioned institutional structures and entrenched faculty or departmental teaching approaches can inhibit interdisciplinary curriculum design collaboration involving academics and, critically, students.

Some HEIs have consciously broken away from the confines that institutional structures can impose on curricula, and have instead sought to develop institutional structures specifically designed to proactively enable interdisciplinary curriculum design and delivery (as well as research collaboration). For example, Olin College in the US is an example of such innovation; building its interdisciplinary curriculum around the "Olin Triangle", which includes studies in Science and Engineering, Business and Entrepreneurship, and Arts/Humanities and Social Sciences (Brennan *et al.*, 2014). Their strategy is based on the design of an innovative curriculum based on the principles of interdisciplinary, project-based and hands-on learning, offering a more flexible and objective-oriented faculty. Just as Healey and Jenkins and Strathclyde's VIP4SD programme have made clear the importance of the objective of research-based education in transforming students from knowledge consumers to providers, so too does Olin in its strategic aim of using its purposely designed interdisciplinary curriculum involving innovative approaches in project-based delivery, which enables students to actively "construct" knowledge rather than having it passively "delivered" to them. However, for most HEIs the challenge is a practical one of how to add this interdisciplinary dimension to well-established and accredited degree curricula that has been predominantly (and in some cases exclusively) mono-disciplinary, and to varying extents constrained by long-standing institutional structures.

However, breaking down disciplinary silos and introducing new ways of teaching can require significant resources, particularly in relation to staff time. For example, Multidisciplinary Perspectives of Sustainable Development module and VIP4SD programme require expertise from professional services and staff from across all faculties. Similarly, the Social Responsibility Pathway relies upon external stakeholder collaboration and engagement. Making the opportunity available for this engagement has been challenging, but there has been a strong will across our University to achieve this (Strachan *et al.*, 2019). However, providing the opportunity for this is not enough; more can and is being done to foster the interdisciplinary culture that will encourage deeper and fuller engagement between staff and students. The needs for ESD programmes, pathways and modules to integrate collaborative aspects of teaching and learning that break out of traditional teaching silos, and the benefits this offers is clear; however, achieving this is not straightforward as has been discussed, but this paper would argue that it is a feature that should always be actively considered and included wherever possible when seeking to integrate ESD in curricula.

Crowded curricula

Another significant barrier to embedding ESD is finding space in curricula for these options; and in relation to the previous section, this challenge can amplify when embedding the same ESD offering across different degree curricula to incorporate some feature of interdisciplinary working. The VIP4SD programme is particularly affected by this. The programme is currently accessible to students in 11 departments, but the ambition is that it will eventually be available to all. This requires not only staff members in all departments implementing their own VIP4SD projects, but also making room for an

elective in curricula across different year groups. Accreditation requirements for certain degrees mean that often it is challenging to create space for an elective in some degree programmes. This has also been a key challenge that the VIP4SD programme has had to address to facilitate the collaboration of students from different year groups, degrees, departments and faculties (Strachan *et al*., 2019).

Strategic whole systems approach

The university's Vision 2025 Strategic Plan includes the intention to embed ESD and the SDGs across curricula as well as ambitious climate targets. This includes plans to ensure an institution-wide approach to sustainable development. For example, the university has developed a vision of Climate Neutral Districts in order to ensure that all operational research and teaching facilities are able to mitigate and adapt to climate issues. This 'whole-systems' approach brings together a range of measures and interventions that make use of natural and physical resources to enable a large-scale transition to a more sustainable and climate-ready built environment. One of the projects involves the Glasgow City Innovation District in the city centre which the University is aiming to make a 'climate neutral' area of entrepreneurial innovation and investment. The project aims to integrate heat, power, transport, climate adaptation and wellbeing solutions that will benefit citizens, businesses and organisations in the Innovation District. This sits alongside existing efforts to deliver a sustainable campus and create pedestrian-first and healthy greenspace at the heart of the University.

The Climate Neutral Districts Vision and scope was created and is led by the University's team of environment professionals in Sustainable Strathclyde, who are responsible for developing and delivering on the university's climate change and social responsibility operational action plan which involves Strathclyde achieving Net Zero by 2040 or sooner, and with milestone reduction of 70% by 2025 and 80% by 2030. The team works with colleagues across the university and with city and region stakeholders to implement sustainability initiatives in line with the university's Climate Change and Social Responsibility (CCSR) Policy.

The Climate Neutral Districts Vision work crucially draws on the expertise of our students. In 2021, 16 sustainability projects related to the Districts Vision and to the University's CCSR Plan undertaken by post-graduate research students. As such, they enable students to bring forward innovative ideas and concepts taken from their learning and apply them to real life problems. The students reflect on their learning and the challenges that they faced when responding to the projects they are working on.

While much of the work being done is at an early stage, there is already an emerging pipeline of learning and teaching opportunity, with the envisioned Climate Neutral District operating effectively as a 'living lab' that can be configured to provide physical and digital connections for our students and staff. Examples of this work include undergraduate architecture students who are taking part in a design competition to visualise what a climate neutral district will look like as part of a COP26 engagement initiative, and a postgraduate student who has identified one mine water (MW) heat potential associated with a potential mine water heat project local to the university premises which could help to decarbonise the premises as well as potentially provide heat to the nearby local community.

The whole-systems approach involves ensuring that there is alignment (as much as possible) between the university's estate or operations, teaching, learning and research, and that these strands become mutually reinforcing in advancing the university's broad sustainability agenda and strategic vision.

Final reflections on lessons learned

With reference to the ESD modules and programmes outlined in this paper, coordinators found that it was important to ensure colleagues and external contributors involved were provided with firm deadlines and clear instructions on how to support associated teaching activity. The value of developing content and materials steadily year on year and allowing students (and their insights) to contribute to this by eliciting regular feedback. In other instances, tapping into established and well-developed resources for students and also staff training and support, e.g. EWB's Engineering for People Design Challenge, is a practical and efficient means of integrating ESD within curricula – if the space can be found.

Lessons were learned also in relation to students, the support they need, and our expectations of their outputs. Many of the initiatives discussed involve group working across disciplines and levels of study, as well as research-based and experiential learning. These are often students' first experience with these kinds of teaching and learning (and in many cases for staff), and so they need support to work effectively and confidently in new settings. This an area for improvement identified within the VIP4SD programme. While it can be sensible and advisable for students to delegate work and tasks along disciplinary lines, this can sometimes create partitions between students that can disrupt the broad team dynamic; working to inhibit interdisciplinary collaboration. To support more integrated and meaningful cross-disciplinary collaboration, interdisciplinary workshops will be introduced to encourage students to understand different disciplinary perspectives and intersections with respect to their common research objectives and targeted SDG(s), which will allow students to foster better working relationships through team-building exercises before they begin developing their projects. In addition, a standardised and collective approach to assessment (as an interdisciplinary group rather than along disciplinary lines) will be introduced to incentivise and improve task and team integration, and foster a more 'collaborative interdisciplinary' group dynamic, and better develop this competency, while also emphasising the value and crucial importance of interdisciplinary working in advancing global sustainable development.

Prior to the enforced pivot to virtual teaching delivery resulting from the global pandemic, some had already argued that disruptive innovation (Maloney, 2020) presented a risk

for HE with the increase of 'purpose-built' online universities, and so it was already becoming increasingly important for 'brick and mortar' Universities to distinguish themselves as the better option for more blended, tangible, transformative, experiential learning experiences. Therefore, the integration of collaborative interdisciplinary modules and programmes framed around the types of real-world challenges set out in the SDGs can offer an ideal vehicle for exactly this kind of learning experience.

While Multidisciplinary Perspectives of Sustainable Development was already an online module pre-coronavirus disease 2019 (COVID-19) pandemic, the other modules and programmes discussed here had to quickly switch to online delivery in response. Alongside the move to Zoom and Microsoft Teams for virtual teaching, a number of online platforms complemented virtual student collaboration. Miro facilitated participatory learning and co-design sessions by allowing students to contribute ideas on a virtual flip chart, and Google Docs also streamlined co-working and editing. Padlet was further used to host a virtual poster session at our ESD student conference, with the ability to like and comment posters replicating the feedback and peer review elements of in-person presentations. While the 'buzz' of an in person poster session may have been missing, the session worked better online in some respects, with students and staff able to access the session for longer and so able to interact with more posters, adding more comments and responding to more questions.

Of course, the move to online learning was not simply a case of embracing new technology. We were additionally given the opportunity to test new pedagogical approaches. One such approach is being piloted by the VIP4SD programme is Collaborative Online International Learning (COIL) (Orsini-Jones *et al.*, 2017) and Virtual Experiential Intercultural Learning (VEIL). This is designed to provide a platform and channel through which participating students can develop their 'intercultural competency', which in addressing global challenges with global stakeholders and partners requires our students (now and after they graduate) to shift their cultural perspective and appropriately adapt behaviour to cultural differences and commonalities. The global network that is the International VIP Consortium – of which Strathclyde is a member – represents fertile ground for interdisciplinary and international research collaboration between undergraduate students working on wicked global research challenges. Here, students' intercultural competency is developed to improve engagement with their international research partners as well as the stakeholders and communities on which their research centres. 'Matchmaking' sessions and tools are currently under discussion to facilitate COIL and VEIL activity across the VIP consortium.

While the global dimension is an inherent feature of sustainable development, we found it was important to make global sustainability applicable in a more local context too. The 'othering' of sustainable development and ESD which only considers communities in the Global South has the potential to reinforce negative stereotypes. Engineering for Global Development and the VIP4SD programme in particular have strove to combat this by encouraging social diversity across their project portfolios.

Another key lesson learned from the Social Responsibility Pathway is that it is important to remember that students are not yet professionals. As before, many will not have much experience of working in professional contexts and it is therefore crucial to provide not only professional conduct training, but to ensure that students are given well-structured work briefs and an appropriate level of challenge and responsibility. It is important that both academic staff and any external partners engaging with students maintain an understanding that students need an appropriate level of support, and are likely to find it difficult to engage proactively, or experience anxiety, if given too vague a brief or too much responsibility without enough guidance. There are also exceptional opportunities for the development of team-working and leadership skills, but students need clear structures and guidance on how to engage with these opportunities and reflect on their development. The pathway works with external partners to ensure that the briefs given to student are clear and challenging, but achievable. Students working in groups must complete planning forms, including the roles that each team member will undertake. In advance of this, they are asked to analyse the roles required within a team, and understand what makes teams function well and the qualities of effective leaders. In their final essays, they are asked to reflect on what aspects of their performance they feel went well and which could be improved upon. There is an emphasis here on the pathway being a developmental experience and that there is an expectation that there will be difficulties and challenges that will provide opportunities for learning. At the same time, there is a need to provide positive end results for all stakeholders with which the programme works and so it is necessary for programme coordinators to be vigilant and proactive in ensuring support is made available as required in order to achieve this.

The Social Responsibility Pathway is furthermore closely linked to Strathclyde's Widening Participation activities, and student accessibility is a key concern of the programme. It is therefore important that all participating students are given meaningful opportunities, especially where there are some areas of work that are popular and have competitive recruitment processes. This means providing greater support to students who need help developing, identifying and articulating their employability skills so that they do not miss out on opportunities and experiences that may be offered to students whose skills are more developed because of underlying privileges, in keeping with the SDGs' 'leave no one behind' principle. The pathway offers detailed professional conduct training and one-to-one individualised support to try to address such issues.

The importance of surfacing and collating diffuse ESD activity across the institution (i.e. mapping) is a key task for identifying the baseline on which further embedding and mainstreaming of ESD will build upon. This is necessary for measuring progress, identifying gaps and reporting internally

and externally. It can also be useful in identifying synergistic and complementary areas for connection and collaboration – as well as any duplication or opportunities for re-purposing of content. Several of these initiatives outlined here feed-in to one another, and an ESD working group has been established in order to promote ESD across curricula and establish appropriate support and training for staff, as well as to enable conversations across disciplines to make these connections. The group has also acknowledged the need to bring together not only staff working on ESD from across the institution, but students too. 2021 saw the first annual ESD@Strath student conference, where students from across the programmes and modules with embedded ESD discussed in this paper came together to showcase the work they had produced throughout the academic year in the form of posters and oral presentations, and share their experiences, findings, and outcomes. Now established, the ESD@Strath conference will provide a focal point in the academic year where staff and students can come together as an ESD community; one we hope will continue to grow each year as new ESD modules and programmes launch, and existing modules reorient towards and integrate ESD. The conference will continue to demonstrate, promote and connect ESD activity across the University and build a broad community of both staff and student activists.

Conclusion

This paper has aimed to show the wide range of approaches that can be taken when seeking to embed a cross-institutional ESD provision in HE curricula. The case studies presented feature prominently at Strathclyde, some having achieved external and international recognition for their innovative approach to embedding ESD and the outputs students have generated through participation in them. In total the programmes outlined in this paper reach approximately 800 students per year, raising their awareness of sustainable development and providing them a platform to combine their disciplinary knowledge and understanding with genuine sense of purpose and activism around the advancement of Agenda 2030.

We have identified the challenges and practicalities associated with the Strathclyde experience to date and suggested some solutions to common problems. That said, the modules and programmes discussed here are still in early stages, and we hope to continue to expand the integration of ESD across our curricula, and attract a broader range of disciplines into this work enabling the development of an interconnected and interdisciplinary portfolio of programmes and modules exhibiting meaningful ESD content.

However, by starting small, we have been able to identify a like-minded "coalition of the willing" who can act as champions, promoting ESD in their own departments and bringing additional interested staff on-board to raise awareness and build a broader community. This has also provided a proof of concept that demonstrated to our institution's executive team that ESD is a moral imperative that not only aligns with the University's socially progressive tradition and strategic vision, but can also be practically implemented across disciplines by applying a range of pedagogies and tools.

Data availability

No data are associated with this article.

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Open Peer Review

Current Peer Review Status: ? ?

Version 1

Reviewer Report 18 October 2021

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Dolors Cañabate
Teaching Innovation Network on Cooperative Learning, Institute of Sciences Education, University of Girona, Girona, Spain

Dear authors,

I understand your analysis but in my reading some questions have arisen:

1. I do consider that there should be a closed link between ESD competences and the instructional approaches. In that sense, I cannot establish, in your discussion, what are the critical pedagogical instructions that foster specific competences. I think that this a major issue which is not addressed in your manuscript. I know that the curricula may be 'closed' but we need to know, for the replicability of your study, what are the competences and instructions that are linked in every case. To me, a table that summarizes this question would help a lot in the reading.

2. I would suggest a critical revision of the strong questions for ESD in each case. It is clear that they address some of the main challenges driven in the Agenda 2030, but in order to avoid generalisations, could you provide with a comparative analysis of all the systems, to go from a more descriptive presentation to a more critical point of view?

3. And 3, the application of the SDGs is difficult in its nature, but how do you see the application of the curricula in 2030. Could you go on introducing more insights on the needed processes than in listing the contents of the curricula? Could you add the centered-processes on students that are needed?

Is the background of the case's history and progression described in sufficient detail?
Partly

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Is the work clearly and accurately presented and does it cite the current literature?

Yes

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Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

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Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Yes

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Yes

Are the conclusions drawn adequately supported by the results?
Partly

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Partly

Is the case presented with sufficient detail to be useful for teaching or other practitioners?
Partly

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Partly

Is the argument information presented in such a way that it can be understood by a non-academic audience?
Yes

Does the piece present solutions to actual real world challenges?
No

Is real-world evidence provided to support any conclusions made?
Yes

Could any solutions being offered be effectively implemented in practice?
Not applicable

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Education for Sustainale Development, Cooperative learning

I confirm that I have read this submission and believe that I have an appropriate level of

expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 05 October 2021

https://doi.org/10.21956/emeraldopenres.15393.r27749

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Douglas Bourn
Development Education Research Centre, Institute of Education, University College London, London, United Kingdom

This is an important article based on a case study of Strathclyde University's engagement with education for sustainable development. The 5 examples chosen are good ones but the discussion on each one of them is over descriptive and not sufficiently analytical. The could have all benefitted from demonstrating clearly the aims, methods and learning outcomes of each course. In places the description of these example reads like a report for internal use.
I thought within the article there is potential for a really interesting piece of work that can be particularly relevant to many universities who are engaging in developing more pedagogically based approaches to ESD.

Fundamentally however the article covers over as a rather confused piece of work both conceptually and in terms of analysis. What is not clear is exactly what is the article trying to address. If it is the different ways in which ESD can be reflected within university programmes and move from being about SD to for SD then there is something particularly distinctive that could be brought out within the article. But this would require a much tighter focus.

A second major problem with the article is the confusion between ESD and the SDGs. They are not the same thing. In places the article seems to be talking about ESD in terms of pedagogical approaches and then goes on to say where specific SDGs are covered in modules. The former ESD is about a distinctive pedagogy, SDGs are a series of internationally agreed goals and targets and their implementation is primarily a curriculum content question for universities.
The article also needs to take into consideration a much broader arrange of literature around ESD in higher education. For example there have been two may collective studies on these areas in recent years one, in the Routledge Handbook series and a recent one edited by Filho et.al and published by Elgar. Where the examples from Strathclyde relate to this broader literature would also be helpful.

So in answer to the specific questions there is in part answers but they need to be much more focused. Above all the article needs to be clear as to how it is defining ESD and sustainable development and what is seen as their relation to the SDGs. Higher education has engaged in many places within the SDGs but often in a tick box way. It seems as though Strathclyde is trying to do something much more than this.

Finally I felt that within the article there was a lot of unnecessary material e.g. about online learning which I do not think particularly relevant to main themes.

In terms of recommending revisions, I would suggest the authors consider the following:

- Be clearer as to its main aim and focus and concentrate on this
- Outline how it sees ESD and relationship to the SDGs
- From a review of relevant literature give rationale for focus of the article compared with other articles in this field. For example is the article implying value and importance of a more transformative approach to ESD
- Be much more specific when describing each module in relation to overall aims of the article
- Make some clear reflective statements on extent to which the examples at Strathclyde are suggesting more transformative approaches.

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Could any solutions being offered be effectively implemented in practice?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Research in education for sustainable development, global citizenship and global perspectives within education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.