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Sustainable Development Goals (SDGs): Assessing the contribution of Higher Education programmes

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Abstract:Universities are engines of societal transformation and can nurture future citizens and navigate them towards sustainability through their educational programmes. Here, we developed an assessment framework for educational institutions to evaluate the contribution of their educational programmes to sustainability, by reviewing the alignment of their intended learning outcomes, to the enabling conditions for a vision of sustainability based on the Sustainable Development Goals (SDGs). The tool is based on a systemic grouping of the SDGs into eight sustainability attributes, namely; *Safe Operating Space*, *Just Operating Space*, *Resilient Sustainable Behaviours*, *Alternative Economic Models*, *Health and Wellbeing*, *Collaboration, Diversity and Inclusion* and *Transparency and Governance*, and uses a word code developed specifically for each sustainability attribute to assess the coverage of the SDGs in masters programmes' learning outcomes. Multi-criteria analysis is then used to compare and rank programmes according to the alignment of their learning outcomes to the sustainability attributes, and their contribution to sustainability. The methodology was tested using data from eighteen masters programmes from one University on a range of subjects, and then applied to forty masters programmes from various UK and a few European Universities focusing on environment and sustainability. Findings demonstrate that even such courses face some important gaps related to health, wellbeing, diversity, inclusion, and collaboration amongst others, and reinforce the need for all universities to understand the contribution of their programmes to sustainability. The assessment tool developed here can help them evaluate how well the knowledge, skills, behaviours, and attitudes students are expected to develop through their programmes will equip them with the competences required for a sustainability vision based on the SDGs to emerge.

Keywords: Sustainable Development Goals (SDGs), assessment framework; learning outcomes; sustainability attributes; master's programmes

1. Introduction

The ongoing discourse about sustainability and the realisation of the 2030 Agenda of Sustainable Development Goals (SDGs) to ensure balance between economic growth, social equity and environmental protection, inclusively for developed and developing countries, leaving no one behind; gives Education central role in their achievement as a catalyst for transformational change [1]. Universities can play an important role in the realisation of the SDGs, as they have long been powerful drivers of global, national and local innovation, economic development, and societal wellbeing [2]. They play a critical role in helping shape new ways for educating global citizens and delivering knowledge and innovation into society. They can contribute to the SDGs through their learning and teaching activities; research; organisational governance; culture and operations; and external leadership [3], and are expected to actively engage in the process. For example, a new league table measuring their success in delivering the SDGs was introduced in 2019 (Times Higher

Education (THE) University Impact Rankings) and included metrics based on 11 of the SDGs, with institutions submitting data on as many or as few of those as they wish; having to report on SDG 17: Partnerships for the Goals, which was included in the overall table (THE, 2019).

It is education, however, out of what Universities can offer that has the greatest potential for contribution to sustainability, and this is reflected in Sustainable Development Goal 4, Quality Education. Higher education is mentioned in target 4.3 which aims to "By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university". Higher education also forms an important part of other goals related to poverty (SDG1); health and well-being (SDG3); gender equality (SDG5) governance; decent work and economic growth (SDG8); responsible consumption and production (SDG12); climate change (SDG13); and peace, justice and strong institutions (SDG16). The Education 2030 Framework for Action (FFA) necessitates reform of the Higher Education sector through international agreements that establish and regulate teaching and learning activities, so that they become aligned with Sustainable Development. Furthermore, this roadmap intends to leverage the power of digital tools, open educational resources and online learning to promote access, equity, quality and relevance. Target 4.7 explicitly mentions Education for Sustainable Development (ESD) as the kind of education that can empower learners with important knowledge, skills and attitudes to pursue sustainability [4].

While there is still debate if ESD should be offered as a stand-alone course or incorporated in all educational offerings, the number of University programmes that explicitly identify themselves and their graduates as representing the field of sustainability has increased globally [5], as well as the number of programmes that incorporate aspects of sustainability within an existing discipline [6]. For example in the US, higher education programmes explicitly focusing on sustainability increased to over 140 in 2012, from 1 in 2006 [7]. In the UK, 91% of university students would like to see Sustainable Development incorporated in their University, 70% agree that Sustainability should be incorporated in all courses and only 17% think that their University does a very good job related to SD [8]. A recent study also showed that the knowledge level of University students regarding the SDGs is low and that much more can be done by Universities to change this [9].

Although a number of Universities have employed effective pedagogies for ESD [10] and several have defined sustainability-related educational outcomes for their programmes [11], little work has been done to evaluate these initiatives; the state, curricular content and effectiveness of University offerings in sustainability. The most comprehensive sustainability curriculum assessments have been done for Australia, where authors [12–14] evaluated the required courses for that country's environmental programmes more generally, including nine programmes granting degrees in sustainability. There have also been reviews that considered the presence of sustainability concepts within specific disciplines in certain geographic areas, for example, engineering in Europe [15] and the built environment in Asia–Pacific [16]. Another review of curriculum contents of undergraduate and masters programmes related to sustainability, found great divergence in the content of those courses and also low degrees of integration between natural and social sciences [5]. Recent research shows indications that Universities are making progress towards integrating the SDGs into curricula, but that this is done in an ad-hoc way and application is not guaranteed mainly because of the broad focus and complexity of integrating the SDGs into teaching [17]. To deal with this complexity it is important to look at the contribution of university educational programmes to sustainability from a systems perspective.

Universities can be engines of societal transformation. They nurture the future leaders, professionals and citizens and can navigate them towards sustainability through their educational programmes. The role of Higher Education in the realisation of the SDGs is therefore its contribution to the transformational transition to sustainability. Sustainability is envisioned as a system state that our society is constantly trying to define and reach, guided by the SDGs and the contribution of education is, thus, to create the enabling conditions for this vision to emerge [18]. This will require defining the knowledge, skills, behaviours, and attitudes, collectively the competences that learners need to develop to realise such a state, and then the curricula, pedagogies, educator training

programmes and learning environments at the level of their educational offerings. While there are generic lists of competences related to educational programmes for sustainability, a more appropriate selection should be based on a localised vision of sustainability. Educational communities therefore, need to define collectively their own sustainability vision of the future in order to define the sustainability competences delivered by their programmes and to put in place the right pedagogies, curricula and assessments for their alignment to the enabling conditions for such vision to emerge [18]. Evaluating how aligned the programmes they offer are to sustainable development, allows Universities to understand the contribution of their educational offerings to achieving the SDGs in a more systemic way.

University programmes have *learning outcomes* that define what graduates should know and be able to do at the end of their studies. Clear intended learning outcomes are a key component of good programme and unit planning and assessment for students. The QAA UK Quality Code for Higher Education: Learning and teaching [19] gives clear guidance surrounding the purpose and design of learning outcomes: *Universities need to ensure that the intended learning outcomes of a programme are explicitly reflected in the intended learning outcomes of its constituent units, and that all learning and teaching activities and associated resources provide every student with an equal and effective opportunity to achieve these outcomes.* Understanding the alignment of a University programme's learning outcomes or the competences the learners need to develop, allows academic staff to find areas of sustainability that are over or under represented in the curriculum, map gaps and take decisions to improve them.

Here, therefore, we develop an assessment framework for educational institutions to evaluate the contribution of their educational programmes to sustainability, by reviewing their intended learning outcomes - unless programmes have already established the competences they target, in which case those can be used in the assessment. The framework takes a holistic and systemic approach based on the sustainability attributes required for the SDGs to realise, avoiding the perils of having to evaluate the integration of each SDG in the programmes' intended learning outcomes separately. Its application can generate empirical evidence on the effectiveness of university programmes and establish a strong argument regarding the potential of education as a tool for achieving the SDGs.

2. Materials and Methods

2.1. The assessment framework methodology

The assessment process is based on a systemic framework that uses the SDGs to develop a vision of a future sustainable society and the enabling conditions for such vision to emerge [18]. It evaluates the alignment of a programme's intended learning outcomes to these attributes as an indication of its contribution to sustainability. It allows even for assessing programmes that do not target sustainability directly, in case they deliver competences that contribute to the emergence of sustainability. The sustainability attributes are grouped as enabling conditions for a vision of sustainability related to the SDGs to emerge (Table 1). These eight groups have been constructed by grouping the SDGs into major systemic attributes and enabling conditions related to: **achieving the safe operating space** (refer to maintaining ecological integrity and not transgressing crucial planetary boundaries conditions); those related to **achieving the just operating space** (include the social foundation of justice, equity and equality for all, now and in the future (intergenerational dimension), under conditions empowering them to lead fulfilling lives), as well as **transparency and responsible governance**, **health and wellbeing**, **diversity and inclusion**, **resilient sustainable behaviours**, and **collaboration** (for partnerships needed between many actors of civic society that lead to innovation), as well as an **economic approach** that is not short-sighted, if to ensure that humanity operates within the safe and just space and thus to promote natural and human wellbeing [18].

Table 1. The sustainability attributes used for assessing the alignment of University programmes to sustainability.

Safe operating space SOS
Living well within planetary boundaries, with reference to the environmental processes that render the earth habitable by life such as: Biosphere integrity, Land-system change, Freshwater use, Biogeochemical flows, Ocean acidification, Atmospheric aerosol loading, Stratospheric ozone depletion, Climate change, novel entities (emerging processes).
Just operating place JOS
Inter and Intra generational equity with reference to the conditions that help humanity thrive now and in the future: social justice and equity, equality, human rights, peace and non-violence and active participation in social life. Social systems that allow people to live fulfilling lives and education provision that helps citizens realise their potential.
Resilient sustainable behaviours RSB
The ethical conditions that enable long-term sustainability: values, norms, behaviours and attitudes related with doing the right thing, responsibility for choices and actions, solidarity, compassion, tolerance and respect for all life. Critical inquiry into challenges and analysis/evaluation of available viewpoints on the issues faced. Ability to view issues from multiple perspectives (interdisciplinary approach) and develop holistic solutions.
Health and Wellbeing HW
Reference to the social, environmental and cultural conditions that can enhance or diminish health and wellbeing: prevention of disease, sound mental health, healthcare systems, social security, water, air and food quality, transport safety, maternal and child health, access to healthcare services, sense of community, mindfulness and effective health and wellbeing management.
Collaboration COL
Reference to the conditions that foster competences such as: working in inter/trans-disciplinary teams, empathy, active listening, appreciating the views of others, resolving conflict, sharing responsibility for task completion, encouraging and motivating self and others to participate and effective communication with wide variety of audiences.
Alternative economic models AEM
Economic models that deviate from aiming solely at economic growth, which jeopardises the safe and just operating space, such as those that mimic nature, focus on systemic change, involve the use of existing or novel technology, promote equity, minimise waste, redefine the meaning or work and growth, preserve natural resources and lift people out of poverty.
Diversity and Inclusion DI
This includes biodiversity (genetic, species, landscapes and ecosystems diversity), diversity of cultures and disciplines, examination of various worldviews and perspectives, gender, ethnicity and disability, as well as their integration, interactions and interdependence from a systems view.
Transparency and Governance TG
Open access to data and procedures at all levels (local, regional, national and international), stakeholder engagement, public participation in decision-making, democratic principles, policies regarding use of data and regulations regarding sharing them.

To evaluate the alignment of a programme's intended learning outcomes to these attributes, we have developed a simple tool that uses textual analysis for the descriptors of learning outcomes and evaluates their alignment to each of these eight sustainability attributes using a word code. The word code was produced in NVIVO 12 software by 1) identifying words that constitute the accepted and commonly used scientific language for each attribute [1,20,29–38,21,39–43,22–28]; 2) by analysing the texts of the benchmark statements provided by the Quality Assurance Agency (QAA) for Higher Education in the UK for specific university subjects that match the sustainable society attributes we systemically selected and 3) specifically for the Diversity and Inclusion word code we analysed Advance HE's reports regarding Athena SWAN [44], Race Equality Charters [45] and the Equality and Diversity in Learning and Teaching in Higher Education [46].

Regarding the QAA documents, we used the following Subject Benchmark Statements:

1. Education for Sustainable Development (ESD) Graduate Outcomes
2. Earth Sciences, Environmental Sciences and Environmental Studies
3. Sociology
4. Social Policy
5. Economics
6. Business and Management
7. Health studies
8. Politics and International relations
9. Law
10. Collaboration statements from all the above texts

By analysing the parts of the documents referring to the defining principles, nature and extent and specific learning outcomes in terms of subject specific and generic knowledge, skills and attributes of graduates for each type of course, we made associations between the benchmark statements and the sustainable society attributes. We then run word frequency query in the above-mentioned benchmark statements and enriched our word codes (Table 2). We did the same with the Equality Challenge Unit documents for DI.

Table 2. The developed word code per sustainability attribute.

SOS | Source = Earth Sciences, Environmental Sciences and Environmental Studies
Global OR Boundary OR Earth OR Boundaries OR Climate OR Planetary OR Land OR Ocean OR Regional OR State OR Biodiversity OR wildlife OR Thresholds OR nexus OR CO2 OR Ecosystems OR Environmental OR Global-Change OR Climate-Change OR Atmospheric OR Resilience OR Safe OR Soil OR Freshwater OR Ozone OR Variable OR Ecology OR Ecological OR Geology OR Geological OR geo OR Hydrology OR Hydrological OR Effects OR Marine OR Uncertainty OR uncertain OR Concentration OR Threshold OR Ecosystem OR Atmosphere OR Flows OR Impacts OR Species OR Nitrogen OR Chemical OR biological OR Biosphere OR geosphere OR hydrosphere OR Phosphorus OR Pollution OR air OR Acidification OR Anthropogenic OR Cycle OR Extinction OR Space OR Chemicals OR Industrial OR Zone OR Holocene OR Anthropocene OR Climate OR Stratospheric OR Aerosol OR Integrity OR interactions OR Biogeochemical OR Greenhouse OR Gas OR Gases OR Emission OR Emissions OR Impact OR Uncertainties OR wicked OR biophysical OR constraint OR constraints OR safety OR mitigation OR adaptation OR complexity
JOS | Source = Sociology and Social Policy
Social OR socially OR community OR intergenerational OR intragenerational OR social-equity OR peace OR underdeveloped OR industrialised OR developing OR active OR humanity OR human OR participation OR society OR Justice OR women OR just OR transformation OR race OR minority OR minorities OR North Or South OR Ethnic OR ethnicity OR regional OR gender OR foundation OR peace OR poverty OR Non-violence OR conflict OR inequality OR inequalities OR future OR ceiling OR population OR changing OR accessed OR

access OR discussion OR income OR men OR need OR rights OR education OR transition OR power OR conditions OR wealth OR Security OR doughnut OR deprivation OR communities OR households OR distribution OR children OR violence OR deprived OR status OR food OR water OR energy OR jobs OR employment OR voice OR resilient OR unemployment OR gap OR people OR concept OR dialogue OR fair OR common OR exploitation OR population-dynamics OR community-dynamics
RSB | Source = Education for Sustainable Development Graduate Outcomes
Sustainable OR sustainability OR competencies OR competences OR competence OR thinking OR normative OR critical OR norms OR values OR value OR norm OR competency OR behaviour OR ability OR self-confidence OR ethics OR ethical OR moral OR ethic OR challenges OR challenge OR educational OR socio OR motivations OR motivation OR informal OR injunctive OR perspective OR responsibility OR responsibilities OR actions OR action OR context OR contexts OR assessment OR citizen OR citizenship OR capacity OR capability OR incentive OR argument OR motivation OR motive OR choice OR choices OR compassion OR tolerance OR tolerant OR solidarity OR respect OR behavioural OR attitude OR attitudinal OR engage OR commit RE engagement OR commitment OR belief OR beliefs OR management OR planning OR virtue OR solutions OR interdisciplinarity OR interdisciplinary OR reflection OR stewardship
HW | Source = Health studies
Wellbeing OR well-being OR welfare OR culture OR cultural OR life or health OR quality OR collective OR happiness OR index OR creative OR intuitive OR history OR historical OR cognitive OR license OR lives OR mental OR mind OR worldview OR equitable OR emotion OR emotional OR cohesion OR identity OR character OR care OR western OR relationships OR relational OR holistic OR satisfaction OR consciousness OR empathy OR feedback OR connections OR interconnections OR prosperity OR joy OR positive OR negative OR vision OR pattern OR thrive OR psychological OR psychology OR mindfulness OR illness OR disease
COL | Source = Collaboration statements from all benchmark documents
Group OR collaboration OR empathy OR cooperation OR cooperative OR together OR mutual OR joint OR jointly OR shared OR loyalty OR member OR participant OR allocation OR communication OR communicative OR communicate OR encourage OR motivate OR resolve OR conflict OR task OR listen OR listening OR motivate OR team OR teamwork OR judgement OR crowd OR participatory OR conversation OR discussion OR activity OR negotiation OR consensus OR allocate OR dominance OR dominate OR coordination OR coordinate OR team-dynamics OR group-dynamics OR transdisciplinarity OR multidisciplinary OR multidisciplinarity OR disciplinary OR transdisciplinary OR disciplines OR collaborate OR stakeholder OR interpersonal
AEM | Source = Economics and Business and Management
Regenerative OR circular OR re-use OR reuse OR remanufacture OR remanufacturing OR recycle OR recycling OR economy OR economic OR consumption OR financial OR indicator OR business OR entrepreneurship OR profit OR alternative OR model OR growth OR waste OR tax OR taxation OR product OR products OR production OR materials OR efficiency OR services OR technology OR technological OR balance OR lifecycle OR life-cycle OR innovation OR innovative OR technologies OR cost
TG| Source = Politics and International relations and Law
Transparency OR open OR open-ended OR openness OR open-mindedness OR open-minded OR open-access OR governance OR policy OR legal OR laws OR law OR government OR political OR framework OR transparent OR integration OR democracy OR democratic OR regulations OR regulation OR interdependence OR procedures OR systemic OR leadership OR strategy OR strategic OR evidence OR decision-making OR regulatory OR international OR transnational OR accessibility

DI | Source = Advance HE Athena SWAN and Race Equality Charters, Biodiversity IPBES, FAO, WWF
Diversity OR inclusion OR inclusivity OR inclusive OR bias OR biases OR genderANDidentity OR stereotype OR stereotypes OR ethnicity OR ethnicities OR belonging OR racial OR variety OR stereotypical OR non-gender OR diverse OR socioeconomic OR domination OR disability OR disabilities OR ethos OR intersectionality OR characteristic OR protected OR BME OR BAME OR role-model OR discrimination OR racism OR anti-racism OR fairness OR parity OR underrepresented OR marginalised OR genetic OR conservation OR loss OR intercultural OR multicultural OR racist OR inequity OR anti

Multi Criteria Analysis (MCA) is then used to evaluate and compare the performance of different courses across all eight sustainability attributes, with the multi-criteria evaluation performed applying the analytic hierarchical process (AHP) methodology. In general, the higher the score, the better the coverage of the course within the concerned attribute. In order to rank the courses in terms of their overall performance across all the criteria, differences are expressed in a condensed way by means of paired comparisons [48]. A positive score implies better alignment of one programme in relation to another while a negative value implies the opposite. A dominance measure of 0 implies an indifference between the compared courses. The method allows for weighting these dominance measures with the aggregated weights of the constituent criteria for the overall dominance score per course to be calculated (although attributes had the same weight in this case). We assumed that all attributes were equally important, and as a result were given the same weight. The final score represents the degree in which an alternative is more or less aligned to sustainability compared to the rest, based on the number of criteria it performs better than the rest. This method is preferred to using the sum or average value of the word code coverage for each attribute, as it offers a more holistic view of how courses compare across all attributes [47]. A simple linear additive evaluation model would not be appropriate as the criteria are not mutually preference independent, and the scores derived from the word-codes do not represent absolute values with defined ranges but act as indicators of comparative performance. For example, courses with very high scores in a few attributes will not rank higher than courses performing better across all attributes. University programmes can, therefore, be ranked according to their contribution to sustainability, by comparing the alignment of their intended learning outcomes to these attributes.

To test the tool, 18 Masters Programmes across several subjects (Engineering, Environmental Policy, Science Communication, Physics, Chemistry, Computing, Mathematics, Medicine and Life Sciences) from the same Higher Education Institution were compared by evaluating the alignment of their Learning Outcomes (LOs) across the eight attributes, considering their disciplinary focus as an indicator of sustainability coverage (Table 3).

Table 3. Performance of the 18 Imperial College London Master's courses' LOs across the eight sustainability attributes based on word codes.

Master's Programmes	SOS	JOS	RSB	AEM	HW	COL	DI	TG
MSc Environmental Technology	4.78	1.24	5.87	1.12	0.31	1.65	0.12	1.87
MRes Ecosystems and Environmental Change	3.66	0.38	2.25	0.38	0.00	2.14	0.42	2.79
MSc Advanced materials for Sustainable Infrastructure	2.16	0.39	2.03	4.91	0.00	1.11	0.00	0.98
MSc Climate Change, Management and Finance	9.03	1.12	2.89	4.28	0.00	0.00	0.00	0.56
MSc Ecology, Evolution and Conservation	1.71	2.32	1.92	0.41	0.00	2.81	1.14	1.22
MSc Environmental Engineering	1.56	0.30	3.78	0.86	0.00	2.47	0.35	0.76
MSc International Health Management	0.14	0.36	3.75	1.31	1.61	1.03	0.00	2.68
MSc Sustainable Energy Futures	3.26	3.41	3.09	2.79	0.12	1.91	0.00	0.35
MRes Bioengineering	0.30	0.00	1.85	0.50	0.20	2.99	0.35	0.75
Mres Green Chemistry	1.02	0.59	3.23	0.96	0.00	1.22	0.23	0.99
MSc Advanced Chemical Engineering	1.49	0.29	2.21	0.82	0.00	2.35	0.34	0.72
MSc Advanced Computing	1.25	0.00	3.41	0.00	0.00	2.04	0.29	0.62

MSc Applied Mathematics	0.57	0.00	1.31	0.20	0.16	1.68	0.00	0.41
MSc Clinical Research	0.91	0.45	3.36	1.42	1.23	0.97	0.45	1.88
MSc Finance and Accounting	0.00	0.00	2.47	7.48	0.00	0.36	0.51	2.76
MSc Optics and Photonics	0.55	0.00	2.09	0.00	0.00	0.80	0.00	0.25
MSc Petroleum Engineering	1.73	0.00	2.35	0.52	0.00	2.30	0.26	0.78
MSc Science Communication	0.00	0.89	3.30	2.54	0.00	2.29	0.00	1.27

Scores from the application of the word-codes for the eight attributes were higher in SOS for the more environmentally oriented programmes e.g. Environmental Technology, Ecosystems and Environmental change and Climate Change, management and finance as expected. Sustainable Energy futures had the highest score in JOS, followed by Ecology, Evolution and Conservation, with all other courses in general, showing zero or low scores of JOS, partly expected with Imperial considered a Natural Science and Technology focused University. The highest scores for AEM were indeed for more financially and business-oriented programmes such as the one in Climate Change, Management and Finance and the one in Finance and Finance and Accounting. Similarly health oriented programmes i.e. MSc International Health Management and MSc Clinical Research showed highest values for HW coverage, while notably most of the courses scored zero. For RSB and COL we expected that most programmes would aspire to develop problem-solving, collaboration, interdisciplinary, critical analysis and ethical inquiry skills to their students and indeed almost all programmes scored well for both, except for the MSc in Climate Change, Management and Finance that scored zero for COL. For DI we expected low scores by all courses, which was indeed the case, with seven of the courses actually scoring zero. Through the MCA method described above (see Supplementary Material Table 6 for details), the programmes were then ranked in terms of their overall alignment and contribution to sustainability (Figure 1).

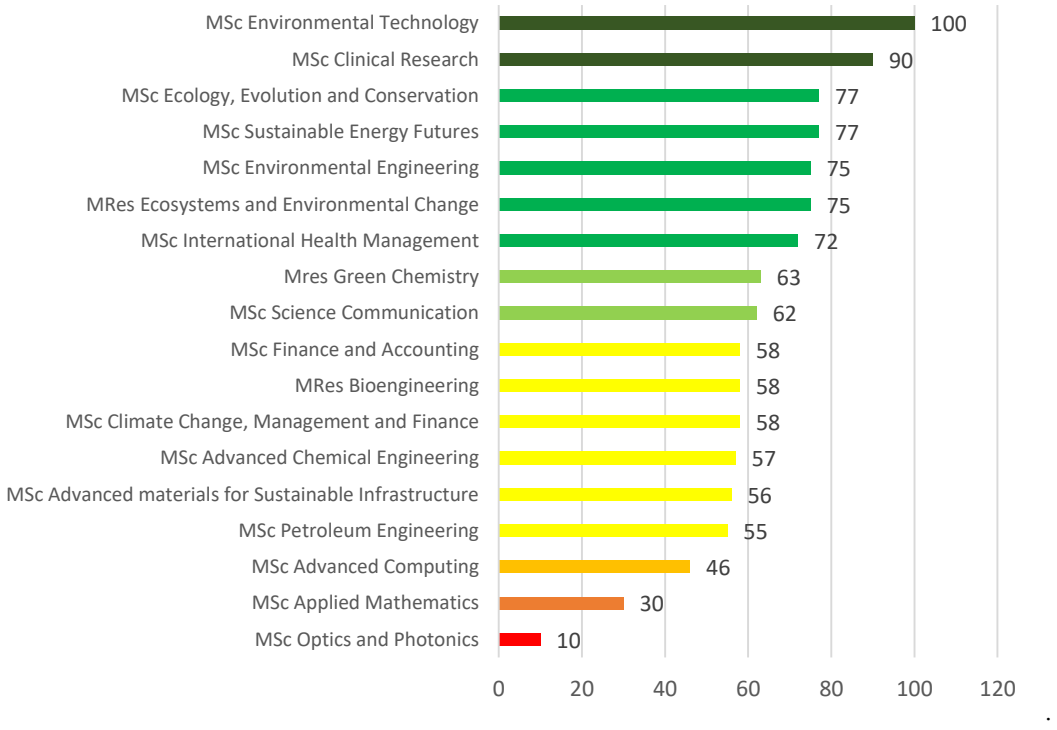

Figure 1. Ranking of 18 of Imperial College London Master's courses based on scores from the application of the word code developed for the eight sustainability attributes examined.

2.2. Application

Forty (40) well established MSc Programmes related to Environment and Sustainability (35 offered by UK and 5 by European Universities) were evaluated using the methodology developed

(Table 4). Each programme's LOs were compared against the word codes related to each sustainability attribute and were then ranked using MCA as described in methodology.

Table 4. List of the MSc Programmes related to Environment and Sustainability evaluated in this study and sources of their learning outcomes used in the assessment (accessed in June 2020).

Programme Title	University	Link
MSc Design Engineering with Sustainability STR	University of Strathclyde, Glasgow	https://www.strath.ac.uk/courses/postgraduatetaught/designengineeringwithsustainability/
MSc Ecology and Environmental Management LVH	Liverpool Hope University	https://www.hope.ac.uk/postgraduate/postgraduatecourses/ecologyenvironmentalmanagementmsc/
MSc Environmental Engineering CRN	Cranfield University	https://www.cranfield.ac.uk/courses/taught/environmental-engineering
MSc Environmental Engineering NWC	Newcastle University	https://www.ncl.ac.uk/postgraduate/courses/degrees/environmental-engineering-msc/#profile
MSc Environmental Management BRN	Brunel University London	https://www.brunel.ac.uk/study/postgraduate/Environmental-Management-MSc
MSc Environmental Management RDN	University of Reading	http://www.reading.ac.uk/ready-to-study/study/subject-area/geography-and-environmental-science-pg/msc-environmental-management.aspx
MSt Sustainability Leadership CAM	University of Cambridge	https://www.cisl.cam.ac.uk/education/graduate-study/master-of-studies-in-sustainability-leadership
MSc Sustainability STM	University of Southampton	https://www.southampton.ac.uk/geography/postgraduate/taught_courses/msc_sustainability.page
MSc Water Sanitation and Health Engineering LDS	University of Leeds	https://courses.leeds.ac.uk/g062/water-sanitation-and-health-engineering-msc-eng-
MSc Environmental Economics and Environmental Management YRK	University of York	https://www.york.ac.uk/study/postgraduate-taught/courses/msc-environmental-economics-management/
Master in Environmental Sciences ETH	ETH Zurich	https://ethz.ch/en/studies/prospective-masters-degree-students/masters-degree-programmes/masters-degree-programmes-system-oriented-natural-sciences/master-environmental-sciences.html
Master in Environmental Sciences WGU	Wageningen University and Research	https://www.wur.nl/en/Education-Programmes/master/MSc-programmes/MSc-Environmental-Sciences.htm
Master in Environmental Sciences and Engineering EPFL	EPFL	https://www.epfl.ch/education/master/programs/environmental-sciences-and-engineering/
MSc in Environmental Studies and Sustainability Science LUN	Lund University	https://www.lunduniversity.lu.se/lubas/i-uoh-lu-SAESS

MPhil in Environmental Policy CAM	University of Cambridge	https://www.graduate.study.cam.ac.uk/courses/directory/lelempepl
MSc Environment and Development LAN	University of Lancaster	https://www.lancaster.ac.uk/study/postgraduate/postgraduate-courses/environment-and-development-msc/
MSc Environment and Sustainable Development UCL	University College London	https://www.ucl.ac.uk/prospective-students/graduate/taught-degrees/environment-sustainable-development-msc
MSc Environmental Technology ICL	Imperial College London	https://www.imperial.ac.uk/study/pg/environmental-policy/environmental-technology/
MSc in Environmental Change and Management OXF	University of Oxford	https://www.ox.ac.uk/admissions/graduate/courses/msc-environmental-change-and-management?wssl=1
MSc in Environmental Science, Policy and Management MESPOM	Several*	https://envsci.ceu.edu/master-science-environmental-sciences-policy-and-management-mespom
MSc Environmental Strategy SUR	University of Surrey	https://www.surrey.ac.uk/postgraduate/environmental-strategy-msc-2020
MSc Environmental Sciences LIV	University of Liverpool	https://www.liverpool.ac.uk/study/postgraduate-taught/taught/environmental-sciences-msc/overview/
MSc Environmental and Natural Resource Economics BGM	University of Birmingham	https://www.birmingham.ac.uk/postgraduate/courses/taught/econ/environment-natural-resource-econ.aspx
MSc Environmental Economics and Climate Change LSE	The London School of Economics and Political Science	http://www.lse.ac.uk/study-at-lse/Graduate/Degree-programmes-2020/MSc-Environmental-Economics-and-Climate-Change
MSc Environmental Engineering UBA	University of Bath	https://www.bath.ac.uk/courses/postgraduate-2020/taught-postgraduate-courses/msc-environmental-engineering/
MSc Environmental Governance MAN	University of Manchester	https://www.manchester.ac.uk/study/masters/courses/list/06967/msc-environmental-governance/
MSc Environmental Leadership and Management NTG	University of Nottingham	https://www.nottingham.ac.uk/pgstudy/course/taught/environmental-leadership-and-management-msc
MSc Environmental Monitoring Research and Management LBR	Loughborough University	https://www.lboro.ac.uk/study/postgraduate/masters-degrees/a-z/environmental-monitoring-research-and-management/
MSc Environmental Policy and Management BRS	University of Bristol	https://www.bristol.ac.uk/study/postgraduate/2020/sci/msc-environmental-policy-and-management/

MSc Environmental Sustainability EDB	The University of Edinburgh	https://www.ed.ac.uk/studying/postgraduate/degrees/index.php?r=site/view&edition=2020&id=32
MSc Integrated Environmental Studies STM	University of Southampton	https://www.southampton.ac.uk/geography/postgraduate/taught_courses/msc-environmental-consultancy.page
MSc Mining Environmental Management EXT	University of Exeter	https://www.exeter.ac.uk/postgraduate/courses/mining-engineering/mining-environment-msc/
MSc Sustainability Planning and Environmental Policy CDF	Cardiff University	https://www.cardiff.ac.uk/study/postgraduate/taught/courses/course/sustainability,-planning-and-environmental-policy-msc
MSc Sustainable Development SAN	University of St Andrews	https://www.st-andrews.ac.uk/subjects/sustainable-development/sustainable-development-msc/
MRes Ecosystems and Environmental Change ICL	Imperial College London	https://www.imperial.ac.uk/study/pg/life-sciences/ecosystems/
MSc Advanced materials for Sustainable Infrastructure ICL	Imperial College London	https://www.imperial.ac.uk/study/pg/civil-engineering/advanced-materials-sustainable-infrastructure/
MSc Climate Change, Management and Finance ICL	Imperial College London	https://www.imperial.ac.uk/business-school/programmes/msc-climate-change/
MSc Ecology, Evolution and Conservation ICL	Imperial College London	https://www.imperial.ac.uk/study/pg/life-sciences/ecology-evolution-conservation/
MSc Environmental Engineering ICL	Imperial College London	https://www.imperial.ac.uk/civil-engineering/prospective-students/postgraduate-taught-admissions/environmental-engineering-cluster/msc-environmental-engineering/
MSc Sustainable Energy Futures ICL	Imperial College London	https://www.imperial.ac.uk/study/pg/mechanical-engineering/sustainable-energy-futures/

* Lund University, the University of Manchester, Central European University, the University of the Aegean, Middlebury Institute of International Studies at Monterey and the University of Saskatchewan.

3. Results

The performance of the forty programmes across the eight sustainability attributes as scores calculated by the word code coverage is presented in Table 5 and their ranking based on their dominance scores from the pairwise comparison in Figure 2 (see Supplementary Materials for interpretations and calculations)

Table 5. Performance of the forty environment and sustainability related master's courses' from UK and European Universities across the eight sustainability attributes based on the word codes.

Master's Programmes	SOS	JOS	RSB	AEM	HW	COL	DI	TG
MSc Design Engineering with Sustainability STR	0.76	0.09	4.00	4.16	0.52	0.18	0.10	0.68
MSc Ecology and Environmental Management LVH	5.17	0.29	5.21	0.21	0.00	0.67	1.00	1.17
MSc Environmental Engineering CRN	6.24	1.58	3.97	3.47	0.13	0.23	0.22	0.41
MSc Environmental Engineering NWC	5.63	2.15	2.22	0.95	0.71	0.00	0.00	0.41
MSc Environmental Management BRN	8.88	1.81	3.26	2.74	0.61	0.00	0.00	1.36
MSc Environmental Management RDN	4.90	1.61	2.82	0.96	1.27	2.02	0.22	1.40
MSt Sustainability Leadership CAB	3.12	2.98	9.29	2.69	0.32	1.27	0.21	5.24
MSc Sustainability STM	2.59	1.45	3.19	0.45	0.55	0.91	0.38	0.30
MSc Water Sanitation and Health Engineering LDS	2.06	2.43	4.82	1.77	1.85	0.48	0.11	1.55
MSc Environmental Economics and Environmental Management YRK	7.27	1.91	3.36	1.05	0.17	0.44	0.78	1.69
Master in Environmental Sciences ETH	5.89	1.41	3.40	1.14	0.58	0.00	0.46	1.02
Master in Environmental Sciences WGU	4.75	1.53	3.63	0.40	0.63	1.31	0.31	1.32
Master in Environmental Sciences and Engineering EPFL	13.99	2.54	1.43	0.00	0.00	2.70	0.00	0.00
Masters in environmental studies and sustainability science LUN	5.31	2.69	8.79	0.52	1.05	1.18	0.00	0.66
MPhil in Environmental Policy CAM	0.58	0.27	6.77	0.81	0.58	1.66	0.00	0.49
MSc Environment and Development LAN	3.91	2.38	2.05	1.10	0.34	0.30	0.56	1.38
MSc Environment and Sustainable Development UCL	8.00	8.12	5.76	0.94	0.00	0.00	0.00	1.06
MSc Environmental Technology ICL	4.78	1.24	5.87	1.12	0.31	1.65	0.12	1.87
MSc in Environmental Change and Management OXF	12.01	2.53	8.06	0.63	0.63	1.82	0.00	1.03
MSc in Environmental Science, Policy and Management MESPOM	8.94	0.64	7.32	0.98	0.20	3.69	0.64	2.46
MSc Environmental Strategy SUR	7.37	1.11	7.22	1.45	1.28	0.37	0.00	2.09
MSc Environmental Sciences LIV	4.61	1.06	2.65	0.29	0.14	2.54	0.48	1.53
MSc Environmental and Natural Resource Economics BGM	1.93	0.74	0.99	1.80	0.26	0.00	0.22	3.17
MSc Environmental Economics and Climate Change LSE	9.90	0.00	2.51	3.55	0.59	2.51	0.00	4.14
MSc Environmental Engineering University UBA	5.44	1.21	4.18	2.70	0.54	1.11	0.13	1.19
MSc Environmental Governance MAN	5.86	0.84	4.04	0.28	0.46	0.84	0.16	2.37
MSc Environmental Leadership and Management NTG	8.55	0.91	8.87	0.54	0.86	0.70	0.22	3.76
MSc Environmental Monitoring Research and Management LBR	4.74	0.54	1.68	0.19	0.14	0.60	0.14	0.77
MSc Environmental Policy and Management BRS	4.94	0.90	3.71	0.41	0.51	1.19	0.29	1.60
MSc Environmental Sustainability EDB	7.02	1.89	4.00	1.19	0.87	1.16	0.34	2.15
MSc Integrated Environmental Studies STM	3.47	1.36	2.65	0.36	0.26	0.97	0.23	0.37
MSc Mining Environmental Management University EXT	3.21	1.46	2.72	1.05	0.04	0.69	0.04	1.93
MSc Sustainability Planning and Environmental Policy CDF	6.33	2.36	4.27	1.09	0.17	0.00	0.19	2.66
MSC Sustainable Development SAN	0.74	3.20	11.88	0.62	2.77	0.68	0.00	3.63
MRes Ecosystems and Environmental Change ICL	3.66	0.38	2.25	0.38	0.00	2.14	0.42	2.79
MSc Advanced materials for Sustainable Infrastructure ICL	2.16	0.39	2.03	4.91	0.00	1.11	0.00	0.98
MSc Climate Change, Management and Finance ICL	9.03	1.12	2.89	4.28	0.00	0.00	0.00	0.56
MSc Ecology, Evolution and Conservation ICL	1.71	2.32	1.92	0.41	0.00	2.81	1.14	1.22
MSc Environmental Engineering ICL	1.56	0.30	3.78	0.86	0.00	2.47	0.35	0.76
MSc Sustainable Energy Futures ICL	3.26	3.41	3.09	2.79	0.12	1.91	0.00	0.35

The programmes are ranked based on the alignment of their learning outcomes to sustainability with their dominance score calculated based on the number of times each programmes performed better that the others for each given attribute. Although most of the programmes examined in this study showed high coverage of SOS which is reasonable as they are environmentally and sustainability oriented, most did not seem to adequately cover DI and HW, both important aspects of sustainability. Diversity, Equality and Inclusion specifically in the UK context is being promoted through Advance HE's race and gender Equality charters as pillars that can lead to sustainable social change. Health and Wellbeing apart from being a stand-alone SDG (SDG3), is an important dimension of the Academic Environment that should be safeguarded and further highlighted as it

355 links not only with increased productivity but is also an important research area. Both DI and HW,
356 which are underrepresented in the programmes considered, are the ultimate ends of SD according to
357 the Daly Triangle, which provides an integrating framework for selecting overarching goals for
358 sustainability interventions [49].
359 Out of the top 10 programmes, 8 scored highly across all sustainability attributes and these are
360 Environmental Sustainability EDB, Sustainability Leadership CAM, MESPOM, Environmental
361 Leadership and Management NTG, Environmental Economics and Management YRK, Water
362 Sanitation and Health Engineering LDS, Environmental Management RDN and Environmental
363 Technology ICL. The remaining 2, Environmental change and management OXF and Environmental
364 strategy SUR scored strongly in SOS and RSB; but zero at DI. With respect to the performance of their
365 LOs alignment to sustainability, they are either related with sustainability, leadership or are
366 focusing on environment and management, economics and engineering and, thus, show integration
367 between different areas of study. The same applies for the European master's programmes as the
368 ones that show integration of different disciplines are higher in the ranking, with MESPOM being
369 first of the five and third in the total ranking. MESPOM, is an inter-university programme allowing
370 students to study in four different countries and become exposed to scientific, technological, socio-
371 environmental and political aspects of environmental change, unique to each location. In terms of
372 LOs it differentiates between knowledge and understanding, skills and values and attitudes which is
373 more appropriate for sustainability competences definition. MSc Sustainability Leadership CAM is a
374 course using workshop format to cover very diverse aspects of sustainability such as business,
375 finance, governance, behaviour, leadership, collaboration and partnerships apart from the main
376 socio-environmental aspects. MSc Environmental Sustainability EDB stresses the interdisciplinary
377 nature of SD and allows students to study the interactions between science, policy, business and
378 governance to address sustainability problems. It provides insides into behavioural and ethical
379 aspects of sustainability as well and integrates modules that range from ecology, to climate change
380 and politics through general and module specific LOs. In general, these programmes employ a
381 systemic and interdisciplinary approach to addressing sustainable development across scales and
382 paradigms that includes its ethical implications, which require critical analysis and the development
383 of sustainability competences. Although, these programmes are performing better than most of the
384 others analysed here, there is still a lot of space to improve and would benefit from recording their
385 gaps and trying to achieve a more balanced representation of the sustainability attributes in their
386 LOs.

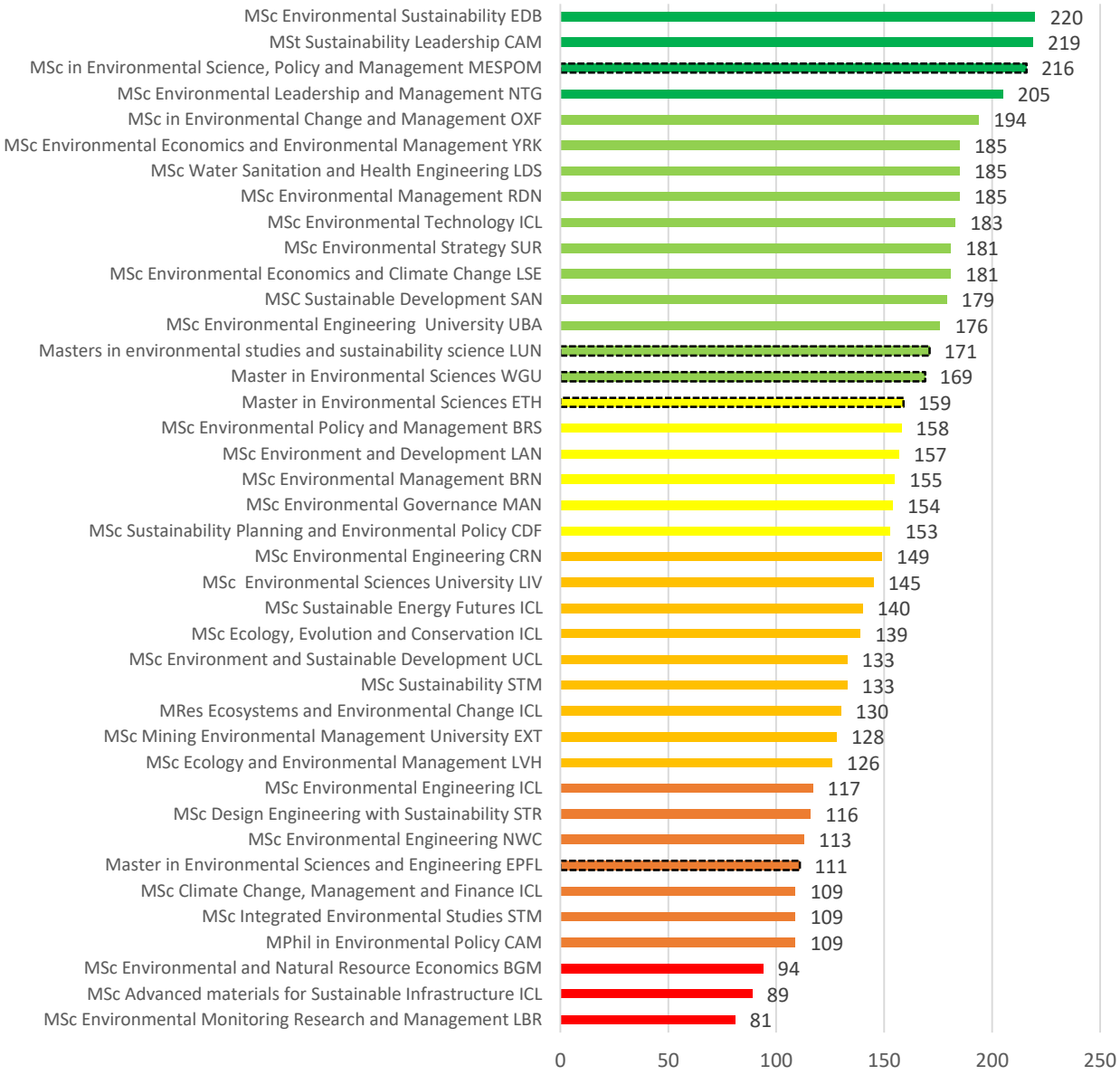

Figure 2. Dominance Scores and ranking of forty Environment and Sustainability related Masters Programmes in terms of their contribution to sustainability based on the alignment of their learning outcomes to key sustainability attributes (the dashed bars represent European Masters courses).

Most of the programmes at the bottom of the rank had scored zero in at least one sustainability attribute, with one programme scoring zero in four. Often the attributes with the lowest scores are in decreasing order: DI, HW, COL, TG and AEM. In terms of their relationship with sustainability, most are related with environmental aspects such as policy, management or engineering, one is specifically related with materials for sustainability and another one related to climate change and finance. In general, these programmes would benefit from incorporating more aspects of sustainability in their LOs, such as JOS, COL, DI, HW, TG and AEM and articulating more specific LOs relating to those aspects.

Comparing masters programmes that include the same topics in their titles, such as those related to Environmental management (9 courses), Environmental engineering (5 courses) and Environmental Science (5 courses), findings show that they do not necessarily score in all (or the same) sustainability attributes, with the ones showing zero score, specifically, to be COL, TG, DI and HW and that they place different emphasis on JOS (moderate to low) and AEM (moderate to low). Surprisingly, a few programmes that include the topic sustainability or sustainable development in

their titles are to score zero in the HW, DI and COL. Also they show big variation in the scores for SOS, AEM and JOS (low to high).

Comparing programmes offered by the same Institution (such as University of Cambridge, University of Southampton and Imperial College London) shows that there can be bigger (CAM ~ 25%), intermediate (ICL ~ 11%) or smaller differences (STM ~ 3%) in the scoring in sustainability attributes between the courses.

Almost 82.5% of the Masters programmes overall ranking values are between 100 and 200 with some outliers, 3 courses below 100 10 and 19% and 4 courses above 200. Our overall values distribution approximates normal distribution (Shapiro Wilks test: sig. =0.510, dF=40, statistic=0.975; kurtosis= 0.59, skewness= -0.764). The mean (151.4) and median values (153.5) show that most programmes have values around 152. One important observation from the graph is that there are some pairs of programmes that show very similar scores, for example, Sustainability leadership CAM with Environmental Sustainability EDB, Environmental economics and climate change LSE with Environmental Strategy SUR and Environment management RDN with Water Sanitation and Health Engineering LDS and Environmental economics and environmental management YRK, and Environmental and Sustainable Development UCL with Sustainability STM. This indicates that when designing or selecting for example a course to attend, reviewing the programme's LOs is important and there seem to be no link between course names and scores. For the academic staff responsible for the programmes assessed understanding the scores per attribute is important, as it can help them redefine their modules intended learning outcomes or selected competences, map the gaps in covering various aspects of sustainability, understand in which areas the place more focus and refine their programmes' descriptors by reforming some of their curricular content.

4. Discussion

The assessment tool developed here offers the first step in a process that will allow HE practitioners to evaluate and improve their educational offerings, increasing their sustainability contribution. Reviewing academic programmes' intended learning outcomes, the tool evaluates how well "what the students are going to achieve at the end of the programme" aligns to sustainability attributes and enabling conditions for the emergence of sustainability. Courses are evaluated in what they aspire to deliver, rather than how effective they are in their delivery. This is important as based on the identified learning outcomes, teaching context, learning activities and assessments are designed. Learning outcomes will drive the pedagogical approach and the teaching practices to achieve them. Relating learning outcomes to sustainability and defining the knowledge, skills, behaviours, and attitudes, collectively the sustainability competences that learners will need to develop through the course will shape their contribution to sustainability. For this contribution to realise, the next step will be their implementation and assessment, collecting the evidence that these outcomes are delivered in practice. Ensuring that LOs are sustainability related will not guarantee that University graduates attain those traits. Assessment of competence development or mastery of the LOs related to sustainability, will allow practitioners to understand how effective their approach is.

The tool can support Higher Education practitioners to make data-driven decisions and modifications in their programmes, to improve alignment to sustainability. Different courses of the same Institution or courses of the same subject but of different Institutions can be compared and ranked. This can help programmes that have similar orientation to identify similarities and differences between them and make appropriate adaptations. Furthermore, comparisons can extend to different geographies and the priorities, gaps, commonalities and differences of HE curricula for Sustainable development can be highlighted across continents [50]. This, in turn will assist the engagement of on and off campus ESD stakeholders, the formation of collaborations between Universities and the local communities and also the realisation that Sustainable Development is equally about its environmental pillar as well as its social and economic ones and should be seen as an integrated concept [50].

Another benefit that the methodology presented in this study specifically offers to MSc programmes' coordinators, curriculum developers and lecturers is that is allows them to be more systematic in articulating LOs for sustainability and also more systemic as they will be able to target sustainability comprehensively. Apart from mapping coverages of attributes and understanding how their programmes relate to sustainability and make improvements by addressing gaps and balancing all aspects of sustainability, they can also design their LOs in a more integrated and systematic way.

From our review of programme descriptors, there are programmes that mention general programme LOs and others that provide LOs for each programme module. In the first group some mention what the students will gain from studying in the programme, while others provide LOs divided into categories; knowledge and understanding, skills and attitudes and values. In the second group of programmes with defined LOs for each course module they either: a) describe briefly the content of each module and state student gains, b) describe the content or aim of each module and list LOs or c) describe content, aim, teaching and assessment methods and LOs. The latter either mention only lists of LOs without differentiation, or a breakdown of LOs into knowledge and understanding and skills, such as intellectual, practical, professional, employability and transferable. Others may mention specific professional competences or graduate attributes. However, we propose that being more specific with stating intended LOs for both the whole programme and for each module is clearer and more useful as it can lead to better teaching methods and also measurable assessment formats to be implemented [51,52]. Last but not least, breakdown of LOs into knowledge, skills and values or use of competences also contributes to better course outcomes [18,53].

The methodology developed here embedded in existing sustainability assessment tools in HE such as the Sustainability Tracking, Assessment & Rating System (STARs) for HE Institutions, can offer benchmarking in terms of evaluating progress toward the SDGs across institutions and geographies [54] as it will highlight similarities and differences as well as gaps in the integration of the SDGs in their LOs and also allow for a more uniform and thus comparable design of LOs across Educational Systems. Currently, sustainability assessment and reporting tools for HE Institutions are focusing mainly on the number of sustainability-related courses, the integration of sustainability themes in current courses, the pedagogical methods used to teach sustainability, educator training courses and SD definitions within the curriculum, whereas they do not examine the courses' learning outcomes' relationship to sustainability [55].

We expect courses that are advanced in their sustainability offerings and have developed their own vision of a sustainable society to also use our methodology and adapt it to reflect the sustainability attributes they have selected. However, they can also compare their criteria to the ones presented in this paper and draw conclusions about which aspects of sustainability they cover most or least and make changes. Also, University course coordinators, curriculum planners and other relevant stakeholders who aim to integrate the SDGs in their courses, can do so by aligning their course's LO with the SDGs in the systemic way we presented. This will enable them to develop relevant pedagogies, learning activities and assessment modes to enhance the development of sustainability competences in their learners [56].

5. Limitations of the study

As limitations of this study we can mention that the developed word codes might not be comprehensive in reflecting the diversity of concepts encompassed in the sustainability attributes used, although we tried to overcome this by using relevant and accurate scientific publications. Furthermore, we tried to make the word codes appropriate for educational purposes so that important terms are captured in the analysed courses' LOs. This was done by use of the QAA benchmark statements and the ECU guiding documents for implementing diversity and inclusion in HE curricula, which add to the validity of the method, as they constitute the accepted standard for designing HE programmes in the UK. Lastly, we excluded words from the word code that may be ambiguous in terms of acquiring different meaning according to context.

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