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Sustainability Education: A systemic framework for evaluating educational outcomes towards the Sustainable Development Goals

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Statement of Originality

I hereby declare that this doctoral thesis is entirely my own work and that where any material could be construed as the work of others, it is fully cited and referenced, and/or with appropriate acknowledgement given.

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Abstract

The UN 2030 agenda of Sustainable Development Goals (SDGs) envisions a future of inclusive equity, justice and prosperity within environmental limits, and places an important emphasis on education as stated in Goal 4. Education is acknowledged as a means for achieving the remaining Goals, with Sustainability as a goal for education in target 4.7. However, the interconnectedness of the SDGs and the complexity of Sustainability as a concept make it difficult to relate the SDGs to educational learning outcomes, with what Education for Sustainable Development (ESD) aims to achieve remaining ambiguous. To address this, the aim of the thesis was to develop a framework to redefine ESD as a tool that can deliver the Sustainability transformation required. Using the SDGs as end points for a Sustainability state, and through a participatory approach, education stakeholders and learners work together to construct a localised vision of Sustainability, relate this to educational outcomes and identify the competences the learners need to develop as citizens for the Sustainability vision to emerge. The framework allows for the development of evaluation tools that can support educational institutions to monitor and manage their progress in transforming societies towards Sustainability.

Universities are engines of societal transformation, can nurture future citizens and can navigate them towards Sustainability through their educational programmes. The contribution of these programmes to Sustainability depends on how well aligned their intended learning outcomes are to Sustainability and then how effective they are in developing these as competences in students. The tool developed therefore first reviews the alignment of University programmes intended learning outcomes to the enabling conditions for a vision of Sustainability based on the SDGs to emerge and then how effective the programmes are in developing Sustainability competences in their students.

The first part is based on a systemic grouping of the SDGs into eight Sustainability attributes, using multi-criteria analysis to compare and rank programmes according to the alignment of their learning outcomes to the Sustainability attributes and their contribution to Sustainability. From its testing using data from a University's eighteen master's programmes on a range of subjects and then application to compare forty UK and European master's programmes focusing on environment and Sustainability, findings demonstrated that even environmental programmes 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 second part of the tool developed covered the effectiveness of educational programmes by evaluating the attainment of Sustainability competences in University students. Its application was demonstrated through a case study of a Master's programme, offering insights of how it can benefit Higher Education practitioners to improve how they deliver their programmes' learning outcomes as Sustainability competences in students, and how they can use the evidence created to monitor progress. As an example, the potential of the tool to inform the programme's ongoing curriculum review was discussed.

Considering the potential to shape learners from a young age towards behaviours aligned with promotion of planetary health and wellbeing, the framework was then applied and further developed for school education. Its application for selecting and assessing learning outcomes for Sustainability was researched in two case studies in the UK, conducted in a primary and a secondary school that followed different approaches in integrating ESD into their curricula. The primary school introduced ESD as the thread that pervades and links all curricular subjects, whereas the secondary school introduced a new course on the SDGs. Both schools were found to be effective in developing the intended learning outcomes in their students, with some weaknesses related to their approach identified as well.

Overall the thesis delivered its objectives, demonstrating the framework's potential to evaluate the contribution of education to Sustainability, as well as to assess students' Sustainability competences development at different stages, contributing to the operationalisation of the role of educational programmes to Sustainability transformation.

Table of Contents

List of Tables

List of Figures

List of Acronyms

AEM Alternative Economic Models

ATDM Assessment tools and Decision-making

AWP Anglian Water Project

AY Academic Year

BE Business and Environment

BIL Becoming an Independent Learner

CATS Credit Accumulation and Transfer Scheme

CEP Centre for Environmental Policy

COL Collaboration

DESD Decade for Education for Sustainable Development

DI Diversity and Inclusion

EAA Environmental Analysis and Assessment

EAM Environmental Analysis and Management

ECTS European Credit Transfer and Accumulation System

ECU Equality Challenge Unit

EE Environmental Education

EEP Environmental Economics and Policy

EFA Exploratory factor analysis

EfS Education for Sustainability

EP Energy Policy

ERM Environmental Resource Management

ESD Education for Sustainable Development

GDPR General Data Protection Regulation

GECP Global Environmental Change and Policy

HE Health and Global Environment

HE Higher Education

HHP Hounslow Heath Project

HW Health and Wellbeing

IBM SPSS and MS excel software programs used for quantitative analysis of data and visualisation (tables and graphs)

ICL Imperial College London

ICREC Imperial College Research Ethics Committee

ILOs Intended learning outcomes

IWM Integrated Water Management

JOS Just Operating Space

LOs Learning Outcomes

MPhil Master of Philosophy

MRes Master of Research

MSc Master of Science

MSt Master of Studies

NVIVO software program used for qualitative and mixed-methods research

OECD Organisation for Economic Co-operation and Development

PESTLE Political, Economic, Sociological, Technological, Legal and Environmental

PM Pollution Management

PMCS Pollution Management Case Studies

QAA Quality Assurance Agency

RCE Regional Centre of Expertise

RSB Resilient Sustainable Behaviours

SD Sustainable Development

SDGs Sustainable Development Goals

SMART Specific, Measurable, Attainable, Relevant and Time-bound

SOS Safe Operating Space

TG Transparency and Governance

UK United Kingdom

UN United Nations

UNECE United Nations Economic Commission for Europe

UNESCO United Nations Educational, Scientific and Cultural Organization

UNFCCC United Nations Framework Convention on Climate Change

USE Urban Sustainable Environment

WCED World Commission on Environment and Development

WEF World Economic Forum

WIA Whole Institution Approach

WM Water Management

WMP Water Management Project

Chapter 1 Introduction

The socio-environmental and socio-economic challenges our society faces, such as climate change, air pollution, unemployment and poverty, necessitate the transition to a more harmonious and sustainable world. Although the concept of Sustainable Development has received criticism by many authors because it sustains economic growth and maintains the business as usual which leads to environmental and social destruction (Niles & Tachimoto, 2018), the UN 2030 agenda of Sustainable Development Goals (SDGs) envisions a future of inclusive equity, justice and prosperity within environmental limits, and places an important emphasis on education as stated in Goal 4. Education is acknowledged as a means for achieving the remaining Goals, with Sustainability as a goal for education in target 4.7.

Indeed, education has long been envisioned as a force of social change; however, mainstream formal education has been criticised as perpetuating established beliefs, values and norms about how society should function that are highly unsustainable (Kaufmann, Sanders, & Wortmann, 2019). Education for Sustainable Development (ESD), envisioned as a transformative paradigm for education towards Sustainability, was first incorporated as important part of learning about environmental and development issues in Chapter 36 of Agenda 21 (UN, 1992) during the Earth Summit in Rio in 1992. The same document further mentioned that ESD aims to increase the capacity of people to address Sustainable Development concerns and that this is related to its effectiveness. The Global Action Programme (GAP) on ESD further highlighted advancing policy, transforming the learning environment, training the educators, empowering and mobilising youth and taking local community action as the ways by which ESD can achieve the transformation of education (UNESCO 2014a, 2014b). Crucial international agreements such as the SDGs and the Paris agreement on Climate Change have further placed education and more specifically ESD at the centre of efforts for their realisation (Wade & Atkinson, 2017) on the basis of its empowerment potential. This potential translates into the knowledge, skills, values, attitudes and behaviours (or competence) of learners that render them capable of thinking and living sustainably. Currently, UNESCO, the main driving force of ESD worldwide, has developed its roadmap, ESD for 2030 (UNESCO, 2020) to align education with the realisation of the SDGs, which further

necessitates the achievement of SDG4/target 4.7 on developing the competences of learners through ESD (UNESCO, 2017a, 2017b).

Although, as a result of all these developments over the last thirty years since the first introduction of ESD, curricula, pedagogies and teaching and learning approaches in many countries have been transformed (Smith et al., 2015), empirical studies on the effectiveness of ESD to empower learners to think, work and act to address Sustainable Development issues are limited (Smith et al., 2015). Educational strategies and policy recommendations for implementing ESD have had limited capacity to make positive impact as they are heavily reliant on perceived beneficial outcomes that have not been assessed (Pauw, Gericke, Olsson, & Berglund, 2015). Further, studies show that learners are increasingly becoming disengaged from Sustainable Development because of its complexity and difficulty in making substantial positive contributions (Velazquez, Munguia, & Sanchez, 2005). All of these undermine the potential of education in enabling Sustainability, question its effectiveness and even leave ambiguous what ESD aims to achieve.

In response, the thesis aimed to develop a framework to redefine ESD as a tool that can deliver the Sustainability transformation required for society to reach a state where the SDGs would have been achieved, and evaluate its potential to measure the contribution of education to Sustainability, as well as to evaluate students' Sustainability competence development at different stages, contributing to the operationalisation of the role of educational programmes to Sustainability transformation.

Chapter 2 Background

2.1 Current issues with the role of education

Education has been deemed a problematic concept and when dealing with Sustainable Development it can become more so (Jickling & Wals, 2008). Orr (Orr, 1991) commented, "It is the highly educated people who are causing the environmental destruction". This shows how unsuccessful education efforts have been so far in challenging the status quo, the values and perspectives that permeate the dominant model of the economy. According to this model, people should be prepared to occupy positions in the market economy instead of questioning what the purpose of economic activity is. This dominant model negates homogeneity across contexts and cultures and does not allow other voices to be heard regarding what is a life worth living and how it can be achieved.

According to Wade (Wade, 2008), education as presently constructed can be broadly divided into three orientations: the vocational/neo-classical, the liberal progressive and the socially critical. She argues that Education for Sustainable Development fits within the socially critical orientation. This is because it enables critical analysis of existing worldviews, values and structures and empowers learners to transform society. She maintains that this critical view should be coupled with a systems or relational approach that recognises that society operates within environmental boundaries and examines the relationships among ESD, Education, Society and the Biophysical environment through multiple spheres of interaction.

To harness education for a common future vision of the world that enables the planet and people to thrive, participatory approaches that allow all stakeholders to become involved, share their views and act, are necessary (Bullock & Hitzhusen, 2015). Such approach in education can liberate people, make them question how things are done and experiment with different ways of doing them to ultimate end up with doing better things (achieving visions) (Blake, Sterling, & Goodson, 2013). This kind of education focuses local efforts that can lead to regional and global actions. It enables people to connect to their local realities and links them with their communities to discuss, (dis)agree and discover common visions, values, ideas and experiments to try. Thus, it is alignment with the aforementioned critical view of education and ESD.

Because of the diversity of beliefs and values that may arise from employing a participatory approach in education to define a Sustainability vision, communities should contextualise them and avoid being prescriptive about them. Instead, they should take an experimental view and decide what works for them and act upon it. Through a pragmatic lens, Sustainability competence (or agency) is the ability to participate in collective decision-making, embrace the plurality of perspectives and engage in active experimentation and deliberation to reveal what works in specific problematic situations and contexts (Rojas, 2019). Education's role in this context will be to develop the citizen's knowledge and skills in SD and cultivate an interest in participation in community.

2.2 Educational approaches that enable Sustainability

The ESD community recognises that the socioeconomic and environmental challenges our society faces today are complex and urgent. Thus, transformative pedagogy is a promising tool for ESD because it emphasises learning that promotes action (Rose & Cachelin, 2013), enables learners to develop their own views, assess different perspectives, values and interests and develop their own observations, arguments and competences to deal with Sustainability issues (Blake, Sterling, & Goodson, 2013). This framework also supports active participation of students in community-driven decision-making to solve local problems (Barnum & Illari, 2016; Medrick, 2013).

Modern cognitive theories have proved that individuals have prior ideas about every domain of knowledge, including SD. Those ideas are shaped by their own experiences, upbringing, interaction with peers and media, and portray their explanations and interpretations of how the world functions (Wadsworth, 1996). According to constructivism, students need to connect new knowledge to pre-existing cognitive structures or challenge them to produce new ideas (Taber, 2011). Moreover, social constructivism maintains that learning is more effective when students collaborate to deliver a certain task (Parker, 1979). Frisk and Larson (2011) contend that the knowledge domain in ESD consists of the following types of knowledge: declarative (about Sustainability challenges), procedural (how and when to take action), effectiveness (responsibility for outcomes and consequences) and social (norms, expectations, pressures). Educational programmes should therefore incorporate these principles to maximise their potential for empowerment and action (Monroe, 2003).

Within transformative pedagogies, project and problem-based pedagogies that encourage collaboration and active learning in ESD have been suggested by various authors as effective for developing Sustainability competences in learners, as they expose students to real-world and authentic situations that require them to manage complexity, work closely with others and make decisions based on trade-offs (Aditomo, Goodyear, Bliuc, & Ellis, 2013; Brundiers, Wiek, & Redman, 2010; J. Segalàs, Ferrer-Balas, & Mulder, 2010; Arnim Wiek, Withycombe, Redman, & Mills, 2011). Recently, Lozano et al. (Lozano, Merrill, Sammalisto, Ceulemans, & Lozano, 2017), using hermeneutics and grounded theory, showed that project and problem-based learning have the greatest potential to empower learners with multiple Sustainability competences.

2.3 Competences for Sustainability

Two notions of competence have emerged in educational practice. The first one is related to professional standards and prepares students for the labour market, often narrowing the perspective of education to merely the accumulation of skills that matter for the economy, such as the skills for the fourth industrial revolution (WEF, 2016). This view is apparent in the early OECD (2005) documents and is thought to have emerged as an opportunity to combat wide unemployment in Europe and overcome the obsolescence of lower order skills promoted by the widespread automation of work (Anderson-Levitt, 2017). The second view sees competence as whole personality development that aligns with personal fulfilment, freedom, active citizenship and participation in shaping all aspects of society and aligns with the framework of ESD (Carm, 2013). This transformative view of competence requires active learning, constructivist epistemologies and transformative pedagogy, as mentioned earlier. In this sense, students develop cognitive, affective and behavioural competence, which allows them to construct their own knowledge, skills, values and emotions by active participation in learning, which in turn enables lasting transformation in them and commitment to action (Sipos, Battisti, & Grimm, 2008). Learning actually increases further through the interaction with others and self-reflection. Action increases by questioning the accepted practices, values and norms and identifying areas that disrespect people's experiences of the socio-economic and cultural context and altering those (Gokool-ramdoo & Rumjaun, 2016).

A recent review (Anderson-Levitt, 2017) found that the concept of competence in primary and secondary education, although widespread, is not global. Regions of the world that have implemented a competence-based approach to school education include most notably Europe, some countries in Africa, Latin America and regions in North America. There have been countries such as South Africa that implemented the model and abandoned it altogether due to resistance from local governments and some countries such as Japan and UK who are swinging between content-based and competence-based education. Using a broader interpretation of the concept, policy documents provide examples of some countries in Asia and America that are using the terms skills, capabilities, targets, goals and educational objectives interchangeably with the term competences (UNESCO, 2016).

The concept of competence is gaining a lot of ground in Higher Education (HE), with many universities worldwide shifting to a competence-based approach (Blanco-Portela, Benayas, Pertierra, & Lozano, 2017). The new ESD guidance for the UK HE sector (QAA, 2020) advocates for designing ESD into curricula, to transform students' ways of thinking and acting so that they become Sustainability change makers. It also advises in favour of linking learning outcomes with ESD competences and designing learning environments that are interdisciplinary or transdisciplinary, learning approaches that are inclusive and accessible for all, policies that support holistic assessment and providing extra and co-curricular activities. All these require highly trained and motivated educators in all levels, educators with the competences to achieve the transformation needed (UNESCO, 2020). However, to address such a challenging problem as the one on the role and effectiveness of ESD in enabling Sustainability, it needs to be seen through a holistic lens such as that which a systems approach can provide.

2.4 Systems thinking as a promising approach in ESD

Education for Sustainable Development is hypothesised as essential for facilitating a transformation to a more harmonious world and a systems approach to evaluate its role and effectiveness in empowering learners with Sustainability competences to do so can offer a novel perspective on how to transform education towards Sustainability and tools to achieve it.

Systems thinking is a holistic approach to analysis that focuses on the way that a system's constituent parts interrelate, how systems work over time and within the context of larger systems (Aronson, 1996). It provides principles and methods through which practitioners intervene in and learn about real world problem situations in order to bring about constructive change. In educational practice it can encourage the exploration of inter-relationships (context and connections), perspectives (each actor has their own unique perception of the situation) and boundaries (agreeing on scope, scale and what might constitute transformation) (Palmberg, Hofman-Bergholm, Jeronen, & Yli-Panula, 2017).

Systems thinking as a promising approach for transforming ESD has been advocated for many times especially considering that Sustainability is a complex concept with dynamically interactive dimensions, i.e. the natural, social and economic (Gasparski & Wilson, 2018; Gokool-ramdoo & Rumjaun, 2016; Iyer-Raniga & Andamon, 2016; Pipere, 2016; Schuler, Fanta, Rosenkraenzer, & Riess, 2018; UNESCO, 2014a). It is now particularly relevant, as the SDGs require an integrated approach to their implementation that avoids the fragmented approach of addressing them as separate priorities, which may be conflicting and undermine efforts to achieve them. Systems thinking was suggested in an earlier doctoral thesis to theoretically support the need for a transition to a new educational paradigm for ESD although it was not empirically tested (Sterling, 2003).

Systems thinking can be used as an overarching methodology to answer research questions around the complexity of SD, educational transformation towards Sustainability, and in particular to set the overall framework of the research investigation. In addition, it can be used to provide the context and interconnections between Sustainability, the role of education and measuring its effectiveness. Lastly and importantly, through its various tools, such as visioning, gap analysis, back casting and multi-criteria analysis, it can enable the participatory approach necessary for including the perspectives of the education stakeholders involved in the transformation, actively engaging them in rethinking education, envisioning Sustainability, making decisions and setting action plans to achieve.

Although education can happen through formal (organised educational system), informal (during everyday activities such as at work, home or during leisure activities) and non-formal (intentionally chosen learning that takes place outside the formal education and training system), this research will focus on formal education settings as this is the model that

has the potential to generate systemic change because it shapes the personalities and capacities of learners (Besson, Huber, Mompoint-Gaillard, & Rohmann, 2014). Although the assessment of effectiveness of ESD can be conceptualised as teacher effectiveness, educational climate effectiveness and learning effectiveness from an education perspective (Stumbo & McWalters, 2010), when seen though a systemic lens for achieving Sustainability it relates to the development of Sustainability competences as educational outcomes. It is considered in terms of increasing student learning gain, i.e. capacity-building, that empowers learners with knowledge, skills, attitudes and behaviours to pursue Sustainable Development (Pauw et al., 2015). The development of Sustainability competences is possible though primary, secondary and tertiary education and thus case studies in these three levels will be investigated.

Chapter 3 Research Aim, Objectives and Structure

3.1 Aim and objectives of this research

The thesis aims to investigate the role and effectiveness of Education in enabling the transition to a sustainable future as envisioned by the 2030 UN Agenda of Sustainable Development Goals, focusing on a case study that highlights the potential of Higher Education to deliver the competences required for Sustainability to emerge and then transferring insights and findings into School Education.

The research objectives are:

1. To evaluate the role of Education in enabling the transition to a sustainable future guided by the SDGs and proposing a framework for assessing its effectiveness (chapter 5)
2. To evaluate how well educational programmes are aligned to Sustainability (chapter 6)
3. To develop and apply a tool for evaluating Sustainability competences in Higher Education programmes (chapter 7)
4. To demonstrate the potential of the framework to deliver improvements in curricula, teaching methodologies and assessments (chapters 8)
5. To adapt the tool for application in School Education programmes and develop insights from case studies (chapters 9)
6. To discuss the potential of the tool to enable educational institutions formalise, operationalise and evaluate their contribution towards the SDGs (chapter 10)

3.2 Thesis structure

Systems thinking is the overarching research methodology employed and the way it is unpacked and applied to achieve the research objectives is described in each chapter. Each chapter includes an introduction that contains a literature overview of the concepts analysed, methodology application, results, and discussion of the findings in relation to the objectives as well as limitations identified and ways to overcome them. More specifically:

Chapter 4 provides the research rationale, consisting of the assumptions of this thesis, ethics review and approval for the use of tools to collect data from students, expected original contributions and complementary methodologies to address the research objectives.

Chapter 5 takes a systems thinking approach to link learning outcomes (LOs) as important educational gain descriptors to crucial conditions for Sustainability as envisioned by the SDGs, to emerge and provides a framework that education practitioners can use to envision Sustainability, select Sustainability competences, pedagogies and monitor and evaluate their efforts.

Chapter 6 demonstrates the development and application of an assessment tool to evaluate the alignment of Higher Education programme's learning outcomes to the SDGs. It uses the eight core Sustainability attributes identified in the previous chapter and employs multi criteria analysis to compare programmes of study and draw insights for their contribution to Sustainability, areas of good coverage and gaps in the educational offerings.

Chapter 7 demonstrates the development and application of an assessment tool to evaluate the attainment of learning outcomes for Sustainability in University studies and highlights its potential through a case study of the Imperial College London MSc Environmental Technology.

Chapter 8 shows the application of the assessment tool to inform a major curriculum review of the MSc Environmental Technology and highlights its outcomes in terms of assisting education practitioners to make decisions related to the improvement of curriculum, pedagogy and assessment.

Chapter 9 demonstrates the adaptation of the assessment framework and its application in primary and secondary education through two case studies in UK schools.

The last chapter (Chapter 10) is dedicated to a critical analysis and discussion of the previous chapters in relation to the overall aim and research objectives of the thesis. An attempt is made to synthesize the findings, make concrete recommendations around the contribution of education to Sustainability and the SDGs through the operationalisation and assessment of Sustainability competences, and suggest ways forward that will be meaningful for educators and learners as well as for policy-makers.

The conclusions section provides a summary of all the insights drawn through this thesis to aid education practitioners in applying the tools and frameworks developed and provides some policy recommendations for the education and ESD sector.

Chapter 4 Rationale of the research

4.1 Research Assumptions

This research assumes that:

1. The SDGs can provide a useful normative framework for educational communities to decide in a participatory way the Sustainability competences they should develop in order to achieve their localised vision of Sustainability (Research objective 1)

2. The alignment of LOs to Sustainability can be assessed by evaluating the extent to which they cover Sustainability attributes related to their SDGs guided vision (Research objective 2)

3. Learners can develop Sustainability competences provided appropriate (aligned to Sustainability vision) LOs are defined and appropriate (aligned to Sustainability LOs) pedagogies and assessments are in place (Research objectives 3 and 5).

4. The evidence collected through the assessment of the LOs' alignment to Sustainability and the assessment of learner Sustainability competences can aid decision making in curriculum, teaching methodology and pedagogy development (Research objective 4)

4.2 Research ethics

Postgraduate University, primary, and secondary school student data through surveys and interviews were collected and analysed as part of this thesis to support the research questions. According to guidance provided by Imperial College on Human Research Ethics, the appropriate steps were taken to ensure compliance of this research with ethical considerations. This research has been granted full approval by the Imperial College Research Ethics Committee (ICREC) as it involves the participation of human subjects and handling their data. The ICREC approval reference is 18IC4498, dated 14 May 2018. There have been two approved amendments since then, on 9 May 2019 and on 22 June 2020. Every effort has been made to ensure compliance of this research with the ethical standards and procedures, including data handling under GDPR, of the other educational institutions involved.

The participants were given participant information sheets and informed consent forms to complete before entering the study. They were informed that they could withdraw at any

point of the study, without this having adverse effect on their relationship with the College and the researchers. The participants were recruited through the formal teaching procedures of the Centre for Environmental Policy of ICL and through its external contacts with schools in the UK. All initial communications happened through emails. The data collected were anonymous and participant confidentiality was maintained throughout the duration of the research. Data will be held accordance to ICL's policies for 10 years and will be used for publications and conference presentations.

4.3 Statement of expected original contributions and research outputs

This research aims to contribute theoretical support of what the role of ESD should be and why and how to assess the effectiveness of ESD in terms of empowering learners with Sustainability competences through a systems thinking lens. In addition, it provides empirical evidence on the effectiveness of the development and application of assessment frameworks and tools for Sustainability competences in University and School case studies.

Specifically, the following are expected as original contributions:

1. A coherent framework for educational institutions to formulate learning outcomes for Sustainability in the form of competences guided by their localised vision of the SDGs
2. A reliable and valid framework for assessing the contribution of HE programmes to the SDGs though evaluating the alignment of their learning outcomes to crucial Sustainability attributes
3. A holistic tool for assessing the attainment of Sustainability competences in University and an adapted version of it for School education
4. Recommendations that will assist educational organisations in decision-making around curriculum reviews, pedagogy and assessment methods transformations and policy making in enabling the integration of ESD into educational programmes

This research has produced the following outputs:

1. Two published papers in the open access peer reviewed journal Sustainability, which have been cited more than 40 times and downloaded more than 18,000 times. The papers include the systemic framework for connecting educational outcomes to the SDGs and the assessment tool for Higher Education programme alignment to Sustainability,
2. A published book chapter in the Springer Nature Book "Education for Sustainability in Primary and Secondary School Education" about the application of the adapted assessment framework and tool for school education,
3. A submitted paper about the application of the framework and assessment tool in the University case study and another one about the findings of the thesis which is currently being written,
4. A University stakeholder workshop at the 2019 Materials Research Society (MRS) Fall meeting and exhibit in Boston USA, training University representatives on the use of the framework,
5. A teacher training workshop in collaboration with the Environmental Education Centre of Piraeus in Greece on the use of the adapted framework for schools,
6. A workshop for Imperial College postgraduate students on the use of active-learning techniques (serious games and computer simulations) to enable Sustainability competences in learners,
7. Presentations of the findings of the thesis in the following international conferences: 2018, 2019 and 2021 MRS Fall meeting and Exhibit, 2018 and 2021 European Meeting of the Regional Centres of Expertise (RCEs) on ESD, 4th Sustainability in Higher Education Conference (2019) and 2021 Advance Higher Education Teaching and Learning Conference.

4.4 Complementary methodologies to address research questions

In table 4.1 additional methodologies and tools used in this research are presented to address the research objectives and the reason why they were selected to support this thesis.

Table 4.1. Methodologies and tools used to address the research questions and their justification

Methodology/tool to address research questions	Reason
1. Literature review	Develop background for research, problem identification, development of assessment frameworks (Research objectives 1, 2, 3, 4 and 5)
2. Surveys (self, peer and team assessment questionnaires), interviews and assessment rubrics to evaluate project reports and deliverables performance tasks.	Collect and validate data on student competences developed during interventions (Research objectives 3, 4 and 5)
3. Case studies (using problem/project-based, collaborative and active learning techniques)	Educational interventions in universities and schools to assess the development of Sustainability competences in learners (Research objectives 3, 4 and 5)
4. Qualitative analysis of literature reviews, curricula, programme specifications and quality assurance report investigations using appropriate software (NVIVO12 plus)	To record, code and map learning outcomes, pedagogies, Sustainability competences and assessment methods and validate the data collected through quantitative methods (Research objectives 2, 3, 4 and 5)
5. Quantitative analysis of results from surveys and other assessment tools using appropriate software (SPSS, MS excel)	To assess the validity and reliability of the assessment measures developed and the effectiveness of educational interventions in delivering the intended competences (Research objectives 2, 3, 4 and 5)

Chapter 5 Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes

5.1 Introduction

Humanity faces many Sustainability challenges, products of complex, often nonlinear, interactions between people and the environment. Our understanding of them is often incomplete and in part clouded by profound uncertainties (Dovers & Handmer, 1992; Voulvoulis & Burgman, 2019). Human behaviour, although not intentionally malicious, is widely recognised as the root cause of most Sustainability challenges. Individual and collective choice can exacerbate environmental, economic and social problems (Pauw et al., 2015). Consequently, addressing pressing Sustainability challenges, such as transgressing critical planetary boundaries (Steffen et al., 2015), requires changes in public perceptions, values, attitudes and behaviours, and the right conditions for these changes to happen (Scoones et al., 2018; UNESCO, 2017a). It requires fundamental changes in the way we think, act, and relate to other biotic and abiotic systems. Arguably, *education* is the most important tool to reshape worldviews and values and has enormous potential to address the Sustainability challenges facing humanity (Cortese, 2003; Trevors & Saier, 2010; UNFCCC, 2015; IIASA, 2018). It can empower learners to embrace Sustainability as a lifestyle choice (Rauch & Steiner, 2013). However, lifestyle choices are often the outcome of external influence by institutions, structures and practices that are beyond the control of the individual (Wals, 2015) and so personal responsibility needs to be seen in a dialectical relationship with collective responsibility.

The Sustainable Development Goals (SDGs) Agenda of the United Nations adopted by world leaders in 2015 includes poverty eradication, climate change mitigation and universal access to education as aims. The SDGs provide a framework of Sustainability goals and targets that is universally accepted and summarise priority action areas to help society achieve justice, prosperity and environmental security. The UN 2030 Agenda acknowledges Quality Education (SDG4) as a means for achieving the remaining SDGs, with Sustainability as a goal for Education in target 4.7. Despite these aspirations, what education for Sustainability aims to achieve is not clear. Earlier policy statements include *Environmental Education* (EE) in 1977 (The world's first intergovernmental conference on environmental education was organized by the United Nations Education, Scientific, and Cultural Organization (UNESCO) in cooperation with the U.N.

Environment Programme (UNEP) and was convened in Tbilisi, Georgia (USSR) from 14–26 October 1977.), the introduction of *Education for Sustainable Development* (ESD) during the Earth Summit in Rio in 1992 (The United Nations Conference on Environment and Development (Rio Summit, Earth Summit) and Chapter 36 of Agenda 21 consolidated international discussions on the critical role of education, training and public awareness in achieving Sustainable Development .), the announcement of the *Decade for ESD* in 2002 during the World Summit on Sustainable Development (A proposal for the Decade of Education for Sustainable Development (ESD) was included in the Johannesburg Plan of Implementation. The United Nations General Assembly, at its 57th session in December 2002, adopted a resolution to start the UN Decade of Education for Sustainable Development (DESD) from January 2005.), the launch of the *Global Action Programme* (GAP) for ESD in 2014(UNESCO World Conference on ESD launched the Global Action Programme on ESD) and recently the *Incheon Declaration* (The Incheon Declaration (Education 2030: Towards Inclusive and Equitable Quality Education and Lifelong Learning for All) was adopted at the World Education Forum, Incheon, Korea R, 2015.) that stressed the important role of education as a main driver of development and realisation of the SDGs in 2015. It is also unclear whether these initiatives have been successful in transforming curricula and teaching approaches towards Sustainability (UNESCO, 2014c).

Empirical studies on the effectiveness of ESD have been limited (UNESCO, 2012). The few studies that have reviewed the learning concepts and educational practices used in ESD highlight discrepancies, incongruence of approaches and deficits in curricula (Mckeown, 2002; Scott, 2015). Educational strategies and policy recommendations for implementing ESD are considered to have had limited positive impact, heavily reliant on perceived beneficial outcomes that have not been assessed objectively (Pauw et al., 2015). Furthermore, studies have found learners increasingly disengaged from ESD (Thomas, 2004). Students and teachers often feel overwhelmed by Sustainability concepts (Lourdel, Martin, & Bérerd, 2006), and misconceptions about the nature of Sustainability and the limited feasibility of making a difference have been further shown to provoke pessimism and diminish motivation (Seatter & Ceulemans, 2017). Sustainability has often been used to manoeuvre students into particular viewpoints (Carew & Mitchell, 2008), rather than empowering them to reach their own conclusions based on critical reflection of the available opinions and evidence. There have been calls to re-evaluate ESD efforts due to the disconnect between environmental education and personal responsibility (Blumstein & Saylan, 2011).

The concept of Quality Education is based on the premise that educational aims are met and purposes fulfilled, with quality seen "in light of how societies define the purpose of education" (UNESCO Global Monitoring Report, 2014). While education, including formal, informal and non-formal awareness and training has been recognised as "a process by which human beings and societies can reach their fullest potential", for years, the purpose of education in industrialized countries has been to educate a workforce, aiming at excellence in a few core disciplines (Laurie, Nonoyama-Tarumi, Mckeown, & Hopkins, 2016). A study conducted recently in 22 Asian countries showed that education places emphasis on preparing students for competitive participation in the global economy, rather than to become critical and responsible members of society in alignment with the objectives of ESD (Mochizuki, 2019). Today, although economic well-being remains an important educational outcome, there have been increasing calls for education to focus also towards global citizenship, social justice and Sustainability (Laurie et al., 2016). The Aichi-Nagoya Declaration 2014 on ESD invites all education systems, from preschool to higher education, to revisit and clarify their purpose, mission and goals and consider educating for a sustainable future.

ESD links with quality education in the sense that it has the potential to empower learners with the knowledge, skills and values needed to promote a sustainable society (Laurie et al., 2016). However, the concept of a sustainable society is contested (Seatter & Ceulemans, 2017). Sustainability as an educational task has not been properly defined, is often considered too vague, distant or abstract, and as a result, Sustainability learning outcomes often lack clarity. As no universal formula for Sustainability exists, ESD has been interpreted in different ways around the world, and often according to context (UNESCO, 2012). In some cases, prescriptive modes of ESD have prevailed—for instance, focusing on training people in how to live their lives more sustainably. However, the uncertainty over which behaviours produce sustainable results has limited their effectiveness. As a result, more reflexive and transformative modes of ESD have emerged that tend to emphasize capacity-building and empowerment of learners to reach their own decisions over behavioural change (UNESCO, 2012). The former rely mainly on instructional forms of teaching and knowledge transfer and the latter more on participation, self-determination, autonomous thinking and knowledge co-creation. As different societies have different boundaries for such processes and a corresponding view of democracy, the lack of global guidelines for ESD would not support educational systems enabling the transformational social change necessary for Sustainability.

How Sustainability is defined and understood, is critical to the design of appropriate educational pedagogies, their implementation, and their potential to deliver what they are designed for. It is hypothesised that for assessments of effectiveness to be meaningful and comparable, a common conceptual understanding of what ESD aims to achieve is needed, a reference base against which to assess educational outcomes. In this chapter, Sustainability is contextualised as a goal for Education, and the aim is to develop a framework that connects the SDGs to educational learning outcomes. Using systems thinking and through a participatory approach, the framework allows education stakeholders and learners to work together to construct a common vision of Sustainability, with Sustainable Development goals as end points. The process then leads to the selection of the competences required for such vision to realise, so that appropriate pedagogies and learning strategies can be developed, and progress towards delivering these competences as learning outcomes assessed.

5.2 Methodology

5.2.1 Sustainability As a Goal for Education: The Need for a Systems Approach

In broad terms, Sustainability is an attempt to reconcile growing concerns about a range of environmental issues with socio-economic objectives. The so-called three pillars of economic, social and environmental Sustainability are not necessarily in alignment, and often create situations that are deemed complex and perplexing, with lack of clarity about the problems, and different interests creating tensions (Niles & Tachimoto, 2018). Sustainability, as seen from five different perspectives in published literature, is captured in Figure 5.1 (Lozano, 2008). The conventional economist perspective supports that Sustainability is an end-point and can be achieved through efficient consumption (Stavins, Wagner, & Wagner, 2003). In this view, Sustainability is equated with economic growth and viability and the negative effects on the environment and society are not considered. The non-environmental degradation perspective is rooted in the *limits to growth* concept (Meadows, DH., Goldsmith & Meadows, 1972). Economic development relies on natural resources and cannot continue indefinitely, as crossing environmental boundaries may cause ecosystem collapse. This view is eco-centric and excludes societal considerations such as poverty, unemployment, human rights and illiteracy from the aim of Sustainable Development. The integrational definition acknowledges that achieving it entails reconciliation of environmental, economic and social

aspects (Elkington, 2013) and is more complete than the previous two. However, it is mainly focused on present activities. The intergenerational definition stems from the Brundtland report (WCED, 1987) and considers the temporal scale of Sustainability, the impact of current decisions on future generations, but nevertheless is abstract in how it bridges the three pillars of economy, environment and society. Lastly, the holistic perspective combines contextual (people, planet, profit) with temporal considerations (short, medium and long-term) to provide a dynamic and evolving concept of Sustainability (Lozano, 2008).

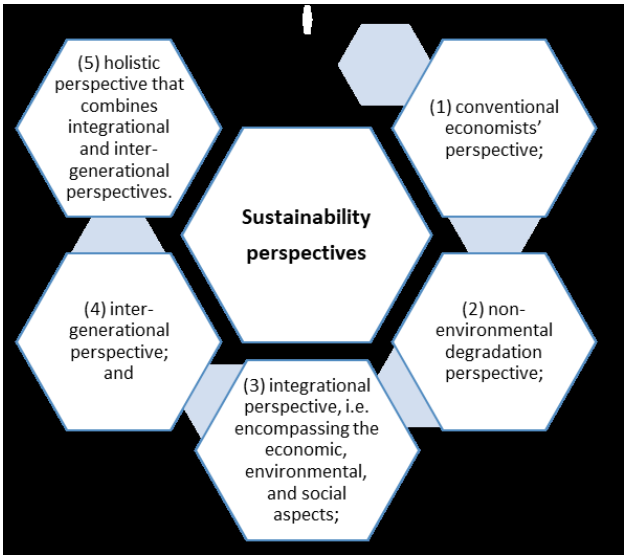

Figure 5. 1. Sustainability as seen from five different perspectives in published literature.

It is this plurality of definitions that has seen Sustainability criticized as a "fuzzy" and vague concept, in terms of effectively communicating its meaning to a wide range of audiences (Eernstman & Wals, 2013). Experts, for example, place more emphasis on the sociological role of how Sustainability affects human-beings (social impact, unbalances, future uncertainty) and how problems of unsustainability can be solved (values, education and stakeholders), while students often see Sustainability more as a scientific-technological subject—down to science to explain and technology to avoid and solve environmental problems (Jordi Segalàs, Mulder, & Ferrer-Balas, 2012). Its complexity can further reduce its appeal to potential stakeholders, including educators and learners, often limiting policy-makers' capacity to include it as the overarching goal of policies (Hák, Janoušková, Moldan, & Dahl, 2018). In practice, this raises the need to look at Sustainability considering interactions between all its dimensions, its multiple scales and overall complexity (Zachary, 2014), a task that most ESD initiatives have struggled or avoided to address in the past.

The SDGs introduced in 2015 as reference and universal guidepost for transitioning to Sustainable Development in the period 2015–2030, are aspirational, and according to the UN 2030 Agenda, are intended to be used as a set of interconnected goals and global targets. They provide a useful normative framework to understand Sustainability, encompassing the vision of a Sustainable Society which is inclusive and takes into account social, environmental and economic capital and has the potential to attract public attention and influence public sentiment (Hák et al., 2018). In this context, our societies and economies need to transform from the current unsustainable state onto a sustainable and resilient path, through an integrative approach that addresses all 17 SDGs, building on their synergies and benefits while alleviating their trade-offs (IIASA, 2018). This is what is often referred to as a systems perspective, with Sustainability seen as a dynamic state that our society is constantly trying to define and reach. This, in turn, means that all 17 SDGs are important for achieving a sustainable society and they should not be seen in isolation. An isolated or reductionist view of the SDGs in policy formulation and application may result in excluding important positive feedback between targets that may enhance efforts and produce multiple benefits or disregarding negative feedback, which will undermine efforts and cause policy resistance (IIASA, 2018).

Systems thinking is widely recognised as an effective way to reframe the SDGs in order to highlight their integration and reflect on important directions towards building sustainable societies, compensating at the same time, for their shortcomings and limitations (Lim, Søgaard Jørgensen, & Wyborn, 2018; Zhang, Prouty, Zimmerman, & Mihelcic, 2016). It offers the potential of a richer view on the relationship between Education and Sustainability, with ESD playing an active role in delivering the transformative changes required for society to move towards a Sustainability state. Such transformation is an ambitious endeavour.

Systems thinking in this chapter is used as an approach to look at the big picture of the role of education in enabling such transformation. It builds on the importance of aspirations in relation to human development and capability theory by facilitating understanding regarding, first, the way that aspirations (Sustainability) are defined, secondly, the way they are connected to capabilities (competences) and thirdly, pedagogies, the processes by which capabilities become functioning. Contrary to overly simplistic political models that seek to deliver pre-defined version of Sustainability, such an approach builds on its value as a metaphor or heuristic for a social ideal and allows ESD to embrace complexity and resist over-simplification.

It is acknowledged that seeing Sustainable Development as an end state, visions of an ideal, sustainable future as influenced by history and culture could turn educational programmes into indoctrination for that kind of future, but here it is assumed that sustainable society as a system state can only emerge as the result of complex interactions between system parameters and conditions with education guiding the transformational process for society reaching such a dynamic state (Palmberg et al., 2017). Building on the wide range of democratic pedagogies that have been discussed in the environmental education literature for over twenty years (Huckle, 2009; Fien, 1993), the participatory and empowering nature of a systems approach, allows "educational aspirations" to be established by localized visions of the SDGs, and again not looking at them as a 'product' (i.e., fixed vision of Sustainability), but as a way of thinking about the enabling factors and conditions necessary for Sustainability to emerge. This approach is consistent with the holistic, ecological worldview that looks more to process than product, recognises the systemic view of change (Fien & Tilbury, 2002), and therefore allows for a more sustainable transformational process.

5.3 A Participatory Conceptual Framework for Sustainability Transformation through Education

Contextualizing the Sustainability challenge through gap analysis from a systems perspective (Figure 5.2), the proposed framework aims to facilitate the process of Sustainability transformation through education, and treats ESD as the means for bridging the gap between the current unsustainable state and a desired sustainable one. The process can accelerate the collaboration of all those involved in education and Sustainability, allow educational institutions to develop a clear vision of what Sustainability means to them and work towards transforming individuals, groups, organisations, communities and systems by developing the competencies needed to transition to a sustainable future (Lozano, Barreiro-Gen, Lozano, & Sammalisto, 2019; UNESCO, 2018). The conceptual framework is based on the following systems thinking techniques: 1. Visioning, to generate a participatory vision of the sustainable state, 2. Back-casting, to identify the enabling conditions for the sustainable state, the kinds of competences the citizens need to develop to realise that state and the pedagogies that should be in place to aid the development of competences and 3. Monitor and evaluation indicators that will give information about the system state and the progress towards the

sustainable state. In the following sections, each part of the conceptual framework is explained in more detail.

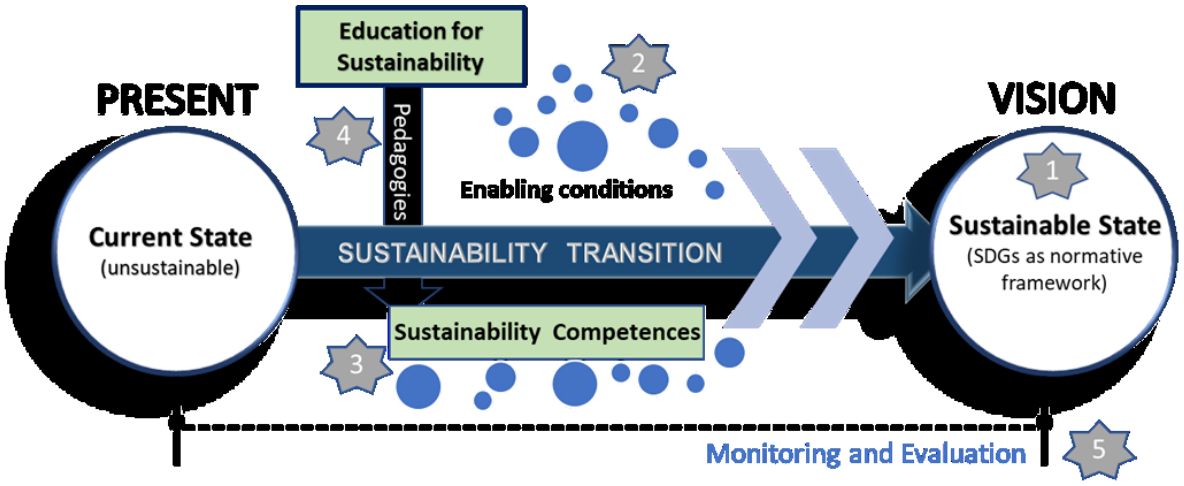

Figure 5. 2. Educational framework for Sustainability transformation and main steps: (1) A participatory vision of Sustainability, (2) enabling conditions for Sustainability, (3) competences for Sustainability transformation, (4) pedagogies and learning strategies for Education for Sustainable Development (ESD), and (5) monitoring and evaluation of ESD competences and distance from sustainable state.

5.3.1. A Participatory Vision of Sustainability

Sustainability does not translate to a fixed predefined version of a sustainable state, but a future that society will aspire to reach, a vision of a world transformed by the SDGs (Glasser, 2018). The implementation of the UN 2030 Global Agenda should be localised to address the needs and requirements of local communities (UCLG, 2018). Indeed, the localisation of the 2030 agenda, involving the engagement of local leaders, regional governing bodies and citizens in a process of participatory co-creation of community spaces, values, relationships and priorities, is considered increasingly central to the implementation of the SDGs (Mansilla & Jackson, 2011). This is an important process, as to achieve the systemic transformation towards Sustainable Development by 2030 and beyond requires collective action, coordination of multiple stakeholders and long-term planning of activities in the local level.

The need for the educational community to define collectively a Sustainability vision of the future, "translating" what achieving the SDGs will mean, should be a participatory process with strong collaboration with local civil society, engaging learners, educators and stakeholders. Participation in the education sector has been found to increase synergies, establish positive

learning environments and promote a culture of collaboration (Lidstone, Wright, & Sherren, 2015). ESD can benefit from wider participation of stakeholders in a dialogue about the vision, mission and educational objectives of the institution, which can be an important driver for Sustainability transformation (Bullock & Hitzhusen, 2015). Stakeholders that can be included in the visioning process could be internal to education such as students, professors, management, administration and service personnel; or external actors, such as local authorities, communities, indigenous populations, suppliers, businesses and citizen associations/movements (Blanco-Portela et al., 2017). Students, in particular, when they become engaged in shaping educational outcomes have been found to develop civic responsibility as a societal norm (Frisk & Larson, 2011).

5.3.2. Enabling Conditions for Sustainability Transformation

"Generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved", often termed as back casting, is considered best practice in long-term planning for Sustainability transitions (Holmberg & Larsson, 2018). Back casting, which is the methodology that binds all the steps of the framework, begins with a projection of the desired outcome(s), and works backwards to understand what is needed for their realisation. In an educational environment, this process could be used to relate educational outcomes to the enabling conditions for the localised vision of Sustainability to emerge. Example of enabling conditions for a vision of Sustainability related to the SDGs is shown in Figure 5.3. This has been constructed by grouping the SDGs into major systemic attributes and enabling conditions. Those related to achieving *the safe operating space* refer to maintaining ecological integrity and not transgressing crucial planetary boundaries conditions (Rockström et al., 2009). Those related to achieving *the just operating space* (Raworth, 2012) 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. Finally, transparency, responsible governance, health and wellbeing, diversity, resilient sustainable behaviours, and partnerships between many actors of civic society that can lead to innovation, are also needed. A localised vision of the SDGs would also require an economy 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.

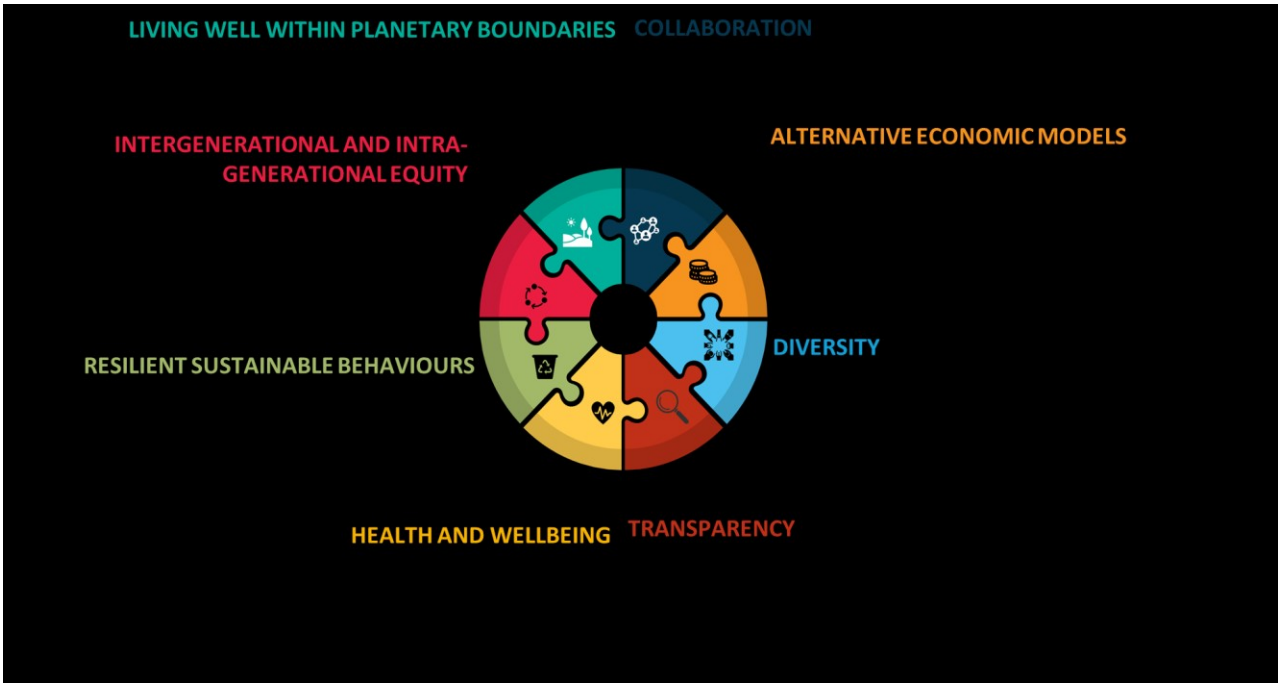

Figure 5.3. Examples of enabling conditions for a vision of Sustainability related to the Sustainable Development Goals (SDGs).

Recent research (Scoones et al., 2018) shows that four planetary boundaries have been crossed: climate change, loss of biosphere integrity, land-system change and altered biogeochemical cycles (phosphorus and nitrogen). Considering the uncertainty in earth system interactions, critical thresholds and tipping points, this increases the risk of compromising the ecological integrity of the earth which is the foundation of society and all economic activity (Dearing et al., 2014). Seen from the perspective of the hierarchy of needs, it offers a framework to explore drivers of behavioural motivation for people to enact the Sustainability conditions (Maslow, 1943). If the Earth system reaches an inhospitable state for all life, this will adversely affect human wellbeing as the satisfaction of physiological needs such as food, water, sanitation, health, housing and energy will not be possible. Safety and security needs, such as employment, security of incomes and livelihoods of citizens, peace and non-violence, law and order, protection from the extreme effect of disasters and epidemics which are second tier needs will also be jeopardised (Yawson, Armah, & Pappoe, 2009). This poses a serious threat in achieving a just society for current and future generations. Collaboration speaks to the feeling of belongingness, the third level in the hierarchy of needs that refers to developing meaningful relationships among people, institutions and nations to combat complex socio-ecological issues (Yawson et al., 2009). Status needs such as esteem, respect, confidence and

achievement can only be enabled if there are adequate conditions that favour effective governance, transparency, diversity and an economic model that does not generate and sustain inequalities but allows the people and the planet to thrive (Raworth, 2012). The last level in the hierarchy of needs, self-actualisation, relates to transcendence, achieving the highest level of self-fulfilment which is based on fulfilling one's potential. This level has been shown to relate with advanced environmental Sustainability which can be enabled when all other conditions including democratic participation, social equity, and transparent governance, technical and economic foundations have been satisfied (Walsh, 2011). Self-actualisation motivates resilient sustainable behaviours driven from an ethical point of acting with a civic sense to prioritise the common good and having the ability of moral judgement, value clarification and critical reflection on personal and collective values (Schank & Rieckmann, 2019).

The interpretation of the SDGs to Sustainability attributes can be used to distil values that are related to ecological system integrity, social justice, equity and equality, human rights and responsibility, empathy and solidarity, health and wellbeing (Keitsch, 2018). Because "Sustainability is itself the emergent property of a conversation about what kind of world we collectively want to live in now and in the future" (Wallace, 2002) its ethical framework requires a critical examination. The SDGs touch on the relationship between nature and humans and mainly propose an anthropocentric view of nature as instrument from which humanity derives resources and various services, however a moderate bio-centric view that recognises the inherent value of nature and prioritises the human-nature experience that contributes to quality of life and wellbeing, connection and empathy towards other beings and the context of development of cultural identity could also be appropriate (Keitsch, 2018). This view would be beneficial for the change of paradigm required to address existential threats such as climate change, since ecological integrity can be severely compromised. This is directly related with satisfying human physiological and psychological needs. The change argued for is not one of simply changing behaviour; it is a change of process that is embedded in values (UNFCCC, 2015). The process relates the ultimate means, the base on which all life, the society and economy rely upon to satisfy the ultimate ends, the higher achievement possible for humanity which is self-actualisation (Meadows, 1998). However, there is a hidden danger, motivating sustainable behaviours on the basis of hope and fear relies on the view that humans can control a future fraught with uncertainty to avoid disastrous consequences (Dahlbeck, 2014). This

psychological vulnerability, especially in students, can be used as a governance tool to manipulate them towards specific actions and raises questions of power. The Sustainability discourse is one with no right nor wrong answers, and requires people empowered to make critical decisions regarding individual and collective actions. Pragmatism advocates for value pluralism, as novel ethical situations and problem contexts can always emerge. These will require openness to perceive the conflicting value systems at play and humanistic inquiry to examine their nature and decide through democratic processes what action to take in the specific context (Minteer, 2011).

5.3.3. Competences for Achieving Transformation

Having constructed a shared vision of what Sustainability will look like, and established enabling conditions to realise it, the next task is to define the knowledge, skills, behaviours, and attitudes, collectively the competences that learners need to develop to realise such a state. This task is important, as the selection of Sustainability competences will transform the curricula, pedagogies, educator training programmes and learning environments at the level of the education system (Carm, 2013). The process should be taking into account all stakeholder views and contributions (Kjaer, Pigosso, Niero, Bech, & McAloone, 2019). Such an approach can allow for more tailored strategies, relevant to the place, time and context of education and therefore result in a widely accepted selection of competences, increasing a feeling of ownership for stakeholders and learners (Kirkman & Voulvoulis, 2017). The task is to define the knowledge, skills, values and attitudes that will empower learners to realise the sustainable state. A pre-set list of common, standard Sustainability competences can also be customised to that localised Sustainability vision. A few authors have attempted to compile lists of Sustainability competences (Glasser & Hirsch, 2016; DeHaan, 2006; Lambrechts, Mulà, Ceulemans, Molderez, & Gaeremynck, 2013b; Rieckmann, 2012; Steffen et al., 2015; Arnim Wiek, Withycombe, Redman, & Mills, 2011), and examples of the ones prevailing in the current literature are summarised in Table 5.1.

Sustainability competences should not only include cognitive components, such as knowledge and understanding of environmental, social, economic and political systems and higher order thinking abilities such as reasoning and synthesising, but also social skills, values and emotions, collectively referred to as the affective domain of learning. Some examples of the former are open-mindedness, intercultural understanding and empathy; and meta-cognitive abilities related to monitoring thinking and action processes that have been found to

also influence behaviour (Barth, Godemann, Rieckmann, & Stoltenberg, 2007; Faham, Rezvanfar, Movahed Mohammadi, & Rajabi Nohooji, 2017). Targeting the alignment between 'what I learn', 'what I think' and 'what I do' can enable a widespread change in mind-set and culture in educational organisations (Lozano, 2013).

Sustainability competences should be complemented by strong disciplinary skills (e.g., in natural, social sciences, engineering and business). Working in inter-disciplinary or trans-disciplinary teams for Sustainability problem-solving requires different views on the same challenges to be expressed and benefits from the integration of multiple perspectives to allow for innovative conceptualisations and creative approaches to emerge (Barth et al., 2007). Furthermore, an ethical framework should underpin these competences. Norms and values related to Sustainability will make these competences have more coherent meaning for building a society where the SDGs are the norm. It has been argued that these competences could result in building unsustainable societies without the support of an ethical compass (Blok, Gremmen, & Wesselink, 2016).

Table 5.1. Examples of competences for Sustainability, based on a synthesis of viewpoints resulting from reviewing key publications in the literature.

• *Systems thinking* is widely accepted as a competence for the learner to be able to understand complex systems, their elements and interactions between natural ecosystems forming our planet and socio-economic subsystems. Furthermore, it has to do with including multiple stakeholder perspectives and worldviews to produce a holistic conceptualisation of reality as an essential part of interdisciplinary collaboration. • *Future oriented thinking* (future thinking, anticipatory, foresighted thinking) is frequently included as a competence and relates to Sustainability in the sense	• *Critical thinking* is explicitly mentioned in several studies and has to do with questioning personal and collective thinking and norms and the application of criteria to reach decisions, which is reflected in wise decision-making. It has also been reported as competence in distanced reflection on individual and cultural models. • *Self-awareness* has to do with understanding of personal motivations, feelings and beliefs, and empathy towards others. It allows one to see the world by experiencing a

of taking into account future implications of current actions or considering future stakeholders' wellbeing when planning and taking decisions.

- *Collaboration* is included as a key competence in several studies, but in some cases captured in the form of effective communication, interpersonal skills for working with other people and inter-personal competences.
- *Strategic thinking* also referred to as wise transformative social change and action competence captures the ability to set goals and plan, implement and evaluate projects.
- *Normative competence* refers to the ability to deal with norms, values and beliefs both of the individual and of society, regarding present and future generations and human and non-human actors.
- *Modelling sustainable behaviour* hypothesises the presence of high-level norms that dictate action when dealing with trade-offs. It is a *discursive competence*, having to do both with receiving and communicating value judgments in neutral manners and shows a relationship with normative competence.

deep emotional connection with reality and other people.

- *Emotional intelligence* is included in elements such as taking into account other perspectives, multicultural understanding, responsibility, empathy, solidarity, self-awareness; if not explicitly mentioned.
- The *ability to use media* has been reported as a competence, but does not feature in most frameworks. However, it could be seen as important, considering that in a globalised and interconnected world messages can be transferred very fast, reaching all communities around the world and enabling them to communicate, collaborate, participate and act together.
- *Integrated problem-solving,* dealing with complex and ill-defined problems and drawing on all other competences to achieve optimal results is increasingly recognised as an important competence.
- *State of the planet knowledge* entails deep scientific understanding of natural phenomena and concepts and it is also worth mentioning as a Sustainability competence.

Virtue, a quality that goes hand in hand with competence and shows a disposition to 'do the right thing in the right situation' should be cultivated in learners. Watching other people

exhibiting the virtuous behaviour (role models), imitating their behaviour and reflecting on one's behaviour have been shown to influence the development of virtue (Blok et al., 2016). The discussion on values is by no means intended as indoctrination, whereby a set of "appropriate values" should be imposed on educational communities (Komasinkski & Ishimura, 2017). On the contrary, there is need for stakeholders to appreciate the diversity of value systems present in any discussion regarding implementing action or problem-solving for the SDGs and establish shared value systems, which will be negotiated and revised (Blok et al., 2016). This ethical compass would need to address the complex and ever-changing discourse on the interface of socio-economic and ecological issues, requiring deep knowledge of the standards, ability to judge which standards are to be followed in wicked situations, reflection on the plurality of value systems and courage to materialise actions based on the decided standards (Schank & Rieckmann, 2019). The focus on learners' values and moral competence is not meant to misdirect the discussion away from collective responsibility. Instead, it aims to highlight that individual actions can have significance; the choices students make, can have a direct link to the development of society (Dahlbeck, 2014). This ultimately could prepare students becoming citizens of a democratic society. When personal norms, values and interests are open to discussion and criticism by a community of people; then they undergo a "peer-review" process that leads to their validation or abolishment. This can also lead to development of ethical inquiry as a competence in students (Minteer, 2011).

5.3.4. Pedagogies for ESD

With Sustainability competences defined as educational outcomes locally, appropriate pedagogies can now be designed. Pedagogies that engage head (cognitive domain), hands (psychomotor domain) and hearts (affective domain) are considered as the most relevant to enable learners develop Sustainability competences (Sipos, Battisti, & Grimm, 2008) and act as important drivers for change. For example, pedagogies appropriate for developing Sustainability competences, such as integrated problem-solving, systems thinking, normative, strategic and interpersonal competences, include project and problem-based learning, active learning, community service learning, critical emancipatory pedagogy, place-based environmental education, ecojustice and community learning and traditional ecological knowledge (Lozano, Merrill, Sammalisto, Ceulemans, & Lozano, 2017). Examples of teaching techniques that can complement these pedagogies include, but are not limited to, case studies, mind and concept maps, life cycle and supply chain analysis, participatory action research and

also the formation of interdisciplinary and jigsaw/interlinked teams (Blake, Sterling, & Goodson, 2013b; Lozano et al., 2017; Jordi Segalàs et al., 2012; Sipos et al., 2008). Several emerging pedagogies review the educator—learner relationship and treat them, both, as partners in change or change—agents (van Poeck, Læssøe, & Block, 2017). Moreover, they enable learners to experience authentic learning environments by working in inter and transdisciplinary teams to help communities overcome Sustainability challenges with mutual benefits (Walter Leal Filho, Shiel, & Paço, 2016).

In this contextual framework, the role of the educator therefore becomes that of a facilitator oriented toward open-ended, collective problem solving, inspired by the visions of Sustainability from the framework's earlier stages. This not only contributes towards competences as learning outcomes, but also fosters creative and reflective interactions among the learners that may enable transformative learning and constitutes an important driver for change. The need for meaningful educator training programmes that will enable schoolteachers and University lecturers develop the knowledge, skills and confidence to embed these teaching techniques is of primary importance as underlined by the GAP on ESD (UNESCO, 2014b). Educators themselves need to develop and implement the processes that will allow their students to become empowered with Sustainability competences (UNESCO, 2018).

5.3.5. Monitoring and Evaluation

While developing appropriate pedagogies and putting educational practices in place is imperative to the transformation process, there is a clear need for monitoring progress and evaluating effectiveness. Two major reviews of ESD practice (Karatzoglou, 2013; Lozano et al., 2015) have revealed that the assessment of ESD outcomes is the component of Sustainability implementation that is lagging behind and so there is no valid justification as to whether the efforts put the last 20 years have been producing the desired change. The assessment of Sustainability competence development will allow for reviewing, confirming or revising the implementation of the framework, ultimately building the evidence base for the impact of ESD in reducing the gap towards the desired sustainable state.

For example, the strength of Sustainability competences developed in learners of universities has been shown positively correlated with contributions to Sustainability (Lozano et al., 2019). Such curricula integrate the three dimensions of Sustainability (environmental, social and economic), cross-cutting themes (e.g., governance, limits to growth, responsibility,

holistic view, people as part of nature) and the appropriate pedagogies (e.g., Case studies: Presenting students with open-ended questions regarding complex real-world cases; community and social justice: students engage in activities that benefit the community and learn at the same time or address social justice issues; and environmental education related: linking scientific understanding of the ecology of a place with emotional motivation to care for the environment.). More specifically, the correlation was very strong for competences such as systems thinking; inter-disciplinary work; anticipatory thinking; justice, responsibility, and ethics; critical thinking and analysis; interpersonal relations and collaboration; empathy and change of perspective; communication and use of media; strategic action; personal involvement; assessment and evaluation; and tolerance for ambiguity and uncertainty. Thus, criteria and standards associated with Sustainability competences' evaluation, collection of reliable data and use of standardised methods to compare values across scales and benchmarks are needed to assess them (Sala, Ciuffo, & Nijkamp, 2015), and can now be easier developed, informed by the framework's previous steps.

Monitoring will allow stakeholders to become actively involved in the process of transition, identify possible gaps in action plans, issues with the pedagogies used, the competences targeted or even their vision of Sustainability. These offer opportunities for improvement, encourage accountability and allow for meaningful changes in a process that needs to be adaptive and dynamic (Soland, Hamilton, & Stecher, 2013). Evaluation can elucidate the development of competences related to Sustainability in learners, redefine the relationship between learners and educators and provide evidence of transformational change (UNESCO Bangkok, 2015). Benchmarking, for example, can break through resistance to change by demonstrating the success of practices, increase accountability, as well as enhance institutional reputation (Soland et al., 2013). The framework proposed allows for the development of evaluation tools that can support educational institutions to monitor and manage their progress towards Sustainable Development.

For this, the use of indicators across four categories (integral Sustainability, the socio-cultural, the environmental and the economic dimensions) each with its own key items for assessing SDG integration in the curriculum has been suggested (Albareda-Tiana, Vidal-Raméntol, & Fernández-Morilla, 2018). The biggest gaps in the University curricula were found to be in relation to the ethical foundation of Sustainability; associated with human rights, dignity and gender issues as well as poverty reduction and climate change mitigation. The use

of rubrics for assessing Sustainability competences, developed during problem-oriented programmes, has also been suggested (Albareda-Tiana, Vidal-Raméntol, Pujol-Valls, & Fernández-Morilla, 2018). Appropriate models and tools for their measurement have been also developed by operationalising the cognitive, affective and behavioural dimensions of ESD in secondary education in Germany (Waltner, Rieß, & Mischo, 2019). A similar study proposed a heuristic model for measuring systems thinking competence and pedagogical capacity in student teachers participating in case studies of non-sustainable patterns of global change (Schuler et al., 2018). The development of ESD indicators regarding the implementation of the GAP has been proposed by others (Waltner, Rieß, & Brock, 2018). Measuring the ESD relevance of teacher training programmes in Germany results demonstrated that student competences can be measured in a reliable way. However, more indicators need to be developed and tested, the effect of socio-demographic factors on the development of competences clarified and data from other levels of education and geographies obtained to have a complete picture.

5.4 Discussion

Addressing the need to contextualize the role of ESD, the framework developed allows both educators and learners to see the bigger picture and understand the role of education in Sustainable Development. Its steps should be considered conceptual, as greater specificity will be highly dependent on context, institutional capacity, problem, timeframe and resources available to the educational redesign process. However, strategy and principles should be transferrable despite the contextual variance inherent in large-scale systems. It is important to note that experimentation and innovation are important components of every social transition and so involved stakeholders should be encouraged to try new approaches, structures and actions to realise their vision (Loorbach, 2010). Reflexive praxis is crucial for providing insights into possible pathways for action, desirable solutions in terms of pedagogies, educational environments and learning methodologies and also combating challenges and barriers that emerge on the way (Gokool-ramdoo & Rumjaun, 2016). Lastly, adaptation, flexibility and openness to change are desirable in any organisational change plan to cope with uncertainty of outcomes. The team of change-agents should recognise their ignorance about how the future will unfold, but at the same time establish methods for data collection and analysis available to all and establish check-points through the process of transition to reflect on actions/strategies and modify them (Dovers & Handmer, 1992).

To address issues of power and individual versus collective responsibility, the implementation of the framework is envisaged through a mixed approach: bottom-up and top-down. This will allow, on the one hand, the building of communities within formal education organisations, such as Universities or schools, to act as niche-points of innovation and change-makers that will initiate, implement, institutionalise and share effective practices (Lozano, 2006a). On the other hand, implementation of this framework at the level of the educational system will favour the alignment of those niche initiatives by enabling transformational change in the current educational policy landscape moving from the macro to the micro level (Kapitulčinová, AtKisson, Perdue, & Will, 2018). The implementation process can be facilitated by establishing a group of Sustainability change-agents/champions within the educational institution (with members from all crucial stakeholder groups identified earlier), who will bear the responsibility of bringing all the stakeholders together to decide on common visions, competences and teaching- learning strategies. Further, they will develop a platform for frequent communication of the plan development, tackle challenges, monitor and evaluate progress in a transparent and inclusive way (Liebhart & Lorenzo, 2010; Lozano et al., 2015).

The application of the framework will provide benefits as part of a whole-institution approach (that targets education, research, operations, administration, community relationships) in formal education settings (e.g., Higher Education (HE) institutions, primary and secondary schools, educator training organisations), where the learning and training environments are aligned to the Sustainability vision, and where institutional changes are taking place to facilitate the Sustainability transformation. Educational organisations often suffer from inertia, as established beliefs of how they should function, how teaching and learning should be practised, and what kind of relationships with the wider community they should seek to develop; can be very powerful and persistent (Sterling & Witham, 2008). Several barriers to the Sustainability transformation of educational institutions have been identified (Holmberg & Larsson, 2018; Lozano, 2006b; Senge, 1991). These are often associated with the internal structure of the institution, administrative, educational, research, and operations-related; including the type of Institution, private or public; and its culture. The latter refers to issues with interdisciplinarity, bureaucracy, competition, lack of collaboration and incentives to cooperate, overcrowded curriculum, and academic silos. In addition, external factors, such as governance issues, inappropriate regulations, and lack or delays in enforcement, topped by lack of pressure from society and low priority given to the task may prevent institutional

integration of Sustainability. For example, agreements or programmes not implemented properly, the absence of Sustainability criteria in quality assurance certification programmes and ranking systems, and overall lack of Sustainability aims have also been identified as impediments (Blanco-Portela et al., 2017). Lack of training and information, negative perceptions about Sustainability, lack of leadership, perceived high cost, lack of interest, and resistance because of work overload among others have been shown to hamper progress with both the academic community and external stakeholders, with lack of resources (allocated budget and dedicated personnel) making things even worse. Proactive educational organisations can transform these barriers to opportunities for redesigning curricula and pedagogies geared to achieving the SDGs (Albareda-Tiana, Vidal-Raméntol, & Fernández-Morilla, 2018). For example, problem-based and active teaching and learning practices; teachers as facilitators of knowledge; interdisciplinary collaboration; flexible management; certification for Sustainability; professors and students acting as change agents; alignment with internal and external community needs; engagement in dialogue; transparency of governance; policies on how to integrate Sustainability in mission, vision and action plans were amongst the opportunities identified (Blanco-Portela et al., 2017). In that direction, the framework developed here makes it easier for these opportunities to be identified, and for whole institution approaches to be developed and aligned to Sustainable Development. Its application can facilitate both the recognition of the importance of the SDGs and of the appropriate design of the curriculum as the means to achieve them (Albareda-Tiana, Vidal-Raméntol, & Fernández-Morilla, 2018). The framework therefore allows education to play a clear and critical role in capacity-building for Sustainability, the process of empowering learners (society) to develop the competences needed for Sustainability to emerge (UNESCO, 2018).

In this chapter, the aim was to redefine the role of ESD in the era of the SDGs from a systems perspective. Therefore, education's transformative potential to facilitate the transition to Sustainability was recognised. A participatory framework that allows education practitioners and stakeholders together with communities of learners to decide on common visions for Sustainability was developed. Although the SDGs are a global framework, localising them in terms of educational outcomes helps the realisation of both community vision and of global priorities. Constructing a common vision of Sustainability guided by the SDGs, can help educators and learners identify constraints and enabling conditions, work together to select the competences needed, develop appropriate curricula and pedagogies, pursue the many

facets of a whole-institution approach and evaluate progress towards Sustainability as a well-defined goal. The proposed framework offers the opportunity of rethinking education as a systemic tool for transformative social change. Nelson Mandela stated in 2003, “Education is the most powerful weapon we can use to change the world”, and today the need for the world to change is more urgent and greater than ever. The road to Sustainability is paved by education, and unless we invest on it, we might never get there.

5.5. Limitations

The main limitation of the framework is its theoretical nature and the fact that it has not been empirically tested widely, and thus not been validated. In Appendix A, I provide evidence of its adaptation and application in a University stakeholder workshop during the 2019 MRS Fall meeting and exhibit. Appropriate guidance was developed on its use by education stakeholders and policy-makers (this was done for the stakeholder workshop, included in Appendix F). There may also be power dynamics at play during the framework application, which may prevent some stakeholders from articulating their voices, or that only dominant voices maybe included. That is why I advocate for a community wide consultation process that will be guided by the principles of equal participation, tolerance over others opinions and inclusivity of diverse perspectives. Conflict may delay the process of vision articulation and competence selection and this should be negotiated and consensus be reached. Lastly, commitment needs to guide the entire process of curriculum transformation and monitoring and evaluation of the process so that the action plan can be seen through. It may be difficult to develop appropriate indicators for assessing the Sustainability competences selected as they are complex but this is addressed in chapters 7, 8 and 9.

Chapter 6 Sustainable Development Goals (SDGs): Assessing the Contribution of Higher Education Programmes

6.1. Introduction

The ongoing discourse about Sustainability and the realisation of the 2030 Agenda of Sustainable Development Goals (SDGs) looks to balance economic growth, social equity, and environmental protection inclusively for developed and developing countries, leaving no one behind. The SDG framework places education in a central role as a catalyst for transformational change (UNICEF et al., 2016). 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 (Australia/Pacific SDSN, 2017). They can help to shape new ways of 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 (Ottersen, 2019) and are expected to actively engage in the process. For example, a new league table measuring the success of Higher Education (HE) Institutions in delivering the SDGs was introduced in 2019 (Times Higher Education (THE) University Impact Rankings, 2019). This included metrics based on 11 of the SDGs, with institutions submitting data on as many or as few of those as they wished but with mandatory reporting on SDG 17: Partnerships for the Goals, which was included in the overall table.

Among the many contributions Universities can make to Sustainability, education has the greatest potential, 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 wellbeing (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 (EFA) necessitates reform of the HE sector through international agreements that establish and regulate teaching and learning activities, so that they become aligned with Sustainable Development (SD). 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 (UNESCO, 2017b).

While there is still debate on whether 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 (O'Byrne, Dripps, & Nicholas, 2015), as well as the number of programmes that incorporate aspects of Sustainability within an existing discipline (Perera & Hewege, 2016). A recent bibliometric study showed that Sustainability education is booming in universities globally, with special focus on students' attitudes, highlighting that research in the field is descriptive rather than empirical (Rodríguez-García, Belmonte, Montoro, & Moreno-Guerrero, 2019). For example in the US, HE programmes explicitly focusing on Sustainability increased to over 140 in 2012, from 1 in 2006 (Vincent, Bunn, & Stevens, 2013). In the UK, 91% of University students would like to see SD incorporated in their University, 70% agree that Sustainability should be incorporated in all courses, but only 17% think that their University does a very good job related to SD (EAUC, Students, Union, & Association of Colleges and the College Development Network, 2019). 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 (Zamora-Polo, Sánchez-Martín, Corrales-Serrano, & Espejo-Antúnez, 2019).

Although a number of universities have employed effective pedagogies for ESD (Fuertes-Camacho, Graell-Martín, Fuentes-Loss, & Balaguer-Fàbregas, 2019), and several have defined Sustainability-related educational outcomes for their programmes (Quality Assurance Agency & Academy, 2014), little work has been done to evaluate University offerings in Sustainability education, such that their quality, curricular content, and effectiveness are largely unknown. The most comprehensive Sustainability curriculum assessments have been done for Australia, where authors (Sherren, 2008, 2006, 2005) 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 (J. Segalàs et al., 2010) and the built environment in Asia–Pacific (Iyer-Raniga & Andamon, 2016). Another review of curriculum contents of undergraduate and master's programmes related to Sustainability found great divergence in the content of those courses

and also low degrees of integration between natural and social sciences (O'Byrne et al., 2015). Recent research indicates 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 (Walter Leal Filho et al., 2019). 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 HE 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 (Kioupi & Voulvoulis, 2019). This will require defining first the competences, i.e., the knowledge, skills, behaviours, and attitudes, that learners need to develop to realise such a state, and then the curricula, pedagogies, educator training programmes, and learning environments at each 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 local vision of Sustainability. Educational communities therefore need to form 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 to align with the enabling conditions for such vision to emerge (QAA, 2018). Explicit evaluation of the extent to which their programmes align with SD allows Universities to understand the contribution of their educational offerings to achieving the SDGs in a systemic way.

University programmes have learning outcomes (LOs) that define what graduates should know and be able to do at the end of their studies. Clear intended LOs are a key component of good programme and unit planning and assessment for students. The Quality Assurance Agency (QAA) UK Quality Code for HE: Learning and teaching (QAA, 2018) gives clear guidance on the purpose and design of LOs: Universities need to ensure that the intended LOs of a programme are explicitly reflected in the intended LOs 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 LOs or the competences the learners need to develop allows academic staff to find areas of Sustainability that are over- or underrepresented in the curriculum, map gaps, and take decisions to improve them.

Here, therefore, an assessment framework is developed for educational institutions to evaluate the contribution of their educational programmes to Sustainability by reviewing their intended LOs—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 be realised, avoiding the perils of having to evaluate the integration of each SDG in the programmes' intended LOs 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.

6.2 Materials and Methods

6.2.1. 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 (Kioupi & Voulvoulis, 2019). It evaluates the alignment of a programme's intended LOs 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 (Table 6.1). These eight groups have been constructed by grouping the SDGs into categories defined by major systemic attributes and enabling conditions, namely: achieving the safe operating space (refers to maintaining ecological integrity and not transgressing crucial planetary boundaries conditions), achieving the just operating space (includes 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), 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 and ensures that humanity operates within the safe and just space to promote natural and human wellbeing (Kioupi & Voulvoulis, 2019).

Table 6.1. The Sustainability attributes used for assessing the alignment of University programmes to Sustainability.

Safe operating space SOS	Collaboration COL
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).	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 a wide variety of audiences.
Just operating space JOS	Alternative economic models AEM
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.	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 of work and growth, preserve natural resources, and lift people out of poverty.
Resilient sustainable behaviours RSB	Diversity and Inclusion DI

The ethical conditions that enable long-term Sustainability: values, norms, behaviours and attitudes related to 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.	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.
Health and Wellbeing HW	Transparency and Governance TG
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.	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 LOs to these attributes, a simple tool that uses textual analysis for the descriptors of LOs and evaluates their alignment to each of these eight Sustainability attributes using a word code was developed. 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 [(Barrington-Leigh, 2016; Barth et al., 2007; Blok et al., 2016; J. W. Cook, 2018; Costanza et al., 2016; Davis, Hennes, & Raymond, 2018; Dearing et al., 2014; Díaz, Settele, & Brondízio, 2019; Escribano, Díaz-Caro, & Mesias, 2018; FAO COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE, 2019; Fath, Fiscus, Goerner, Berea, & Ulanowicz, 2019; Giovannoni & Fabietti, 2013; Guo & Jamal, 2007;

Hinchliffe et al., 2018; Kjaer et al., 2019; Komasinkski & Ishimura, 2017; Macarthur, 2012; Raworth, 2012; Remington-Doucette, Connell, Armstrong, & Musgrove, 2013; Rockström et al., 2009; Schank & Rieckmann, 2019; Steffen et al., 2015; Sterling, Glasser, Rieckmann, & Warwick, 2017; The Ellen MacArthur Foundation & Foundation, 2015; UNICEF et al., 2016; WWF, 2018)]; (2) by analysing the texts of the benchmark statements provided by the QAA for HE in the UK for specific University subjects that match the sustainable society attributes systemically selected; and (3) specifically for the Diversity and Inclusion word code, Advance HE's reports regarding Athena SWAN (ECU Gender Charter Athena SWAN, 2017), Race Equality Charters (Equality Challenge Unit, 2016), and the Equality and Diversity in Learning and Teaching in HE (Equality Challenge Unit & Higher Education Academy Scotland, 2016) was analysed.

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

- Education for Sustainable Development (ESD) Graduate Outcomes
- Earth Sciences, Environmental Sciences and Environmental Studies
- Sociology
- Social Policy
- Economics
- Business and Management
- Health studies
- Politics and International relations
- Law
- Collaboration statements from all the above texts

By analysing the parts of the documents referring to the defining principles, nature and extent and specific LOs in terms of subject specific and generic knowledge, skills, and attributes of graduates for each type of course, associations were made between the benchmark statements and the sustainable society attributes. Then word frequency queries were run in the above-mentioned benchmark statements and enriched the word codes (Table 6.2). The same was done with the Equality Challenge Unit documents for DI.

Multi Criteria Analysis (MCA) was then used to evaluate and compare the performance of different courses across all eight Sustainability attributes, with the multicriteria evaluation performed through the analytic hierarchical process (AHP). 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 (Saaty, 1987). 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). All attributes were assumed equally important, and as a result were given the same weight. The final score represents the degree to which an alternative is more or less aligned to Sustainability compared to the rest, based on the number of criteria on which it outperforms 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 (Department for Communities and Local Government, 2009). 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 LOs to these attributes.

Table 6.2. The developed word code per Sustainability attribute.

SOS | Source = Earth Sciences, Environmental Sciences and Environmental Studies	COL | Source = Collaboration statements from all benchmark documents
Global; Boundary; Earth; Boundaries; Climate; Planetary; Land; Ocean; Regional; State; Biodiversity; wildlife; Thresholds; nexus; CO2; Ecosystems; Environmental; Global-Change; Climate-Change; Atmospheric; Resilience; Safe; Soil; Freshwater; Ozone; Variable; Ecology; Ecological; Geology; Geological; geo; Hydrology; Hydrological; Effects; Marine; Uncertainty; uncertain; Concentration; Threshold; Ecosystem; Atmosphere; Flows; Impacts; Species; Nitrogen; Chemical; biological; Biosphere; geosphere; hydrosphere; Phosphorus; Pollution; air; Acidification; Anthropogenic; Cycle; Extinction; Space; Chemicals; Industrial; Zone; Holocene; Anthropocene; Climate; Stratospheric; Aerosol; Integrity; interactions; Biogeochemical; Greenhouse; Gas; Gases; Emission; Emissions; Impact; Uncertainties; wicked; biophysical; constraint; constraints; safety; mitigation; adaptation; complexity.	Group; collaboration; empathy; cooperation; cooperative; together; mutual; joint; jointly; shared; loyalty; member; participant; allocation; communication; communicative; communicate; encourage; motivate; resolve; conflict; task; listen; listening; motivate; team; teamwork; judgement; crowd; participatory; conversation; discussion; activity; negotiation; consensus; allocate; dominance; dominate; coordination; coordinate; team-dynamics; group-dynamics; transdisciplinarity; multidisciplinary; multidisciplinarity; disciplinary; transdisciplinary; disciplines; collaborate; stakeholder; interpersonal.
JOS | Source = Sociology and Social Policy	AEM | Source = Economics and Business and Management

Social; socially; community; intergenerational; intragenerational; social-equity; peace; underdeveloped; industrialised; developing; active; humanity; human; participation; society; Justice; women; just; transformation; race; minority; minorities; North; South; Ethnic; ethnicity; regional; gender; foundation; peace; poverty; Non-violence; conflict; inequality; inequalities; future; ceiling; population; changing; accessed; access; discussion; income; men; need; rights; education; transition; power; conditions; wealth; Security; doughnut; deprivation; communities; households; distribution; children; violence; deprived; status; food; water; energy; jobs; employment; voice; resilient; unemployment; gap; people; concept; dialogue; fair; common; exploitation; population-dynamics; community-dynamics.	Regenerative; circular; re-use; reuse; remanufacture; remanufacturing; recycle; recycling; economy; economic; consumption; financial; indicator; business; entrepreneurship; profit; alternative; model; growth; waste; tax; taxation; product; products; production; materials; efficiency; services; technology; technological; balance; lifecycle; life-cycle; innovation; innovative; technologies; cost.
RSB | Source = Education for Sustainable Development Graduate Outcomes	**DI | Source = Advance HE Athena SWAN and Race Equality Charters, Biodiversity IPBES, FAO, WWF**
Sustainable; Sustainability; competencies; competences; competence; thinking; normative; critical; norms; values; value; norm; competency; behaviour; ability; self-confidence; ethics; ethical; moral; ethic; challenges; challenge; educational; socio; motivations; motivation; informal; injunctive; perspective; responsibility; responsibilities; actions; action; context; contexts; assessment; citizen; citizenship; capacity; capability; incentive; argument; motivation; motive; choice; choices; compassion; tolerance; tolerant; solidarity; respect; behavioural; attitude; attitudinal; engage; commit RE engagement; commitment; belief; beliefs; management; planning; virtue; solutions;	Diversity; inclusion; inclusivity; inclusive; bias; biases; gender-identity; stereotype; stereotypes; ethnicity; ethnicities; belonging; racial; variety; stereotypical; non-gender; diverse; socioeconomic; domination; disability; disabilities; ethos; intersectionality; characteristic; protected; BME; BAME; role-model; discrimination; racism; anti-racism; fairness; parity; underrepresented; marginalised; genetic; conservation; loss;

interdisciplinarity; interdisciplinary; reflection; stewardship.	intercultural; multicultural; racist; inequity; anti.
HW | Source = Health studies	TG| Source = Politics and International relations and Law
Wellbeing; well-being; welfare; culture; cultural; life; health; quality; collective; happiness; index; creative; intuitive; history; historical; cognitive; license; lives; mental; mind; worldview; equitable; emotion; emotional; cohesion; identity; character; care; western; relationships; relational; holistic; satisfaction; consciousness; empathy; feedback; connections; interconnections; prosperity; joy; positive; negative; vision; pattern; thrive; psychological; psychology; mindfulness; illness; disease.	Transparency; open; open-ended; openness; open-mindedness; open-minded; open-access; governance; policy; legal; laws; law; government; political; framework; transparent; integration; democracy; democratic; regulations; regulation; interdependence; procedures; systemic; leadership; strategy; strategic; evidence; decision-making; regulatory; international; transnational; accessibility.

To test the tool, 18 master's programmes across several subjects (engineering, environmental policy, science communication, physics, chemistry, computing, mathematics, medicine and life sciences) from the same HE Institution were compared by evaluating the alignment of their LOs across the eight attributes, considering their disciplinary focus as an indicator of Sustainability coverage (Table 6.3).

Table 6.3. Performance of the 18 Imperial College London master's courses' Learning Outcomes across the eight Sustainability attributes using the word codes developed

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 orientated 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 generally showing zero or low scores of JOS, which is partly expected with Imperial considered a natural science and technology focused University. The highest scores for AEM were indeed for more financially and business-orientated programmes such as the one in Climate Change, Management, and Finance and the one in Finance and Accounting. Similarly, health orientated programmes, i.e., International Health Management and Clinical Research, showed highest values for HW coverage, while notably most of the other courses scored zero. For RSB and COL it was expected that most programmes would aspire to develop problem-solving, collaboration, interdisciplinary, critical analysis, and ethical inquiry skills in their students, and indeed almost all programmes scored well for both, except for Climate Change, Management, and Finance that scored zero for COL.

For DI low scores were expected in all courses, which was indeed the case, with seven of the courses scoring zero. Through the MCA method described above (see Appendix B Table 6 for details), the programmes were then ranked in terms of their overall alignment and contribution to Sustainability (Figure 6.1).

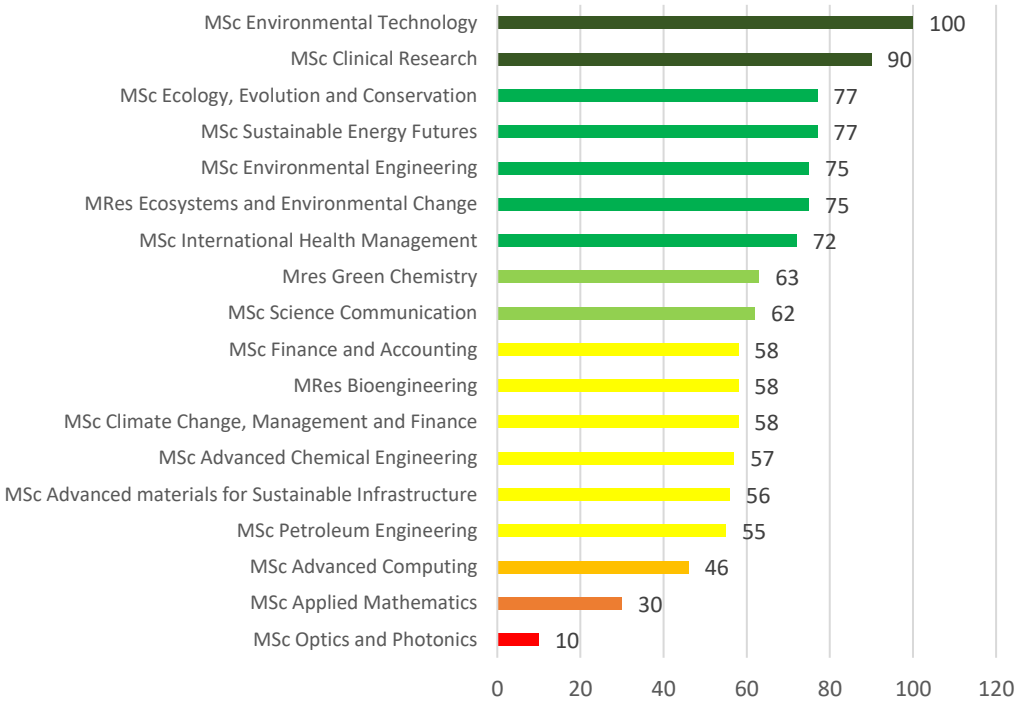

Figure 6.1. Ranking of 18 of Imperial College London master's courses through multi-criteria analysis using the scores from the application of the word code developed for the eight Sustainability attributes examined.

6.2.2 Application

Forty (40) well-established master's programmes related to environment and Sustainability (35 offered by UK and 5 by European universities) were evaluated using the methodology developed (Table 6.4). Each programme's LOs were compared against the word codes related to each Sustainability attribute and were then ranked using MCA as described earlier.

Table 6.4. List of the MSc Programmes related to environment and Sustainability evaluated in this study with links to the sources of their learning outcomes used in the assessment incorporated in their titles (accessed in June 2020).

Code	Programme Title	University
MScSTR	MSc Design Engineering With Sustainability	University of Strathclyde, Glasgow
MScLVH	MSc Ecology & Environmental Management	Liverpool Hope University
MScCRN	MSc Environmental Engineering	Cranfield University
MScNWC	MSc Environmental Engineering	Newcastle University
MScBRN	MSc Environmental Management	Brunel University London
MSCRDN	MSc Environmental Management	University of Reading
MStCAM	MSt Sustainability Leadership	University of Cambridge
MScSTM	MSc Sustainability	University of Southampton
MScLDS	MSc Water Sanitation and Health Engineering	University of Leeds
MScYRK	MSC Environmental Economics & Environmental Management	University of York
MasterETH	Master's in Environmental Sciences	ETH Zurich
MasterWGU	Master's in Environmental Sciences	Wageningen University and Research
MasterEPFL	Master's in Environmental Sciences & Engineering	EPFL
MasterLUN	Master's in Environmental Studies & Sustainability Science	Lund University
MPhilCAM	MPhil Environmental Policy	University of Cambridge
MScLAN	MSc Environment & Development	University of Lancaster
MScUCL	MSc Environment & Sustainable Development	University College London
MScETICL	MSc Environmental Technology	Imperial College London
MScOXF	MSc Environmental Change & Management	University of Oxford

Code	Programme Title	University
MScMESPOM	MSc Environmental Science, Policy & Management	Several *
MScSUR	MSc Environmental Strategy	University of Surrey
MScLIV	MSc Environmental Sciences	University of Liverpool
MScBGM	MSc Environmental & Natural Resource Economics	University of Birmingham
MScLSE	MSc Environmental Economics & Climate Change	The London School of Economics and Political Science
MScUBA	MSc Environmental Engineering	University of Bath
MScMAN	MSc Environmental Governance	University of Manchester
MScNTG	MSc Environmental Leadership & Management	University of Nottingham
MScLBR	MSC Environmental Monitoring Research & Management	Loughborough University
MScBRS	MSc Environmental Policy & Management	University of Bristol
MScEDB	MSc Environmental Sustainability	The University of Edinburgh
MScIESSTM	MSc Integrated Environmental Studies	University of Southampton
MScEXT	MSc Mining Environmental Management	University of Exeter
MScCDF	MSc Sustainability Planning & Environmental Policy	Cardiff University
MScSAN	MSc Sustainable Development	University of St Andrews
MResICL	MRes Ecosystems & Environmental Change	Imperial College London
MScAMSIICL	MSc Advanced Materials For Sustainable Infrastructure	Imperial College London
MScCCMFICL	MSc Climate Change, Management & Finance	Imperial College London
MScEECICL	MSc Ecology, Evolution & Conservation	Imperial College London
MScEEICL	MSc Environmental Engineering	Imperial College London
MScSEFICL	MSc Sustainable Energy Futures	Imperial College London

* 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.

6.3 Results

The performance of the forty master's programmes across the eight Sustainability attributes is presented in Table 6.5, and their ranking is based on their dominance scores from the pairwise comparison in Figure 6.2 (see Appendix B for interpretations and calculations).

The programmes are ranked based on the alignment of their LOs to Sustainability with their dominance score calculated based on the number of times each programme performed better than 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 environment and Sustainability orientated, most did not seem to adequately cover DI and HW, both important aspects of Sustainability.

Table 6.5. 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
MScSTR	0.76	0.09	4.00	4.16	0.52	0.18	0.10	0.68
MScLVH	5.17	0.29	5.21	0.21	0.00	0.67	1.00	1.17
MScCRN	6.24	1.58	3.97	3.47	0.13	0.23	0.22	0.41
MScNWC	5.63	2.15	2.22	0.95	0.71	0.00	0.00	0.41
MScBRN	8.88	1.81	3.26	2.74	0.61	0.00	0.00	1.36
MScRDN	4.90	1.61	2.82	0.96	1.27	2.02	0.22	1.40
MStCAM	3.12	2.98	9.29	2.69	0.32	1.27	0.21	5.24
MScSTM	2.59	1.45	3.19	0.45	0.55	0.91	0.38	0.30
MScLDS	2.06	2.43	4.82	1.77	1.85	0.48	0.11	1.55
MScYRK	7.27	1.91	3.36	1.05	0.17	0.44	0.78	1.69
MasterETH	5.89	1.41	3.40	1.14	0.58	0.00	0.46	1.02
MasterWGU	4.75	1.53	3.63	0.40	0.63	1.31	0.31	1.32
MasterEPFL	13.99	2.54	1.43	0.00	0.00	2.70	0.00	0.00
MasterLUN	5.31	2.69	8.79	0.52	1.05	1.18	0.00	0.66
MPhilCAM	0.58	0.27	6.77	0.81	0.58	1.66	0.00	0.49
MScLAN	3.91	2.38	2.05	1.10	0.34	0.30	0.56	1.38
MScUCL	8.00	8.12	5.76	0.94	0.00	0.00	0.00	1.06

MScETICL	4.78	1.24	5.87	1.12	0.31	1.65	0.12	1.87
MScOXF	12.01	2.53	8.06	0.63	0.63	1.82	0.00	1.03
MScMESPOM	8.94	0.64	7.32	0.98	0.20	3.69	0.64	2.46
MScSUR	7.37	1.11	7.22	1.45	1.28	0.37	0.00	2.09
MScLIV	4.61	1.06	2.65	0.29	0.14	2.54	0.48	1.53
MScBGM	1.93	0.74	0.99	1.80	0.26	0.00	0.22	3.17
MScLSE	9.90	0.00	2.51	3.55	0.59	2.51	0.00	4.14
MScUBA	5.44	1.21	4.18	2.70	0.54	1.11	0.13	1.19
MScMAN	5.86	0.84	4.04	0.28	0.46	0.84	0.16	2.37
MScNTG	8.55	0.91	8.87	0.54	0.86	0.70	0.22	3.76
MScLBR	4.74	0.54	1.68	0.19	0.14	0.60	0.14	0.77
MScBRS	4.94	0.90	3.71	0.41	0.51	1.19	0.29	1.60
MScEDB	7.02	1.89	4.00	1.19	0.87	1.16	0.34	2.15
MScIESSTM	3.47	1.36	2.65	0.36	0.26	0.97	0.23	0.37
MScEXT	3.21	1.46	2.72	1.05	0.04	0.69	0.04	1.93
MScCDF	6.33	2.36	4.27	1.09	0.17	0.00	0.19	2.66
MScSAN	0.74	3.20	11.88	0.62	2.77	0.68	0.00	3.63
MResICL	3.66	0.38	2.25	0.38	0.00	2.14	0.42	2.79
MScAMSIICL	2.16	0.39	2.03	4.91	0.00	1.11	0.00	0.98
MScCCMFICL	9.03	1.12	2.89	4.28	0.00	0.00	0.00	0.56
MScEECICL	1.71	2.32	1.92	0.41	0.00	2.81	1.14	1.22
MScEEICL	1.56	0.30	3.78	0.86	0.00	2.47	0.35	0.76
MScSEFICL	3.26	3.41	3.09	2.79	0.12	1.91	0.00	0.35

Diversity, Equality, and Inclusion, specifically in the UK context, are 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 links not only with increased productivity but is also an important research area. Both DI and HW, which are underrepresented in the programmes considered, are the ultimate ends of SD according to the Daly Triangle, which provides an integrating framework for selecting overarching goals for Sustainability interventions (Meadows, 1998).

Out of the top 10 programmes, eight scored highly across all Sustainability attributes. These are Environmental Sustainability EDB, Sustainability Leadership CAM, MESPOM, Environmental Leadership and Management NTG, Environmental Economics and Management YRK, Water Sanitation and Health Engineering LDS, Environmental Management RDN, and Environmental Technology ICL. The remaining two, Environmental Change and Management OXF and Environmental Strategy SUR scored strongly in SOS and RSB but zero in DI. With respect to the performance of their LOs' alignment to Sustainability, they are either related to Sustainability and leadership or are focusing on environment and management, economics, and engineering and thus show integration between different areas of study. The same applies for the European master's programmes: the ones that show integration of different disciplines rank highly, with MESPOM being first of the five European programmes and third in the overall ranking. MESPOM is an inter-University programme allowing students to study in four different countries and become exposed to scientific, technological, socio-environmental, and political aspects of environmental change, unique to each location. In terms of LOs, it differentiates between knowledge and understanding, skills, values, and attitudes, which is more conducive to Sustainability competences definition. MSc Sustainability Leadership CAM is a course using a workshop format to cover very diverse aspects of Sustainability such as business, finance, governance, behaviour, leadership, collaboration, and partnerships, apart from the main socio-environmental aspects. MSc Environmental Sustainability EDB stresses the interdisciplinary nature of SD and allows students to study the interactions between science, policy, business, and governance to address Sustainability problems. It provides insights into behavioural and ethical aspects of Sustainability as well and integrates modules that range from ecology to climate change and politics through general and module specific LOs. In general, these programmes employ a systemic and interdisciplinary approach to addressing SD across scales and paradigms that includes its ethical implications, which require critical analysis and the development of Sustainability competences. Although these programmes are performing better than most of the others analysed here, there is still a lot of room for improvement and all would benefit from recording their gaps and trying to achieve a more balanced representation of the Sustainability attributes in their LOs.

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 to environmental aspects such as policy, management, or engineering, one is specifically related to materials for Sustainability, and another one is 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.

Comparison of master's programmes that include the same topics in their titles, such as those related to environmental management (nine courses), environmental engineering (five courses), and environmental science (five courses), show that they do not necessarily score in all (or the same) Sustainability attributes. Zero scores were observed in COL, TG, DI, and HW, and programmes 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 score zero in the HW, DI, and COL and show substantial variation in their 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 large (CAM ~ 25%), intermediate (ICL ~ 11%), or small differences (STM ~ 3%) in the scoring on Sustainability attributes between courses.

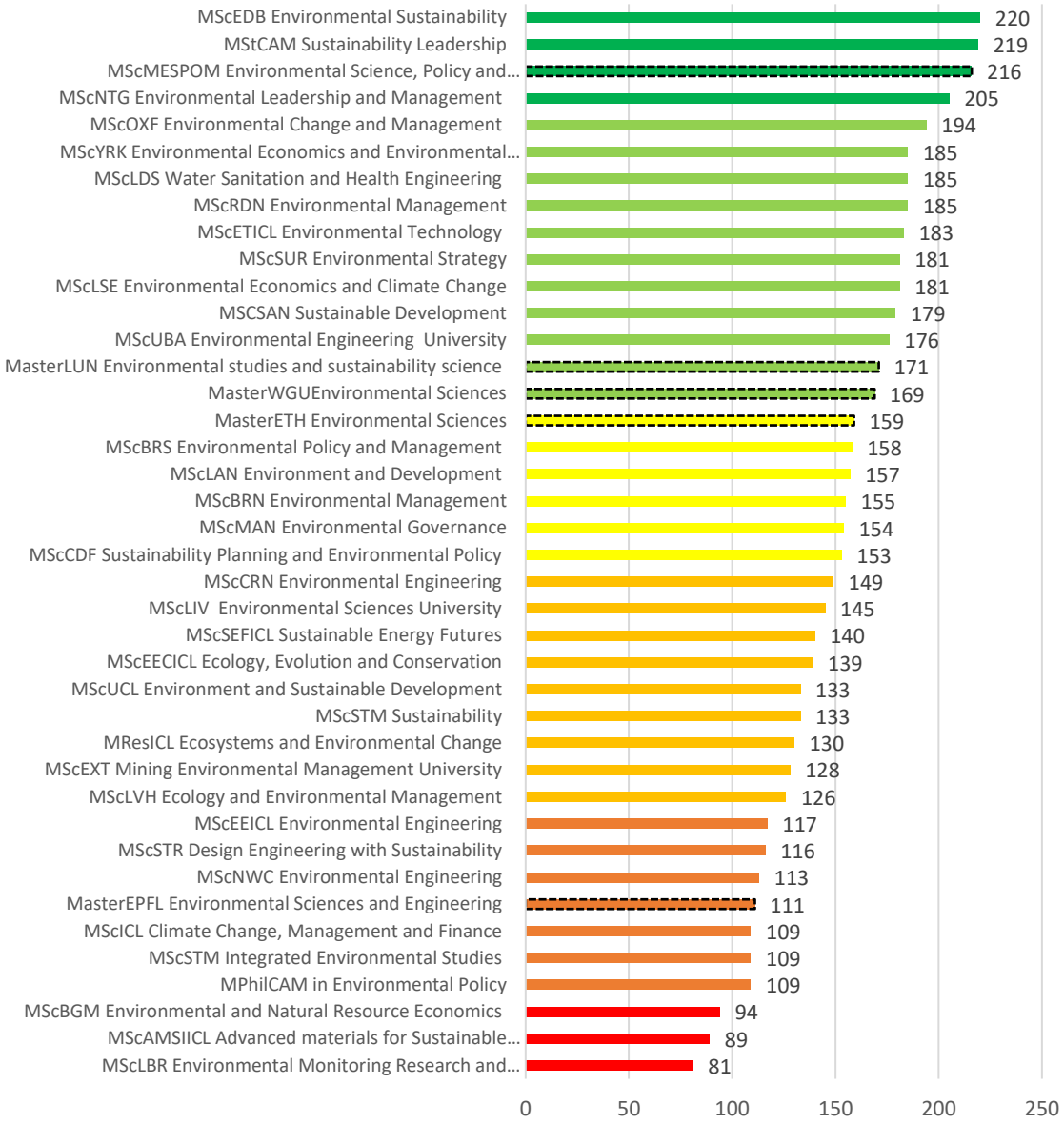

Figure 6.2. Dominance scores and ranking of forty environment and Sustainability related master's Programmes in terms of their contribution to Sustainability, based on the alignment of their learning outcomes to key Sustainability attributes (the dashed bars represent European master's courses).

Almost 82.5% of the master's programmes' overall ranking values are between 100 and 200, although some outliers are noted: three courses score below 100 and four courses above 200. The overall values distribution approximates a 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, Environment Management RDN with Water Sanitation and Health Engineering LDS and Environmental Economics and Environmental Management YRK, and Environment and Sustainable Development UCL with Sustainability STM. This indicates that when designing a course (from the educator's perspective) or selecting a course to attend (from the student's perspective), reviewing the programme's LOs is important, as there seems to be no link between course names and scores. For the academic staff responsible for the programmes, understanding the scores per attribute is important, as it can help them redefine their module's intended LOs or their selected competences, map the gaps in covering various aspects of Sustainability, understand in which areas they place more focus, and refine their programmes' descriptors by reforming some of their curricular content.

6.4 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 LOs, the tool evaluates how well "what the students are going to achieve at the end of the programme" aligns with Sustainability attributes and with the 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 teaching context, learning activities, and assessments are designed on the basis of these learning outcomes. LOs will drive the pedagogical approach and the teaching practices to achieve them. Relating LOs to Sustainability and defining the knowledge, skills, behaviours, and attitudes that learners will need to develop through the course will shape their contribution to Sustainability. For this contribution to become realised, 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 HE practitioners to make data-driven decisions and modifications in their programmes to improve alignment to Sustainability. Different courses delivered by the same institution or courses in the same subject but delivered by different institutions can be compared and ranked. This can help programmes that have a similar orientation to identify similarities and differences between them and make appropriate adaptations. Furthermore, comparisons can extend to different geographies such that the priorities, gaps, commonalities, and differences of HE curricula for SD can be highlighted across continents (Franco et al., 2018). 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 SD is equally about its environmental pillar as well as its social and economic ones and should be seen as an integrated concept (Casey & Sturgis, 2018).

Another benefit that the methodology presented in this study specifically offers to MSc programmes' coordinators, curriculum developers, and lecturers is that it 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 coverage 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 the review of programme descriptors, there are programmes that mention general programme LOs and others that provide LOs for each programme module. With respect to the first group, some mention what the students will gain from studying in the programme, while others provide LOs divided into categories such as knowledge and understanding, skills, attitudes, and values. The second group either: (a) describe briefly the content of each module and 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 (Casey & Sturgis, 2018; Chun, 2010). Last

but not least, breakdown of LOs into knowledge, skills, and values or use of competences also contributes to better course outcomes (Kioupi & Voulvoulis, 2019; Shephard et al., 2015).

The methodology developed here, when 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 (Lidstone et al., 2015). It will highlight similarities and differences as well as gaps in the integration of the SDGs in their LOs and allow for a more uniform and thus comparable design of LOs across educational systems. Currently, Sustainability assessment and reporting tools for HE Institutions focus 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, but they do not examine the courses' LOs' relationship to Sustainability (Ceulemans, Molderez, & Van Liedekerke, 2015).

Courses that are advanced in their Sustainability offerings and have developed their own vision of a sustainable society are expected to use the 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 chapter and draw conclusions about which aspects of Sustainability they cover most or least and make changes. 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 LOs with the SDGs in the systemic way presented. This will enable them to develop relevant pedagogies, learning activities, and assessment modes to enhance the development of Sustainability competences in their learners (Evans, 2019).

A recent systematic literature review on the evolution of the concept of Sustainability in the educational field with emphasis on HE shows similar results (Perera & Hewege, 2016). Specifically, it highlights the environmental orientation of ESD in its first years, with special emphasis on biodiversity issues that later evolved to include socio-cultural, ethical, behavioural, governance, and health dimensions. This shows a transition to more holistic views of ESD that, although present in the literature about how ESD curricula, teaching, and learning approaches should be designed, is not found in practice.

6.5 Limitations

As limitations of this study, it can be mentioned that the developed word codes might not be comprehensive in reflecting the diversity of concepts encompassed in the Sustainability attributes used, although this was overcome by using relevant and accurate scientific publications. Furthermore, there was an effort 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, words that may have been ambiguous in terms of acquiring different meanings according to context were excluded from the word code.

Chapter 7 The contribution of Higher Education to Sustainability: The development and assessment of Sustainability competences

7.1 Introduction

Education can play a crucial role in the realisation of the Sustainable Development Goals (SDGs) and the transformational transition to Sustainability. This is reflected in SDG 4 and mainly in target 4.7 that explicitly suggests "by 2030 ensure all learners acquire knowledge and skills needed to promote Sustainable Development , including among others through education for Sustainable Development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to Sustainable Development " (UNESCO, 2017b). Educational institutions have a role to play in the transformation required for Sustainability to emerge by equipping graduates with the competences required to serve as citizens of a sustainable future (Kioupi & Voulvoulis, 2019). The role of Higher Education Institutions is particularly crucial, as they prepare the future professionals with the knowledge and skills, i.e. the competences, needed to address pressing challenges such as climate change, violent conflict and health emergencies that society is facing today (Rieckmann, 2012; Wals & Jickling, 2002). Thus, integration of Sustainability principles in education curricula is an important endeavour for Higher Education (Lukman & Glavič, 2007). This endeavour requires a Whole Systems Approach, starting by a shared vision of Sustainability as a system state that our society is constantly trying to define and reach; establishing the curricula, pedagogies, educator training programmes, and learning environments that will enable learners to develop the competences for such a vision to realise; while making interconnections between all aspects of the organisational and operational structure of the institution (Bullock & Hitzhusen, 2015).

The ongoing discourse about Sustainability and the realisation of the SDGs makes research into Sustainability competences all the more pertinent. Competences represent an integrated set of knowledge, skills, attitudes, and values that people bring into play in different contexts (society, education, work, and family) to address situations involving complex challenges (Brundiers et al., 2020; Dale & Newman, 2005; Rowe, 2007). Moreover, competences refer to both performance ability to deliver a task and willingness to engage in the task, and therefore have direct links to motivation, worldview and values (Shephard, Barth,

& Rieckmann, 2018). Over the past few years, Sustainability education programmes, reflecting the interdisciplinary and collaborative nature of the new science of Sustainability, have made significant progress in conceptualizing key competencies for Sustainable Development (Perez Salgado, Abbott, & Wilson, 2018; Salovaara, Soini, & Pietikäinen, 2020). Foresighted or anticipatory thinking, systems thinking, interdisciplinary work, and participation are examples of some of the competencies targeted by Higher Education Sustainability Programmes (Barth et al., 2007; Rieckmann, 2012; Arnim Wiek, Withycombe, & Redman, 2011).

The integration of competences in HE curricula, in turn, has implications for the educational process as the curriculum content, pedagogy and assessment should ensure the defined educational outcomes are met. A curriculum for Sustainability should provide space for learners to explore, analyse and engage with the world around them holistically, develop the competences that will enable them tackle its complexities and realise the vision of the agenda 2030 (Osman, Ladhani, Findlater, & McKay, 2017). Research relating Sustainability competences to appropriate pedagogies for their development concludes that among the most effective approaches are problem- and project-oriented learning (Leal Filho, Shiel, & Paço, 2016; Lozano et al., 2019, 2017) as they offer opportunities for active, collaborative and action-oriented learning and foster research skills (Wim Lambrechts & Van Petegem, 2016). Authentic assessment is framed in the form of learning experiences that progress from simple to complex and ultimately prepare students to apply their competences to real-world situations with teachers acting as facilitators (Dlouhá & Burandt, 2015). Taking into account the aspirational component of Sustainability competences, relating them to the willingness to act and showcase application of the capability embedded in knowledge and skills (Holm, Vuorisalo, & Sammalisto, 2015), assessments need to be designed in ways to enable students to demonstrate the intended competences.

The consistency between competences, defined learning outcomes, and ways to teach and assess them is a significant indicator that the curriculum engages students in authentic learning about Sustainability (Shephard et al., 2015; Starcic, Terlevic, Lin, & Lebenicnik, 2018). While clearly progress has been made incorporating Sustainability in University educational offerings, there is little available research on the extent to which HE institutions are effective in equipping students with Sustainability competences (Karatzoglou, 2013). In fact, there is a clear need for the development and application of evaluation tools that can support universities to monitor and manage their contribution to Sustainability. The contribution of

their educational programmes towards the SDGs can be monitored, benchmarked and improved by evaluating their effectiveness in delivering intended Learning Outcomes (LOs), as competences developed by learners, once the alignment of such competences to Sustainability has been assessed (Kioupi & Voulvoulis, 2019).

Building on the assessment framework for evaluating the alignment of LOs to the SDGs developed in the previous chapter (Kioupi & Voulvoulis, 2020), a tool for evaluating and developing assessments of Sustainability competence in students is presented here. The tool considers and evaluates the capacity of existing assessments of learning to enable students to apply their competences, and goes beyond just giving evidence on the effectiveness of HE programmes, towards measuring student empowerment with knowledge and skills for closing the gap toward their Sustainability vision of the SDGs.

7.2 Methodology

The Sustainability competence assessment tool evaluates a programme's assessments in measuring the development of competence in learners and proposes ways to evaluate their competences, once their alignment to Sustainability has been evaluated. It requires assessments designed to allow students to mobilise and apply these competences to respond to a number of challenges in a way that students develop the associated intended competences. The interconnected nature of competence selection, effectiveness of pedagogies, curriculum content and assessment for the development of competence in learners forms the basis of the tool that enables HE institutions evaluate the development of their learners' Sustainability competences (Figure 7.1).

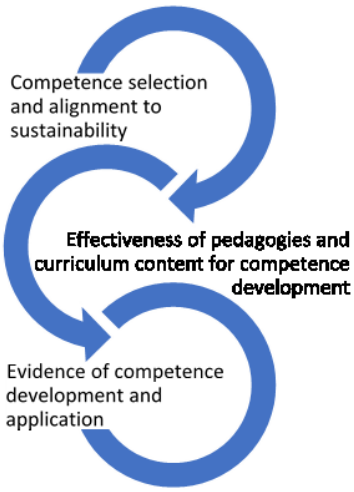

Figure 7.1. Conceptual framework for the Sustainability competence assessment tool

The assessment tool comprises five steps (Figure 7.2). To start the assessment (step 1), teaching staff and programme coordinators are encouraged to translate their programmes LOs into a set of competences targeted by their course to deliver, if those have not been yet specified. Consultation with the academic staff, students participating in the programme and other relevant stakeholders, such as alumni and professional accreditation bodies, can further facilitate this step. The process of translation examines the following curricular concepts to ensure constructive alignment between LOs, content, pedagogy and assessment: 1) 'what is the student expected to know and do?', 2) 'what is to be taught and learnt?', 3) 'how is it to be taught and learnt?' and 4) 'how is it to be assessed?' (Bergsmann et al., 2015). Then (step 2), competences are defined using clear statements of what the students need to master and describing their cognitive, affective, behavioural and metacognitive dimensions (Leuders et al., 2017). Performance indicators for each dimension state what the learner is expected to know and be able to do and should be appropriate for the level of study they target. The indicators of competence performance reflect learners' cognitive abilities such as knowledge (Frisk & Larson, 2011), understanding (Krathwohl, 2002) and applied skills (Hidalgo & Fuentes, 2013; Waltner et al., 2019). In addition, indicators include socio-emotional skills, which are attitudinal and behavioural (Hidalgo & Fuentes, 2013; Shephard et al., 2015; UNESCO, 2017a); and metacognitive abilities related with the evaluation of intentions and actions (J. W. Cook, 2018; Lai & Viering, 2012).

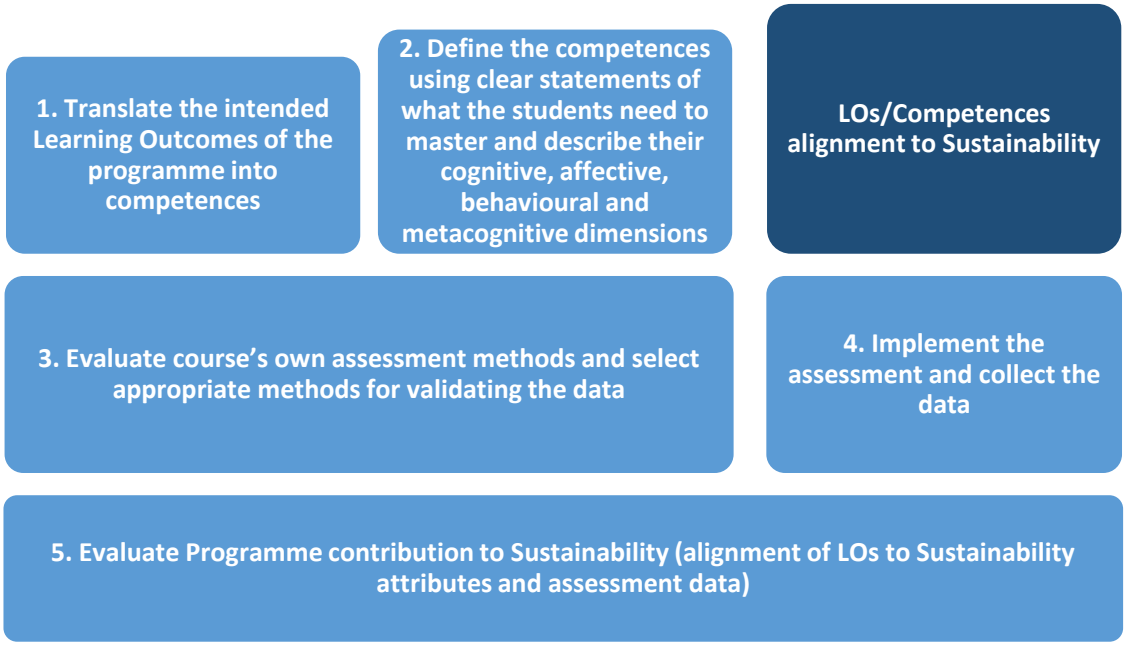

Figure 7.2. Representation of the five steps included in the assessment tool. To perform step five a combination of data from LOs alignment to Sustainability and competence assessment is required.

The assessment tool then (step 3), requires the evaluation of the course's own assessment methods to establish how well these methods assess students' competence development and if necessary, the development of new ones. These assessments can be formative, used during the course to motivate learning and/or summative at course completion to evaluate learning. To facilitate this evaluation, a typology of methods is provided for the assessment of Sustainability competences sourced from the literature (Kioupi & Voulvoulis, 2019) in Table 7.1. These can assist programme coordinators to develop new assessments when existing ones are found inadequate, as well as incentivising curricula that encourage competence development while giving students the opportunity to reflect on them (Holm et al., 2015).

Assessments should offer students opportunities to develop agency by engaging in authentic learning (Ceulemans et al., 2015; Walter Leal Filho et al., 2019). Research considers active learning tasks, such as case studies, complex, real-world project and problem-based tasks related to Sustainability (comprising environmental, social and economic challenges), to contribute to Sustainability competences' development (Caniglia et al., 2018; Starcic et al., 2018). This is because students are enabled to act upon their knowledge, skills and attitudes, experience them and be in the position not only to understand what they entail but to use them as well (Dlouhá & Burandt, 2015; Frisk & Larson, 2011; Shephard et al., 2018). Furthermore, these tasks should assist not only the development of students' content knowledge, but also further transformation of their abilities through cognitive dissonance (Fosnot & Perry, 1996), collaboration (Probst et al., 2019) and active contribution (Dlouhá & Burandt, 2015; Holdsworth et al., 2019).

The students faced with complex tasks will utilise their previous knowledge and skills, and act from certain worldview, value-orientation and perspective as starting point (Pritchard, 2013; Waltner et al., 2019). As they uncover more information on the task, link different concepts, engage in discussions with others, test their own ideas and compare them with

others, they stretch their zone of proximal development (Daniels, 2016). This mobilises them to develop a plan of action with a clear purpose, which is to be in control of their learning and apply it in the real world, thus master it as a consequence (Trencher et al., 2018; van Poeck et al., 2017; Wilhelm, Förster, & Zimmermann, 2019). When assessments have been designed to require learners to demonstrate how they have developed the programme's competences and how they can apply them to respond to a number of challenges, the formal assessment process can start.

Table 7.1. Sustainability competences and some appropriate tools for their assessment based on literature review.

• **Competence:** Systems thinking • **Assessment tools:** Concept maps (conceptual diagrams that represent the relationships between concepts) (Brandstädter, Harms, & Großschedl, 2012), computer simulations of complex systems and qualitative modelling of systems (elements, interactions and impact analysis) (Fanta, Braeutigam, & Riess, 2019; Riess & Mischo, 2010), self-assessment surveys (Ateskan & Lane, 2018) and problem scenarios where students are asked to bridge the gap between the current state and a goal or desired state (Grohs, Kirk, Soledad, & Knight, 2018). • **Competence:** Future oriented thinking • **Assessment tools:** Scenario construction (defining goals, objectives, processes, exploring what will happen, can happen or should happen), visioning exercises (exploring various desirable futures), foresight (identification of emerging trends and uncertainties), back-casting (exploring the feasibility of scenarios and visions)	• **Competence:** Modelling sustainable behaviour • **Assessment tools:** Student Conference (students organise, submit abstracts, papers, peer-review, hold roundtable discussions and present) (Larkin, 2014), reasoning exercises, observations of students performance and completion of assessment rubrics (Redman et al., 2020), SuliTest (survey that measures Sustainability knowledge and skills) (Décamps, Barbat, Carteron, Hands, & Parkes, 2017), Sustainability values test (Shepherd, Kuskova, & Patzelt, 2009). • **Competence:** Critical thinking • **Assessment tools:** Argument mapping, debates, critical essay analysis (Beyer, 2003; Bradford, 2017), critical writing (Brown, 2015; Van Gelder, 2015); critical thinking questionnaires, reflective writing (Straková & Cimermanová, 2018). • **Competence:** Self-awareness • **Assessment tools:** Self-assessments and focus groups (Redman et al., 2020),

(Brundiers et al., 2020; C. N. Cook, Inayatullah, Burgman, Sutherland, & Wintle, 2014; OECD, 2006; Withycombe, 2010).

- **Competence:** Collaboration
- **Assessment tools:** Collaborative problem-solving activities, such as projects and case studies (working together to form aim, objectives, goals and outcomes for a specific problem or case), transdisciplinary work (working with academic and community stakeholders to define and address a problem) (Brundiers et al., 2020; Caniglia et al., 2018); collaborative computer assessments and games (Chopade et al., 2018; OECD, 2017), focus groups and interviews (Scager et al, 2016), self and peer assessments (Ohland et al., 2012; Redman, Wiek, & Barth, 2020).
- **Competence:** Strategic thinking
- **Assessment tools:** Case study analysis, stakeholder analysis (who has power and interest over a plan), SWOT analysis (strengths, weaknesses, opportunities and threats of an action), devising strategies (identify short and long term goals and objectives and map actions), force field analysis (explore drivers and barriers to change and plan action accordingly) (Ajimal, 1985; Mulder, 2014; Pickton & Wright, 1998; Redman et al., 2020).
- **Competence:** Normative thinking
- **Assessment tools:** Argument mapping (diagrammatic analysis of arguments, reasoning and evidence), six hats thinking (seeing a problem through different perspectives), debates (supporting computer based self-evaluations (Achcaoucaou et al., 2014), the 4Cs framework (conviction, convincing, compelling, conforming) (Frisina, 2014), reflective writing (Straková & Cimermanová, 2018), rubrics (NRCC, 2019)
- **Competence:** Emotional intelligence
- **Assessment tools:** Six hats thinking, Emotional intelligence appraisal (a performance-based assessment) (Bradberry & Su, 2006), MSCEIT test (picture-based test) (Mayer, Salovey, Caruso, & Sitarenios, 2003).
- **Competence:** ability to use media (media literacy is about the use, critical understanding and communication of information through media)
- **Assessment tools**: presentations, videos (Gama & Barroso, 2017), podcasts (Kemp, Mellor, Kotter, & Oosthoek, 2012), blogs, social media posts (Arnett, Christensen, & Nelson, 2014), self-assessment and independent assessment rubrics serve to assess the use of media (Vuorikari, Punie, Carretero, & Van Den Brande, 2016), evaluating message, content, target audience, motives in a media piece as essay (Vuorikari et al., 2016), interaction/collaboration/communication analytics through digital platforms (Chejara, 2020).
- **Competence:** Integrated problem-solving
- **Assessment tools:** Complex problem scenarios where the student is physically or through computer simulations asked to solve (Krkovic, Mustafic, Wüstenberg, & Greiff, 2018), socio-ecological dilemmas (Bögeholz, Eggert, Ziese, & Hasselhorn, 2017), serious

opposing views on a statement), normative scenarios (how things should be) (Brown, 2015; Kivunja, 2015; OECD, 2006; Van Gelder, 2015). • **Competence:** effective communication • **Assessment tools:** Oral presentations, written reports, essays, portfolios and lab or course diaries.	games (Whalen, Berlin, Ekberg, Barletta, & Hammersberg, 2018) and social simulations (Sierra, 2020). • **Competence:** State of the planet knowledge **Assessment tools:** Tests, exams and essays/reports (for checking knowledge and understanding, written communication, analysis and synthesis) (Redman et al., 2020); New Environmental Paradigm scale (survey that measures pro-ecological worldview) (Anderson, 2012), SuliTest (Décamps et al., 2017), multiple choice test (systems, action and effectiveness knowledge) (Liefländer, 2015).

The formal assessment process (step 4) aims to both evaluate student performance or progress and provide evidence on the efficacy of the learning and teaching process. The assessment should help students monitor their own progress and reflect on their learning experience, while also providing the data for staff to reflect on the students' level of achievement, and revise teaching methods accordingly. The process can be facilitated by the development and application of rubrics that consist of fixed scales with points corresponding to the performance indicators descriptions of the competences assessed, making it easier to measure and communicate students' performance of these (Idrissi, Hnida, & Bennani, 2017). These indicators consist of levels, such as below basic, basic, intermediate and advanced, and assist the educators to score the ability of the students to perform the task described (Bubb, 2012). The rubrics can be easily adapted for student reflection on their developed knowledge, skills and attitudes. Apart from educator and student rubrics, assessment data can be collected from peer-assessment surveys, problem-solving tasks, and observation of student work, interviews and focus groups with the students, project-work and other tools (Table 7.1). Data from these assessment tools in combination with the data from the formal assessment methods can be used in order to triangulate the assessment results (using two or more assessment measures to deduce the performance of a student or a team) for validity reasons (Wim Lambrechts & Hindson, 2017).

The formal assessment process offers opportunities for learning to both students and educators. Educators can make the criteria known to the students in advance and be transparent about their aims (feed-up). The results will help the educators provide personalised feedback to students or groups, regarding gaps in their competence development and help them learn as much as they can (feed-back). They can also give them rich information on which areas to focus their teaching efforts so that the overall effectiveness of their course can be increased. Students can also benefit, as they develop the ability to self-assess and plan their own future learning trajectories (feed-forward) (Lambrechts, Mulà, & Van den Haute, 2010). A desirable threshold value should be decided by teachers and stakeholders involved in the assessment to be used as a benchmark for determining the programme's level of success.

Once the competence assessment is concluded, the contribution of a programme to Sustainability can then be evaluated by combining its results to those from the LOs alignment to Sustainability (step 5). In this final step of the assessment, the contribution of the educational programme to closing the gap towards their Sustainability vision can be measured. This assessment (outlined in the previous chapter (Kioupi & Voulvoulis, 2020)) aims to benchmark the intended LOs against eight crucial Sustainability attributes: Safe Operating Place, the Just Operating Place, Resilient Sustainable Behaviours, Alternative Economic Models, Health and Wellbeing, Transparency and Governance, Diversity and Inclusion and Collaboration, for the SDGs to be realised. Analysis of the combined results can identify potential restraining/limiting factors in terms of achieving Sustainability and assist the decision-making processes of the stakeholders involved.

The tool has been applied in the context of a well-established MSc Programme in the environmental field at one of the top Universities in the UK, and findings are discussed in the context of additional data collected, as well as an evaluation of the tool through direct input from students via self-reflective questionnaires.

7.3 Application of the assessment framework

7.3.1 The case study

The Master's programme in "Environmental Technology" at Imperial College London (Table 7.2) has a general orientation towards Sustainability as is stated in its vision, mission and

practices (curriculum development, teaching and learning methodologies) that allows for this kind of experimentation (Centre for Environmental Policy, 2018, 2019).

Table 7.2. Information about the Master's Programme in Environmental technology

Programme Information		Total Credits	
Programme Title		*ECTS*	*CATS*
MSc Environmental Technology		90	180
Awarding Institution	Imperial College London	*Faculty*	Faculty of Natural Sciences
Department	Centre for Environmental Policy	*Main Location(s) of Study*	South Kensington Campus
No of Options (elective modules for specialisation)	8	*No of students*	150

Entry Requirements	
Academic Requirement	The minimum requirement is normally a Bachelor's Degree with Honours in any subject. Students holding a 2:1 UK Bachelor's Degree are treated on a case-by-case basis and in accordance with the College's MSc entry requirements
Non-academic Requirements	If an applicant holds a lower class Bachelor's Degree they should normally have at least three years' relevant work experience. Their application is treated on a case-by-case basis.
English Language Requirement	IELTS score of 7.0 overall (minimum 6.5 in all elements).
Admissions Test/Interview	All shortlisted applicants are interviewed either in person or online.

The programme's specification documents can be found at:
https://www.imperial.ac.uk/study/pg/environmental-policy/environmental-technology/

The course aims to equip students with the necessary knowledge and skills to pursue a career in the environmental sector. It also aims to develop in learners the ability to solve

Sustainability problems through an interdisciplinary and systems approach, using critical enquiry, developing their ability to communicate and manage self and resources independently and as part of a group, and applying analytical, research and ICT tools appropriately (Centre for Environmental Policy, 2018). The course spans three terms, the core course term, the option term and the independent research term. The pedagogical approaches used in teaching and learning include both teacher-centred techniques (lectures, demonstrations aided by audio-visual tools) and learner centred strategies (discussions, collaborative projects, independent research essays, small group seminars, policy seminars, practical exercises, case studies, computer-based activities). The students are mostly assessed on the knowledge they gain through exams and on the skills they develop through project work reports, collaborative and independent essay writing and practical exercises results/reporting.

The assessment case study was implemented during the academic year, 2018-19 and the programme's LOs are listed in Table 7.3.

As an established MSc course, its learning outcomes had already been translated into competences over the years and in consultation among the Programme Director, Teaching staff (Lecturers and Fellows), Programme Developers (Senior Strategic Teaching Fellow), Students and Alumni.

The analysis of the course's competences found problem solving for Sustainability challenges to be a primary LO related to analytical, research and critical thinking skills. Much attention overall is given to collaboration and communication in interdisciplinary contexts and to the ability to understand and deal with complex socio-environmental systems. Decision-making and strategic thinking are crucial for assessing different options and deciding on a course of action. Self-awareness and regulation is an important ability related to understanding the role one can play when engaging in Sustainability issues and coping with the challenges faced. However, anticipatory or future thinking that has to do with assessing the future implications of decisions made, developing scenarios, projections and visions, and value thinking that has to do with the analysis of different value-sets, worldviews and perspectives are given less attention. Thus, students' future thinking and value thinking are not always explicitly targeted.

For this study, the focus was on the option term and students of the Water Management, Pollution Management and Environmental Analysis and Assessment options of the programme were recruited. Those students were selected as they constitute three different and self-contained subgroups showing some variation in competences and assessments while constituting parts of the same course. The gender, student status and ethnicity data for the students recruited per group are summarised in Table 7.4.

Table 7.3. MSc Environmental Technology Learning Outcomes (Academic year 2018-19) and translated competences.

MSc programme LOs 2018-19	Competences
1. Analyse, critically assess and solve Sustainability based problems	*Sustainability Problem-solving*
2. Be skilled in interdisciplinary thinking and working under uncertainty	*Interdisciplinary thinking and work*
3. Be able to communicate and collaborate with specialist experts across a range of disciplines and various stakeholders	*Collaboration and effective communication (oral and written)*
4. Develop knowledge and understanding of environmental science, technology and policy concepts and principles	*Environmental Science, Technology and Policy literacy*
5. Be able to apply natural and social science research methodologies, techniques and tools for experimentation, data collection and analysis	*Research competence (social and natural sciences methods)*
6. Develop management, negotiation and communication skills	*Systems thinking*
7. Integrate and evaluate information from various sources	*Critical thinking, reasoning and reflection*
8. Plan, conduct and write-up a programme of original research	*Strategic Thinking*
9. Communicate research, strategies and policy implications effectively through presentations and professional reports	*Decision-making competence*
10. Analyse and assess the natural/ social science literature effectively	*Self-regulation, self-awareness and management skills*
11. Use Information and Communications Technology	*Digital skills*
12. Learn independently with open-mindedness and critical enquiry	
13. Learn from the shared experiences with others	
14. Develop self-confidence, efficiency and resilience	

15. Formulate strategy to address Sustainability problem (prevention, mitigation, remediation)
16. Assess different options and weigh trade-offs to reach decision

Table 7.4. Gender, student status and ethnicity data for the sample of students recruited

Natural Sciences Option Data		
Gender	**Student status**	**Ethnicity**
Water Management Option (WM)		
60% Women, 40% Men	20% Home/UK, 80% Overseas	65% Chinese, 15% White, 15% Asian, 5% Black
Pollution Management Option (PM)		
81.25% Women, 18.75% Men	18.75% Home/UK, 12.5% EU, 68.75% Overseas	56.25% Chinese, 31.15% White, 6.25% Black Caribbean, 6.25% prefer not to say
Environmental Analysis and Assessment (EAA)		
64.3% Women, 35.7% Men	7.1% Home/UK, 7.1% EU, 85.8% Overseas	78.6% Chinese, 14.3% Asian, 7.1% White

The competences that the programme aims to develop and assess in the students of these options can be found in Table 7.5. To evaluate competence performance in those students, competence statements and indicators covering the cognitive, affective and behavioural aspects of competence were developed, applying the procedure outlined in the methodology section (Appendix C Table 1). Performance levels for each indicator of competence were structured in consultation with staff, with five levels of performance ranging from below basic, basic, intermediate to advanced and expert. The accepted level of performance is basic, which corresponds to 50% - 60% performance score, deemed as satisfactory for the MSc student to pass. The below basic level corresponds to poor/limited ability to perform the task considering the MSc level (<50%). Intermediate ability shows good (above satisfactory) performance in the task with occasional shortcomings (60-70%), advanced level shows very good performance showing novel insights into the problem (70-80%) and

expert performance shows high degree creativity and innovative thinking (>80%). The target threshold for the performance of the students of this programme in the selected competences was set at Intermediate (60-70%).

An examination of options' pedagogical approaches showed the courses to be project-based, with students engaging in active and collaborative learning, developing solutions related to water management (WM Option), waste management (PM Option) and environmental quality assessment (EAA option) problems, targeting competences specific to these options (Table 7.4). The projects and case studies involved authentic and real world decision-making, problem-solving and consulting processes with clearly defined roles for the students and tutors who facilitated the learning (Donnelly & Fitzmaurice, 2005). Those active learning pedagogical approaches have been found appropriate for competence development, as they require self-directed learning, management of group work, interactions with peers, lecturers, stakeholders, and exposure to real-life socio-environmental contexts (Trencher et al., 2018).

The formal assessment methods used in the options, where shown to include both oral presentations (formative and summative) as well as written reports of student work (summative) - either individual or group-based- with some variation across the three groups. In addition, exams played an important role in assessing knowledge and understanding of scientific concepts, environmental management and assessment practices. These assessment methods offered opportunities for data collection regarding the selected competences (Table 7.5) according to the typology presented in Table 7.1. The oral presentations and written reports aimed to assess effective communication. In the project reports, the students were asked to develop system models and thus use systems thinking; short and long-term strategies to address problems and thus strategic thinking; cope with future uncertainties related to environmental, political and financial changes and thus future thinking. They also had to consider the values and needs of stakeholders, manage trade-offs and make decisions, thus use decision making and collect, analyse and synthesise appropriate data to support their decisions and conclusions and thus use their research and critical thinking skills. However, collaboration, self-regulation, team monitoring and leadership were only assessed through informal discussions between the educators and the students during meetings regarding project progression.

Considering that, the formal assessments could capture competence development and to triangulate the results, the existing assessments were supplemented by educator assessment rubrics and student self-assessment surveys (Appendix C, Tables 2 and 3). In addition, this was done to give educators and students the opportunity to assess and reflect on individual and group work and the development of student competences. Lastly, this was done to give voice to the students, as traditionally, only the educators evaluated student learning for this course module.

Table 7.5. Description of option modules, assessment methods used and competences assessed in the MSc Environmental Technology

Option (Module)	**Assessment tools used**	**Competences assessed**
Water Management	**Exam and course work**	Knowledge and understanding of water systems and Water management
Anglian Water Project (AWP) (work in small groups*)	Group report and course work	Systems thinking and dealing with complexity Future thinking and dealing with uncertainty
Hounslow Heath Project (HHP) (work in two big groups*)	Group presentation and Individual report	Critical thinking, reasoning and reflection Research competence Strategic thinking and transformative action Collaboration and effective communication Decision-making Self-regulation, self-awareness and management skills
Environmental Assessment and Analysis	**Exam and course work**	Knowledge and understanding of resource depletion and contamination assessment and management
Hounslow Heath Project (HHP) (work in two big groups*)	Group presentation and Individual report	Systems thinking and dealing with complexity

Option (Module)	**Assessment tools used**	**Competences assessed**
Waste Management Project (WMP) (Phase 1: work in small groups*) (Phase 2: work in two big groups*)	Phase 1: Group report and individual presentation Phase 2: Individual report and group presentation	Future thinking and dealing with uncertainty Critical thinking, reasoning and reflection Research competence Strategic thinking and transformative action Collaboration and effective communication Decision-making Self-regulation, self-awareness and management skills
Pollution Management	**Exam and course work**	Knowledge and understanding of pollution problems and pollution assessment and management
Waste Management Project (WMP) (Phase 1: work in small groups*) (Phase 2: work in two big groups*)	Phase 1: Group report and individual presentation Phase 2: Individual report and group presentation	Systems thinking and dealing with complexity Future thinking and dealing with uncertainty Critical thinking, reasoning and reflection
Pollution management Case Studies	Group presentation and Individual report	Research competence Strategic thinking and transformative action Collaboration and effective communication Decision-making Self-regulation, self-awareness and management skills

*The students who participated in the AWP worked consistently in teams of 4 to 5 people throughout the duration of the project. The students who worked in the WMP started in groups of 3 people and half-way through the project merged into two big groups consisting of 15 students. Lastly, HHP students worked in two big groups throughout the project.

Both the educator rubrics and the self-assessment survey (Appendix C, Tables 2 and 3) consisted of 8 rubrics, corresponding to the 8 competences targeted (Table 7.4) by the option modules, asking educators and students to assess the level of competence shown when

working on the project. The rubrics were given to the educators to assess student reports and the surveys were given to the students to complete at the end of their project work. Twelve (12) educator assessment rubrics and 81 student self-assessment questionnaires were collected in total. The self-assessment survey was administered to the AWP, WMP and HHP students and not the PM case studies students as the project work of the first three groups was similar and I was not given access to the PM students.

Next, the data collected from the formal assessments, the educator rubrics and the self-assessment surveys are presented. Lastly, the data from the assessment of competences were combined with the data from the alignment of the programme's ILOs to Sustainability assessed previously to understand how the master's programme is achieving its Sustainability vision and what the constraining factors are.

7.4 Results

The results of the formal assessment for the three groups of students are summarised in Table 7.6, showing the average marks for the students of the Water Management, Pollution Management and Environmental Assessment and Analysis collected through the various assessment methods used for the needs of the programme per option.

Table 7.6. Average marks for each option module per assessment method

Option (Module)	**Assessment**	**Competences assessed**	**Average Mark**
Water Management (N=19)	**Exam and course work (total)**	**All the below**	**69**
Water systems and Water management	Exam	Knowledge and understanding	**66**
Anglian Water Project (AWP) coursework (work in small groups*)	Group report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making	74

Option (Module)	**Assessment**	**Competences assessed**	**Average Mark**
	Individual presentation	*Collaboration & Effective communication* *Self-regulation*	*72*
Total for AWP coursework			**74**
Hounslow Heath Project (HHP) coursework (work in two big groups*)	Individual report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making Effective communication	**72**
Environmental Assessment and Analysis (N=17)	**Exam and course work**	**All the below**	**67**
Resource depletion and contamination assessment and management	Exam	Knowledge and understanding	**64**
Hounslow Heath Project (HHP) coursework (work in two big groups*)	Individual report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making Effective communication	**73**
Waste Management Project (WMP) coursework (Phase 1: work in small groups*)	Phase 1: Group report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making	69
	Individual presentation	*Collaboration & Effective communication* *Self-regulation*	*71*
Waste Management Project (WMP) coursework (Phase 2: work in two big groups*)	Phase 2: Individual report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking	65

Option (Module)	**Assessment**	**Competences assessed**	**Average Mark**
		Decision-making Effective communication	
Total for WMP coursework			**68**
Pollution Management (N=16)	**Exam and course work**	**All the below**	**67**
Pollution problems and pollution assessment and management	Exam	Knowledge and understanding	**65**
Waste Management Project (WMP) coursework (Phase 1: work in small groups*)	Phase 1: Group report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making	69
	Individual presentation	*Collaboration & Effective communication* *Self-regulation*	*72*
Waste Management Project (WMP) coursework (Phase 2: work in two big groups*)	Phase 2: Individual report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making Effective communication	67
Total for WMP coursework			**69**
Pollution management Case Studies (PMCS) coursework	Group report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making	69
	Individual presentation	*Collaboration & Effective communication* *Self-regulation*	69
Total for PMCS coursework	Total		**69**

In terms of knowledge and understanding, the students of the WM option received 66 (B merit upper), the students of EAA options received 64 (B merit lower) and the students of the PM option received 65 (B merit upper). The qualitative description for the category 65 - 69% is *"A very good grasp of the subject and evidence of ability to synthesize and criticize including use of supplementary reading, but falling short of excellence in one or more of these aspects"* and for the 60 - 64% is *"A good grasp of the subject and some evidence of ability to synthesize and criticize"*.

In terms of the other competences evaluated (Table 7.6), the students of the WM option received marks between 72 and 74, which represent the A distinction category. The qualitative description for 70-79% was *"Showing a thorough grasp of the subject, and ability to synthesize and criticize, with critical use of supplementary reading, occasionally falling below a general level of excellence (i.e. original insights and innovative thinking)".* The students of the EAA option received marks between 65 (B merit upper) and 73 (A distinction) in terms of systems, future, critical and strategic thinking, decision-making and research skills (Table 7.6) for both the individual and group coursework, 71 (A distinction) for collaboration, effective communication and self-regulation and in their small group work. The students of the PM option received marks between 67 and 69 (B merit upper) for the competences systems, future, critical and strategic thinking, decision-making and research skills, and for collaboration, effective communication and self-regulation received marks between 69 (B merit upper) and 72 (A distinction). In all cases, group competences received higher average scores than individual ones.

In addition to the formal assessment criteria for the educators and feedback forms for the students, educator assessment rubrics and student self-assessment questionnaires regarding the selected competences (Appendix C, Tables 2 and 3) were developed. The educator assessment rubrics results showed for the students of the WM option intermediate (60-69%) to advanced (70-79%) level in the competences systems, future, strategic, decision making, critical thinking and research skills and intermediate level for collaboration, effective communication and self-regulation. For the students of the EAA option the results showed intermediate level for all competences, apart from collaboration, effective communication and self-regulation for which the results showed intermediate to advanced level. For the students of the PM option the results showed intermediate level for all competences. The rubrics mainly

assisted the educators to assess more easily and clearly the level of student competence, as the formal assessment criteria were only focused on assessing the coursework produced (e.g. reports and presentations), and give rich and targeted feedback for each competence examined in the feedback report given to the students. The students, on the other hand, received feedback on their individual as well as group work. An example of the feedback given to a group of students of the WM option based on the formal assessment criteria and the educator rubrics is provided in Appendix C Table 4.

According to the educator assessment rubrics, this team scored advanced level in systems thinking and research skills, while intermediate in all others (critical, future, strategic thinking, decision making, collaboration, effective communication and self-regulation). Comparison of formal assessment results for competences with rubric levels show that in most cases, the rubric scores are in accordance with the marks, but in some cases, they assign lower scores. The justification for this can be that they provide more level of detail in the evaluation of the student performance. Nevertheless, in most cases the results although lower were in the same qualitative category. Students received written feedback from the educators in their feedback forms as well as through the rubrics regarding their competences. In addition, they were given a self-assessment survey to reflect on their developed competences through teamwork. The same survey allowed educators to gain understanding about the performance of the students as a team and thus assess their collaboration competence. Tables 7.7a, b and c show the self-assessment results per project. Notably, WM students self-assessed their competences higher than PM and EAA students. Systems thinking for WM and PM and decision making for EAA students were the strongest competences, whereas research skills for WM, collaboration for PM and future thinking for EAA were the weakest competences reported by the students.

Table 7.7a. Descriptive Statistics of the self-assessment survey results of the WM students

	N	Minimum	Maximum	Mean	Std. Deviation	Normalised scores
Systems thinking	19	3.00	5.00	4.16	.602	78.95

Future thinking	19	2.00	5.00	3.68	.885	67.11
Decision making	19	2.00	5.00	3.84	.602	71.05
Critical thinking	19	3.00	5.00	3.68	.582	67.11
Collaboration	19	3.00	5.00	3.84	.501	71.05
Research skills	19	1.00	5.00	3.63	1.012	65.79
Self-regulation	19	2.50	5.00	3.76	.586	69.08
Strategic thinking	19	3.00	5.00	4.00	.667	75.00
Valid N (listwise)	19				Average	70.64

Table 7.7b. Descriptive Statistics of the self-assessment survey results of the EAA students

	N	Minimum	Maximum	Mean	Std. Deviation	Normalised scores
Systems thinking	32	1.00	5.00	3.41	1.012	60.16
Future thinking	32	1.00	5.00	3.09	1.174	52.35
Decision making	32	1.00	5.00	3.78	.870	69.53
Critical thinking	32	1.00	5.00	3.56	.948	64.06
Collaboration	32	1.00	5.00	3.41	1.043	60.16
Research skills	32	2.00	5.00	3.14	.961	53.52
Self-regulation	32	1.00	5.00	3.69	.896	67.19
Strategic thinking	32	1.00	5.00	3.55	.910	63.67
Valid N (listwise)	32				Average	61.33

Table 7.7c. Descriptive Statistics of the self-assessment survey results of the PM students

	N	Minimum	Maximum	Mean	Std. Deviation	Normalised scores
Systems thinking	30	3.00	5.00	3.77	.679	69.17
Future thinking	30	2.00	5.00	3.43	.817	60.83
Decision making	30	2.00	5.00	3.50	.777	62.50
Critical thinking	30	2.00	5.00	3.37	.669	59.17
Collaboration	30	2.00	5.00	3.23	.935	55.83

Research skills	30	2.00	5.00	3.43	.898	60.83
Self-regulation	30	2.00	5.00	3.57	.774	64.17
Strategic thinking	30	2.00	5.00	3.50	.820	62.50
Valid N (listwise)	30				Average	61.88

Overall, the students perceive their strongest competence to be Systems thinking and their weakest competences Future thinking and Research skills; however, the results do not show great difference between the strongest and weakest competence (mean comparison: future thinking/research skills=3.36 and systems thinking=3.72). Nevertheless, they represent different competence levels, intermediate for future thinking/research skills and advanced for systems thinking.

Comparing student self-assessment scores with formal assessment marks, it can be seen that in all cases students self-assessed lower. However, there is compatibility between the formal assessment marks and student self-assessment scores for WM and EAA students in terms of level of performance. In the first case, both assessments show A Distinction (advanced competence) and in the latter case, both assessments show B Merit (intermediate competence). On the other hand, the PM students gave lower scores to themselves than the educators did (B Merit/intermediate from the students and A Distinction/advanced from the educators respectively). A reason why the students may self-assess research skills differently could be that they have been exposed to different research experiences in their undergraduate studies (Imafuku, Saiki, Kawakami, & Suzuki, 2015). In addition, students may have limited ability to self-assess their skills if not adequately trained, and this may be reflected in the overall lower scores reported (Cassidy, 2007).

Findings from implementing the assessment tool demonstrate that the competences translated from the programme's intended LOs have many similarities with the suggested collection of competences for achieving the SDGs in the literature (Kioupi & Voulvoulis, 2019; Wiek et al., 2016) and that the coursework simulated authentic consultancy processes, which allows for the development of these competences. The programme's assessment methods are appropriate for the assessment of the intended competences, and when complemented with competence models, educator rubrics and student self-assessment surveys, they generate rich information that can be used by both educators and students as decision-making tool to make improvements in their teaching and learning pathways. Furthermore, the programme is

effectively enabling the attainment of its intended competences to the students. The data show that for most competences the students self-assess in the intermediate (future thinking, collaboration and research skills) to advanced level (systems, critical, strategic, decision-making, self-regulation) and also received marks from B Merit (intermediate competence) to A Distinction (advanced) competence according to the formal departmental assessments and educator rubrics. When compared to the threshold set by the department (students to achieve at least intermediate level, 60-70%), the results show successful educational outcomes.

The final step of the assessment tool is to inform the programme's stakeholders involved about achieving their Sustainability vision and here the results of the current assessment are combined with the results of the alignment of the programme's LOs to the SDGs. The MSc Environmental Technology scores high in terms of its LOs alignment to Sustainability compared with other Environment and Sustainability related master's programmes in the UK and EU according to findings of the previous chapter (Kioupi & Voulvoulis, 2020). Some areas of low coverage of Sustainability attributes include the Just Operating Space (JOS), Health and Wellbeing (HW) and Diversity and Inclusion (DI). Consequently, this provides additional validation to the fact that the competences translated from the LOs actually are Sustainability competences. Since the assessment data show that students score intermediate and above in those competences, the MSc Environmental Technology is successful in developing Sustainability competences to its students. However, the education practitioners should be able to reflect on these evaluation data to monitor their progress and inform their decisions. Thus, they should consider that the Sustainability attributes JOS, HW and DI in their case become constraining factors to achieve their Sustainability vision and they should address them in a curriculum review. In terms of the competences needed to achieve their vision, knowledge and understanding of Sustainability issues, collaboration, future thinking and research skills are flagged by students as their weakest competences and thus should be targeted by the curriculum developers and educators through potential curriculum reviews. Lastly but importantly, there will be benefits for the assessment of competences in case the master's programme management and teaching team consider inclusion and refinement of the educator rubrics and student self-assessment surveys developed for the programme.

7.5 Discussion

The tool is designed for use by Higher Education practitioners to evaluate student competence development. The ultimate aim is to help HE institutions evaluate their contribution to the SDGs by empowering graduates with Sustainability competences. The tool that aims to assess the alignment of ILOs to Sustainability (chapter 6) (Kioupi & Voulvoulis, 2020) in combination with the tool that assesses the development of competences in learners will generate the data that HE practitioners will use to assess how close they are to achieving their Sustainability vision. It is crucial to not only have the LOs aligned to Sustainability but to generate evidence that these competences are actually being developed in learners as they will be the future Sustainability citizens who will enable Sustainability to emerge. This way the effectiveness of the programme or educational offering in terms of achieving pedagogical outcomes and future societal outcomes can be measured.

It is important for the HE institution before assessing LOs and competences to have generated a clear vision of Sustainability they would like to achieve (framework chapter 5). The vision would be guided by the SDGs, and the LOs would be defined as important systemic contributors to that vision. Nevertheless, even if this process is not entirely followed or the HE practitioners are unsure whether the LOs they have already formulated are appropriate, they can check their alignment to Sustainability and identify gaps to remedy before assessing competence development in learners. Then, the tool described here will help them to translate their Sustainability aligned LOs into competences. This process ensures that they are actually Sustainability competences. The tools can help them improve/modify their assessment methods to enable active experience and appropriate assessment of the defined competences. This will generate evidence on the one hand, for the effectiveness of their teaching and learning approaches to develop those competences in students and on the other hand, to prepare learners who will be the future Sustainability citizens, as they will be empowered with Sustainability competences. In conclusion, assessments should be generating data and insights that help educators and students to make evidence-based decisions in terms of their teaching and learning respectively and at the same time help them identify and remediate barriers in achieving their Sustainability vision.

This chapter addresses an important need in the academic education community because of the multiple perspectives on Sustainability on the one hand, and the diversity of

existing competence frameworks and assessment tools on the other. All HE Institutions should prioritise a focus on participatory approaches in formulating competences for Sustainability that fit an institution's vision, mission, aims and needs, instead of a prescriptive approach of applying predefined competence frameworks. Moreover, this approach focuses on designing the selected Sustainability competences into the learning and assessments activities. Thus, both leaners and educators benefit from clarity/transparency of educational aims, effectiveness of pedagogies and accountability/ownership of outcomes. In addition, the data generated from the assessment tools enable HE practitioners identify gaps in terms of Sustainability attributes needed for their vision to emerge and barriers that prevent students from developing Sustainability competences.

Two recent systematic literature reviews on assessment tools for Sustainability competences (Cebrián, Segalàs, & Hernández, 2019; Redman et al., 2020) place emphasis on the fact that Universities put a lot of effort in compiling pedagogies that will enable Sustainability competences in learners, rather than thought on which assessments are appropriate for them. The tool, placing emphasis on competences translated from LOs based on the programme's mission and aim, offers a methodology for education practitioners to consider which methods to use for targeted competence assessment. Furthermore, the studies show that the most frequently used assessment tools are self-assessment questionnaires and surveys, followed by reflective writing (essays, reports diaries) and focus groups/interviews. The least used and maybe more refined tools are concept maps, coursework assignments and rubrics. Therefore, a combination of the above tools is needed to capture competence development in students and application in appropriate teaching and learning activities. As such, the case study presented here includes some best practice on how to do it. Both reviews show that the number of papers addressing Sustainability competence assessment have been increasing since 2010, but they mention that because of the different conceptualisation of competences and the lack of a common framework for their operationalisation and assessment comparison among studies is difficult.

The case study yields some useful suggestions to HE practitioners to assist them when applying the competence assessment tool. The programme coordinators need to make sure the competences represent not only the main curricular, pedagogical and assessment aspects, collectively the educational ecosystem, but reflect an awareness of the diversity of

perspectives, voices and cultures comprising the staff and student bodies as well as relevant societal aspects, such as ones related to professional life and emergent social transitions. This can happen by setting and agreeing values to guide their participatory process. As far as the assessment methods are concerned, the education practitioners should focus on the ones that enable students actively experience the competences they are expected to develop and reflect on them. They can thereby connect the cognitive, affective and behavioural aspects of competence with its metacognitive aspects, which have been found effective in enabling intrinsic motivation and longer-term engagement (Soland et al., 2013). It is also important to offer the students a variety of those assessment tools to both cater to the diversity of student learning styles and to capturing the complex aspects of the competence constructs (Bergsmann, Schultes, Winter, Schober, & Spiel, 2015).

Regarding using the assessment of competence data to make decisions, the educators are advised to use various types of data not only to capture richer information about the development of competence but also to validate the results. In the case study, formal assessment marks, educator rubrics and student self-assessment surveys were used to achieve triangulation of the findings. Educators can select from various available tools to validate their data and thus they may also use observation, checklists, student portfolios, peer-assessments, performance tasks or other (Table 7.1). Using a variety of competence assessment tools, educators can gather richer data and draw concomitant insights on the impact of their teaching practices on student learning on individual and group basis. These can help them make decisions around adapting the pedagogies that support the competences in cases of curricular reviews and to point out areas for improvement.

One important decision-making point regarding the use of the tool is group work. Although students benefit from working in groups as they are challenged to develop their competences further, the size of a group can greatly influence the decision making processes performed by the group (Patel, Pettitt, & Wilson, 2012). For example, the bigger the group, the less each member will be able to say. A larger group may inhibit certain individuals from contributing due to peer pressure. In addition, systems thinking is a competence that relates to systems analysis, and applying the necessary modelling and mapping of stakeholders and interactions may be more difficult in big groups as there may be many points of view, higher complexity and more conflict (Patel et al., 2012). This means that when engaging the students

in collaborative project work, there should be a careful selection of the size of the group and of the roles the students will play within the group. This may be correlated with their educational and professional background and personality.

While the tool presented here focuses on competences for evaluating a programme's contribution to Sustainability, it should be noted that competence-based assessments have also been the subject of criticism. This is attributable to the complexity of assessing poorly understood concepts, resulting in the potential to narrow the curriculum because of the increased focus on what is assessed at the expense of non-tested skills, which receive decreased attention. This entails the danger of overlooking important aspects of the student's personality as there may not be appropriate assessment methods to capture them and the caveat that using performance levels can negatively label teachers and students, thus influencing their attitudes (Markus, Cooper-Thomas, & Allpress, 2005). Competence assessments alone cannot benefit educators and students if it not coupled with systemic interventions such as teacher training sessions, involving time and cost requirements for developing relevant assessment material that is sensitive to class or cohort size and norms and behaviours that create resistance to change.

Despite these reservations, competence-based assessments place the importance of assessment not only on the outcomes of learning but equally on the process and experiences that led to those outcomes (Hutchings, Ewell & Banta, 2012). Their approach further provides specific, targeted and actionable feedback to the educator and student (Casey & Sturgis, 2018). Competence selection should ideally start with defining what the Sustainability vision the educational institution is trying to achieve is according to the SDGs. This entails a participatory and normative process, whereby all educational stakeholders make decisions according to accepted Sustainability values and principles about the things that matter most to them about their community (Kioupi & Voulvoulis, 2019). Although competences are complex as constructs and difficult to assess, they also reflect the multidimensional, integrated and performance-based nature of assessment and in terms of their Sustainability definition, they can act as indicators of closing the gap towards a Sustainability vision. Lastly and importantly, competences are important for entering and progressing in a professional environment as they are sought after by employers and used in applicant screening tests (WEF, 2016).

Further considerations for the education practitioners viewing this case study include the fact that the assessment framework was applied in a master's course that already had strong links with Sustainability. For programmes that have weaker links to Sustainability as well as other types of courses, for example Undergraduate University courses, Doctoral training programmes or School education contexts, it should be applied to serve the needs of education stakeholders. The case study was based on a sub-set of the students attending the master's course and could be extended to cover the entire sample of students to better support the results. Future use of more diverse assessment tools such as peer assessment of competences or observation checklists would increase the reliability of the results.

7.6 Limitations

The reliability and validity of the self-assessment questionnaires has been determined in a separate study (chapter 8) and measures to reduce bias have been applied. Some measures taken to reduce bias in the questionnaires were the provision of strict performance criteria through rubrics and the fact that multiple surveys were recorded for each group so every member acted as assessor of team performance (Vleuten van der, Sluijsmans, & Joosten-ten Brinke, 2017). Self-assessment questionnaires have some shortcomings, the most important being positive response bias and leniency effect (Lipnevich, MacCann, & Roberts, 2013). The results of this study show that students self-assess lower than the educators assess them, thus limiting the possibility of positive response bias or leniency. Educator rubrics have drawbacks too, some of these being that in some cases they are difficult and time consuming to use, educators may find it hard to assign a specific level to a student or coursework and they may be subject to user biases. These potential problems were addressed by testing the rubrics with the educators and improving their clarity and usability based on the comments, and by asking three independent assessors to use them to assess each piece of coursework and subsequently calculating interrater reliability using Fleiss kappa and Kendall's tau correlation coefficients. The results showed statistically significant moderate agreement among the three (~0.41).

Suggestions for further research in terms of the assessment tool include validating its use by applying it in other educational contexts, such as other master's and undergraduate

courses or even secondary and other post-secondary school courses. Its effectiveness as a decision-making tool can be validated in specific case studies that aim to collect and analyse data and make judgements to guide curriculum reviews. The Whole Institution Approach advocated by recent policy developments (UNESCO, 2020) emphasises that institutional and contextual aspects play an important role in the University's contribution to Sustainability. A Higher Educational institution, and specifically a University, is a multi-level organisation that has many different functions (education, research, operations, community outreach) and so Sustainability competence development is not only the aim of its educational activities but also of numerous other institutional pursuits (Setó-Pamies & Papaoikonomou, 2016). Thus, Sustainability competence development should be seen holistically i.e. from an educational, institutional and contextual perspective (Dlouhá & Burandt, 2015) and become aligned with whole system effectiveness in promoting competences for Sustainability.

Chapter 8 UK University case study: Application of assessment tool as part of a major curriculum review

8.1 Introduction

In the previous chapter, the Master's Programme Environmental Technology was presented as a case study for the application of the competence assessment tool during the academic year 2018-2019. The programme was found to contribute generally to Sustainability through its ILOs, which are aligned to eight major Sustainability attributes, but scoring low specifically in terms of JOS, HW and DI. Further application of the assessment framework showed that the MSc programme supports competences translated from the ILOs and some appropriate assessments in place to evaluate the development of the competences it targets in students. Appropriate educator rubrics and self-assessment surveys were further developed based on a competence model developed and described for the selected competences.

The result of the assessment showed that although students scored from intermediate (B merit) to advanced (A distinction) in the intended competences, which supports the proposition that the programme enables students to attain the competences, some competences require more specific focus, according to the educator and student assessments. These are knowledge and understanding of Sustainability issues, collaboration, future thinking and research skills. Considering the wider context of the programme, there was misalignment of the assessments with ILOs, exams were extensively used to evaluate student knowledge and understanding; and self and peer assessments were not common practice and were certainly missing from some of the options (personal communication with Dr Samira El Boudamoussi, Strategic Teaching Fellow at CEP).

The master's programme underwent a significant curriculum review during the academic year 2018-2019 and the new curriculum was in place for the following academic year 2019-2020. The curriculum review was undertaken in order to align the master's programme with the new Learning and Teaching Strategy rolled out by Imperial College London in 2018. The renewed educational vision mandated action in the following areas: review of curricula and assessments, evidence-based transformation of pedagogy, introduction of more interactive teaching, digitally enhanced learning and fostering an inclusive and diverse culture (Imperial College London, n.d.). The College's strategic approach in terms of curriculum reviews

prioritises the introduction of innovation in learning that will lead to the development of higher order thinking skills in students. This idea is aligned with competence-based education and some of the important higher order thinking skills targeted through the strategy are critical thinking, problem-solving, creativity, empathy and understanding of others' perspectives, collaboration, professionalism, independent learning, and self-efficacy. This focus on graduate attributes is complemented by the introduction of authentic assessments to evaluate the competences developed (Imperial College London, 2018).

In this chapter, the main aspects of the curriculum review of the Master's Programme Environmental Technology are presented as well as the application of the assessment tool developed. The results are compared with the previous assessment to draw conclusions about the effectiveness of the curriculum review and its impact on the attainment of competences.

8.2 The main aspects of the curriculum review

The curriculum review mainly focused on the assessment methods used in the master's programme, but some structural changes were also introduced in both the core course and the option term. The updated core course comprises three interconnected modules: the Natural World, the Human World and the Human Nature Interface that together aim to introduce the learners to the complexities of current Sustainability issues and enhance knowledge and understanding of coupled socio-environmental and socio-economic systems (Centre for Environmental Policy, 2019). Moreover, the compulsory "Becoming an Independent Learner" (BIL) module, spanning two terms (core course and option term), replaced and enhanced the previous series of workshops that aimed at resilience and relaxation. This module focuses on students' personal, professional and transversal skills that span many different types of skill, including but not limited to enhancing personal and collective wellbeing, quantitative and qualitative data analysis, critical thinking and problem solving.

In the option term, there still eight options offered; however, some have modified titles and focus to reflect the realities of contemporary environmental science and policy problems, and others have been discontinued and replaced (Imperial College London, 2020). The options Business and the environment (BE), Energy Policy (EP), Environmental Resource Management (ERM) and Global Environmental Change and Policy (GECP) remained, but with polished ILOs

and aligned assessments. The options Water Management and Environmental Analysis and Assessment were renamed to Integrated Water Management (IWM) and Environmental Analysis and Management (EAM) to further enhance a systems thinking approach and take a holistic view of managing the interactions between human activities and the environment. The Pollution Management (PM) and Health and Global Environment (HGE) were discontinued, with parts of them integrated in the new Urban Sustainable Environments (USE) option and the enhanced EAM option. Lastly, the Environmental Economics and Policy (EEP) option was introduced.

In terms of assessments, students are assessed for their group work through peer assessment and feedback so that they can develop their skills in interdisciplinary collaboration. It is worth mentioning that peer assessment has two components: self-assessment and other assessment, both aimed at improving contribution to group work (Centre for Environmental Policy, 2019). Exams are no longer used; however, some formative knowledge and skills-based online assessments help students check their understanding of content and development of skills. New or revamped assessments include group concept maps, video presentations, poster sessions, panel discussions, argument maps, force field analysis, critical reading and analysis, debates, and interdisciplinary case studies.

For all parts of the core course and option term, there is better alignment between ILOs and assessments as the Administration of the MSc introduced criteria-based rubrics for marking student work, focusing on high level thinking skills (personal communication with Dr Samira El Boudamoussi, Strategic Teaching Fellow at CEP). This is significant, as the previous marking criteria were not aligned with the ILOs and were used to assess the quality of the output the students produced e.g. essay, report, exam, rather than the attainment of the ILOs in students. In general, all ILOs (core course, option term and project term) are mapped to the programme's general ILOs.

8.2.1 What has been achieved through the curriculum review in terms of addressing the results from the application of the assessment framework?

The previous study highlighted the competences that required more attention in terms of generating enabling conditions to achieve them. These were knowledge and understanding

of Sustainability, collaboration, future thinking and research skills. The new curriculum clearly addresses those competences. Knowledge and understanding of Sustainability is supported by the changes in the core course, which highlight the natural and human aspects of Sustainability as well as their interactions. Elements of Sustainability are also reflected in the options around the environment (water, land and natural resources), economy, business, policy (solving pressing Sustainability problems), global change and governance in the new option Urban Sustainable Environments. However, the social pillar of Sustainability is given less attention, and this is a substantial weakness.

Regarding collaboration specifically, in both the core course and option ILOs, group work is emphasised; however, it is not present in the general programme ILOs. In contrast to the previous curriculum, collaboration is assessed through peer and educator assessment. Through BIL teaching approaches, the students are encouraged to reflect on teamwork and learn ways to improve it. Collaboration is an important aspect of interdisciplinary work in learning for Sustainability and although in the previous curriculum collaborative learning was used as a pedagogical approach, it was not highlighted in the ILOs and thus was not assessed. Thus, its inclusion in the ILOs in the revised curriculum constitutes a significant improvement.

Future thinking skills are included in general ILO 6, which states that students on completion of the programme will "*critically assess evidence of impact from current Sustainability policy and practice, and anticipate future risks in the context of evolving Sustainability challenges"*. This ILO should be mapped in all core course and option term ILOs to maximise its impact on student attainment. However, in terms of the core course ILOs, it is mapped in natural world ILOs, related with assessing the impact of human nature interactions and evaluating uncertainty and in the Human Nature Interface ILOs, by referring to and assessing the impact of human-environment interactions. It is not mapped in the human world module ILOs and BIL. All option ILOs cover ILO6 mainly as assessing the impact of human activities on the environment and or society, modelling and simulating future impact and anticipating and evaluating risks. In the previous curriculum, it was only found in Health and the Global Environment (HGE) and Business and environment (BE) option ILOs as assessing impact on health and the environment and anticipating future Sustainability developments and in ERM option as the scenarios appraisal model for tackling resource challenges in ERM.

Regarding research skills, the revised curriculum includes a redefinition of the competence from applying natural and social science research methods in the previous version to critically engaging with various qualitative and quantitative research methods. Furthermore, the curriculum review allowed for the formulation of specific ILOs for the final student research project in the summer term. Training in research methods was given attention in both the previous and the revised curriculum at two stages: in the core course and just before the start of the independent research project as part of the research methods fortnight. Another positive aspect of the revised curriculum is that research is specifically linked with Sustainability and environmental policy in terms of the broader areas it has to address.

The new formative and summative assessments that were introduced in the core course and option modules are very much aligned with the competences the programme is aiming to develop in the students. Concept maps help assess student systems thinking skills; video presentations and poster sessions enable effective communication; argument maps enable the evaluation of decision making, critical and value thinking skills; force field analysis and interdisciplinary case studies enable the evaluation of future and strategic thinking and collaboration competences; and debates enhance collaboration, research skills and critical thinking.

In the option term specifically, the options previously studied (WM and EAA) introduced a new module learning activity entitled 'integrated management tools workshops'. During the activity, students are trained in problem definition/structuring, in actively applying systems thinking and other environmental management techniques, such as decision-making tools. Every workshop session allows a group of students to explore different questions and engage in discussion with their peers and the coordinator. In addition, the students participate in fieldwork related to the topic of the workshops. During fieldwork they can gain richer insights on the problems they are defining (Centre for Environmental Policy, 2020b, 2020a). Another modification was in the format of project work for the WMP, which changed from having two rounds of collaboration in 2018-19, first in small and then in big groups, to students working throughout the project in three small groups in 2019-20.

Regarding the aligned Sustainability attributes with the master's programme's ILOs, the earlier assessment showed low scores in terms of Health and Wellbeing (HW), Diversity and Inclusion (DI) and Just Operating Space (JOS). Health and Wellbeing (HW) is explicitly

mentioned in the core course overview as part of the compulsory Human World and as part of BIL, focusing on personal (resilience, mindfulness, emotion management) wellbeing and collective wellbeing through unconscious bias and active bystander training. The latter training opportunities are linked with departmental efforts to establish a culture that minimises the occurrence of discrimination and harassment of any type, thus contributing to collective health and wellbeing. In the option term, HW is only included in the ILOs of the Urban Sustainable Environments (USE) option. The discontinuation of the Health and the Global Environment option has weakened the direct links of the master's programme with the Health aspects of Sustainability.

Diversity and Inclusion (DI) is articulated in the overall programme outcomes of the revised curriculum as understanding Sustainability from different perspectives and including diverse opinion, but it is not reflected equally in the core course and various option ILOs apart from the Energy Policy (EP) and Integrated Water Management (IWM). In EP the aim is to examine various perspectives on energy policy and in IWM, the aim is to communicate with stakeholders from different backgrounds. Appreciation of the diversity of lifeforms (biodiversity) is part of the compulsory core course module Natural World. Another effort towards increased DI is represented by enabling master's student representation in the Athena SWAN committee for promoting (gender) equality in the academic environment. Cultural diversity, although underrepresented in the previous and revised curriculum, is part of The Imperial College Graduate attributes that stress graduates should understand and value different cultures and perspectives.

Just operating space (JOS) is articulated in the overall description of the core course specifically as engaging with issues such as poverty in the Human World module and the SDGs in the Human Nature Interface module. It is part of five out of the eight options' ILOs: Energy Policy, Business and Environment, Global Environmental Change and Policy, Integrated Water Management and Urban Sustainable Environment Options. The ILOs mention analysis of social systems, societal implications of environmental change, social justice, stakeholder interactions and impact on and of decisions. However, there is still ground to cover in incorporating the social aspects of Sustainability in both the core course term and the option term to achieve a balanced representation of Sustainability dimensions.

8.3 Methodology

The competence assessment framework discussed in the previous chapter was applied for the second time in academic year (AY) 2019-2020 and the results from the formal assessments were collected, which included the educator rubrics, and the student self-assessments of the IWM and EAM options. The competences translated from the reviewed ILOs remained largely the same and are shown in Table 8.1. As one of the main aims of this chapter is to make comparisons between the results of the two AYs before and after the curriculum review, I will refer to the AY 2018-2019 as AY 1 and to AY 2019-2020 as AY 2. It should be mentioned that the formal assessment methods in AY 2 included assessment rubrics for the educators incorporating parts of the criteria developed the previous year as per my recommendations (Appendix D). Those new rubrics contain the following levels of performance: Poor (F, Fail) 0%, 25%, 35% and 45%; Satisfactory (C, Pass) 55%; Good (B, Merit); 65%, Excellent (A, Distinction) 75%, 85% and 100% (Appendix D). The Teaching Fellows of the Department validated the educator rubrics of the master's programme over the summer of 2019 by comparing the results they generated to the traditional assessment marking criteria (personal communication with Strategic Teaching Fellow). Lastly, the assessment methods did not include an exam for assessing knowledge and understanding; instead, they included an individual essay based on the tools module workshops and related field trips (Table 8.2).

Table 8.1. MSc Environmental Technology Learning Outcomes (Academic year 2019-20) and translated competences.

MSc Environmental Technology ILOs	Competences
At the completion of the master's programme the students will be able to:	
1. demonstrate a broad understanding of Sustainability from a range of perspectives relevant to environmental technology	*Sustainability literacy related to environmental technology*
2. critically engage with a broad range of appropriate literature	*Critical thinking, reasoning*
3. critically engage with a range of quantitative and qualitative research methods	*Research skills*

4. critically select from and use a range of problem-solving strategies and tools to tackle complex and unfamiliar ill-structured problems in a self-directed manner	*Strategic thinking*
5. gather, analyse, synthesise and critically evaluate appropriate information relevant to environmental technology and Sustainability	
6. critically assess evidence of impact from current Sustainability policy and practice, and anticipate future risks in the context of evolving Sustainability challenges	*Future thinking*
7. draw out original insights and develop creative solutions to Sustainability problems	*Creative problem-solving*
8. take responsibility for decision making, taking into account the trade-offs and ethical considerations inherent in decision-making	*Decision-making*
9. communicate effectively to a range of audiences using a variety of media	*Effective communication*
10. manage their own development in a range of appropriate transferable and professional skills	*Self-regulation and agency*
11. take responsibility for your own learning and develop confidence in your own abilities to tackle complex Sustainability challenges	

The most important weakness of the updated general ILOs of the programme is that there is no mention of collaboration as a competence the students will develop after participation in the programme. This is actually a paradox as the core course and option ILOs include this competence. The most important strength is the explicit inclusion of future thinking skills and a greater emphasis on Sustainability, responsibility and the ethical considerations and implications when making complex decisions.

Table 8.2. Description of option modules, assessment methods used and competences assessed in the MSc Environmental Technology in AY 2019-2020

Option (Module)	Assessment tools used	Competences assessed
Integrated Water Management	**Course work**	**All the below**
Integrated Management Tools (IMT)	Individual study paper	Knowledge and understanding of water systems and water management and broader Sustainability issues, systems thinking, critical thinking research skills strategic thinking academic writing effective communication
Anglian Water Project (AWP) (work in small groups)	Group report and course work	Systems thinking and dealing with complexity Future thinking and dealing with uncertainty
Hounslow Heath Project (HHP) (work in two big groups)	Group presentation and Individual report	Critical thinking, reasoning and reflection Research competence Strategic thinking and transformative action Collaboration and effective communication Decision-making Self-regulation, self-awareness and management skills
Environmental Assessment and Management	**Course work**	**All the below**
Assessment Tools and Decision-Making (ATDM)	Individual study paper	Knowledge and understanding of resource depletion and

Option (Module)	Assessment tools used	Competences assessed
		contamination assessment and management, systems thinking, critical thinking research skills strategic thinking academic writing effective communication
Hounslow Heath Project (HHP) (work in two big groups)	Group presentation and Individual report	Systems thinking and dealing with complexity Future thinking and dealing with uncertainty
Waste Management Project (WMP) (work in small groups)	Group report and individual presentation	Critical thinking, reasoning and reflection Research competence Strategic thinking and transformative action Collaboration and effective communication Decision-making Self-regulation, self-awareness and management skills

For comparative purposes, the AY 2 case study recruited only the students of the IWM and EAM options as samples as the PM option had been discontinued, but some of its elements had been integrated in the EAM option. The gender, student status and nationality data for the students recruited per group are summarised in Table 8.3.

Table 8.3. Gender, student status and nationality data for the sample of AY 2 students recruited

Natural Sciences Option Data		
Gender	**Student status**	**Nationality**
Integrated Water Management Option/IWM		
79% Women, 21% Men	50% Home/UK, 14% EU, 36% Overseas	50% UK, 29% Chinese, 14% EU and 7% USA
Environmental Analysis and Management/EAA		
60% Women, 40% Men	33% Home/UK, 67% Overseas	33% UK, 47% Chinese, 20% Asian

8.4 Academic Year 2019-20 Results and Discussion

The results of the formal assessment for the two options are summarised in Table 8.4, showing the average marks for the students of the Integrated Water Management and Environmental Assessment and Management options, collected through the various assessment methods used for the needs of the programme per option.

Table 8.4. Average marks for each option module per assessment method for AY 2 students

Option (Module)	**Assessment**	**Competences assessed**	**Average Mark**
Integrated Water Management (N=14)	**Course work (total)**	**All the below**	**70**
Integrated Management Tools (IMT)	Individual study paper	Knowledge and understanding of water systems and water management and broader Sustainability issues, Systems thinking, Critical thinking Research skills Strategic thinking Academic referencing Effective communication	**67**
Anglian Water Project (AWP) coursework (work in small groups)	Group report	Systems thinking Future thinking Critical thinking	72

Option (Module)	**Assessment**	**Competences assessed**	**Average Mark**
		Research skills Strategic thinking Decision-making	
	Individual presentation	*Collaboration & Effective communication* *Self-regulation*	*77*
Total for AWP coursework			**75**
Hounslow Heath Project (HHP) coursework (work in two big groups)	Individual report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making Effective communication	**70**
Environmental Assessment and Analysis (N=15)	**Course work (total)**	**All the below**	**67**
Assessment Tools and Decision-Making (ATDM)	Individual study paper	Knowledge and understanding of resource depletion and contamination assessment and management, Systems thinking, Critical thinking Research skills Strategic thinking Academic referencing Effective communication	**66**
Hounslow Heath Project (HHP) coursework (work in two big groups)	Individual report	Systems thinking Future thinking Critical thinking Research skills Strategic thinking Decision-making Effective communication	**71**
Waste Management Project (WMP) coursework	Group report	Systems thinking Future thinking	69

Option (Module)	**Assessment**	**Competences assessed**	**Average Mark**
(work in small groups)	*Individual presentation*	Critical thinking Research skills Strategic thinking Decision-making *Collaboration & Effective Communication* *Self-regulation*	*64*
Total for WMP coursework	Total		**68**

The students of the IWM option received higher overall option mark than the students of the EAM option. Specifically, the average mark of the IWM falls in the performance level Excellent-A Distinction according to the new marking rubric, which is described as *"Exceeds the expected requirements of a Master's degree. Engagement with critical thinking skills in most places. Draws robust conclusions based on analysis, synthesis and evaluation of multiple disciplines or viewpoints. Insightful in places"*. By contrast, the average mark for the EAM option falls in the performance level Good-B Merit "*Meets the expected requirements of a Master's degree. Demonstrates engagement with critical thinking skills in most places, with some lapses. Descriptive passages still obvious, but develops a good strategy from the analysis, synthesis and evaluation of multiple alternatives and viewpoints*".

The students of both options show Good-B Merit score in individual knowledge and understanding of the specific subject area of Sustainability of their option and related competences (systems, critical, strategic, research skills, effective communication and academic referencing). The students of the IWM option show high score (Excellent-A Distinction) in all Sustainability competences in both the HHP and AWP and notably for collaboration & effective communication and self-regulation. On the other hand, the students of the EAM option show lower Good-B Merit score in the WMP and notably the lowest score in collaboration & effective communication and self-regulation and Excellent – A Distinction in the HHP. This may have to do with the different project requirements of the WMP and HHP. In almost all cases, individual competences received lower (even if marginally) scores than

collective competences. The exception was the mark for the HHP individual report that was higher for the students of EAM option.

The educators in AY2 were provided with formal assessment rubrics to assess the individual student competences for the individual study paper and the group competences for the AWP, HHP and WMP collaborative projects as part of the curriculum review. In Figure 8.1, the results for the IWM and EAM students' competences are presented as evaluated via the individual study paper and by the use of the educator rubric.

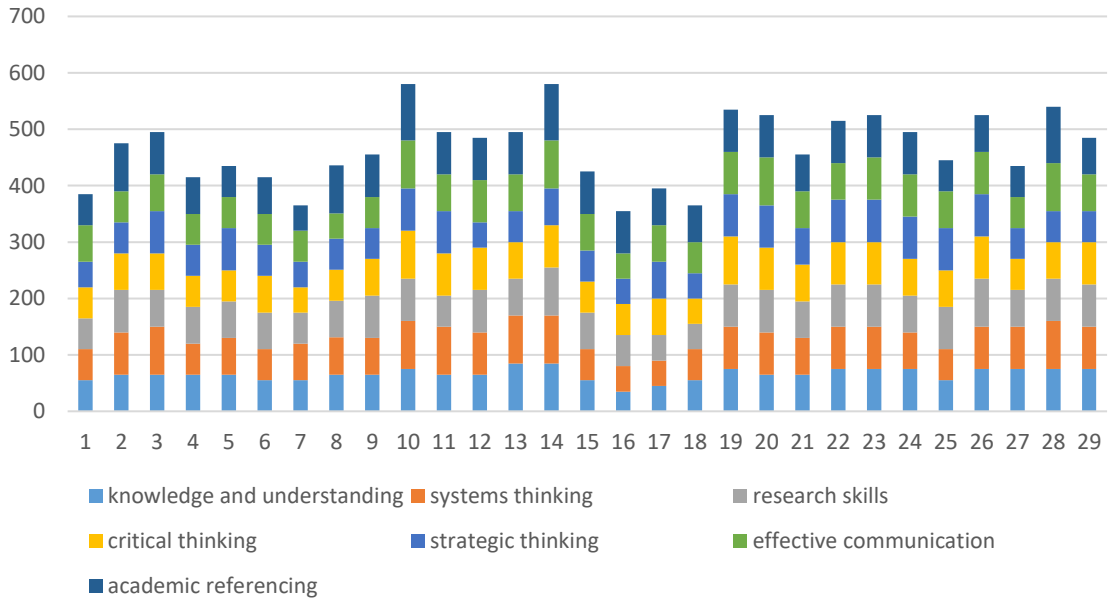

Figure 8.1. Bar chart showing the aggregate competence scores for the students of the EAM and IWM options based on the assessment rubrics for the individual essays. Each competence receives a score between 0 (lowest performance) and 100 (highest performance). The overall score results from the aggregation of the scores in the seven competences.

The students 1 to 15 come from the EAM option and the students 16 to 29 come from the IWM option (Figure 8.1). Students with aggregate score <400 and >350 scored satisfactory-C pass on average (4 students), the ones with aggregate score >400 and <500 scored Good – B merit (17 students) and the ones with aggregate score >500, scored Excellent – A distinction (8 students). In terms of the competences assessed, the highest average score was for academic referencing (72) and the lowest for strategic thinking (62) as shown in Figure 8.2. The results (Figure 8.2) show that the only competence the students seem to master as group is

academic referencing (>70). On the other hand, for all the other competences extra effort is needed by the students and the teachers in order to reach higher level of competence. A similar graph to Figure 8.2 can be generated for every student so as to provide them with a visual representation of their competence level, so they can start tracking their performance and focus on how they are progressing. This concept is in alignment with ipsative assessment, where students reflect on their work, identify strengths and weaknesses, and set personal targets on which to improve their competences (Isaacs at al. 2013).

Similarly to AY1, AY2 students were given self-assessment questionnaires (Appendix C) to complete regarding the selected competences (Table 8.2). The results from the self-assessment questionnaire of AY2 students are show in Table 8.5.

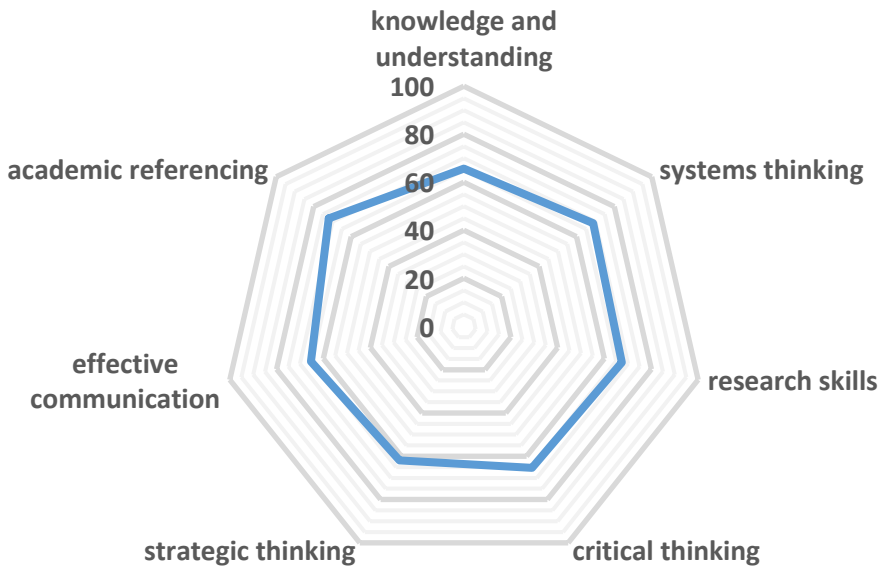

Figure 8.2. Spider chart showing the average competence scores for the students of the IWM and EAM options evaluated through the individual study paper.

Table 8.5. Descriptive Statistics – Self-assessment results AY2 students

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Normalised Scores
Systems thinking	43	4.00	1.00	5.00	4.0930	.92102	77

Future thinking	43	4.00	1.00	5.00	3.6047	.87667	65
Decision making	43	4.00	1.00	5.00	3.9070	.86778	73
Critical thinking	42	4.00	1.00	5.00	3.5714	.96633	64
Collaboration	43	4.00	1.00	5.00	3.5116	1.12063	63
Research skills	39	4.00	1.00	5.00	3.5128	.96986	63
Self-regulation	42	4.00	1.00	5.00	3.7738	1.00123	69
Strategic thinking	42	4.00	1.00	5.00	3.7143	.89131	68
Valid N (listwise)	39						

The students of AY2 perceive their strongest competence to be systems thinking and the weakest to be collaboration and research skills. The results do not show any great difference between the strongest and weakest competences (mean: 3.51-4.09) as they fall into the same performance level of "advanced". The normalised scores show that students perceived themselves to be in the Excellent - A distinction level for systems thinking and decision making, in the Good – B merit category for all the other competences. This result may be attributed to the introduction of the tools module workshops aimed at further developing the students' systems thinking skills by analysing problems to identify root causes and using decision-making tools to suggest the appropriate course of action.

There is good agreement between the marks the educators assigned to the students and the marks the students assigned to themselves in terms of the competences examined. This adds to the validity of the results. The students still score above the threshold of intermediate performance (B-merit, 60%) and thus show that they develop the intended competences.

8.4.1 Comparison between AY1 and AY2 results

Comparing the AY2 and AY1 assessment results in terms of the attainment of the intended competences, it can be seen that there are not many differences in the average scores of the students. Specifically, the overall average mark of the AY2 students of the IWM option is 70, while for AY1 it was 69; however, it represents a higher performance level of Excellent-A Distinction than the previous score. The mark for the individual study paper, which on average was 67 and replaced the exam in AY2, actually corresponds well with AY1 average mark of 66; however, its weighting in the total mark is different. The individual study paper

provides further benefits for both the educators and the students as it can provide information about student knowledge and skills as well as other Sustainability competences (Table 8.2).

Similarly, the average final score for the EAM option, which for AY2 is 67, is exactly the same as for AY1. This according to the new marking rubric corresponds to Good-B merit. Furthermore, the mark for the individual study paper of the EAM option for AY2 was 66 and corresponds well with the exam mark for AY1 which as 65. The average marks for the AY2 HHP are similar between the IWM and EAM students and comparable to AY1. The AY2 AWP average mark is marginally higher and the WMP average mark is the same as for AY1. However, the AY2 WMP shows a lower average score compared to the AWP and HHP score, which may be attributed to the different format of the group work.

Regarding competences in AY2, because of the introduction of the assessment rubrics as part of the formal assessment methods, it was much easier for the educators to evaluate them and give feedback to the students than in AY1. It benefited the students as well, as they were able to understand the evaluation criteria in advance and work towards them to improve their performance.

Students in AY2 perceive their strongest competence to be Systems thinking, similarly to AY1 students, although they self-assess higher, and their weakest competences to be Collaboration and Research skills. Research skills was also perceived as the weakest competence in AY1, together with future thinking skills. The master's programme administration strengthened the incorporation of Future Thinking in the programme's ILOs and this may be reflected in these results. Students of AY2 may still consider Research skills to be weak, as they come from different disciplinary backgrounds and so they have different research qualifications. Nevertheless, this could mean that they actually want to improve those skills as they are in a master's level and may have not had experience of actively doing research in the past. The low score in Collaboration could be attributed to the type of group work they had to do, although in AY2 the students had more opportunities to develop their skills in collaboration through the BIL and core course modules.

When comparing total student results between Year AY1 and AY2 it can be seen that for all competences AY2 students self-assess higher than AY1 students; however, there is statistically significant difference between the two AYs only for Systems Thinking according to

Mann-Witney U Test (p=0.008) and the effect size for this difference is medium (Cohen's d=-0.42) . The results from the comparison are presented in Table 8.6.

Table 8.6. Results from non-parametric analysis of variance based on mean ranks – Mann-Witney U test to compare self-assessment results of AY1 and AY2 students

Competences	STY	N	Mean Rank	Sum of Ranks
Systems thinking*	AY 1	81	**56.62**	4586.50
	AY 2	43	**73.57**	3163.50
	Total	124		
Future thinking	AY 1	81	59.20	4795.50
	AY 2	43	68.71	2954.50
	Total	124		
Decision making	AY 1	81	59.10	4787.00
	AY 2	43	68.91	2963.00
	Total	124		
Critical thinking	AY 1	81	60.83	4927.00
	AY 2	42	64.26	2699.00
	Total	123		
Collaboration	AY 1	81	61.30	4965.00
	AY 2	43	64.77	2785.00
	Total	124		
Research skills	AY 1	81	58.38	4729.00
	AY 2	39	64.90	2531.00
	Total	120		
Self-regulation	AY 1	81	59.68	4834.00
	AY 2	42	66.48	2792.00
	Total	123		
Strategic thinking	AY 1	81	60.51	4901.50
	AY 2	42	64.87	2724.50
	Total	123		

The moderately higher results in systems thinking may be explained by the introduction of a new seminar module at the start of the option term in AY2 that aimed to help students apply systems thinking to define a specific problem related with water, waste and pollution management. The seminars took place before their project-work started to help students gain experience in understanding problems, mapping stakeholders, and defining gaps between current and desired states. Overall, the curriculum revision seems to have had a marginal positive effect for the students of AY2 compared to AY1 students for all other competences. From the perspective of the students who were given the opportunity to self-assess their competences, the revised curriculum seems to have helped them boost their systems thinking skills. Lastly, although the curriculum review addressed some important aspects, such as making more explicit the competences of systems thinking, collaboration and future thinking skills in the ILOs and in the educational activities, it only slightly addressed the low scores in the Sustainability attributes of JOS, HW and DI. Thus, more targeted action needs to be taken in the future through a more in-depth curriculum review.

8.5 Reliability and Validity of the self-assessment survey

Regarding reliability of the questionnaire used, which is the degree to which the results obtained by a measurement and procedure can be replicated (Alias, 2005), it was tested using internal consistency as proxy. Though reliability importantly contributes to the validity of a measure, it is however not a sufficient condition for the validity of a questionnaire (Bolarinwa, 2015).

The internal consistency of the student questionnaire was tested using Cronbach's alpha in IBM SPSS Statistics V. 25 Software package. The general convention in research has been prescribed by Nunnally and Bernstein (Nunnally & Bernstein, 1994), and states that one should strive for reliability values of 0.70 or higher. The results for reliability are shown in Table 8.7. Very good internal consistency was observed for the questionnaire.

Table 8.7. Reliability Statistics for the student self-assessment questionnaire used in AY 1 and 2

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.879	0.882	8

Face validity for the questionnaire was ensured by using the competence model developed for the intended competences translated for the participating options in the case study and by asking Sustainability researchers to review the questionnaire and suggest corrections. The questionnaire was also piloted with five PhD students to make sure the language was appropriate and there were no confusing parts that could be misinterpreted. Exploratory Factor Analysis (EFA) was performed to check content validity using SPSS software. EFA was used to reduce the dimensions measured by the questionnaire so that most of the variance observed could be explained based on extracted factors. The interrelationships between the items of the questionnaire were modelled to check whether these items have similar patterns of responses, and may thus be grouped together to create a construct (UCLA: Statistical Consulting Group, n.d.). The analysis was done using all the data from the two years of study to achieve a good sampling size for the analysis (MacCallum, Widaman, Zhang, & Hong, 1999).

The EFA was run in SPSS for the complete dataset and Principal Axis Factoring was specifically used as extraction method as it is appropriate for ordinal data (UCLA: Statistical Consulting Group, n.d.). The initial tests of the merit of applying EFA on the data (sampling adequacy and sphericity) showed that they are fit for dimension reduction (Table 8.8).

Table 8.8. KMO and Bartlett's Test results for applying EFA to the student self-assessment questionnaire

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.878
Bartlett's Test of Sphericity	Approx. Chi-Square	447.536
	df	28
	Sig.	.000

The factors to be extracted were experimented with and concluded that a good solution according to the literature (Raubenheimer, 2004) would be to extract two factors as they would explain 55.36% of the total variance observed. To achieve simple structure the Direct Oblimin method was selected as rotation method. This oblique method assumes correlations between the factors and is in accordance with real-life cases, as all of the competences examined are interconnected. The results are presented in Table 8.9.

Table 8.9. Factor loadings for each of the eight self-assessed competences of the student questionnaire in EFA

	Factor	
	1	2
Decision making	1.179	-.429
Systems thinking	.710	
Strategic thinking	.652	
Critical thinking	.506	
Collaboration		1.041
Research skills		.600
Future thinking		.537
Self-regulation		.523

Extraction Method: Principal Axis Factoring.

Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 5 iterations.

According to the results, Decision making and Value thinking, Systems thinking, Strategic thinking and Critical thinking load to Factor 1, while Collaboration, Self-regulation, Future thinking and Research skills load to Factor 2. This means that the questionnaire discriminates between cognitive and non-cognitive dimensions of competence. Factor 1 relates to analysing problems in a holistic and critical way, making decisions and devising plans to carry out as potential solutions. Factor 2 relates to affective dimensions such as collaboration and self-regulation, and also psychokinetic dimensions such as research skills. Future thinking in the competence model is more aligned with the skills of defining current and future states and making projections, predictions and scenarios and also has a normative

component as the ability to envision sustainable futures entails the assumption of including collective values, worldviews and aspirations (Achcaoucaou et al., 2014).

The MSc Environmental Technology seems to encourage the achievement of its intended competences in students as the data show that for most competences their performance as assessed by educators if Good-B Merit to excellent – A Distinction. Moreover, the students self-assessed in the intermediate (future thinking, collaboration and research skills) to advanced level before the curriculum revision took place, whereas after the curriculum revision they self-assessed at advanced level in all competences. This indicates that the content, teaching and assessment changes that took place have benefitted competence development in students, with most positive impact seen on systems thinking.

The MSc Environmental Technology already has a long tradition of consulting academic staff, students and employers for developing its curriculum, and is oriented towards environmental Sustainability. According to the newly published QAA ESD guidance by Advance HE (QAA, 2020), all HE practitioners are strongly advised to embed ESD and the SDGs into their educational offerings in a systemic way. The framework enables all HE practitioners to check the alignment of their course ILOs to Sustainability. Using the data from the application of the framework, the administrative committee of the MSc Environmental Technology can make appropriate decisions on how to address the gaps identified in JOS, HW and DI.

8.6 Recommendations for the Master's programme in Environmental Technology

The Master's programme Environmental Technology shows good alignment of its ILOs with Sustainability attributes; however, the gaps for JOS, HW and DI are persisting in AY2. The administrative committee should actively try to address these gaps by reviewing the ILOs so as to ensure that they target the social aspects of Sustainability such as justice, equity, equality, diversity, inclusion, health and wellbeing for current and future generations, for developed and developing countries, in the Global North and the Global South. Next, they should align all other ILOs for the core course, option term and independent project term with those general course ILOs, this gap is most prominent for collaboration. There may be a need to increase JOS, HW and DI in separate option themes or to embed them in all options. Lastly, all the assessments and pedagogies used should be enabling the competences translated from the

ILOs and support the Sustainability attributes. It is expected that a data-driven approach to curriculum review will generate less resistance if it is planned and not imposed. Change is possible if all staff involved identify aspects requiring transformation and collectively try to address them, with the support of senior leadership (Crosling, Edwards, & Schroder, 2008).

Change could be achieved by making a cultural expansion in the curriculum to include other political philosophies and knowledge systems, research methods from various social disciplines, including less mainstream approaches (Traditional Ecological Knowledge, Ecofeminism, and Ecojustice) and tools developed by ethnic minorities to deviate from Western centric worldviews (Blewitt, 2008). This would enable the graduates to develop qualitatively distinguishing capabilities of understanding and resolving global problems and exhibit inter-cultural understanding, which are important attributes in an interconnected world. An internationalisation of the curriculum would entail at the first level introducing cultural sensitivity and international awareness through the examination of what each culture sees as understanding of the natural world, the human nature relationship, and understanding of causality (Cobern, 1996). This is especially important, as the programme claims to take an interdisciplinary approach to viewing Sustainability, which departs from the traditional compartmentalisation of knowledge maintained by Western thinking. This approach would enable different worldviews to be formulated and examined and various research methods to be explored.

Another way towards closing the gaps would entail a taking a holistic view of human and natural health and wellbeing, which are inextricably linked. For that to be achieved, there is not only the need to include them and teach them as part of the curriculum but also to experience them as part of the culture of the department. The same applies for enhancing diversity and inclusion. These could be implemented through more democratic processes that enable students and other stakeholders to participate in the design of the programme's ILOs and other aspects of the curriculum. Another aspect to investigate is the hidden curriculum, which refers to ways of communicating, behaving, using spoken and body language to convey various messages that are not contained in the educational material used. This hidden curriculum may be exclusive of others' voices and opinions and perpetuate an "accepted" view of thinking and behaving (Guo & Jamal, 2007). To reverse that, enhancing student and staff sense of belonging to the academic community as well as their ability for self-reflection and

creating enabling environments where students and staff can interact, support each other and forge their relationships will promote DI (Morgan & Houghton, 2011).

Lastly and importantly, the curriculum review strengthened some of the weakly incorporated competences in the programme's ILOs, such as future thinking and collaboration. It also managed to introduce varied assessment that captures not only knowledge and skill development but also competence development in learners. There is need for a continuing comprehensive evaluation of the effect of the curriculum review on teaching practice, student experience and learning culture, selecting and monitoring indicators of change and success every year and reviewing them to suit the needs of the learning community.

8.8 Limitations

The application of the assessment tool in AY 2019-2020 was dictated by the methodology used in the AY 2018-2016 case study in order to obtain comparable results. Thus, the framework was applied in the same options as last year with the downside that PM option had been discontinued. The sample of AY2 students was smaller than the AY1 one, as fewer students selected the IWM and EAA options. This may have had an effect on the statistical analysis comparisons between the two academic year results, but was accounted for in the selected tests. As only specific options of the master's programme participated in the case study, the future application of the assessment tool in the entire programme as part of the core course and option terms will provide additional validation for the tool. Shortly after the questionnaire was disseminated, the University went into lockdown and thus on the days of the dissemination some students were absent due to self-isolating, travelling or studying at home due to the covid-19 pandemic.

Chapter 9 Assessing learning outcomes for Sustainability in primary and secondary schools in the UK

9.1 Introduction

Recent international commitments around Sustainability, such as the Sustainable Development Goals and the Paris agreement targeting climate change, have highlighted the central role of Education in achieving their stated goals and targets (UNESCO, 2018, 2020). The SGDs specifically target quality education and state that ESD is its integral component and the learners should be empowered with knowledge, skills, attitudes, values and behaviours aligned with Sustainability, citizenship, human rights, gender equality, cultural diversity and peace education (UN SDG4, 2021). This view of education through international agreements coincided with a shift in Education policy that showed education systems moving towards evidence-based practices. This evidence-based orientation has been associated with the assessment of learning outcomes or competences in learners as the means for improving the effectiveness of education offerings (Leutner, Fleischer, Grünkorn, & Klieme, 2017).

In the UK, school assessments have already been used to collect evidence of students' alignment with key stage expectations, referred to as attainment targets. These targets specify the knowledge, understanding and skills related to specific subjects that learners are expected to have acquired by the end of an educational level and to be assessed on against a predetermined set of criteria, to help improvement of the student, teacher and school and provide reliable information to the parent (Department for Education, 2014). The first national strategy regarding Sustainable Development titled "Securing the Future" was rolled out in 2005 (DEFRA, 2005a), which coincided with the start of the UNESCO decade for ESD in 2005 (UNESCO, 2014d). In chapter 2 of this strategy, education was included as a means to enable positive behavioural change that is critical for achieving the sustainable future envisioned by the UK government. Specifically, education can help learners form desirable habits for Sustainability early on and these can be transformed to sustained behaviours throughout their lives (DEFRA, 2005b). This was aligned with an effort to make every school an environmentally sustainable school that teaches about Sustainable Development through the curriculum and by example. One of the primary objectives of this plan was that 'all learners will develop the skills, knowledge and value base to be active citizens in creating a more sustainable society'.

Another result of the strategy was the implementation of the National Framework for Sustainable Schools in 2006 to urge schools to consider Sustainable Development in teaching, learning, school management and community engagement (Government Office for London, 2007; Reynolds & Scott, 2011).

An evaluation of the status of ESD in the UK as the Decade was approaching its end showed that although multiple ESD initiatives existed across the UK and showed good practice in teaching, learning and teacher training, these were relatively small scale, mostly project based and within fixed timescales (UK National Commission for UNESCO, 2013). In terms of policy around ESD implementation, there was no uniform view or action on how ESD could be widely adopted in formal, informal and non-formal education, with significant variation among the nations of England, Northern Ireland, Wales and Scotland and thus there was need for a national strategic framework. A few years later, a second report assessed initiatives relating to the Global Action Programme on ESD and to the SDGs as well (UK National Commission for UNESCO, 2017). That report found that there were still many grassroots initiatives in schools, higher education, local community groups and businesses; however, there was still no government framework within which those initiatives could be supported, flourish and their impact on achieving Sustainable Development could be assessed (UK National Commission for UNESCO, 2017).

In terms of evaluation of the effectiveness of implementing ESD in the UK, the national strategy developers were in favour of approaches that assessed learners' Sustainability literacy to provide evidence. However, the resulting consultations of the UK government with its advisors led instead to the development of an ESD indicator that had to do with the institutional effectiveness of introducing ESD, based on a self-assessment instrument aimed at sustainable schools (Huckle, 2009).

Considering the evidence-based orientation of education in general and ESD specifically, and the gap in reliably evaluating learner empowerment with Sustainability competences required for them to become the future citizens of society, a framework for assessing learning outcomes for Sustainability was developed using systems thinking and described in detail previously (chapter 5) (Kioupi & Voulvoulis, 2019). It outlines five steps as part of a participatory process of selecting and assessing learning outcomes for Sustainability

and had been applied in Higher Education programmes (chapters 6 and 7)(Kioupi & Voulvoulis, 2020).

In this chapter, the application of the framework is presented in two case studies around the assessment of Sustainability learning outcomes in school education in the UK during the 2018-2019 school year; the first in a primary school academy, which has eco-school status, and the second in an independent co-educational secondary school. The two schools have different approaches to curriculum implementation. The former has more freedom to develop its own curriculum being an Academy, satisfying the Education Act (2011) requirements at the same time whereas the second is an independent school following the national curriculum but having the flexibility to introduce unique courses for innovative teaching and learning (UK government, types of schools, n.d. a).

9.2 Case studies – framework application

The case study approach was selected as the appropriate tool to demonstrate the application of the framework in school education, as it would enable the teachers and researcher to gain insights into the education for Sustainable Development practices employed in the schools (Lapan, Quartaroli, & Riemer, 2012). It would further help the teachers and researcher collect various types of data, both qualitative and quantitative so that when analysed in the context in which the curriculum, learning activities and assessment for Sustainability learning outcomes take place they can provide the base for actionable decisions by the educational communities (Baxter & Jack, 2015). Lastly, it would make sure that the newly developed pedagogical assessment tools would meet the needs of the schools and capture the benefits and limitations of the framework.

The steps of the applied framework for selecting and assessing Sustainability competences can be found in Figure 9.1. The framework uses a participatory approach, whereby the researcher works with the school stakeholders to implement every step of the framework, have open and meaningful discussions around their values, aims and objectives, research, teaching, learning and assessment methods, exchange feedback, use and analyse data transparently and identify ways to improve practices (Bullock & Hitzhusen, 2015; Dlouhá & Pospíšilová, 2018). The first step of its application started with bringing together the relevant

education stakeholders of the two schools and discussing the Sustainability vision they would like to achieve. This involved several meetings with the head teacher and teachers of the primary school and with the coordinator and teachers of the Global Goals course of the secondary school. In the following meetings, there were discussions around the competences needed for their learners to become the future citizens of this sustainable future and on the pedagogies and assessments they used to develop and evaluate the selected competences. In the final meetings, those teaching and learning activities and assessment methods were reviewed against their capacity to develop the selected competences in learners and the researcher worked with the teachers to revise them and to develop new ones. In every step, it was ensured that the decisions made reflected the realities, aims and needs of primary and secondary school teachers and students.

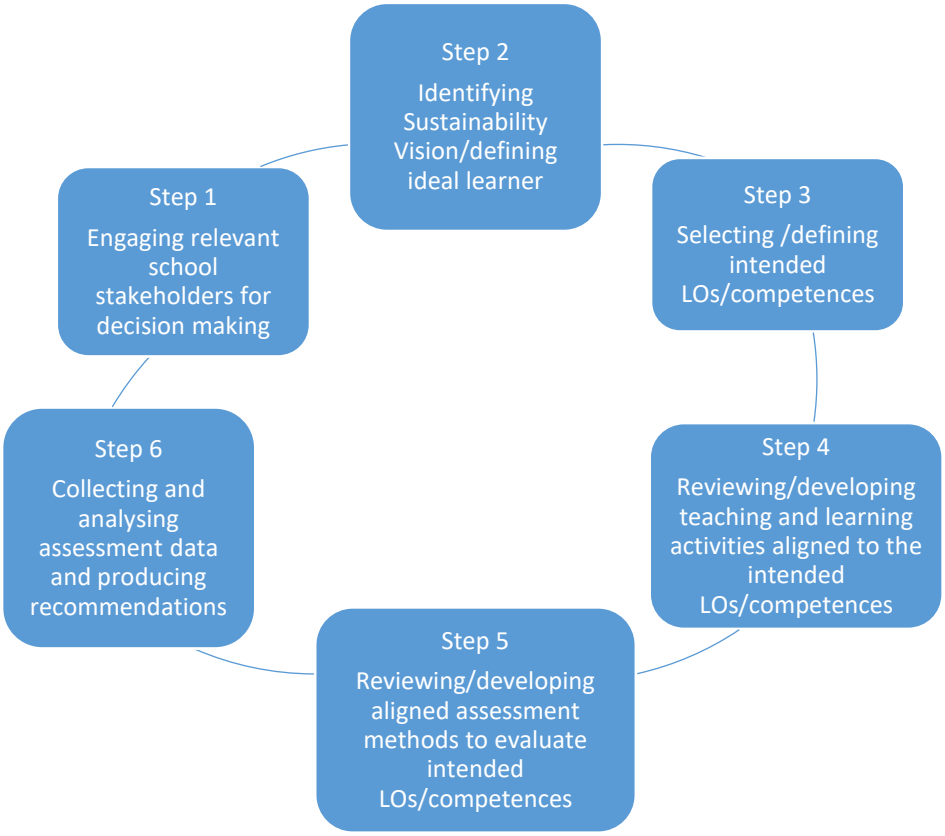

Figure 9.1. The six steps of the applied framework for selecting and assessing Sustainability competences in primary and secondary schools.

9.3 Primary school case study

The primary school is located in the home counties of England and is an Academy school. Academy schools in England are publicly funded independent schools that are not obliged to follow the national curriculum (UK government, n.d. a). While Academies have more freedom in terms of curriculum and term schedules, they are still required to adhere to the Department for Education's rules on admissions, special education needs and exclusions (UK government, n.d. a). The primary school is recognised as a leading Eco-school, has held 'Green Flag' status for over four years, and more recently, in 2015, was chosen as one of nine schools in the UK to be a part of the Eco-School's Ambassador programme (personal communication with head teacher). The school has identified seven Sustainability themes to focus on as part of the eco-school programme and these are Energy, Healthy Living and Food, Recycling and Waste, Water, Biodiversity, Transport and Global Perspective (personal communication with head teacher). These Sustainability themes are interlinked with its curriculum, which follows the Harmony Framework. The Harmony Framework is a unique model of learning which guides how and when the curriculum is taught at the school – including the core subjects of English, mathematics, sciences, computing and religious education (Dunne, 2020). This model of learning consists of four main concepts: Values, Principles of Harmony, Enquiries of Learning, and Great Works. The school's seven Values are Respect, Kindness, Honesty, Responsibility, Courage, Forgiveness and Joy (personal communication with head teacher). The values set by the school are then linked to the Principles of Harmony created by HRH the Prince of Wales and help incorporate themes of Sustainability (Dunne, 2020).

Following the establishment of Values and corresponding Principles, the curriculum then incorporates Enquiries of Learning, which determine what core subjects are taught when and the additional subjects such as ESD included in the curriculum in six half-term periods (Dunne, 2020). Once an enquiry is complete, the students then engage in Great Works. The primary school uses Great Works as an opportunity for students to reflect on what they learned over the half term through a memorable activity or event (Dunne, 2020). Examples of Great Works completed at the school in the past include planting an orchard of fruit trees and creating a leaflet on solar energy (personal communication with head teacher). The entire Harmony framework encompasses Sustainability as a thread that links all the enquiries undertaken by the students.

From discussions about the vision and mission of the school with the headmaster and the teachers, it was found that it is deeply rooted in Sustainability as it states: *'Sustainable living and learning is at the heart of the curriculum and everything we do at our school, with all our half-termly year group learning enquiries directly linked to an element of sustainable living. We look to develop energy and environmentally conscious individuals who care about the world around them and understand what is required to sustain individual, team and global well-being'* (personal communication with head teacher). This vision and mission definition of the school is aligned with the systemic framework's definition of a sustainable state citizen (Kioupi & Voulvoulis, 2019).

As per the adapted framework presented earlier in Figure 9.1, step 1 was taken to identify and engage the relevant stakeholders and thus I worked with the teachers and headmaster of the school to understand their ESD for the SDGs activities. The school had already developed a vision for Sustainability and ideal learner profile and thus we further discussed it in our meetings (step 2). Next, we held discussions around their intended Learning Outcomes (LOs) (step 3). The LOs envisaged pupils with affinity for sustainable living, having eco-conscience and showing care for the world around them. After that, we checked the constructive alignment among the LOs, teaching and assessment activities (steps 4 and 5) to evaluate if they enable the development of those LOs in pupils. Lastly, assessment data were collected and results analysed to make some conclusions and recommendations. The process as well as specific adjustments made is described in more detail in this section.

In our initial discussions with the headmaster and the teachers of the school, they shared their aims in terms of the Year 4, 5 and 6 curriculum and Sustainability, which were directly linked with the concepts of food, water and energy. The interlinkages among food, energy and water are crucial for achieving Sustainability and as concepts are challenging for students of young age to grapple (Barrutia, Ruíz-González, Villarroel, & Díez, 2019; Opitz, Blankenstein, & Harms, 2017; Oztas & Oztas, 2017; Walshe, 2008). At the same time balancing the water, food and energy nexus is a prerequisite for achieving the Sustainable Development Goals and has profound links with all of the SDGs (Simpson & Jewitt, 2019). A recent report found that because of urbanisation, population and consumption growth, the demands for energy, water and food would increase by 50%, 40% and 35% respectively by 2030 (Yillia, 2016).

Because of the importance of the water, food, energy nexus concept for environmental Sustainability and after consultation with the teachers of the school, the focus of this study was placed on Years 4, 5 and 6. The assessment of Year 4, 5 and 6 pupils' knowledge, skills, attitudes and behaviours regarding food, water and energy systems would happen after they had participated in the relevant Enquiries of Learning during the school year of 2018-2019. The Year 4, 5 and 6 teachers selected specific learning outcomes regarding Sustainability they intended their pupils to attain. For Year 4 students this was knowledge of food production systems (conventional vs organic), where food comes from and what is food waste, what is produce seasonality and why it is important, skills in growing their own produce (vegetables) and appreciation of healthy food and behaviours that lead to consuming healthy food. For Year 5 the learning outcomes included knowledge of water usage (direct and indirect), water footprint and how to decrease it, where water comes from and where it goes after its use, links between water use and vegetable production and consumption, attitudes toward responsible water use and reduction of wasteful behaviours. For the year 6, the LOs included knowledge of energy as a physical quantity, its uses and measurement units, sources of energy, energy production, distribution and carbon footprint, skills in assessing the energy use of efficient and conventional electrical devices, monitoring and explaining the energy usage at school and adopting behaviours conducive to energy saving a school and at home.

The teachers involved in teaching those subjects participated in a discussion around the pedagogies and the assessments used in Years 4, 5 and 6 to attain the intended LOs. The Year 4 pupils engaged in writing essays in topics such as organic food production, ethical farming methods and food miles. They also had to map countries and their products to understand how food travels and state their opinions in consuming local versus imported produce in terms of Sustainability. Lastly, they had to describe one day in the life of a farmer and design and create the packaging of and market a healthy snack as part of an arts project. During the half term, the pupils were responsible for weighing and measuring food waste from the school kitchen and were asked to figure out ways to reduce waste before recycling it as compost. They also had an outdoor activity where the school gardener explained the importance of wildflower meadows for maintaining local biodiversity and the pupils identified important flower species. Another part of the outdoor lesson required pupils to split time between sieving compost, re-potting and watering seedlings. Other activities included in the

outdoor lesson required students to weed a section of the garden, sow seeds and plant potatoes. The activities required active engagement in knowledge and skills development and were deemed appropriate for the students. However, there was no targeted assessment to evaluate the development of the LOs in the students.

The Year 5 pupils engaged in activities around river geography and ocean protection and were also responsible for monitoring the school's water use through the ecoDriver tool on a weekly basis as well as measuring how much water is wasted at the end of each lunch time to ensure maximum savings (personal communication with Year 5 teachers). As these learning activities were not entirely in alignment with the intended LOs I collaborated with the teachers and the head teacher of the school to enrich the activities around water to meet the selected LOs. The resulting curriculum engaged the pupils in activities regarding direct and virtual water use in an average UK household per day. The pupils calculated their own water footprint, worked in groups to identify ways by which they could reduce their own direct and virtual footprint. They further examined the link between direct and virtual water use and food production and calculated the water needed to grow a vegetable locally versus growing it abroad and importing it. They discussed vegetable production in the greenhouses of Almeria Spain, an area with arid climate and serious water stress to understand the practices involved in securing water for growing the vegetables. Lastly, they developed videos around water use in everyday life and in agriculture. In terms of the assessments, these were developed in consultation with the teachers and head teacher as the existing ones included pledges the students made around their personal water use.

As part of the Energy Sustainability theme in Year 6, the primary school aims to lower their energy consumption by relying on renewable energy sources from on-site solar panels as well as an on-site biomass boiler (personal communication with head teacher). In addition, the school strives to deploy energy saving methods by creating weekly energy competition targets for each school building to motivate and educate the students on sustainable energy consumption. The school assigns the energy monitoring and tracking to the Year 6 students who use ecoDriver, an energy monitoring software system, on a weekly basis and share the results at school assemblies (Dunne, 2020). The year 6 curriculum around energy was further enhanced through consultations with the teachers and the headmaster of the school, as it did not fully capture the intended learning outcomes. After the adaptations were made, it included

inquiry-based activities around the use of energy at home, how energy is produced and distributed, what is 1 kWh and what kinds of activities you can perform with it, energy consumed in household activities by household appliances, debate over renewable and non-renewable sources of energy and personal carbon footprint calculation. Assessment tools were developed for this year's activities to capture the LOs attainment by the students.

The developed assessment tools were questionnaires assessing student cognitive (knowledge and skills), affective (attitudes) and behavioural (actions) dimensions of learning about food, water and energy in Years 4, 5 and 6. This classification of LOs was suggested by the school teachers and was found appropriate in the relevant literature for assessing LOs related to the SDGs in primary school education (UNESCO, 2017a). The questions included a mix of open-ended, select the right choice, classification and Likert-scale questions as the intention was to capture the different types of knowledge, emotions and attitudes the students managed to develop (UNESCO, 2017a). Year 4 pupils were also asked to draw storyboards to assess their attitudes around conventional and organic food. For these storyboards, the pupils were asked to draw pictures and explain with captions the life of a conventionally versus an organically grown tomato. Through providing visual explanations, students consolidate their learning, as they are required to perform deeper processing of the information and produce more complete mental models (Bobek & Tversky, 2016). The analysis of the storyboards was based on contextualisation by use of the text descriptors on the drawings, segmentation that was implemented by design and qualitative coding of the themes presented in the segments of the storyboards and the emotions expressed (Loureiro, Grecu, de Moll, & Hadjar, 2020).

Due to administrative complications, it was not possible to administer the questionnaire developed for Year 5 pupils and thus the results are not reported as part of this study. The Year 5 and 6 pupils and teachers were also asked to complete a feedback form regarding the new activities that were introduced as part of the curriculum and the results are reported.

The questionnaires were administered as follows:

- 31 Year 6 pupils completed the energy questionnaire and pupil feedback form and 1 teacher completed the teacher feedback form,

- 26 Year 5 pupils completed the pupil feedback form and 1 teacher completed the teacher feedback form, and
- 59 Year 4 pupils completed the food questionnaire.

The questionnaires comprised questions around the cognitive, affective and behavioural LOs targeted by the Year 4, 5 and 6 Curricula. The storyboards were only distributed to Year 4 pupils. The analysis of the quantitative parts if the questionnaires was done using MS Excel software and for the analysis of storyboards and open-ended questions, NVIVO for qualitative analysis was used.

Year 6 energy questionnaire results:

The questionnaire for Year 6 can be found in the Appendix E (Year 6). Here the main findings from the data collection and analysis are reported. Pupils have good knowledge of everyday energy use including where and when they use it and are able to share examples of activities. Almost half of them were able to correctly identify an energy saving light bulb as opposed to a conventional one based on energy rating data. Three quarters of the pupils managed to tag correctly at least eight energy sources as renewable or non-renewable, with biofuels often misunderstood as non-renewable.

Almost all pupils (except for two who did not know or gave irrelevant responses) supported the idea that renewable energy sources are better for the environment and people. Most responses highlighted the positive aspects of renewable and the negatives of non-renewable energy. No negative aspects of renewables, nor positive aspects of non-renewable energy were mentioned. The responses were framed as benefits for the environment if using renewables, such as *reusability, no pollution, being natural and eco-friendly* and as drawbacks for people if using non-renewables, such as *risk to health and leads to poverty*, and the environment, such as *climate change and generally harmful to the environment*, without further explanation (Figure 9.2).

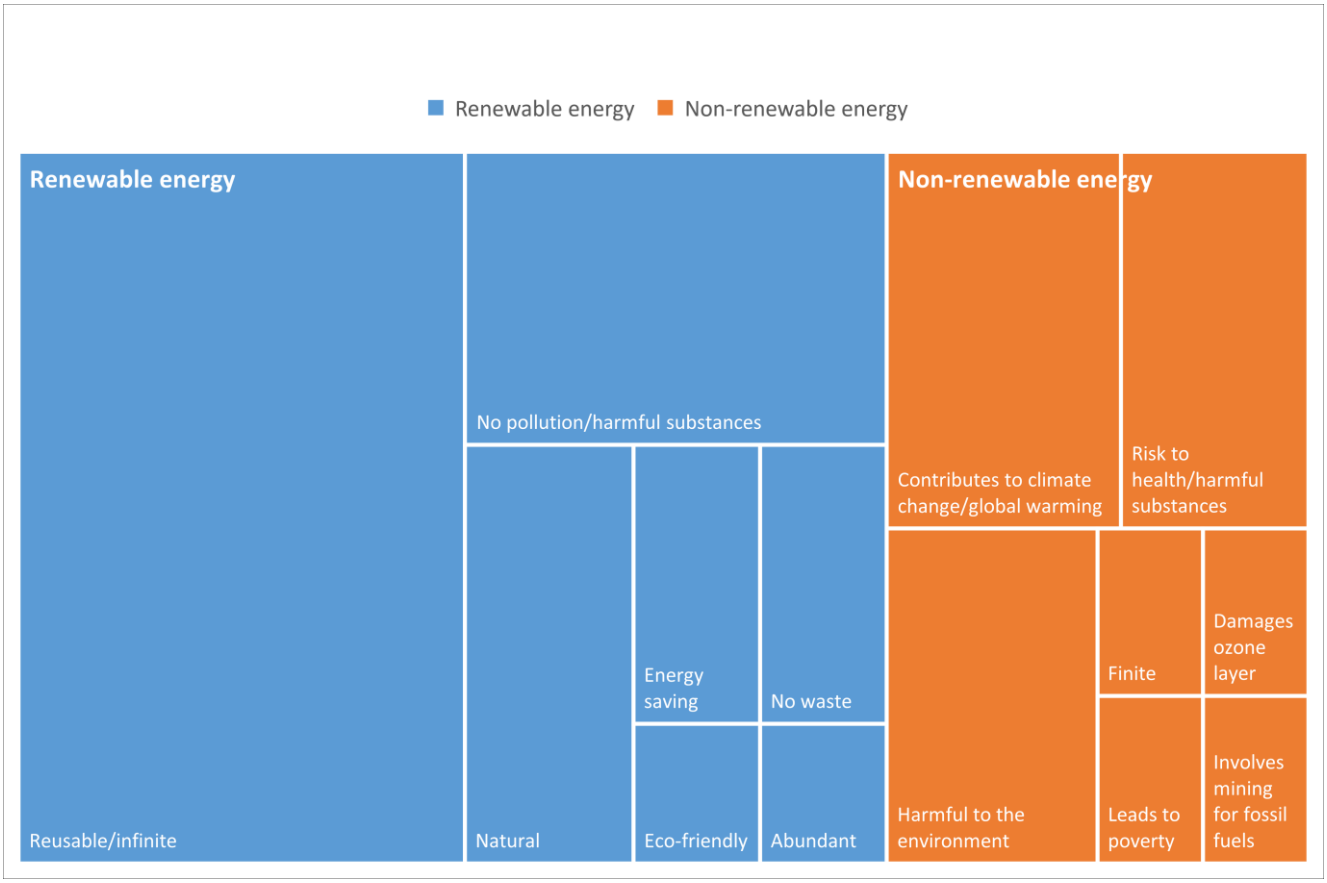

Figure 9.2. Pupil responses to Q4: "Which energy sources are better for the environment and people: Renewable or Non-renewable? Explain why" by theme and frequency of response

Almost one third of the pupils could correctly identify that the electricity in the school came from the installed solar panels on the buildings roofs on sunny days, but gave no response for cloudy days. Only one third answered both parts of the question mentioning non-renewable, national grid and fossil fuels and main energy supply for the source of electricity on cloudy days. Out of those, only two were able to explain why. The majority of pupils thought that the school uses less electricity on weekends than on weekdays and said that this is because of fewer people in the buildings. Five explained further, giving reasons such as fewer lights are on, no heating, no smart-boards and no computers are used, no lunches are cooked and so the kitchen is not in use.

Regarding engaging in energy saving behaviours most pupils mentioned: walk more, turn off lights, heating and other electric/electronic devices when not in use, use solar panels, eat cold lunches, use natural light at home/school, use less the mobile phone, TV and computer, do more outdoor activities, order meals online, switch to sustainable energy

providers, establish no-electricity/electricity free days or hours every week, use less water, earth day participation, open windows instead of using fans, use more blankets instead of more heating, use energy from wind turbines, take shorter showers, write instead of using PC and spend less time in front of screens.

Some of the behaviours they suggest (bold letters) are not directly related to energy usage and some are related to water usage, showing that pupils made links between energy and water or energy and its sources.

The results from the pupil and teacher feedback forms can be found in the Appendix E (Year 6).

Year 5 water questionnaire results:

Unfortunately, the questionnaire was not administered to the students as the teacher responsible was on maternity leave at the time and the other Year 5 teacher was too busy to do so. The results from the pupil and teacher feedback forms can be found in the Appendix E (Year 5).

Year 4 food questionnaire results:

The top five topics (83% of the responses) linked with organic food in the pupil open-ended responses were that it is free from chemicals and pesticides and thus better for the environment and human health, it is more expensive than conventional food and that animals are treated better in organic farming. Other less common responses mentioned that organic food is more natural, tastes better, has worse appearance and size than conventionally grown and travels less (food miles) to arrive to the consumer.

Most of the pupil responses around the positives of organic food relate to the *absence of chemicals and pesticides that make it good for the environment and health* as in Q1 (Figure 9.3). Most of the negatives relate to *high prices,* that *it is or can become infested and that it thus needs good washing before using* or *it expires quickly*. Other less common responses include that *organic food is more tasty, natural, clean and fresh* and that *some problems with it are that it can be cross-contaminated by conventional food as it may be in close proximity to it, has smaller crop sizes, less variety and can produce more food waste as it spoils easily*. One controversial aspect is that organic food is associated with both more and less food miles.

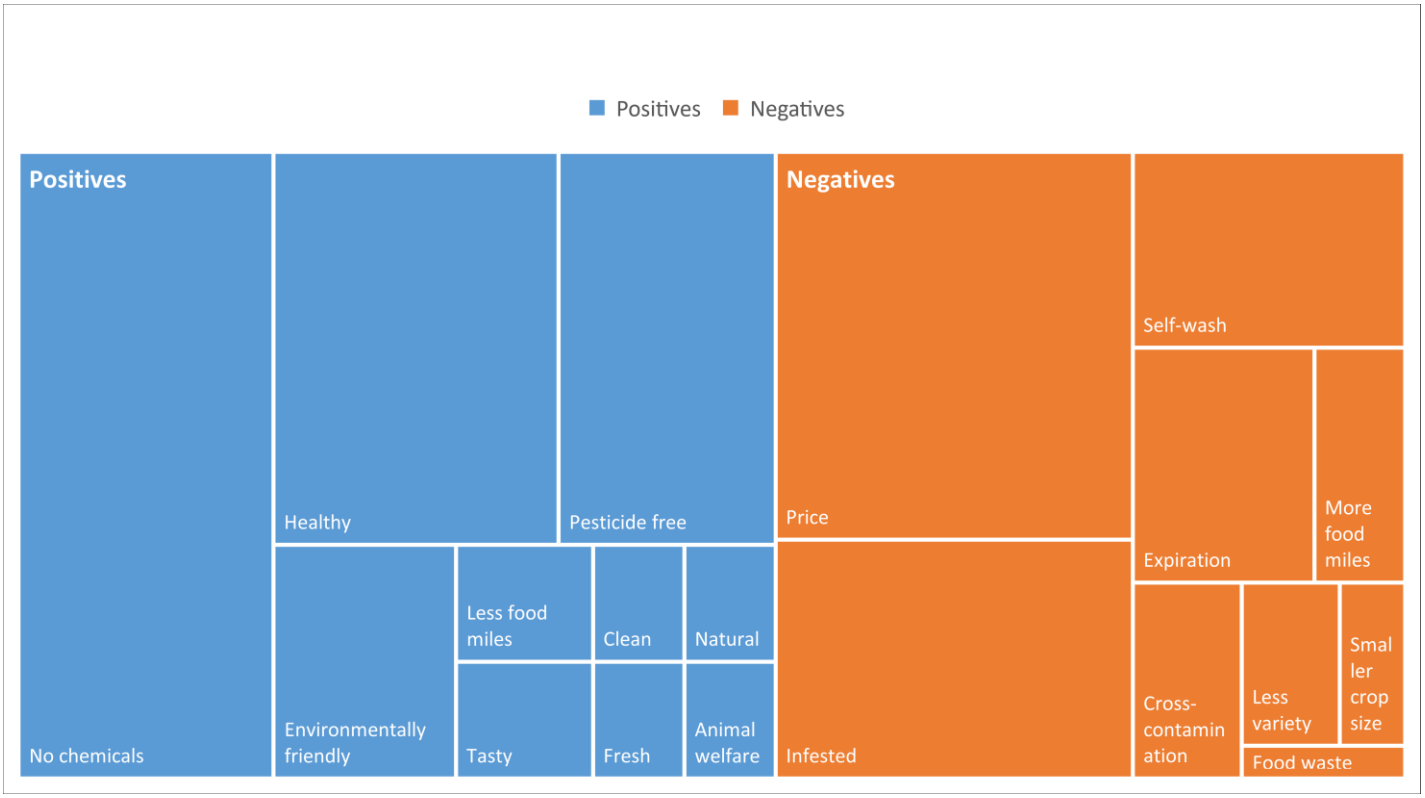

Figure 9.3. Pupil responses to Q2: "Why do you think organic food is good for you? Can you think of some problems or challenges with organic food?" by theme and frequency of response

The majority of pupils managed to identify correctly the origin of at least eight out of ten fruits. Three quarters of the pupils could categorise correctly 4 to 6 of the fruits and vegetables according to harvest season; none correctly categorised all eight of them.

Most pupils discussed the importance of recycling food waste in terms of reusability and minimisation of waste that ends up accumulating in the environment or home. The ecology topic resulted from student responses, which detailed different ecological processes including

composting and soil composition and importance of cycling nutrients back to plants. The waste topic was a result of students who argued the importance of recycling in relation to the reduction of food waste and its uselessness if it is not reduced. The circular economy topic encapsulates responses which detailed the need to reuse or repurpose things for the benefit of people and their activities, while the environment topic included any response which mentioned positive or negative effects on the environment (figure 9.4).

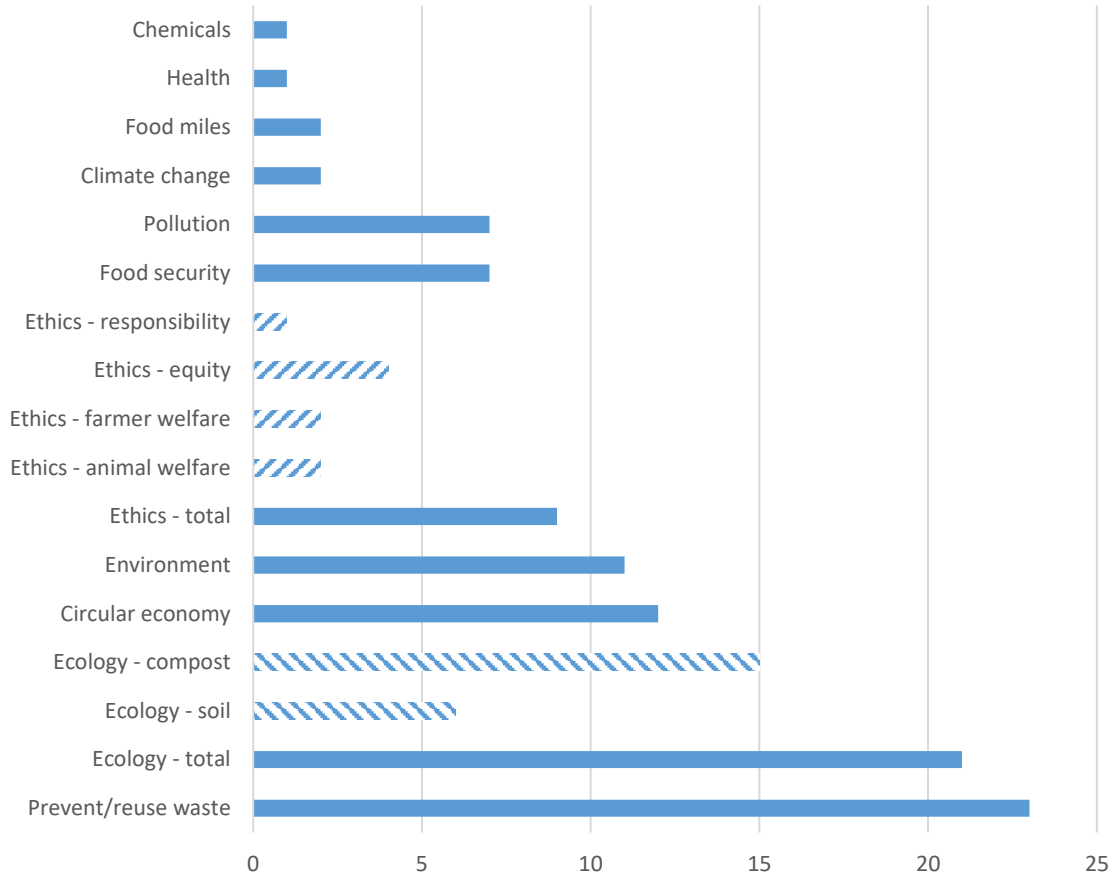

Figure 9.4. Topics introduced by pupils to respond to Q5 (number of responses per concept). The striped bars refer to sub-concepts identified within major concepts (adapted from Starke, 2019).

Year 4 storyboard results:

Twenty-nine (29) storyboards were collected, as only one of the two Year 4 teachers was able to implement the activity with the students (example storyboard can be found in Appendix E). After reading through the storyboards and analysing the drawings, open

qualitative coding was used to record the themes that emerged in the storyboards. After that, the number of pupil responses was calculated that included each theme. The main themes that were identified in the Year 4 organic and conventional tomato storyboards are shown in Figures 9.5 and 9.6.

For the organic food storyboard, the most frequently mentioned theme was ecology. This includes ecological processes such as the water and nutrient cycles, the soil community and root systems. In comparison, pesticides and bugs were the most frequently identified themes regarding the conventional food. These two themes included the use of pesticides in any capacity to protect conventional food from harm as well as the presence and removal of bugs from conventionally farmed crops. Another theme related to that was the reference to pesticides in three cases as substances that boost the growth of crops, which constitutes a misconception of why and how pesticides are used in conventional farming (Figure 9.6, pesticide-confusion).

Comparing the two storyboards it is clear that all pupils refer to the organically farmed tomatoes as vegetables that grow because of important ecological processes in the soil, because of the sun and the water they receive from farmers, whereas the conventionally grown tomatoes grow with pesticides that kill bugs and water that contains chemicals to help them grow faster. In almost all the storyboards, the final drawing shows a happy, healthy, safe and chemical free organic tomato ready for consumption and in contrast, an unhealthy, unsafe unhappy and chemical-laden conventional tomato that is also harmful for people. In eight out of the 29 storyboards there was differentiation in the drawings for the organic and conventional ones. The differences most often referenced the origin of the seeds used for organic vs conventional farming, the latter being “sourced from abroad”, “suspicious” or “secret”; the packaging in which the seeds arrive, which for organic is cardboard and for the conventional plastic, and the planting practices, which for organic seeds include good spacing and spread out planting to ensure the seeds grow in good conditions and for the conventional include packed planting and inadequate care (Starke, 2019). Other differences include transport of conventional food most often by planes or lorries, which causes pollution, and in one case, transport by plane is referenced for organic tomatoes. Lastly, the students personified the tomatoes, showing them having faces which are smiling or are conveying

positive feelings in the case of organic and crying, frowning or conveying negative feelings in the case of the conventional tomatoes (Starke, 2019).

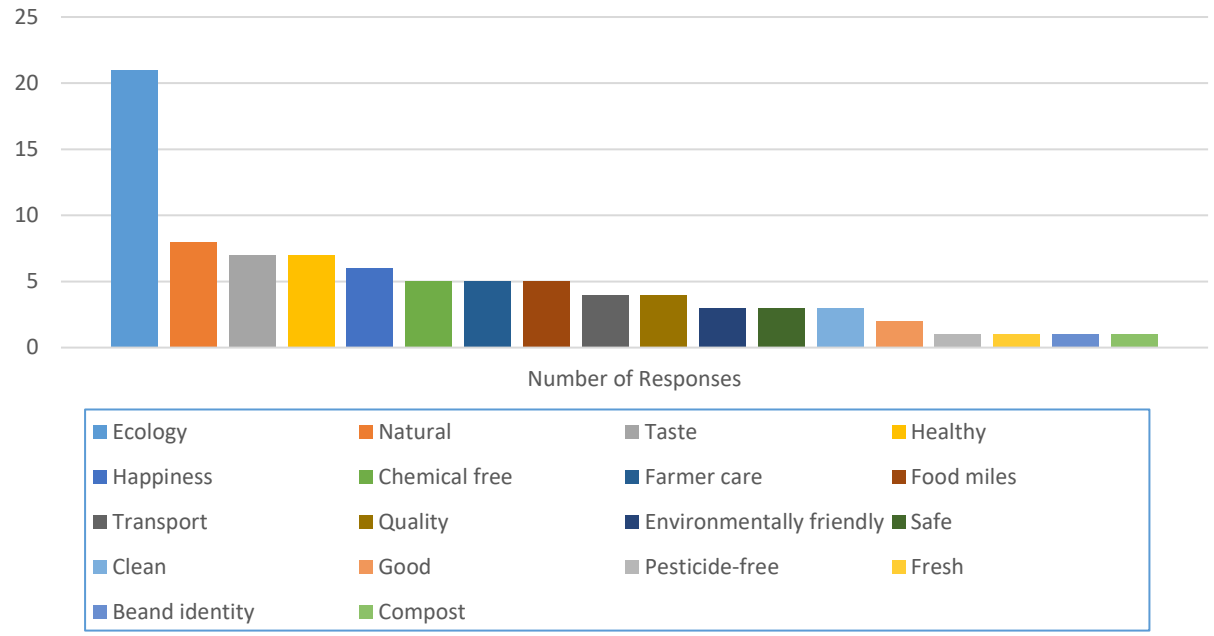

Figure 9.5. Frequency of the main themes identified in organic food storyboards (adapted from Starke, 2019).

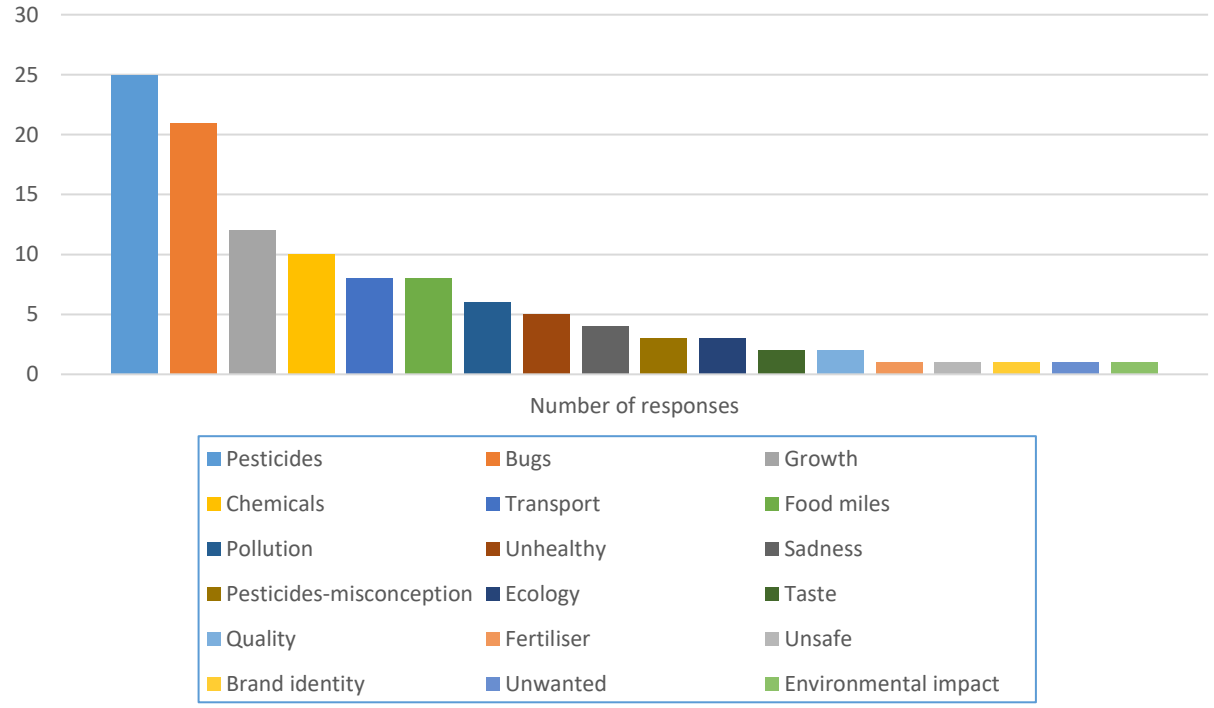

Figure 9.6. Frequency of the main themes identified in conventional food storyboards (adapted from Starke, 2019).

9.4 Secondary school case study

The secondary school is a co-curricular independent school located in West London. Independent schools in the UK, also known as private schools, charge fees to attend instead of being funded by the government (UK government, n.d. b). The secondary school has a strong ethos toward social inclusivity as it aims to offer opportunities for a well-rounded education to students from various backgrounds and operates a bursary award system (personal communication with school teachers). As an independent school, it does not have to follow the national curriculum. The school follows the UK curriculum and complements it with courses developed in-house to prepare the future citizens of the 21st century.

The school has an educational vision around its reputation and the outstanding learning environment it aims to provide to students to help them become active citizens, which is quoted below: *"Our vision is to be the leading co-educational school in the United Kingdom, providing young people from all backgrounds with a life-changing education that equips and inspires them to make a positive impact on society and to excel in the wider world"* (personal communication with course coordinator). Associated with its vision is the set of competences the school aims to develop in all of their students, which are:

- independent learning and research
- critical thinking, analysis and evaluation
- written, oral and multi-media communication skills
- collaborative working and problem-solving
- intercultural knowledge and understanding
- knowledge and understanding across a wide variety of disciplines
- capacity for creativity and imagination
- a love of learning

These competences are complemented by the student learner profile that is used to measure the success of the school's education strategy. The ideal graduate of the school should be promoting international understanding, human rights and social justice, be sensitive to the importance of environment and Sustainability, be responsible and respecting ethics, hard-working, tolerant and open-minded, critical thinker and resourceful, hardworking and committed to act for a better world (personal communication with the teachers of the school). The identified competences are in alignment with the competences for achieving the SDGs

found in the international literature (Kioupi & Voulvoulis, 2019; UNESCO, 2017a; Arnim Wiek, Withycombe, & Redman, 2011).

The vision, educational aims, strategy and commitment to nurture Sustainability sensitive future citizens aspired by the school, made it an appropriate candidate to apply the research methodology. I specifically collaborated with the coordinator and responsible teachers for the Global Goals course, which is offered to Year 9 students of the school. The Global goals course runs throughout the school year and offers the opportunity to students to learn and act for the UN SDGs. During the autumn term, pupils carry out an investigation on all the SDGs and identify a specific Sustainability challenge with the aim being to find out the root causes of the problem. These challenges are related to the Global goals but the students look at how problems are manifested across scales. The key is for pupils to find something they are passionate about and pursue it. Then in the spring and summer terms, the students form teams and work on a specific challenge they feel passionate about and link it to one or more of the SDGs. They meet with the teachers and their groups fortnightly, but also maintain collaboration and communication through online platforms and out of school meetings with their peers. In the meetings, they discuss progress and challenges and brainstorm solutions. The aim is by the end of the school year for each group to have engaged in at least one action that will benefit the community and help progress toward the targeted SDGs.

As per the framework (figure 9.10), the coordinating teacher team of the Global Goals course (step 1) became engaged and worked to understand the school's vision toward Sustainability and discuss the competences that will contribute to that vision (step 2). The school was already advanced in having defined school wide competences and LOs for the Global Goals course. The teachers identified the following competences (step 3), which are central to the realisation of the aims of the course, and to prepare the students to be Sustainability citizens:

- Systems thinking to allow them to understand the root causes of problems,
- Reflective thinking that allows them to be independent learners,
- Critical thinking that allows them to conduct valid research around the SDGs,
- Self-regulation that allows them to cope with failure,
- Collaboration to help them become team players and

- Problem-solving and action to enable them develop creative and practical solutions and take action on them.

The students engaged in a programme of learning activities throughout the school year to develop their knowledge, plan and implement their projects and present their outcomes in a school fair at the end of the school year. These learning activities included, as part of the autumn term, analysing problem scenarios, doing literature research around the SDGs and root causes of Sustainability problems, learning and using PESTLE[1] analysis to understand problems, engaging in presentations around the outcomes of problem scenarios, and discussions to provide feedback to their peers' work. For the spring and summer terms, the pupils mostly engaged in project-based learning, identifying challenges linked to the SDGs, and planning, implementing and presenting their projects (personal communication with coordinator). This project-based learning was supported by activities for setting SMART project goals[2], using the Double Diamond[3] design process for defining problems and developing courses of action and the six hats[4] technique for analysing a problem through multiple perspectives and thinking creatively about its solutions. All the activities were aligned with the selected competences' development in the pupils (step 4), but there was lack of appropriate assessment methods (step 5).

Regarding the need for assessing the competences the students developed by participating in the Global Goals course and to reflect the experimental nature of this unique offering to the students of the school, the teachers suggested more "informal" ways of assessing the learning outcomes. After organising two meetings with the teachers and the coordinator of the course, the teachers highlighted the importance of empowering the pupils to assess their own performance during the course, as they worked both independently and in groups and the course did not follow traditional teaching methods, but it was student-centred.

[1] PESTLE is a framework for analysing key factors that may affect an problem or decision, which are Political, Economic, Sociological, Technological, Legal and Environmental

[2] SMART is a framework used for setting Specific, Measurable, Attainable, Relevant and Time-bound goals

[3] The Double Diamond design process enables problem solving through: discovery/research into the problem (diverging), defining/synthesising area of focus (converging), ideation (diverging) of potential solutions and implementation (converging) of solutions that work

[4] Six Thinking Hats is a useful approach used to look at problems from a number of important perspectives, depending on the colour of the hat the problem is interrogated for retrieving information (white hat), expressing emotions (red hat), judging (black hat), being optimistic (yellow hat), being creative (green hat) and thinking about thinking (blue hat)

The teachers also highlighted that the students should have the opportunity to receive feedback on their final project presentation and that there was a need to evaluate their final product. After understanding the needs of teachers and pupils in terms of how to conduct the assessment and searching in the literature, we jointly developed the assessment tools. The tools comprised a self-assessment questionnaire based on an adaptation of the self-efficacy scale suggested by Bandura (Bandura, 1994; Bandura, 2006), to enable students evaluate their degree of agency; a team assessment questionnaire to allow students to evaluate their group work and a peer assessment questionnaire to assess the final project product/presentation the pupils developed.

The self-assessment questionnaire included 28 questions that asked the pupils to rate their self-efficacy to perform specific tasks on a scale from 1 to 5, where 1 denotes strongly disagree with the statement and 5 denotes strongly agree and one open-ended question about the role of the pupil in delivering the project work. The research shows that students of this age are able to use Likert type scales to assess their own performance (Chambers & Johnston, 2002). The questions were carefully selected to represent the areas of competence the course aims to develop in the students, but there was no indication of which statements represented which competences. The team assessment questionnaire comprised 21 statements around how they worked as a group, how they regulated group work and how they coped with difficulties. The pupils had to read each statement and select Yes, Partially or No to describe to what extend the statement described their group work. At the end, they had to complete an open-ended question about how they worked together as a group. The final assessment questionnaire was used by pupils to assess their peer's final product/presentation and was based on six groups of criteria. The criteria examined the Research and Development that went to develop the project, how Realistic and Relevant, Innovative and Creative, Sustainable and Scalable it was, if it was the outcome of Collaboration and how well it was Communicated at the school fair. The students assigned 1 (for poor) to 5 stars (for top performance in a criterion).

The self and peer assessment questionnaires were disseminated to one class of the Global Goals course of 23 pupils. The final questionnaire was disseminated to the entire Global Goals cohort to evaluate the project presentation during the fair and 123 completed forms were collected. The results of the questionnaires were analysed quantitatively using MS Office

Excel and IBM SPSS software. The results of the analyses are reported in the next section and are discussed with respect to the research framework.

Self-assessment questionnaires results:

The reliability of the self-assessment questionnaire was assessed using reliability analysis on SPSS and the results show high reliability of the measure with Cronbach's a being 0.917, which is in the accepted value range of >0.7. The statements used in the self-assessment questionnaire were grouped according to the intended competences they described and can be found in the Appendix E (Year 9). The analysis of the self-assessment questionnaire produced the results shown in Table 9.1.

Table 9.1. Descriptive statistics of the results of the self-assessment questionnaire for the Year students

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
I can identify problems related to the SDGs	23	4.00	1.00	5.00	4.2174	.19838	.95139	.905
I can link the problem we identified to one or more SDGs	23	4.00	1.00	5.00	4.3043	.20309	.97397	.949
I can explain why we selected the specific problem to work on	23	2.00	3.00	5.00	4.3913	.15061	.72232	.522
I can identify sources of information related to the problem we identified	23	4.00	1.00	5.00	3.9130	.20769	.99604	.992

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
I can select the most appropriate information to include in my work	23	3.00	2.00	5.00	4.1304	.19177	.91970	.846
I can explain both the root causes, and the effects of our chosen problem	23	3.00	2.00	5.00	3.8261	.14947	.71682	.514
I can combine information from various sources to understand the problem	23	4.00	1.00	5.00	4.0000	.18861	.90453	.818
I can explain how the problem affects my school	23	4.00	1.00	5.00	3.8261	.22363	1.07247	1.150
I can explain how the problem affects my community	23	2.00	3.00	5.00	4.4783	.12367	.59311	.352
I can explain how the problem affects my country	23	2.00	3.00	5.00	4.4348	.13811	.66237	.439
I can explain how the problem affects the world	23	3.00	2.00	5.00	4.4348	.16426	.78775	.621
I can cope with failure during doing my work for the Global Goals Course	23	4.00	1.00	5.00	3.8261	.26414	1.26678	1.605

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
I can manage my own learning during the Global Goals Course	23	3.00	2.00	5.00	4.0435	.19355	.92826	.862
I can mention existing solutions to the problem (mean)	23	2.00	3.00	5.00	4.0652	.15175	.72777	.530
I can propose new solutions to the problem	23	3.00	2.00	5.00	3.8261	.17391	.83406	.696
I can explain why the solution selected is appropriate for the problem	23	2.00	3.00	5.00	4.2174	.15344	.73587	.542
I can identify the limitations of the solution we suggested	23	2.00	3.00	5.00	4.3913	.15061	.72232	.522
I can collaborate with my team members	23	4.00	1.00	5.00	4.2609	.22857	1.09617	1.202
I can understand my team members' needs	23	3.00	2.00	5.00	4.3913	.16321	.78272	.613
I can cope with complex problems	23	4.00	1.00	5.00	3.6522	.18446	.88465	.783
I can communicate my work to other people effectively	23	2.00	3.00	5.00	4.1304	.18117	.86887	.755
I can work as part of a team	23	4.00	1.00	5.00	4.1739	.20519	.98406	.968

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
I can develop a plan to implement the solution we suggested	23	3.00	2.00	5.00	3.8261	.16215	.77765	.605
I can reflect on my work and make changes if needed	23	3.00	2.00	5.00	4.1304	.18117	.86887	.755
I can evaluate the effectiveness of our solution (mean)	23	2.00	3.00	5.00	4.0435	.15372	.73721	.543
I can give constructive and helpful feedback to my team members about their work	23	3.00	2.00	5.00	3.9130	.16530	.79275	.628
I am open to receive feedback from team members about my work	23	2.00	3.00	5.00	4.2609	.16890	.81002	.656

The statements for which the highest score was assigned were: I can explain how the problem can affect my community, my country and the world. These statements are part of the systems thinking construct. The lowest scored was assigned to the statement: I can cope with complex problems. For all the statements the students self-assessed between 3.7 and 4.5, which shows that they perceive they are advanced in those competences. Cases where the lowest assigned value was 1, which means strongly disagree, are also reported as they highlight were the educators should place more emphasis. These statements' values are highlighted in orange in Table 9.2. These include statements about students' ability to work in teams and

collaborate with others, to cope with complex problems and failure, and lastly to identify and combine information to understand the problem and how it links to the SDGs.

The results for the entire class in terms of the competences assessed are shown in figure 9.7.

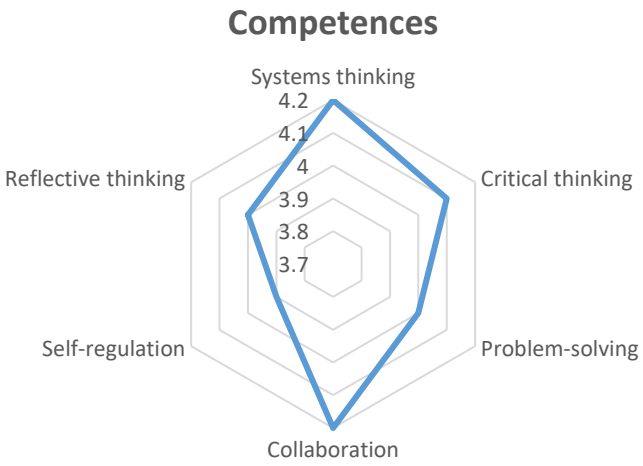

Figure 9.7. Results of the six competences assessed in the secondary school case study

The students self-assess higher in Systems thinking and collaboration, while they perceive their weakest competence to be self-regulation. The intermediate competences were critical thinking, reflective thinking and problem solving. There were six groups of students working on six projects around the SDGs in the class. They were given the team assessment questionnaire to assess their group work, as they themselves as well as the educators would benefit from having information on their work. The statements used in the team assessment questionnaire were grouped according to three competences: teamwork, difficulty coping as a team and team regulation (Appendix E, Year 9). The results of the analysis of the team assessment questionnaire per group of students are shown in figures 9.8, 9.9 and 9.10.

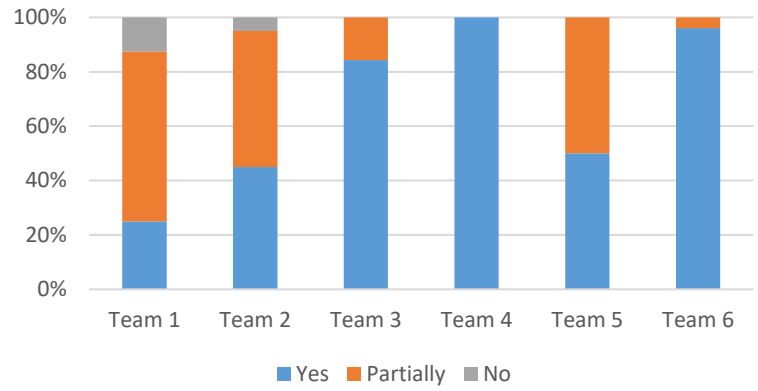

Figure 9.8. Teamwork assessment results for the six groups of secondary school students (stacked columns)

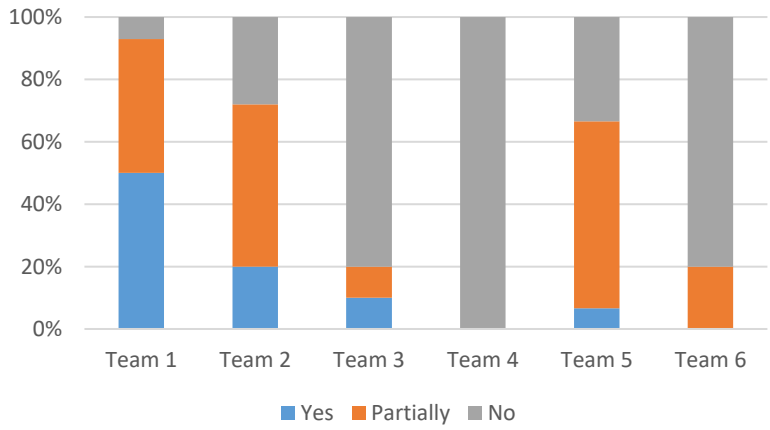

Figure 9.9. Difficulty coping with the project as team assessment results for the six groups of secondary students (stacked column)

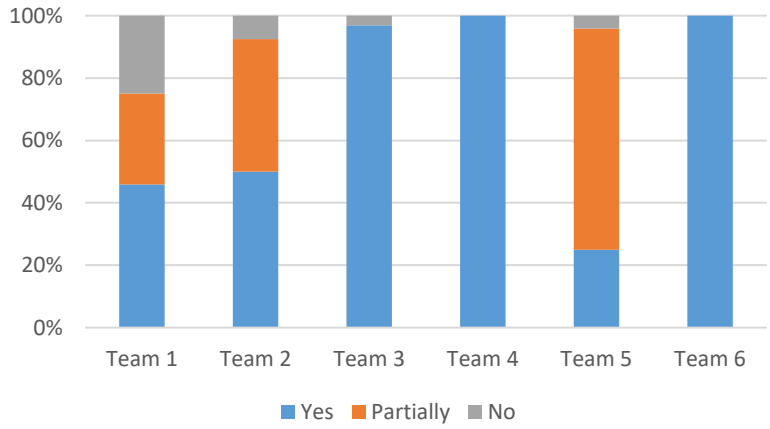

Figure 9.10. Team regulation assessment results for the six groups of secondary students (stacked columns)

The combined results from the three Figures show that teams 3, 4 and 6 had the highest team-work competence, faced the least difficulties in coping with working as a group, and had the highest ability to regulate their team work. However, teams 1, 2 and 5 had the biggest problems with group work, regulation and coping with difficulties, and the efforts of educators should focus on these groups to enable them to achieve better results.

In terms of the open-ended questions for the self and team assessment questionnaires, the main themes that were introduced in the students' responses are presented below. In the self-assessment questionnaire, the students mentioned the specific roles they had in the group such as coming up with the initial idea, researching the topic, identifying existing and new solutions, communicating with external organisations to implement action, encouraging and motivating group members to continue with project work, mediating when problems in collaboration arose and developing the final prototype. In the team assessment questionnaire, the students of the groups that had problems with collaboration mentioned they argued a lot, had difficulty supporting their opinions with arguments, were slow as a group, arguing was sometimes fun and when deciding to solve their differences they could be productive. The groups that had good collaborations mentioned that they discussed their problems and challenges and listened to each other to help overcome difficulties, they had chemistry as a group and they were producing a lot of ideas on which they were ready to compromise if the group in its entirety did not agree with them. The results of the final assessment questionnaire, which was about peer reviewing class projects are presented in Figure 9.11.

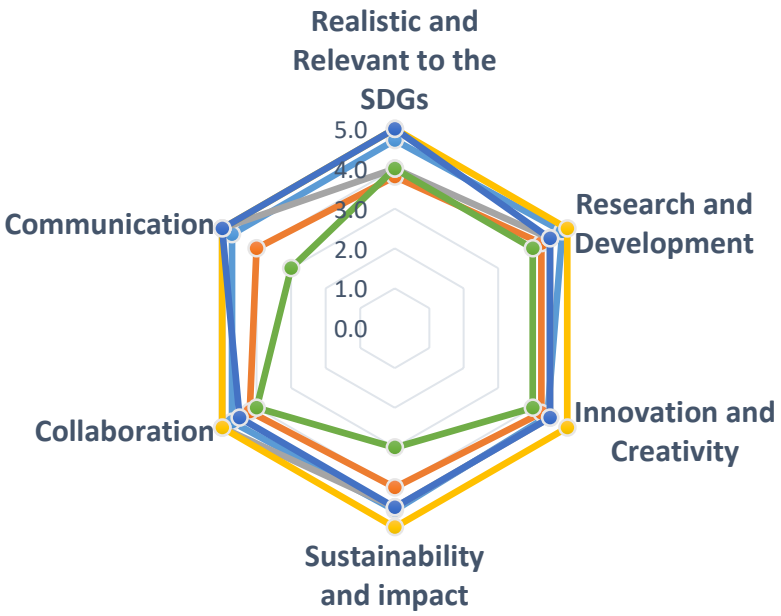

Figure 9.11. Peer review assessment results for the six projects of the student groups based on six criteria

The highest score of five stars was given to the project safety app and closely behind were the project plastic buffet and leftovers cookbook. The lowest scores were given to the website for teen issues and reusable cups projects, which received low scores in Sustainability and impact, communication, and being realistic and relevant to the SDGs. The open-ended feedback the peer reviewers gave was around the creativity of the idea, that groups went the extra length to develop outstanding prototypes and that the ideas are clear, clever, can be used by everyone and that they can produce big impact in solving the problems identified.

9.5 Discussion

The primary school results support the proposition that, in terms of science literacy, which is the main cognitive LO assessed through the questionnaires, Year 6 and Year 4 pupils actually seem to have attained cognitive objectives of factual knowledge of energy and its uses at home and school, energy saving products, renewable and non-renewable sources of energy and organic and conventional food systems, origin and seasonality of food and food waste. However, when asked to provide explanations and support their opinions with arguments only a few students were able to do that. Conceptual and procedural knowledge around scientific concepts in energy and food systems need to be mobilised in students in order for them to gain deeper conceptual understanding and achieve scientific reasoning (Koerber et al., 2017). The Year 6 students that show the ability to explain concepts did so in the topics of “where energy is found” and “how it can be used” but were not able to link different forms of energy or discuss energy transformations, interpret energy data and explain “where energy comes from”. They also showed misconceptions around ozone layer depletion being a consequence of using non-renewable energy sources. Year 4 students show some conceptual understanding of ecology concepts linked with soil processes such as decomposition of food waste, plant water absorption and the role of soil communities in plant growth, but have misconceptions around the use of pesticides and other agrochemicals in conventional farming.

Some authors provide validated science literacy models that show three levels in the abilities of primary school students to understand and reason scientifically and these are the naïve, intermediate and scientific (Pollmeier et al., 2017). The results show that for some

concepts students are intermediate in their explanations e.g. ecology concepts in food systems as they recognise the processes that are involved but do not provide accurate explanations; or energy provision at school and energy performance of products as they are able to explain only part of question that is related to their direct experiences and cannot provide explanations for parts they cannot control for. Some students have naïve conceptions that are not aligned with any scientific explanation but these are few in number. A small proportion of Year 6 students used entirely scientific explanations in the open-ended questions. Those students were able to identify energy not only in devices we use but in our bodies and in the environment as well, such as solar energy; were able to discuss the energy units to make informed decisions about energy saving, and explain how solar energy is converted to other types of energy in solar panels and that the electricity grid provides energy from various sources.

Another aspect of teaching that became apparent through the assessment questionnaires was that of framing. Both Year 6 and Year 4 students showed biased responses in questions regarding comparisons of renewable and non-renewable and organic and conventional food products. Students were strongly in favour of the perceived "sustainable" option, be it renewable energy or organic food, and expressed strong emotions around it. In the case of energy sources, they only mention the positives of renewable and the negatives of non-renewable energy and in the latter case they equate organic food with positive aspects, emotions and feelings and conventional only with negative ones. When asked to think about problems with organic food they managed to identify concepts around price, infestation by bugs, need for more washing than conventional, food miles it has to travel and its potential to generate more food waste as it expires more easily due to not being treated with chemicals. This shows their ability to think critically around organic food but when it comes to their attitudes and emotions, they stay extremely positive stating that people should consume only organic food unless they are poor and thus not able to afford it. This is because of its perceived health and environmental benefits, which are not necessarily supported in the scientific literature, and the better farmer and animal welfare. Year 6 students show some ability of critical thinking in terms of the number of concepts they introduced in their open-ended responses, which is 2 to 3, but still overall think that non-renewables only cause harm to the environment and the health of people.

In terms of behavioural outcomes around energy, water and food systems, the Year 6 students identified many actions that can be taken to reduce the energy footprint at home and school and some of them included direct links with reducing water usage, which shows an ability of linking different concepts and thinking systemically. This is also apparent in Year 5 responses around actions to reduce their water footprint, which include consuming locally produced and seasonal food. Most Year 4 students in terms of their behaviours stated they already eat organic food at least in school and that their parents will support them by changing their behaviours so they can eat organic food at home as well. A few students stated they already eat only organic food while one mentioned they have never tried organic food. Two students also added that it is important to check the certification of the products you buy as in some cases food that is claimed to be organic is not in reality.

Linking the results of the assessment to the vision the school is trying to achieve, the school should focus on developing conceptual understanding and scientific reasoning skills in students, as well as their ability to think critically. This is important to achieve the energy and environmentally literate citizen who can make sustainable choices that is envisioned by the school. Developing activities that enable students to engage in scientific thinking, inquiry and reasoning skills related to physical, chemical and ecological processes in energy, water and food systems would enable the students to achieve a higher level of competence in science literacy (Zimmerman, 2007) and help them make informed decisions as future citizens (Bögeholz et al., 2017). Presenting the topics of the curriculum in a balanced way, allowing students to form their own opinions, and enabling all voices to be heard and all perspectives to be explored would benefit their critical thinking skills (Cotton, 2006). The assessment results also show that students can form strong attitudes, emotions and dispositions for sustainable behaviours that have roots in ethical beliefs of "doing the right thing" for people and nature from a very young age. Nevertheless, this behavioural predisposition needs to be coupled with a strong foundation of scientific literacy and critical thinking so that students align their actions with both their beliefs and values and are able to consider multiple aspects of an argument and decide on what needs to be done.

The secondary school aimed to develop six core Sustainability competences in students through the Global Goals course. The results of the self-assessment showed that all students perceived they significantly developed all of these competences (mean >3.7), assigning higher

scores to systems thinking, collaboration and critical thinking and lower to reflective thinking, self-regulation and problem solving. After discussions with the students, it was evident that the open ended format of the course, although being beneficial to them, also posed some challenges. Mostly discussed were the difficulty of coming up with realistic projects and completing them within the available time, communicating with external stakeholders and getting them interested to help them, redesigning their projects in cases of failure, being responsible for the entirety of their projects, working as a team and receiving questions and feedback on their projects from teachers and their peers. In terms of working together, which was assessed through the team assessment questionnaire, the students showed a high degree of teamwork, team regulation and coping with difficulties; however, some teams assessed their work lower but were able to identify what the problems were as well as coping strategies to solve them. All of the groups managed to complete their projects on time and the final peer assessment showed that their work was of intermediate to high quality (scored 3 to 5 stars). The highest variability in marks was for the communication and Sustainability and impact of the projects, which shows that these need to be paid attention to.

Regarding the school's vision to develop environmentally and Sustainability minded learners who will show understanding of international affairs and will be responsible, hard-working, critical thinkers and will be committed to creating a positive impact on the world, the results show that these aims can actually be obtained. The students mentioned during our discussions that the Global Goals course helped them open their minds to the Sustainability challenges faced globally. They were able to make links between global challenges and local, or national community effects. However, in the self –assessment questionnaire they scored low in linking how these challenges are related with their school life. Students also commented that the way to succeed in completing their projects was to be responsible for them, working hard and only asking for teacher or parental support when they were faced with challenges they could not solve on their own. However, students had challenges working as a team, coping with failure and making alternative plans. All of the projects were able to showcase Sustainability and real-world impact according to the peer-assessment results. Students felt highly creative throughout conceiving, planning and implementing their projects; nevertheless, they felt that most of their original ideas were not realistic enough and had to rethink them.

As this was the first time the school implemented some form of assessment of the learning outcomes of the Global Goals course, it will be beneficial for the school to keep and enrich the implemented assessments. This will assist both the teachers and students in terms of keeping track of their progress and identifying and addressing challenges throughout project implementation. Although the school is doing a very good job in using a variety of active learning methods to encourage the students to develop the intended competences and implement sustainable, realistic and impactful projects, they do not ensure continuity of those projects the following years and thus the students become disengaged. It is crucial to find ways to scale those projects so that students can derive meaning from them, which is important for sustaining their engagement with ESD (Mickelsson, Kronlid, & Lotz-Sisitka, 2019). After discussing some of these challenges with the teachers, I suggested that the students should study the work of scientists/entrepreneurs who tackle Sustainability challenges and gain a better understanding of how they work to develop the solutions that exist.

Another way to help the students overcome the identified difficulties is to have them discuss with the previous cohort to identify which problems they tackled, how they coped and which solutions they provided, and build on those. Furthermore, there was discussion with teachers on how they could encourage the school's administration and the local council to take up some of those projects so that they can be implemented on a larger scale the coming years and students can continue being engaged in them. Lastly, the students would benefit from some classes on giving and receiving feedback because this will improve their interactions and reduce the stress they feel when others assess their work. They can have a class on strategies regarding coping with failure, as these will help them develop important life skills (Sarason & Sarason, 1981).

The application of the framework in the two schools confirmed the potential of ESD programmes for transforming visions, intended leaning outcomes, pedagogies and assessments towards Sustainability. It also confirmed that the constructive alignment of all elements of the curriculum contributes to the development of students' Sustainability competences. Thus, primary and secondary schools would definitely benefit from applying the framework and adapting it to meet their needs and priorities. Both schools had the advantage of flexibility in implementing curricula for Sustainability and were quite advanced in terms of

the ESD practices. This highlights that giving flexibility to schools to design their curricula would be an important step in advancing educational policy around ESD.

This chapter aimed to demonstrate the application of the framework for selecting, operationalising and assessing Sustainability competences development in primary and secondary schools. Both schools had defined visions related to Sustainability and a flexible curriculum that allowed them to develop and implement their ESD programmes. The primary school adopted an ESD integration approach that linked all subjects of the curriculum with principles of Sustainability, while the secondary school developed a dedicated course for the students to actively learn about the SDGs. As both schools were innovative, active and flexible in their approaches, the framework benefitted them by providing a systemic and systematic tool to evaluate their efforts. Both case studies show good examples of operationalising competences, using innovative, active and flexible pedagogical approaches, but also practical and realistic assessment tools. Nevertheless, there is still room for improvement. The primary school ESD curriculum could benefit from more attention in equipping pupils with science competences and critical thinking so that students can make informed decisions; and the educators could encourage pluralism in learning by developing a more balanced curriculum that includes diverse perspectives. The framework can also assist the secondary school to implement ESD programmes for their entire cohort of students with confidence as the effectiveness of the Global Goals course in equipping learners with Sustainability competences has been supported.

9.6 Limitations

The main limitations of this study are related to the adaptation of the framework for use in primary and secondary school education, which resulted in some of its steps becoming more condensed to fit the operations and time availability of the two schools. Thus, the schools' predefined visions of Sustainability and definitions of the ideal graduate were used and there were some discussions with the teachers and head teachers on what it is they aim to achieve as providers of education for Sustainability. For the next steps of the framework, I worked with them to identify intended competences to achieve those visions for the specific programmes that were used as case studies and not for the entire schools, as well as assessed

the alignment of pedagogies and assessment used in those programmes with their intended LOs. In some instances, due to difficulty liaising with the teachers responsible, the dissemination of some assessment questionnaires was not possible. The questionnaires, although used to assess the development of competence in pupils, are not comprehensive assessment tools that tackle all the dimensions of the competences assessed but are based on important indicators, identified in the literature and discussions with the teachers, as proxies by which to collect data on those competences. Self and team assessment questionnaires are subject to a number of biases, but by piloting them with other students and rewriting them according to the feedback from both teachers and students, by giving clear guidance to students on how to use them and averaging the results of multiple assessors for team and peer assessments, these were minimised.

Chapter 10 Overall Discussion

Both education and Sustainable Development have been criticised in recent years for vagueness and lack of tangible outcomes in terms of improving societal conditions. This thesis identified early on that Sustainable Development is not a well-defined concept and thus it can lead to disengagement of educators and learners (Kioupi & Voulvoulis, 2019). The SDGs have offered the opportunity for a new conceptualisation of Sustainable Development as a systems state that our society is trying to achieve and this research identified Sustainability attributes that describe this state (Chapter 5). Thus, education is crucial for the realisation of the SDGs and drives the transformation to this sustainable state, because it directly links to the Sustainability attributes through enabling Sustainability competences in learners (research objective 1).

Another contested concept in the literature was the concept of Sustainability competence, which ranged from a narrow definition of knowledge for Sustainability to problem-solving and generic lists of knowledge and skills prescribed for achieving Sustainability integration in education (Brundiers et al., 2020; Arnim Wiek, Withycombe, & Redman, 2011). This thesis defined competence as the indicator for achieving a sustainable state which is not predefined, but decided by the educational community according to their Sustainability vision. Thus, the effectiveness of education is related to empowering learners with Sustainability competences to become the citizens of this sustainable state (Chapter 5). Consequently, the selection of competences or LOs is not based on generic lists that promise vague Sustainability outcomes, but on the priorities of the educational institution, and the assessment of effectiveness is locally relevant as it is aligned with the selected competences (research objective 1).

Important for the success of the process of Sustainability transformation are the pedagogies used by an educational institution/programme of study, but only if aligned with the selected competences (research objective 1). A study on the impact of ESD on student learning in 18 countries found that pedagogy is a better predictor of Sustainability competence development than the introduction of Sustainability content (Laurie, Nonoyama-Tarumi, Mckeown, & Hopkins, 2016). ESD pedagogies have some specific characteristics, which are active engagement of the learner (student-centred), enabling multiple voices to be heard and worldviews to be elaborated (pluralism), collaboration among peers and the educator to solve

problems and tasks (collaborative problem solving), critical reflection on values, beliefs and actions (critical pedagogy) and planning and implementing action on real world cases (project based learning). All these require a shift from traditional teaching techniques in education such as lecturing or direct teaching (UNESCO, 2018). Authors (Wade, 2012) further suggest the importance of transdisciplinary communities of practice that generate new knowledge and transformative ESD practice, use virtual and physical learning environments and adapt their operations to the context. For all educators and especially those of HE institutions, this poses difficulties as it requires them to develop skills in using new ways of teaching, which can be challenging and may generate resistance towards implementing ESD altogether (Lambrechts, Mulà, & Van den Haute, 2010).

As competence-based education is fast pervading University Education, it requires methods to describe, model and assess competences (Bergsmann, Schultes, Winter, Schober, & Spiel, 2015; Idrissi, Hnida, & Bennani, 2017). Specifically, for ESD, a competence-based approach is advocated to achieve the transformation of learning towards the SDGs (UNESCO, 2017). This thesis explored the development and testing of frameworks and tools with Higher Education practitioners around ILO alignment with Sustainability, competence definition and assessment (research objectives 2 and 3) and showed that they are realistic and can offer the evidence base needed for decision-making (Chapters 6, 7 and 8). This material can be used in educator training workshops for capacity building in ESD.

The use of the assessment tool for alignment of learning outcomes to Sustainability in (environmental) Sustainability master's programmes curricula showed the diversity of ILOs towards Sustainability formulated (Kioupi & Voulvoulis, 2020) (research objective 2). This is in alignment with the pluralistic view of SD. However, the application of the tool showed how Sustainability programmes on the one hand are limited in their ILOs as they mostly target its environmental dimensions and much less the social, health and wellbeing, diversity and inclusion, transparency and governance; and on the other, how they can widen the scope of their curricula to include the eight Sustainability attributes identified in this research. Furthermore, these findings contradict recent studies (Salovaara et al., 2020) that support the uniform inclusion of the list of five suggested Sustainability competences (systems thinking, anticipatory, strategic, interpersonal, and normative competencies) by (Wiek et al., 2016) in all master's programmes for Sustainability, with the addition of the three competences of diverse thinking, methodological plurality and autonomy. Master's programmes (and in general,

University programmes) ILOs need to reflect the diversity of perspectives of stakeholders that formulated them and the values they prioritise, and not prescribed lists of competences to achieve Sustainability. These lists of Sustainability competences should be viewed with caution as they will not necessarily serve a master's programme's specific aims about the type of graduates they want to develop based on science and society's needs, nor lead to Sustainability, as they do not include a normative definition, vision or description of the kind of Sustainability they aim to achieve.

The findings of this thesis contradict the instrumental view of competence that some authors employ (Markus, Cooper-Thomas, & Allpress, 2005) to support the idea that a competence-based approach in education could narrow the curriculum as the focus is on what is assessed and thus non-tested skills receive decreased attention. This research showed that competences, although complex as constructs and requiring special assessment, reflect the multidimensional, integrated and action based nature of learner agency to enact Sustainability and their assessment goes beyond testing knowledge and understanding, which is what traditional assessments do.

Competence assessment offers opportunities to educators to establish criteria and indicators of performance that include cognitive, affective and behavioural dimensions and examine more holistically, what areas can be targeted in the ILOs of their educational programmes (research objective 3). The students gain a more dynamic view of assessment as they are not only assessed by educators but can assess themselves and their peers in what can be a very educational experience that can sharpen their judgement (Boud, Lawson, & Thompson, 2015; Ohland et al., 2012).

In addition, a major importance of competence assessment is that it focuses not only on the outcomes of learning, but also on the process and experiences that led to those outcomes (Hutchings, Ewell, & Banta 2012) demonstrated by the fact that the learning and assessment activities used in the case studies prioritised the lived experience of competence. It further provides specific, targeted and actionable feedback to the educator and student on which they can work and improve (Casey & Sturgis, 2018).

Here it is cautioned that competence-based approaches in curriculum design will not unquestionably lead to better learning, student-centred pedagogies and improved assessment and this is not only a matter of constructive alignment as discussed earlier (Chapter 7). It is also a matter of theoretical underpinning of curriculum design and pedagogy. Thus, if behaviourist

competence approaches prevail (McLeod 2017) then the emphasis will be on the observed behaviour as the outcome of the learner's interaction with their learning environment. This view will only endeavour to measure the observed behaviour, and will not focus on the cognitive and affective dimensions that influence it. It will focus on the environmental interaction, in terms of stimulus and response that enables the performance of action, which is mostly teacher induced.

If a constructivist view (McLeod, 2019) is employed in pedagogy design, as the implemented case studies show, then the learning environment becomes dynamic; it allows learners to express their own views and explain their thinking and in return, offers opportunities for challenging their views and ways of thinking or reinforcing them. This was obvious in the University case study, where students were challenged to understand an open-ended management problem with highly uncertain data and future implications, combine their views and navigate the complexities they faced to provide a strategy for the industry which they consulted. In the secondary school case study, the students selected the Sustainability problem on which to focus on their own, but were given guidance and previous training in identifying and linking Sustainability problems to the SDGs. They faced a lot of complexity and challenges with project realisation, but at the same time managed to persevere either due to having selected the topic themselves and thus were committed or because the teachers/team mates encouraged them to do so. The primary school case study endeavoured to challenge the students through linking concepts (such as water, food and energy) and exposing the connections between seemingly unrelated processes (e.g. growing food in other countries and consuming it in the UK results in virtual water transport) to offer them a holistic view of the nexus.

Students' emotions and attitudes are given attention in constructivism as they condition, prepare or inhibit student learning (Huber & Seidel, 2018). Attention to these was more obvious in the primary school case study as the questionnaire analysis showed the students had positive attitudes toward Sustainability both in advance and after the learning activities. In the University case study, emotions were mainly related with how the students worked in teams and regulated conflict, while a similar approach was found in the secondary school with the students also focusing on recovering from failure. Because of the link between emotions, attitudes and behaviours than can lead to Sustainability action (Sleurs, 2011) , the learning environment should offer rich opportunities for learners to experience emotions and

develop or change their attitudes toward learning and Sustainability if appropriate, including through interacting with peers and educators. The affective domain of learning should be considered by education practitioners and policy-makers in the field of school and University ESD as it can enable development of Sustainability competence for the longer-term, and be given equal attention to the cognitive and behavioural domains.

Another aspect of interest for education practitioners, curriculum developers and policy makers is what strategy to use when planning curriculum reviews, especially in the University sector (chapter 8). It would be beneficial for them to set clear targets for transformation based on data collections they implemented before the review (Research objective 4). This will help making comparisons before and after the review to see what has changed and by how much, what was a success and what a failure. However, it is crucial to start a curriculum review with envisioning alternative sustainable futures (through a participatory process) (Amsler, 2019), thinking on how these can be achieved and then reformulating ILOs in order to align with them. Checking the completeness of ILOs with respect to the Sustainability visions generated can be done by applying the assessment tool provided (chapter 6) to achieve holistic representation of Sustainability attributes. This can inform the entire process of the review and become an opportunity to integrate Sustainability holistically, as the education stakeholders can problematize on the eight Sustainability attributes by discussions on, for example: What does living well within planetary boundaries mean? How can we achieve inter and intra generational equity and justice? How can we develop resilience as a community? What is transparent governance for us? How can we achieve inclusion and diversity? What are the important factors that contribute to our health and wellbeing? How can we achieve transdisciplinary collaboration? How can we change the current economic model of ecological destruction and injustice? This way the curriculum will have a solid foundation of visions, principles, and aligned ILOs to which to link the teaching and assessment activities.

The adaptation of the assessment tool for school education (research objective 5) further demonstrated the effectiveness of this approach in primary and secondary schools. However, it also helped identify some barriers that hinder the effectiveness of ESD in these education levels. The concept of competence has not previously been used in primary school education in the integrated form used in the case study. In most cases competence is assessed as environmental knowledge gain or environmental attitudes' change (Kioupi & Arianoutsou,

2016; Legault & Pelletier, 2000) in students participating in environmental education programmes. The primary school decided to select cognitive, affective and behavioural learning outcomes around the environmental dimensions of the Water Food Energy Nexus because of their simpler form and due to time limitations. Thus, the environmental knowledge dimension of Sustainability competence was more prominent in the primary school than holism and pluralism, which are integral parts of ESD. This lack of holism and pluralism could be related to the opinion of teachers that the developmental stage in which the primary school pupils are in their learning is premature and would pose difficulties for the students to grasp. School education practitioners should focus on knowledge, attitude and behavioural gains around all three pillars of Sustainability for school students participating in ESD programmes, engaging many perspectives on what can be sustainable and what not (Pauw et al., 2015). By contrast, the secondary school case study aimed to look at Sustainability competences holistically and bring in multiple perspectives (environmental, social, economic, psychological) in Sustainability. This was apparent in the projects the students developed around the SDGs and in their self and team assessments. However, the ability of students to cope with failure and conflict was low, which shows that although secondary school students can engage in challenging Sustainability projects as such, they need to be provided with tools on how to self-regulate and collaborate.

This thesis has investigated the basic principles of education's effectiveness to enable transformation towards Sustainability. One important principle is that education efforts around ESD should be pursued and implemented at all levels of education as they can provide unique benefits for the learners and increase their potential for transformational change.

Starting early in primary school, students showed their capacity for early systems thinking (Chapter 9) as they were able to link concepts such as food and water, energy and water though the case study we implemented using active learning pedagogy that do not have obvious connections in mainstream education approaches. They were also able to think critically as shown by the number of topics they could introduce to explain Sustainability concepts and by being able in some cases to suggest pros and cons for some controversial issues. They were also found to be able to uphold Sustainability values, attitudes and behaviours around water, energy and food use/practices and preventing waste. These hold promise that ESD pedagogies can enable the development of complex competences in students from an early age (8-11 years old). This is in accordance with published studies

(Ampuero, Miranda, Delgado, Goyen, & Weaver, 2015; Assaraf & Orion, 2010) that support the proposition that transformative pedagogies have high potential to empower students with Sustainability competences. The school students positively influenced their peers' and families' behaviours in favour of Sustainability through discussions during and after the activities, as reported by their teachers. This can generate a ripple effect of transformation in the community on condition that the school employs a holistic and pluralistic approach to Sustainability and avoids framing thoughts and actions as "good/desirable" and "bad/undesirable".

Secondary school students, on the other hand, were found to be better able to integrate the environmental, social and economic dimensions of Sustainability, and work independently to research and provide solutions to local Sustainability problems during their engagement in the project-based learning activities. As they were adolescents, research supports the idea that they were more likely to develop Sustainability behaviours through engaging in challenging active learning activities in the school and then transferring this to out of school settings (Uitto, Boeve-de Pauw, & Saloranta, 2015). They were also able to work collaboratively to develop their projects to a much higher capacity than primary school students were, but they needed to be supported by their teachers in doing so. They showed high capacity for systems thinking, critical thinking, problem solving and self-reflection, all of which are important for their personal learning growth and for addressing Sustainability challenges. Such an assessment of Sustainability competence in secondary school education addresses an important gap as there is limited research at this specific education level (Pauw et al., 2015). However, their ability to cope with failure and deal with feedback from peers and educators is something that requires attention and further development as it will define their future engagement with Sustainability action.

In secondary schools, the curriculum is much more fragmented than in primary schools, as the students are offered opportunities to develop their knowledge and skills in many different subjects. This may have some benefits in terms of improving subject-specific literacy but fails to develop the whole-personality of the student. ESD requires integration of different subjects, concepts and skills and should not be treated as an add-on to the curriculum. Rather, it should be integrated holistically giving the opportunity to students to be part of it throughout their secondary school studies.

Higher education learners are an important target of ESD efforts as they will be the

leaders of tomorrow and have the capacity to apply their Sustainability competences in various professional and societal roles (Weiss, Barth, & von Wehrden, 2021). University students are a great force for transformation as through their communities and networks they have the potential to mobilise local communities and develop local Sustainability solutions. Youth stakeholders are regarded as an important actor of the ESD for 2030 initiative for achieving the SDGs and their empowerment and mobilisation is one of the five priority areas of this action plan (UNESCO, 2020).

The focus of ESD at this level should be to enable University students to work collaboratively in transdisciplinary groups and show empathy and understanding toward diverse perspectives. Enabling them to think systemically, strategically and critically will empower them to identify the root causes of problems, prioritise and implement targeted action. Their capacity for future, normative thinking and self-regulation is something the Universities must invest in as it will assist them in developing long-term solutions, balancing current and future needs and impacts and engaging in ethical inquiry with communities to prioritise ethical frameworks appropriate for enabling visions of Sustainability to become reality (Minteer, 2011). Higher Education institutions should recognise that Sustainability should be part and parcel of teaching, research, community engagement and operations and that this can be achieved by the selection and integration of appropriate Sustainability competences by the education institution stakeholders (Molderez & Ceulemans, 2018).

The different levels of education pursued different approaches in implementing ESD, with the primary school integrating Sustainability as the connecting thread of all subjects taught, the secondary school included a unique course in its curriculum around the SDGs and the University offered a master's programme of study oriented toward Sustainability. The findings show that all approaches succeeded in enabling students develop their intended Sustainability outcomes but to different extents.

In the primary school, the lack of holism and pluralism was considered a barrier to truly empowering students with critical thinking in making informed decisions; in the secondary school, the lack of programme integration and continuity within the curriculum resulted in reduced student and teacher engagement with Sustainability; and in the University, the reduced attention to important Sustainability attributes such as health and wellbeing, diversity and inclusion and the social dimensions of Sustainability resulted in narrower approaches to teaching and learning that potentially undermined the holistic development of students as

competent Sustainability practitioners. These barriers have been identified by other authors who stress that the integration of Sustainability across the programme of study is more difficult in secondary education than primary (Taylor et al., 2019). This because of the rigid structure of the curriculum, but it is nevertheless worth investing in ESD being the central part of a school's work due to its benefits for student learning (Fredriksson, Kusanagi, Gougoulakis, Matsuda, & Kitamura, 2020).

In HE, having a programme of study about Sustainability is considered to be an isolated initiative especially if Sustainability in other areas of the institution is rather low (operations, research, governance, outreach) and there is a lack of an integrative framework for the guiding, support and linking activities at the institutional level (Weiss et al., 2021). Policy-makers should therefore consider implementing changes at the secondary level, as a siloed approach to different topics, whereby ESD is just another add-on in the curriculum, does not enhance learning and there is a strong movement in the UK that advocates the need for a whole school approach that ensures all students engage in Sustainability action (British Educational Research Association, 2021). At the University level, a WIA could lead to the ideal collaborative paradigm change towards Sustainability which merges bottom-up and top-down approaches in all its dimensions (Weiss et al., 2021).

This research also demonstrated the importance of participation, experimentation and pluralism in achieving Sustainability transformation. All educational institutions in our case studies (University, primary and secondary school) engaged various stakeholders, to a greater or lesser extent, in decisions regarding their visions, educational curricula, learning outcomes, activities and assessments. They were open to collaborating with the researcher to experiment during the research interventions with new ways of looking into their ESD programmes. For example, the secondary school teachers were open to implementing assessment of competences, although their programme was not formally marked, and experimenting with different types of assessments although they had no prior experience with these. They generated insights and knowledge around why they did things the way they did, such as the primary school teachers who wanted to instil a Sustainability ethos in the students of the school that sometimes resulted in positive or negative framing of the concepts used, but also wanted to try other ways of teaching them, such as through inquiry that enables the students to investigate the concepts in focus.

The University stakeholders were open to considering a competence-based approach

in formulating LOs and its benefits, such as the use of rubrics to evaluate the different performance levels, but at the same time they recognised that the process can pose challenges for academic staff (unfamiliarity, inconsistency, time consuming assessment) as well as for the students (working towards performance levels and not marks, needing more support). The differences in the selection and operationalisation of Sustainability competences in the different case studies supported the pluralistic view of Sustainability integration that caters for diverse needs and enables each education community to pursue their own vision of Sustainability and concept of the ideal learner.

This research argues as other studies have done previously (Wade & Atkinson, 2017) that education for Sustainability is crucial for the realisation of the SDGs agenda. The findings of the thesis prove that a systems approach to the integration of the SDGs into education has the potential to transform education toward Sustainability and benefit learners through reorienting ILOs towards Sustainability, aligning curricula, learning and assessments and empowering them with Sustainability competences (research objective 6). The SDGs as an element of intentional design in education can offer normative goals that can motivate intentions to act and bring about change (Caniglia et al., 2021). However, this has to be done explicitly by selecting ILOs aligned to the SDGs (such as those though our framework), leaving no one behind by tackling power asymmetries (such as those between the educator and the student, the head teacher and the teachers, the programme director, academic staff and students) through equal participation and by giving opportunities to all groups (educators, students, directors etc.) to develop and exercise their agency through co-production.

Integration of the SDGs through a systems approach can start in various ways. It may be through the education part of the University such as by selecting ILOs aligned to the Sustainability attributes, but it can also start through research on the SDGs, or engagement in outreach projects for the SDGs with the local and global community (Weiss et al., 2021). This was discussed as part of the WIA of integrating the SDGs in all aspects of the educational institution (chapter 5). Starting by integrating the SDGs through their translation into Sustainability attributes in educational offerings and identifying Sustainability competences to achieve them can incentivise and condition other internal and external stakeholders to do the same, as these are broad areas that can be used to transform all aspects of the educational institution. Having achieved that first stage, the transformation towards Sustainability initiated in the educational communities would potentially diffuse into the local or regional

communities through synergies among educational institutions and local stakeholders and by the graduates of those institutions working actively for and with those communities. The expected outcome would be progress towards achieving the UN 2030 SDGs and this can be quantified in the indicators selected by the global community (Costanza et al., 2016; Muff, Kapalka, & Dyllick, 2018).

Those Sustainability transitions should happen in niches all around the world, and education can provide the ecosystem to foster them (Scoones et al., 2018). Of course, higher system parameters such as cultural shifts and societal changes can help align all those efforts toward Sustainability to achieve natural and human wellbeing (Boyer, Peterson, Arora, & Caldwell, 2016). All those niches will nurture diverse communities of practice, creating a mosaic of various ideas, perspectives and approaches. Education Institutions can be the hubs that generate the appropriate conditions for these niches to thrive and enable the interactions among various stakeholders. It is crucial that all educators and stakeholders who have been trained in the dominant paradigm of education unlearn it and be open to new ideas, however challenging this maybe (Wade, 2008). It is in the diversity of those interactions and openness to innovation that new ideas can be generated within communities. The ideas can be turned into actions and thus communities can provide Sustainability services to society and an antidote to homogeneity. This effort can be catalysed by Regional Centres of Expertise (RCEs) on ESD[5], which can share best practices with HE institutions, schools and other formal, non-formal and informal educational organisations (United Nations University Institute for the Advanced Study of Sustainability, 2021).

One important barrier in the success of ESD programmes in empowering learners with Sustainability competences, as discussed earlier, is the lack of educator capacity to do so. Educator professional training that builds the capacities of educators to initiate education for the SDGs (UNESCO, 2020) is needed to translate curricular guidelines into usable pedagogies. It would make sense to train the educators on how to use the framework we developed (Chapter 5) to define Sustainability visions around the SDGs and select competences, something which has already been done through a conference workshop (Appendix A). Furthermore, the adaptation of the assessment tool (Chapter 6) for the alignment of LOs to

[5] Regional Centres of Expertise (RCEs) on ESD are networks of local/regional institutions mobilised to jointly promote all types of learning for a sustainable future and are regulated by the United Nations University. There are currently 127 RCEs worldwide and cover the Global North and South.

the SDGs for use by educators and the development of relevant training material as well as the provision of training on the use the assessment tool for the competences so that they can assess the attainment of Sustainability competence in their learners can all help educators align with QAA guidance on ESD (QAA, 2020).

Essential in implementing educator training is the why and how to do it. The main reason behind training educators in ESD is to enable them to start the process of transformation of education, but there are other desired outcomes as well. One very important outcome is to render teachers autonomous agents for Sustainability education in schools (Kumaravadivelu, 2001). This way they will be able to challenge their own assumptions about teaching and learning, be critical about their practices, identify opportunities for transformation and know when to apply what and why. In addition, they will be better positioned to empathise with their learners, understand their background and perspectives and use it as material to enable constructive learning development for both the learner and the teacher.

The learner comes to the education setting having not only their own knowledge, skillset, worldviews, values and life experiences but also their own socio-political consciousness and educational history. This is alternatively called cultural capital and may enhance or inhibit learning especially if the learning environment is biased or not inclusive of the differences among learners (Cobern, 1996). The learner is influenced, according to Bronfenbrenner's ecological systems theory, by various spheres with which they interact (Crawford 2020). Immediate is the family, peers, educators, community members and the interactions among them. At an intermediate level, the learner is indirectly influenced by social, economic and governance structures, ideologies and attitudes of the culture. Lastly, at the outmost level, the learner is influenced by the environmental changes and transitions in larger time scales that influence the life events of a learner (Guy-Evans, 2020). In order to address this aspect of cultural capital and the spheres of influence in learning, it would be useful if educators and learners engaged in a pedagogy that enables them to explore their life experiences, accepted worldviews and values and the very practice of Sustainability and education and challenge them to come up with new conceptualisations (Kumaravadivelu, 2001).

This more meaningful interaction between the educator and the learner will offer opportunities for exploring research questions around Sustainability, but also about the essence of education and the aims of society. Further, investigation using appropriate tools

may revolutionise the sector of education for Sustainability by offering research insights into how teachers and learners engage in Sustainability and motivate their actions. As to the how, the UNESCO roadmap for 2030 urges action upon leaders and staff of teacher training organisations in formal and non-formal education, leaders and staff of private companies, policy-makers, educators of all kinds and levels and international education and Sustainability organisations to include ESD for 2030 training in all educator professional development and assessment programmes (UNESCO, 2020). This training should not only be offered by accredited bodies, but also from peers and mentors within an institution. Importantly, every institution should have appropriate policies in place around educator training but should also enable, promote and celebrate the achievements of its educators and learners.

Another important implication of this research is that transformation of teaching, learning and assessment on its own will make a difference for educators and learners but not for the entire organisation, if it not coupled with systemic interventions at the structural level that overcome resistance to change (Lambrechts et al., 2010). This research stresses that a WIA is needed for true transformation of an educational institution or community towards Sustainability, which is also one of the priorities of ESD for 2030 (UNESCO, 2020). This approach necessitates change in all the dimensions of the educational institution so that learners "learn what they live and live what they learn". What this means is that not only the educational dimension (outcomes, pedagogies, assessments), but also the governance and culture, the facilities and infrastructure, the engagement with the broader community and the professional practice within an institution need to be underpinned by Sustainability principles. This way the transformation will be systemic, lasting and in depth.

To facilitate the whole systems transformation of an educational institution towards Sustainability, the inclusion of the self-assessment rubric (Appendix F) that HE practitioners can use to evaluate the integration of the SDGs into the various institutional dimensions of their education organisation can be a productive step. This rubric was discussed and tested with HE stakeholders at the MRS 2019 Fall meeting and exhibit conference workshop in Boston USA on the 1st of December 2019 (Appendix A). The rubric includes criteria that evaluate the different dimensions of the WIA and the scoring follows a three level point system. It works by assigning a score of zero if the integration in the specific criterion is not at all fulfilled, a score of one if it is partially fulfilled and a score of two if it is fulfilled. The dimensions include learning outcomes, pedagogy, curriculum, assessment, culture, governance, research, professional

practice and development (academic, research), infrastructure/resources (human, material, abstract) and Context (local, regional, global).

The rubric can be used to understand the current level of Sustainability integration of an educational institution and set goals to achieve. It was aligned with the generalised vision of the SDGs and the eight Sustainability attributes developed in chapter 5. It allows an institution to monitor how they are using resources and thus if they are within the safe operating space (research, infrastructure, resources and operations), if they are achieving the just operating space (outcomes, pedagogy, curriculum, research, culture), health and wellbeing (culture, governance and operations), collaboration (culture, governance, pedagogies, context), alternative economic models (governance and operations), diversity and inclusion (outcomes, pedagogy, curriculum, assessment, governance, research, culture and operations), resilient sustainable behaviours (outcomes, pedagogies, curriculum, assessment, culture, governance, professional practice and development and operations) and transparency and governance (governance, culture, assessment and operations). It can complement the framework and tools discussed earlier for ESD.

The application of the systemic framework for integrating the SDGs into educational outcomes and aforementioned assessment tools has already been applied for courses with environmental and Sustainability orientation in all three levels of education. This was done to evaluate application and demonstrate to other education communities how to benefit from these approaches, but also to show the variety of ESD approaches used and that they are far from being ideal but are worth pursuing, reviewing and improving. Future research using as case studies educational programmes of various levels (primary, secondary and tertiary: undergraduate and postgraduate) not already aligned with Sustainability is needed to further assess the benefits the framework can offer. Comparisons could be made among programmes of study and conclusions drawn on the effectiveness of various approaches in different disciplines and levels.

Further research could focus on the continuity of competence development through the different educational levels to identify developmental indicators of how knowledge, skill and behaviour are actually evolving through the learner's educational journey. What is more, longitudinal studies that follow the graduates of ESD programmes into their educational and societal roles and assess their application of Sustainability competences in the service of community would verify the lasting effect those approaches can have on learners. Finally yet

importantly, a review of how far the educational communities are in terms of achieving their SDGs targets and in depth discussions with them on how education and the development of Sustainability competences or the WIA influence their achievement would be crucial for the Sustainability transformation of the community. The former can happen through the use of the indicators of specific SDGs (United Nations, 2018) that are important for the communities or through the use of various existing tools such as the gap frame (Muff, Kapalka, & Dyllick, 2017) and the latter can happen through focus groups and/or interviews with education stakeholders on the evidence they can bring on the impact of education in achieving the SDGs.

Other opportunities to take this research forward could focus on assessing the effectiveness of teacher empowerment with capacities for SDGs integration through the use of the system framework and tools in teacher training sessions, how this reflects in their teaching practice, curriculum, pedagogy and assessment design and implementation, and how it affects student development of competence. Assessing the effectiveness of WIAs in terms of integrating a SDGs vision in governance, operations, education, research and community engagement and outreach would show the added benefit of the self-assessment methods and allow for comparisons and lessons to be shared among educational institutions.

In terms of further policy recommendations, the first and most important would be to grant freedom to education institutions to manage their vision, mission, curricula, learning outcomes, pedagogies and assessments using participatory and systems approaches. This can happen as a mix of a bottom-up and top-down method. An important factor would be to encourage holism and pluralism in learning outcomes as well as in practices used so that learners can be empowered to make critical and informed decisions around challenging Sustainability issues and have the capacity for working in inter- and transdisciplinary teams. The definition of competence and the constructive alignment among ILOs, pedagogies and assessments should be highlighted in all policy documents around ESD in order to help educators achieve positive outcomes. The five-step framework and derived assessment tools could be included in educator and policy-maker training and in policy documents around increasing the effectiveness of ESD, as it has already demonstrated its potential to generate impact through a workshop with Higher Education representatives. Sustainability should be regarded as integral part of education and incorporated in education agendas of all countries as an enabling factor for achieving the SDGs, but also education should be incorporated in all Sustainability agendas as a crucial enabling factor for societal transformation.

Chapter 11 Conclusions

The thesis explored the concept of Sustainability and the role and effectiveness of education in enabling a transition to a sustainable society as envisioned by the Sustainable Development Goals, taking a systems thinking approach. The key findings are summarised below:

- Sustainability is complex concept, means different things to different stakeholders and causes disengagement in educators and students and thus a clear definition is needed.
- The definition of Sustainability as a systems state that our society is trying to reach guided by the SDGs provides clarity as to the aim pursued.
- The systemic framework that links educational outcomes to the Sustainability attributes (Safe Operating Space, Just Operating Space, Resilient Sustainable Behaviours, Alternative economic Models, Health and Wellbeing, Collaboration, Transparency and Governance, Diversity and Inclusion) necessary for the sustainable state to emerge demonstrated the crucial role of education for enabling the transition to a sustainable state and that:
- Sustainability competences are the indicators for achieving the sustainable state through education, using the five steps presented (participatory visioning, identification of Sustainability attributes, selection of competences of the citizens of the sustainable state, pedagogies and assessments to enable competence development and measure progress).
- An assessment tool that evaluates the alignment of Higher Education (HE) programmes' learning outcomes (LOs) to Sustainability offers the first step in a process that will allow HE practitioners to assess and improve their educational offerings, increasing their contribution to Sustainability, was developed.
- The application of the tool demonstrated that Environmental and Sustainability master's programmes in the UK (and some in Europe) still mostly incorporate the environmental dimension of Sustainability in their LOs and less so the social, economic, health and wellbeing, collaboration, diversity and inclusion, transparency and governance dimensions. This does not represent a balanced view of Sustainability or the SDGs. Higher Education programmes can be compared according to their

performance in contributing to the SDGs using the tool developed, can map the areas of good and poor Sustainability attribute integration into their LOs and can take appropriate decisions for improvements.

- The constructive alignment between LOs, competences, pedagogies and assessments is an important indicator that the curriculum is enabling Sustainability competences in learners.
- A tool was developed to evaluate the assessment methods used in Higher Education on their capacity to enable the development of Sustainability competences in learners that prioritises the experience of the competence assessed in the learners.
- The process of translation of LOs to competences, the development of assessment models/tools and their application to evaluate competence development in learners was demonstrated through a University case study as a way of assessing effectiveness.
- The data collected from the application of the assessment tool can be used to inform a curriculum review in a University case study as well as provision of recommendations for beneficial changes.
- A comparison was conducted of competence assessment data before and after the review to generate insights on the benefits and challenges posed in terms of empowering students with Sustainability competences.
- The framework used in the University case study for use in primary and secondary education showed the effectiveness of employing a participatory approach in deciding learning outcomes for Sustainability and then assessing them in learners, and further concluded that:
- The primary school had an integrated approach for ESD in its curriculum but faced the challenge of framing Sustainability as “good” or “bad”, which prevented students from developing critical thinking and independent decision-making skills and that:
- The secondary school employed a fragmented approach in ESD offering a specific course for the SDGs to the students of Year 9, but managed to help them develop the intended competences. However:
- It did not ensure continuity of engagement with Sustainability for the students, nor a holistic Sustainability strategy for the entire school, which would enable the

transformation of the whole school towards Sustainability. This needs to be taken into account by the school community.

- The systemic framework can offer educational institutions a way to systematise, assess their contributions to the SDGs, and initiate Sustainability transitions through the diffusion of Sustainability competences in their surrounding communities.
- The assessment tool that evaluates the alignment of learning outcomes to the SDGs was developed, applied and generated evidence on the gaps around the coverage of Sustainability attributes by educational programmes, but also provides a starting point for implementing changes in curricula so they can be holistic and pluralistic in terms of Sustainability integration.
- The selection, operationalisation and assessment of Sustainability competences was demonstrated in three case studies of different education levels (Tertiary, Secondary and Primary), showing its applicability and effectiveness across levels and providing evidence that Sustainability should be continuously pursued through every level of education to empower learners with Sustainability competences.
- The three case studies demonstrated that a systemic approach in ESD for the SDGs is more desirable, as it does not consider each SDG separately but focuses on the Sustainability attributes of visions that the educational stakeholders define for their communities and thus they make sense in terms of their values, priorities and needs.
- The case studies further demonstrated that learning environments, pedagogies and assessments that enable the learners to develop and experience Sustainability competences are effective in empowering them with those competences.
- Especially in secondary and higher education, cultivating the ability of students to assess their own performance as well as their performance of working as a team helps them take ownership of their learning.
- In primary education, increasing pluralism when teaching around Sustainability topics is beneficial for students' systems and critical thinking and overcomes framing biases.
- The fragmented and siloed view of different disciplines prevails starting from secondary school and moving to University education. The primary school is the only education level that offers an integrated view of Sustainability throughout its curriculum, but for

much of the secondary school and higher education, Sustainability is still viewed as an add-on to the “mainstream” objective of excellence in specific disciplines.

- The systemic view of the SGDs has the potential to enrich the curriculum and drive whole-personality development in learners.

In terms of policy recommendations,

- A key recommendation emerging from the thesis is the need to grant freedom to education institutions to manage their own curricula, learning outcomes, pedagogies and assessments using participatory approaches for ESD and avoid prescription of practices (focus on process instead).
- Another important factor in this would be to encourage pluralism in learning outcomes as well as in practices used, so that learners can be empowered to make critical and informed decisions around challenging Sustainability issues and have the capacity for working in inter- and transdisciplinary teams.
- The process of definition, selection and operationalisation of competence provided and the constructive alignment among learning outcomes, pedagogies and assessments should be highlighted in all policy documents around ESD in order to help educators achieve positive outcomes regarding effectiveness.
- The five step systemic framework for linking the educational outcomes to the SDGs (chapter 5) and the assessment tools for evaluating the contribution of programmes to Sustainability and the development of competence in learners (chapters 6, 7, 8 and 9) should be included in educator and policy-maker training, to expose them in this new way of thinking, allowing them to understand how they could benefit from this application in light of the evidence presented in this thesis through application in case studies and workshops with Higher and School education representatives.

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Appendix A Findings from the application of the systemic framework in a HE workshop organised for the 2019 MRS Fall meeting and exhibit

The framework we presented in chapter 5 regarding using systems thinking to achieve the SDGs through education for Sustainable Development by selecting and developing Sustainability competences in learners was used in workshop with University stakeholders to collect evidence that is it applicable in practice. In order to use the framework in a format that would be user friendly and would enable participants to carry out its steps we developed a canvas (Appendix F) applying design thinking into the process. The sustainable community change canvas for HE institutions consists of three sections: strategic change, systemic change and action for change. The strategic change part contains the visioning process of how the SDGs can be translated into a vision of a HE institution, the participatory part of identifying the groups of people who should be included in the articulation and realisation of the vision, the backcasting part that addresses how the community can reach their vision by identifying enabling conditions and barriers on the way and the monitoring and evaluation part for identifying and monitoring metrics of progress toward the vision. The systemic change part has to do with the competences needed to achieve our collective vision and how can these competences be implemented as part of a WIA into not only teaching and learning but research, culture, infrastructure and governance. The action for change part includes a timeline that enables stakeholders to record and plan their intended actions in the next 3, 6 and 12 months and beyond to achieve their vision.

During the implementation phase of the framework with representatives from 20 Universities and 10 countries during a scientific conference, we found out that an introduction to the SDGs is crucial for participants to understand their meaning and reflect on how they provide a blueprint for achieving Sustainability. There is need for facilitators who already have experience with embedding Sustainability in HE institutions who can guide participants in using the canvas and framework and discussing what each section asks them to do. In addition, facilitators help synthesize the views of the members of the group to have an inclusively articulated vision of the SDGs. The participants needed guidance in selecting competences to achieve their visions as they were not very familiar with the concept of competence and with the WIA, for which separate materials were provided.

The participants were allocated into four groups of 6-7 members and worked in those groups using the canvas and supplementary material we provided them with. The results of the framework application can be found in the following table:

Group 1:

Vision: Mandatory required course on the topic of Sustainability to generate positive impact in creating cultural change and a mindset around Sustainability. Many people around the University use project based learning for teaching various modules and courses around engineering, natural and social sciences.

The course will be guided by the SDGs framework and the different departments and course leaders will have the flexibility to structure that course around their needs so it has the potential to include all the SDGs.

Stakeholders: Students, Champion (faculty member), Admin, current allies, environment, health and safety officers, office of feasible planning and others not directly involved in curriculum development.

Enabling conditions-barriers: people involved to stay connected and motivated, organise regular meetings and having a positive mindset of achieving the vision but having discussions on the why and how to do it

Progress monitoring: not a check box exercise such as we have the course or not but rather if the course achieves its objectives which is widespread behavioural change around the campus (using psychology metrics to capture that)

Competences: systems thinking, future thinking, collaboration, change maker skills, metacognitive skills to reflect on what would the SDGs as an overarching framework for the project development, planning and monitoring would mean.

WIA: Not yet fulfilled

Timeline: No timeline identified.

Group 2:

Vision: Reduction of lab waste (chemical), smart labs, education: design of graduate seminars, workshops, and orientation programmes

Sustainability as organic implementation through a long-term process, which involves educating for changing culture and touches on individuals from every lab to turn them to Sustainability officers

SDGs 4, 12, 9, 6, 3 and 11.

Stakeholders: PIs, researchers, support staff, lab safety officer, Sustainability officer

Enabling conditions-barriers: discuss about Sustainability in group meetings, highlight economic value, which means saving money for PIs, implement rewards for good behaviour, communicate more activities to other labs for motivation, empower researchers, bring people to the same vision of incorporating Sustainability into daily activities.

Progress monitoring: Track trash, paper, waste, power use and purchase records. These will vary from lab to lab and there can be discussions around how we can do a better job.

WIA: Not yet fulfilled

Competences: No competences mentioned.

Timeline

3 months: Meeting- implementation/initiate (present case studies) allocated time in meetings for people to discuss about Sustainability and what they are or should be doing, form committee and appoint Sustainability resource officers (inspired people should step up), establish baseline and metrics that make sense locally and are determined by the lab

6 months: posters to motivate and share news, hold group meetings, review metrics quarterly, establish lab competition share best practices and how champions are enacting the Sustainability actions in their labs.

12 months: Evaluate competitors, reward and celebrate.

Group 3:

Vision: Increase communication to facilitate responsible resource usage, better resource management (clean room, equipment, water use), development of technician guidelines, limiting resources used, increasing awareness, funding for project, replace, reduce, how project is related to Sustainability should be included in funding norms for general research, scholarships for females irrespective of socio-economic background, more communication between groups and talks from different types of people.

SDGs: 17, 12, 4

Stakeholders: University level (establish program), programme coordinators, lab managers, community outreach, work with industry

Academic staff and students

Enabling conditions-barriers: waste of time for professors or safety managers, create new position of Sustainability officer/champion or increase pay of existing position.

Ignorance, lack of time, more funding, incentives and education

Progress monitoring: Implement water, energy tracking system, resources and energy monitoring, survey program to track progress, train, certify, foster communication between different lab groups University wide, social event once a month with free food

Competences: good communication skills, positive outlook, self-awareness, research competences, use media effectively, strategic thinking

WIA: Partially fulfilled

Timeline

3 months: Establish contact with lab officers, monthly meeting with lab safety manager coordinator, additional integration.

6 months: Implement resource tracking, larger workshop

12 months: evaluation of progress, communicate results to senior leadership, look into the creation of permanent positions, continuous improvement of the University performance, and grow to include more significant educational programs for all HE stakeholders

Group 4

Vision: To develop a critical consciousness about green and renewability as a brand

SDGs 1, 4, 12, 13, 10

Stakeholders: Primary: Professors of different disciplines (humanities, chemistry, engineering, physics, economics, art, health and social science) and student leaders, secondary: students, industry leaders and low performing schools

Enabling conditions -barriers: Arrogance, poverty, ignorance, conspicuous consumption, culture, lack of connections, reaching/meeting people where they are = relevance, people taking themselves too seriously

Progress metrics: Who is showing up, policy or program change, percentage of people in committees for action

WIA: Not yet fulfilled

Competences: critical thinking, systems thinking, future thinking, collaboration and self-awareness

Timeline:

3months: core committee formed

6 months: planned calendar of events for 2020-2021

12 months: Institutionalise the committee and have agreed members to run it

From the data collected in the workshop, the emerging priority for the participants is to create a culture and mindset around Sustainability in their Universities that will lead to behavioural change, gender equality, improved education and efficient resource management. Only one group of participants thought that through education the University can tackle all SDGs, while most other groups focused on specific SDGs, with *SDG4 Quality Education* and *SDG12 Responsible production and consumption* included by all. Regarding the competences selected, different groups selected different competences to achieve their visions. Systems thinking, future thinking, collaboration and self-awareness were selected by more than one groups, while some unique competences where metacognitive abilities to reflect on the meaning of the SDGs, positive outlook and change maker skills.

Regarding the stakeholders involved apart from the academic, research and administration staff and the students, the participants discussed around the idea of a Sustainability officer or champion in each department and also about community and industrial partners such as schools and corporations. The Sustainability champion is an inspired and capable of initiating action person who is a shaper of the vision and early adopter of the strategic importance of the SDGs. The Sustainability champion will have as main responsibility to communicate clearly with all the stakeholders important information about the strategy, enablers and barriers, model the behaviours that should be widely adopted in the HE institution and resolve any conflicts that may be generated. It will also be the main person for the monitoring and evaluation process based on the participatory defined metrics.

Around the enabling conditions for change, most participants suggest that the vision should be a uniting element that will generate wide involvement, while some suggest that some kinds of incentives such as rewards, paid positions or higher salaries or fostering a healthy competition among labs could motivate stakeholders to engage. Another crucial aspect to enable the achievement vision is to “meet people where they are” this means to understand their realities, concerns and needs and with them to develop a vision, strategy and progress monitoring system that is relevant to them. This approach is more likely to increase the psychological ownership of process of change and reduce potential conflicts inherent in organisational change. Another view revolves around an optimistic and positive mindset, organising meetings to build and keep momentum and helping people staying connected and empowering them to act by discussing “why” and “how”. This view has a lot in common with the enabling approach to Sustainability transformation, which advocates for an optimistic, process-oriented, relational and capacity building stance. This view prioritises common values that drive the why behind transformation, is looking to what can be and not to what is not, facilitates current and emerging connections between the stakeholders, democratises processes by use of deliberations on ways to achieve the vision and aims to build agency in participants.

The most important barriers to achieving their vision as perceived by the participants can be categorised as personal such ignorance, arrogance or taking oneself too seriously and systemic, such as lack of time due to other pressing commitments or conflicting priorities, lack of funding and resources, lack of incentives and education, poverty, conspicuous consumption, negative culture and lack of connections among the stakeholders. Some of the barriers are related with personal responsibility and this may link with lack of information on the purpose and process of change, which can be overcome easily by disseminating the relevant information to the stakeholders, but it may be related with non-engagement based on idea that personal involvement and action have little potential for bringing about change. In that case making all actors involved fully aware of their role, mission and impact they can have in achieving Sustainability in the HE institution may help them overcome their disbelief. In terms of systemic barriers, they can be categorised into two groups internal to the institution and external or part of the wider context. Internal barriers can be the lack of resources, incentives and education around Sustainability as well as the silos among disciplines and the culture of competition and individualistic learning that make collaboration and interdisciplinarity impossible. To avert these in depth discussion on what are the implications of the status quo as academic practice and what dissatisfies or disappoints the stakeholders about it may initiate a dialogue for change.

Wider barriers may include lack of societal interest in Sustainability and thus lack of funding opportunities and other resources as well as established norms such as conspicuous consumption that influence the operation and relationships within HE institution. These deeply ingrained attitudes can be overcome if people are encouraged to critically examine the assumptions on which they operate as society. For example by asking, “How much is enough?”, “How much will make us happy?”, “Does away exist?”, “Is the Earth limitless? “or “Are our actions really not connected to the impacts we see?” through meaningful education. Examination of these assumptions will enable us to see how we are part of larger systems and how our behaviours influence societal interest in Sustainability and thus funding opportunities and other support available to implement Sustainability. All of these are different parts of a feedback loop that are reinforced or diminished by underlying norms.

The participants were trained in the process of using the framework and canvas with a view to implementing it when going back to their Universities with their stakeholders and in their own contexts and we offered to give them support if they run into any problems. We managed to secure some seed funding for 10 projects that would start in the academic yea 2020-2021 to help them with any expenses they would initially have. We developed a platform where the interested Universities would submit their projects regarding the SDGs and a list of criteria for awarding the funding. Unfortunately, due to the covid-19 pandemic, which coincided with the call for projects on the SDGs, there was a postponement of the applications for funding until the return to some normality of University life.

Appendix B Multi-criteria Analysis supplementary material

Table 6. Pairwise comparisons between the 18 Imperial College master's programmes' LOs total performance on the eight Sustainability attributes. The table reports their positive or zero dominance scores (in each pairwise comparison all Sustainability attributes scores are compared one by one and their difference is either +, - or 0, this is summed for all criteria and reported here).

Pairwise comparison	MSc Environmental	MRes Ecosystems and	MSc Advanced materials	MSc Climate Change,	MSc Ecology, Evolution	MSc Environmental	MSc International Health	MSc Sustainable Energy	MRes Bioengineering	Mres Green Chemistry	MSc Advanced Chemical	MSc Advanced Computing	MSc Applied Mathematics	MSc Clinical Research	MSc Finance and	MSc Optics and Photonics	MSc Petroleum Engineering	MSc Science Communication	
MSc Environmental Technology	0	5	7	6	5	6	5	5	6	7	6	6	7	4	5	8	6	6	**100**
MRes Ecosystems and Environmental Change	3	0	5	3	3	4	5	4	5	4	5	6	7	3	4	7	4	3	**75**
MSc Advanced materials for Sustainable Infrastructure	1	2	0	3	3	4	4	2	5	2	4	4	5	3	3	5	4	2	**56**
MSc Climate Change, Management and Finance	2	4	3	0	3	3	3	3	4	3	4	3	5	3	3	5	4	3	**58**
MSc Ecology, Evolution and Conservation	3	4	4	4	0	5	4	3	5	5	5	6	7	4	4	6	4	4	**77**
MSc Environmental Engineering	2	3	3	4	2	0	4	4	5	4	7	7	7	3	4	7	5	4	**75**
MSc International Health Management	3	3	3	4	4	4	0	3	5	4	5	5	5	4	5	6	5	4	**72**
MSc Sustainable Energy Futures	3	4	5	4	5	4	4	0	4	5	5	4	5	4	5	7	5	4	**77**
MRes Bioengineering	2	3	3	4	3	2	3	4	0	3	4	5	6	1	3	5	3	4	**58**
MRes Green Chemistry	1	3	5	4	2	3	4	3	5	0	4	3	6	3	4	7	4	2	**63**
MSc Advanced Chemical Engineering	2	2	3	3	2	0	3	3	4	3	0	6	7	2	3	7	4	3	**57**
MSc Advanced Computing	2	1	3	4	1	0	3	4	2	4	1	0	5	3	3	5	2	3	**46**
MSc Applied Mathematics	1	1	2	2	1	1	2	2	1	2	1	2	0	1	3	5	1	2	**30**
MSc Clinical Research	4	5	5	5	4	5	4	4	7	5	6	5	7	0	5	8	6	5	**90**
MSc Finance and Accounting	3	3	4	4	3	3	3	3	4	3	4	3	4	3	0	4	4	3	**58**
MSc Optics and Photonics	0	0	1	1	1	0	1	0	2	0	0	0	1	0	2	0	0	1	**10**
MSc Petroleum Engineering	2	3	3	3	3	2	3	3	4	3	3	4	6	2	2	6	0	3	**55**
MSc Science Communication	2	4	4	3	3	3	3	3	4	5	4	4	5	3	3	5	4	0	62

Table 7. Pairwise comparisons between the 40 environment and Sustainability related master's programmes' LOs total performance on the eight Sustainability attributes. For specific courses details please refer to Table 4 in 2.2 Application.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Score
1	0	2	3	5	4	2	2	3	1	3	3	2	5	3	4	3	4	2	2	2	2	3	5	4	1	2	1	3	2	1	4	4	4	3	3	3	5	3	3	5	**116**
2	6	0	4	4	3	3	2	4	4	3	4	3	4	2	4	4	3	2	2	1	2	3	4	3	3	2	1	6	3	2	4	4	3	3	3	4	4	2	4	4	**126**
3	3	4	0	5	4	3	2	5	3	2	5	4	5	3	4	3	4	4	2	2	3	4	6	3	4	4	2	5	4	1	5	6	3	3	5	5	5	4	5	5	**149**
4	3	4	2	0	2	2	2	5	1	2	2	4	4	2	4	3	2	3	2	3	1	4	4	2	3	3	2	5	4	1	5	3	1	2	4	4	2	4	4	3	**113**
5	4	5	4	4	0	4	2	5	2	3	5	4	4	3	5	5	4	4	2	3	3	5	5	3	4	4	3	6	4	2	6	5	3	2	5	5	4	5	5	4	**155**
6	6	5	3	5	3	0	3	6	3	2	4	6	5	5	7	5	5	5	5	3	4	5	6	4	5	5	4	8	4	2	7	6	3	4	5	7	5	5	5	5	**185**
7	6	6	5	6	5	4	0	6	7	6	5	4	6	6	6	5	6	5	5	5	6	5	8	4	5	6	5	7	5	5	6	7	7	5	5	7	6	6	6	4	**219**
8	5	4	3	3	2	2	2	0	3	2	3	2	5	1	4	3	3	3	1	2	3	4	6	4	3	5	3	6	4	1	5	5	3	3	4	5	5	4	4	3	**133**
9	6	4	5	7	6	5	1	5	0	5	6	5	5	4	6	6	5	3	4	3	5	5	6	4	4	4	3	5	4	4	5	5	6	3	4	5	6	6	6	4	**185**
10	5	5	6	6	5	6	2	6	3	0	5	5	5	4	5	5	5	3	3	3	3	7	5	3	4	4	3	7	5	3	6	6	5	3	6	6	6	5	6	5	**185**
11	5	4	3	5	2	4	3	5	2	2	0	3	5	4	5	4	3	5	2	3	2	5	5	3	4	5	3	7	5	1	7	5	3	3	6	6	5	4	6	5	**159**
12	6	5	4	4	4	2	4	6	3	3	5	0	5	3	5	4	4	3	2	2	3	5	6	4	5	5	3	8	4	1	8	6	3	3	5	7	6	4	4	5	**169**
13	3	3	3	3	3	3	2	3	3	3	3	3	0	2	3	3	2	3	3	2	3	3	4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	2	**111**
14	5	6	5	5	4	3	2	7	4	4	4	5	5	0	5	5	3	4	3	3	3	5	5	3	4	5	3	6	5	4	7	5	4	2	5	5	5	5	4	4	**171**
15	4	4	4	3	2	1	2	4	2	3	2	3	4	2	0	3	3	3	1	1	1	3	3	2	3	4	2	4	4	2	5	3	3	2	3	3	3	3	2	3	**109**
16	5	4	5	5	3	3	3	5	2	2	4	4	5	3	5	0	5	3	3	3	2	4	6	2	3	3	3	6	3	2	6	5	5	3	5	6	5	6	6	4	**157**
17	4	4	4	4	2	3	2	5	3	3	4	4	4	4	4	3	0	2	3	1	2	4	3	2	3	4	2	5	4	3	5	3	3	3	4	4	3	4	5	4	**133**
18	6	6	4	5	4	3	3	5	5	5	3	5	5	4	5	5	6	0	3	3	3	6	6	3	4	4	3	7	5	2	6	6	5	4	5	7	6	5	6	5	**183**
19	6	6	6	5	5	3	3	7	4	5	6	5	4	4	6	5	4	5	0	4	4	5	5	4	5	6	4	7	6	4	7	5	5	3	5	6	6	5	5	4	**194**
20	6	7	6	5	5	5	3	6	5	4	5	6	6	5	7	5	7	5	4	0	5	7	4	4	5	6	4	8	6	5	6	6	5	4	7	7	5	6	8	6	**216**
21	6	6	5	6	4	4	2	5	3	5	6	5	4	4	6	6	5	5	3	3	0	6	5	3	4	5	3	6	6	4	5	5	5	2	5	5	4	5	6	4	**181**
22	5	5	4	4	3	3	3	4	3	1	3	3	5	3	5	4	4	2	3	1	2	0	5	4	3	4	3	6	3	2	4	4	2	3	6	7	4	4	6	5	**145**
23	3	4	2	2	1	2	0	2	1	3	2	2	3	2	4	2	3	2	2	4	2	3	0	1	1	2	1	4	2	2	2	3	3	2	4	3	2	4	5	2	**94**
24	4	5	5	5	4	4	4	4	4	5	5	4	4	4	5	6	5	5	3	4	4	4	6	0	5	5	4	6	5	4	5	5	5	4	6	5	4	5	5	5	**181**
25	7	5	4	5	3	3	2	5	4	4	4	3	5	4	5	5	5	4	3	3	4	5	7	3	0	5	3	7	5	2	6	6	4	4	5	6	6	4	6	5	**176**
26	6	6	4	5	4	3	2	3	4	4	3	3	5	3	4	5	4	4	2	2	3	4	6	3	3	0	1	8	3	2	4	6	3	3	4	6	5	4	5	5	**154**
27	7	6	6	6	5	4	3	5	5	5	5	5	5	5	6	5	6	5	4	4	5	5	7	4	5	7	0	8	6	3	5	6	6	4	6	6	5	5	5	5	**205**
28	5	2	3	3	2	0	1	2	3	1	1	0	5	2	4	2	3	1	1	0	2	1	4	2	1	0	0	0	0	0	2	3	2	2	3	4	4	2	4	4	**81**
29	6	5	4	4	4	4	3	4	3	3	3	4	5	3	4	5	4	3	2	2	2	5	6	3	3	5	2	8	0	1	7	5	3	3	5	7	5	4	4	5	**158**
30	6	6	6	7	6	6	3	7	4	5	7	7	5	4	6	6	5	6	4	3	4	6	6	4	6	6	5	8	7	0	8	8	5	4	5	7	6	5	6	5	**220**
31	4	4	3	3	2	1	2	3	3	2	1	0	5	1	3	2	3	2	1	2	3	3	5	3	2	4	3	6	1	0	0	4	3	3	3	5	4	3	3	4	**109**
32	4	4	2	5	3	2	1	3	3	2	3	2	5	3	5	3	5	2	3	2	3	4	5	3	2	2	2	5	3	0	4	0	2	4	4	6	5	5	5	2	**128**
33	4	5	5	5	3	5	1	5	2	3	4	5	4	3	4	3	3	3	2	3	2	6	3	2	4	5	2	6	5	3	5	6	0	2	5	5	4	6	6	4	**153**
34	5	5	5	5	5	4	3	5	5	5	5	5	5	5	5	4	4	4	4	5	5	5	3	4	5	4	6	5	4	5	4	5	0	5	4	5	5	4	3	**179**
35	5	4	3	4	3	3	3	4	4	2	2	3	4	3	5	3	3	3	3	1	3	2	4	2	3	4	2	5	3	3	5	4	3	3	0	5	3	3	4	4	**130**
36	5	3	3	3	2	1	1	3	3	2	2	1	3	2	4	2	2	1	1	1	2	1	4	2	1	2	2	4	1	1	3	2	2	3	2	0	3	3	4	2	**89**
37	3	3	3	4	2	3	2	3	2	2	2	2	3	2	4	3	2	2	1	3	3	4	4	3	2	3	3	4	3	2	4	3	2	2	4	3	0	3	3	3	**109**
38	5	5	4	4	3	3	2	4	2	3	4	4	5	3	5	2	3	3	3	2	3	4	4	3	4	4	3	6	3	3	5	3	2	3	4	4	4	0	5	3	**139**
39	5	2	3	4	3	3	2	4	2	2	2	4	4	4	6	2	2	2	3	0	2	2	3	3	2	3	3	4	4	2	5	3	2	4	3	3	4	2	0	4	**117**
40	3	4	3	4	3	3	4	5	4	3	3	3	5	3	4	4	3	3	3	2	3	3	5	2	3	3	3	4	3	3	4	6	3	4	4	5	4	5	4	0	**140**

1. MSc Design Engineering with Sustainability STR; 2. MSc Ecology and Environmental Management LVH; 3. MSc Environmental Engineering CRN; 4. MSc Environmental Engineering NWC; 5. MSc Environmental Management BRN; 6. MSc Environmental Management RDN; 7. MSt Sustainability Leadership CAM; 8. MSc Sustainability STM; 9.MSc Water Sanitation and Health Engineering LDS; 10.MSc Environmental Economics and Environmental Management YRK; 11.Master in Environmental Sciences ETH; 12.Master in Environmental Sciences WGU; 13.Master in Environmental Sciences and Engineering EPFL; 14. MSc in Environmental Studies and Sustainability Science LUN; 15. MPhil in Environmental Policy CAM; 16. MSc Environment and Development LAN; 17. MSc Environment and Sustainable Development UCL; 18. MSc Environmental Technology ICL; 19. MSc in Environmental Change and Management OXF; 20. MSc in Environmental Science, Policy and Management MESPOM; 21. MSc Environmental Strategy SUR; 22. MSc Environmental Sciences LIV; 23. MSc Environmental and Natural Resource Economics BGM; 24. MSc Environmental Economics and Climate Change LSE; 25.MSc Environmental Engineering UBA; 26. MSc Environmental Governance MAN; 27. MSc Environmental Leadership and Management NTG; 28. MSc Environmental Monitoring Research and Management LBR; 29. MSc Environmental Policy and Management BRS; 30. MSc Environmental Sustainability EDB; 31. MSc Integrated Environmental Studies STM; 32. MSc Mining Environmental Management EXT; 33. MSc Sustainability Planning and Environmental Policy CDF; 34. MSc Sustainable Development SAN; 35. MRes Ecosystems and Environmental Change ICL; 36. MSc Advanced materials for Sustainable Infrastructure ICL; 37. MSc Climate Change, Management and Finance ICL; 38. MSc Ecology, Evolution and Conservation ICL; 39. MSc Environmental Engineering ICL; 40. MSc Sustainable Energy Futures ICL.

Interpretation of Table 5 results

Analysing Table 5 results shows that coverage of the SOS is high for all programmes except for MPhil in Environmental Policy CAM, MSc Design Engineering with Sustainability STR and MSc Sustainable Development SAN. All analyses were done using equal weights for all Sustainability attributes. JOS shows lower coverage than SOS and Sustainability oriented programmes as well as health and environmental engineering and management programmes are on the high end of coverage. MSc Environment and Sustainable Development UCL shows the highest coverage, while MSc Environmental Economics and Climate Change LSE shows no coverage at all. Six masters programmes around ecology, economics, engineering and applied science with elements of Sustainability show the least coverage for JOS. All programmes show coverage of RSB which was expected, however MSc Environmental and Natural Resource Economics BGM and Master in Environmental Sciences and Engineering EPFL show the lowest coverage. For AEM most programmes show low coverage and the Masters related with ecology, environmental science or policy or governance and management or engineering show least coverage. HW shows the second lowest coverage among all attributes. Actually, eight master's programmes show very low or no coverage at all, rendering it the most underrepresented attribute. COL attribute is covered by most programmes, however, contrary to expectation six programmes show no coverage at all. Regarding DI, it shows the least coverage out of the eight Sustainability attributes examined with 13 programmes showing no coverage at all. Those programmes are related with Environmental Studies, Sciences and Management, Climate Change and economics and a few with Sustainable Development . Lastly, TG is covered by most programmes however coverage is low. Programmes related with environmental engineering/studies and Sustainability show least coverage and the Master in Environmental Sciences and Engineering EPFL shows no coverage at all.

Our hypothesis is supported as all courses that have a strong environmental dimension show higher coverage of SOS, courses that have to do with finance and economics as well as engineering show higher coverage of AEM and courses that are related with health management/engineering and sanitation show higher coverage of HW. For JOS since no specifically socially-oriented courses were examined, the coverage is higher in Sustainability and engineering courses. For RSB coverage is high for all courses as expected, however COL, TG and DI coverage is found lower than hypothesised. As general recommendation, environment and Sustainability oriented courses should consider the gaps in AEM, COL, HW, TG and DI discussed in this study and redevelop their learning objectives.

Appendix C Supplementary material for the assessment tool of Sustainability competences in Higher Education

Table 1. Competence statements and indicators for the options modules assessment

Competence statements	Indicators
Systems thinking and dealing with complexity	Application of interdisciplinary approach Stakeholders needs analysis and assessment Systems analysis and conceptual modelling Scenario, projection and vision development
Future thinking, creativity and dealing with uncertainty	Uncertainty evaluation Current and future states analysis Creative problem-solving
Critical thinking, reasoning and reflection	Evidence collection, analysis and assessment Reasoning and argumentation Reflection on work Qualitative and quantitative data analysis Use of digital tools for data analysis and preentation
Research competence	Application of assessment, decision-making and management tools Strategy development and application Assessment of barriers and adaptation to changing conditions
Strategic Thinking and Transformative Action	Working responsibly Resolving conflict and showing empathy
Collaboration and effective communication	Communicating effectively Assessing decision criteria and balancing trade-offs
Decision-making and value thinking	Reaching consensus decision Value, worldview and perspective analysis Leadership and role management
Self-regulation, team monitoring and leadership	Emotion management Self-reflection and motivation
Knowledge and understanding of water systems and Water management	Know the pathways and processes in water systems Know and apply the framework of contaminant behaviour within water systems Describe environmental, social, economic, technical and legislative pressures in water systems Know about different water management options
Knowledge and understanding of resource depletion and contamination assessment and management	Describe the fundamental causes of resource depletion and contamination in environmental systems Identify the interdisciplinary nature of these challenges. Know, apply and assess the relevant policy and legislative frameworks.
Knowledge and understanding of pollution problems and pollution assessment and management	Know about the scientific, technical and policy aspects of the most significant current UK pollution problems Analyse pollution problems Identify and evaluate appropriate technical and policy responses Apply pollution modelling and assessment techniques

Table 2. Educator Assessment rubrics:

PERFORMANCE LEVEL RUBRICS FOR ASSESSING SUSTAINABILITY COMPETENCES

SYSTEMS THINKING AND DEALING WITH COMPLEXITY

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Cannot produce a conceptual model of the system, show serious misconceptions or inability to think about factors influencing the problem (political, social, economic and environmental), do not identify different stakeholders' perspectives on the issue and are unable to select intervention points to take action.	Can produce only a fragmented conceptual model of the system without showing relationships between parts, show incomplete understanding of factors influencing the problem and include only some stakeholder views, while having difficulty in identifying intervention points to take action.	Can produce an adequate conceptual model of the system and provide information on important factors influencing it and basic explanations of relationships between parts, take into account most stakeholder perspectives and identify points to intervene in the system with occasional errors.	Can think holistically about the problem and provide an effective conceptual model with comprehensive consideration of factors influencing it (such as political, economic, social, environmental), include stakeholder influence and power on the issue as well as their perspectives and are successful in identifying ways to intervene in the system (leverage points) that will have positive outcome.	Can think creatively to develop an insightful and holistic representation of the system (parts, relationships, scales), interpret the factors that affect its behaviour, consider the perspectives of all involved stakeholders and develop innovative ways to intervene in the system that integrate the previous analyses .

FUTURE AND CREATIVE THINKING AND DEALING WITH UNCERTAINTY

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Do not mention any past events that may influence the issue nor craft any scenarios/projecti ons about the future. Suggest only one option for dealing with the problem and fail to deal with lack of data, contradictions and uncertainty.	Identify past events but fail to show how they relate to the issue, develop incomplete scenarios/projection s about the future and overlook important details and implications of the problem. Can only produce limited alternatives to the problem, usually spontaneous without doing adequate research.	Adequately identify past events that have influenced the issue as well as provide plausible future projections/scenario s. Reference current and future states' demands, dealing with uncertainty and implications surrounding the problem and propose adequate alternative options.	Identify past influences and future developments (scenarios, projections) regarding the issue and inclusively take into account present and future generations' needs. Generate variety of effective options paying thoughtful attention to the problem, implications of actions and tackle misconceptions and uncertainties that are commonly overlooked.	Able to creatively produce a continuum regarding the issue integrating past, present and future in a way that brings to light hidden dimensions of the problem, take into holistic consideration implications of actions and emergent system properties and propose transformative solutions that address uncertainty and ambiguity.

DECISION MAKING, VALUE THINKING AND COMMUNICATION

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Make a decision that is not reasonable, do not consider trade-offs nor take into consideration client and stakeholder values and show inability to incorporate different worldviews and perspectives. Report does not convey professionalism.	Select alternative that is biased, consider limited trade-offs, take into account only economic values of client, and show difficulty understanding different worldviews and perspectives. Report fails to communicate important challenges, approaches and solutions.	Select a reasonable alternative by considering various trade-offs, take into consideration client and different stakeholder economic and environmental values, and can understand different worldviews and perspectives. Report adequately addresses client's needs.	Select a decision that meets criteria towards numerous trade-offs, effectively map variety of economic, environmental and social values related to the issue and appreciate different worldviews and perspectives. Report communicates challenges, approaches and solutions clearly.	Select consensus decision that optimises trade-offs, making sure all perspectives/worldviews are respected. Comprehensively integrate environmental, social and economic values of client and stakeholders. Report is clear, of high quality and conveys professionalism to the client.

STRATEGIC THINKING AND TRANSFORMATIVE ACTION

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Do not suggest actions for addressing the problem and thus cannot initiate transformation, strategy is not present, so work fails its purpose.	Suggest limited actions that cannot produce significant results and so transformation cannot be achieved. Deploy incomplete strategy and the recommendation proposed does not cover crucial aspects of the issue.	Propose actions that show understanding of the issue, the strategy is effective for dealing with some aspects of the problem and the solution is adequate but does not address important obstacles.	Propose actions that show deep insight into the problem and bring to light strategic planning aspects that are commonly overlooked such as adaptability to change and overcoming crucial obstacles.	Suggest holistic action that shows novel insight to the problem, develop highly adaptive strategies for changing conditions, addressing obstacles and barriers and the solution provided establishes a model for creative/innovative work of high quality.

CRITICAL THINKING, REASONING AND REFLECTION

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Fail to provide evidence for the collection of data/information, significantly misinterpret the information, do not identify criteria for the decision task, are not aware of own assumptions, limitations and biases and do not reflect on their work, thus judgements are weak.	Provide some evidence for collecting data/information, interpretations show significant misunderstandings, selected decision criteria are irrelevant, assumptions, limitations and biases are not clearly identified, reflection on work is poor and thus judgements are limited.	Present valid evidence for collecting data/information, produce appropriate interpretations, the criteria used to assess alternatives are adequate as well as the descriptions of thinking/methodological barriers (assumptions, biases, limitations) and reflection on work, thus judgements give adequate results.	Present relevant and accurate information on which data and interpretations were based and convey deep insight into the problem. Identify valid criteria to reach decision and explain in detail thinking/methodological barriers and how they influenced results. Insightfully reflect on work and provide valid revisions.	Combine relevant/accurate information in innovative ways to produce robust and transparent judgements. By using valid criteria to assess alternatives and methods to overcome assumptions, limitations and other barriers, their results are of high quality. Reflection on work and adjustments inspire confidence on suggested approach.

RESEARCH TOOL/DIGITAL COMPETENCE (analytical tools for modelling and decision-making and digital tools presenting and preparing report)

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Lack quantitative analysis skills and ability to use decision making and digital tools to support research methodology and communicate the work and so do not deliver the project outcomes.	Have basic quantitative analysis skills and ability to use decision making and digital tools to support research methodology, communicate work and so produce limited outcomes.	Have sufficient quantitative analysis skills and ability to use decision making and digital tools to support research methodology and communication of the work and so make a significant contribution.	Have good quantitative analysis skills and ability to use decision making and digital tools to support research methodology and communication of the work and so add value to the work.	Have advanced quantitative analysis skills and ability to use decision making and digital tools to support research methodology and communication of the work and so the work is highly successful.

SELF-REGULATION, TEAM MONITORING AND LEADERSHIP

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Team members were not motivated to do the work, lacked ability to manage emotions, group processes and leadership were absent and this restrained the team's ability to deliver.	Roles and tasks were not clear or agreed, team members were easily derailed, occasional leadership and external support helped the team to manage the problems.	Had clear roles, became occasionally demotivated, showed ability to manage emotions most of the times without external support and overall had adequate outcomes	Actively encouraged and motivated each other, monitored personal emotions and kept feeling motivated by exchanging feedback and overcame problems on their own.	Engaged in collaborative approach with effective leadership from the start, had high level of ownership and accountability, learnt from each other and delivered high quality work.

COLLABORATION AND EFFECTIVE COMMUNICATION

Level 1 Below basic	Level 2 Basic	Level 3 Intermediate	Level 4 Advanced	Level 5 Expert
Did not show shared understanding, responsibility and commitment to the task, nor attempted to resolve conflict and establish group interactions, team members did the work individually. Limited or poor ability to communicate work orally and in writing.	Had difficulty working as a group, interactions between group members were present only after prompting and conflict did not allow consensus decision on how to do the work. Basic communication oral or written. Inability to convey some important messages.	Were committed to the task most of the times, had effective communication and showed empathy toward each other, so group interactions yielded positive outcomes. Good communication skills oral or written. Ability to convey important messages, with occasional shortcomings.	Group interactions were favoured from the beginning and negotiation allowed team members to resolve conflict and reach consensus decisions. Very good communication skills both oral and written. Conveying messages effectively.	Collaboration challenges were not perceived as barriers to doing work but as opportunities for synergies and conflict was managed to create added value for the project. Excellent communication skills both oral and written. Conveying messages effectively and efficiently.

Table 3. The self-assessment survey

Date:

Please provide the number of your team:

Option:

Module:

SYSTEMS THINKING AND DEALING WITH COMPLEXITY **(time scale, client's perspective, stakeholders' needs, project objectives, interdisciplinarity)**	**Please tick one**
Project complexity was overwhelming, and both I and my team were unable to cope and produce what was required for the project.	
Project complexity was overwhelming and had negative influence on my team, as we could only produce parts of what was required for the project.	
Project complexity interfered with our ability to deliver but at the end we managed to produce most of what was required for the project.	
Project complexity was manageable, but we could have been more creative and effective in producing what was required for the project.	
Project complexity was appreciated by both me and the team, and we were able to address it creatively and effectively to produce what was required for the project.	
FUTURE AND CREATIVE THINKING AND DEALING WITH UNCERTAINTY	Please tick one
I was not able to cope with the lack of data, lack of support and uncertainties associated with the project.	
I had limited success in coping with the lack of data, lack of support and uncertainties, but by making assumptions, asking for help and developing scenarios/projections I managed to produce parts of what was required for the project.	
I was able to cope with the lack of data, lack of support and uncertainties associated with the project and managed to produce most of what was required for the project.	
My contribution was effective in dealing with the lack of data, lack of support and uncertainties, and we delivered what was required by the project.	
I saw the lack of data, lack of support and uncertainties associated with the project as opportunities and so we managed to produce an integrative, creative and transformative solution that was in line with client's expectations.	
DECISION MAKING, VALUE THINKING AND COMMUNICATION	Please tick one
We had problems doing the work, did not deliver what was required and miscommunicated to the client our approach.	

We did the work, did not deliver what was required and miscommunicated to the client our approach.	
We did the work, delivered what was required but miscommunicated to the client our approach.	
We did the work, delivered what was required and communicated our findings to the client very well.	
We delivered added value to what clients expected and engaged effectively.	
CRITICAL THINKING, REASONING AND REFLECTION	Please tick one
The lack of evidence, reason and reflection in our work produced a weak result.	
We provided some evidence, reason and reflection but overall limited results.	
The evidence, reason and reflection provided was appropriate, and produced adequate results.	
Our use of evidence, reason and reflection was effective in producing what was required for the project.	
Evidence, reason and reflection was of high quality and inspired confidence to the client.	
COLLABORATION, RESPONSIBILITY AND CONFLICT RESOLUTION	Please tick one
Working in a group was a real challenge, we argued most of the time and ended up doing most work individually.	
Working as a group was difficult; interactions between members were present only after prompting and conflict prevented decision from being reached.	
Most of the times team members were committed to the task, showed empathy to each other and so interactions yielded some positive outcomes.	
Group interactions were effective, negotiation between team members helped overcome conflict and reach consensus decisions.	
Our collaboration challenges were seen as opportunities for synergies and creative work, conflict was managed appropriately to create added value for the project.	
DIGITAL/ICT/RESEACH TOOLS COMPETENCE **(quantitative skills and application of decision-making tools)**	Please tick one
My lack of skills in quantitative analysis and problems with the application of decision-making tools limited my ability to deliver what was needed for the project.	
My ability for quantitative analysis, use of decision-making tools and overall research methodology was basic and produced limited outcomes.	

My skills in quantitative analysis and competence in the use of decision-making tools enabled me to have a significant contribution towards important outcomes.	
My ability for quantitative analysis, use of decision-making tools and overall research approach was very good and added value to our project.	
My ability for quantitative analysis, use of decision making tools and overall research methodology enhanced the rigor of our approach and contributed to the overall success of the project.	
SELF-REGULATION, TEAM MONITORING AND LEADERSHIP	Please tick one
Lack of leadership, problematic group dynamics and lack of self-regulation have restrained our ability to deliver.	
My role in the team was not clear or accepted, my team-mates were easily derailed and we needed plenty of external support to cope.	
My role in the team was clear, group processes were monitored but lack of leadership and motivation limited our ability to deliver.	
I felt encouraged and motivated, received and gave constructive feedback and overall our team managed to overcome difficulties on its own.	
Our group's collaborative approach, ownership and accountability have enabled me to deliver high quality output and learn from other team-mates.	
STRATEGIC THINKING AND TRANSFORMATIVE ACTION	Please tick one
Our team lacked a coherent strategy and was unsuccessful in adapting to project conditions and overcoming barriers.	
Our team had difficulty devising a strategy for addressing project needs and failed to deal with some of the project's challenges.	
Our team strategy was adequate, we managed to adapt and lifted some obstacles, but with great effort and pain.	
Our team strategy was effective, gave new insight to the problem and helped us adapt to change and overcome obstacles for the majority of the work.	
Our team's strategy was flexible, highly adaptive to changing conditions and creatively overcoming barriers through a process that we all enjoyed.	

Table 4. Feedback example given to a group of students of the WM option based on the formal assessment criteria and the educator rubrics and personalised feedback given to student regarding their presentation skills.

"A good contextual introduction of the project. Thoroughly mentions the current situation in the area and the environmental, social, economic and political systems that interact to produce it (systems thinking), but misses background/historical information on the region (future thinking). Consideration of the balance between "social, environmental and economic" aspects, values and views to develop a successful strategy (strategic thinking and decision-making) – is aligned with wider context and Sustainability principles. *The use of the DPSIR analysis is a clear and informative method to display identified drivers, pressures, states, impacts and responses for the strategy (research and decision making skills). Very effective mass balance diagram with added suggestions for addressing needs that clearly conveys the complexity of the system and where solutions could be implemented (research skills and systems thinking). A good inclusion of the stakeholder analysis matrix, clearly displaying who the stakeholders are, however this is missing from the stakeholder analysis tables in the appendix. In addition, the stakeholder analysis is not integrated in the recommendations sections and thus not linked to the solutions proposed (critical thinking). An in depth Interventions section. It is clear that each intervention has been well researched with evidence of wider reading coupled with a critically analysis of each intervention based on literature (research and critical thinking skills). This ties in nicely with the recommended and viable options from leakage, smart meters to constructed wetlands and biosolids management. All strategies include phasing which is important (strategic thinking).* *The MCA could have been be more targeted to the mass balance diagram and thus would have yielded more appropriate options (decision-making and critical thinking). Currently, it is targeted to stakeholders, which is a good idea, but it misses other important parameters such as financial and social barriers and environmental regulations (critical thinking). Sustainable Development of the area although mentioned in the introduction should have been incorporated more in the approach you took to address the problem in terms of calculating future scenarios and their implications and clearly stating the assumptions you made to construct them (future thinking).* *The report has an excellent format. The clarity of writing, which is regularly cited from a variety of references, really adds to the report. There is excellent use of figures and diagrams, which are correctly labelled (effective communication). On a very few occasions there are references missing, on p 2, (16.5.1) and p 6 (2.1.1.)".* Personalised feedback given to a student of the same team through the report on the individual presentation: A *"Very clear and confident delivery to the room, well done! Very good posture, volume and pacing, kept eye contact, tried to help team mates with difficult questions and managed to tackle the tricky ones, had a very good overview of the whole project and presentation and conveyed messages effectively (collaboration and effective communication)".*

Appendix D Revised marking rubrics after the curriculum review of the MSc Environmental Technology

Table 1. CEP marking rubrics: essays

Performance levels	Poor (F-Fail)				Satisfactory (C-Pass)	Good (B-Merit)	Excellent (A-Distinction)		
Criteria	**0%**	**25%**	**35%**	**45%**	**55%**	**65%**	**75%**	**85%**	**100%**
Problem statement 15%	No work submitted	No problem definition or representation of the system is developed.	Develops a representation of the system that is inaccurate. The problem statement is very unclear and vague.	Develops a fragmented or incomplete representation of the system. The problem statement is unclear or poorly defined	Develops a descriptive representation of the system (parts, relationships, properties) but with marked lapses and some attempt to define the problem.	Develops a complete representation of the system (parts, relationships, properties) that leads to a good definition of the problem but with some lapses.	Develops a complete representation of the system (parts, relationships, properties) that leads to a concise definition of the problem.	Develops a complete and holistic representation of the system (parts, relationships, properties) that leads to a tight delineation of the problem's contours.	Develops an insightful and holistic representation of the system (parts, relationships, properties) that leads to a tight delineation of the problem's contours.
System analysis 15%	No work submitted	No factors or actions that affect the system's behaviour are identified.	Factors or actions identified are irrelevant or do not affect the system's behaviour.	Factors and actions identified are relevant, but it is not clear how they affect the system's behaviour.	Analyses and interprets relevant factors and actions that affect the system's behaviour.	Analyses and interprets some but not all the relevant factors and actions that affect the system's behaviour.	Analyses and interprets the most relevant factors and actions that affect the system's behaviour.	Analyses and interprets the main factors and actions (political, economic, social, environmental) that affect the system's behaviour.	Analyses and interprets all the important factors and actions (political, economic, social, environmental) that affect the system's behaviour.
Literature 15%	No work submitted	No literature is used.	Literature used is limited and mainly irrelevant to the problem stated.	Literature used is only partially relevant to the problem stated.	Literature used is relevant in most places but lacks variety in the types of sources (e.g. reviews, reports, articles). The perspectives,	Literature used is relevant but with some lapses. A limited variety of sources is used to attempt to understand the perspectives of some relevant stakeholders	Relevant literature and a variety of sources are used to explore the perspectives, values and worldviews of the most relevant stakeholders involved. Their influence and power	Highly relevant literature and a wide variety of complementary sources are used to explore the perspectives, values and worldviews of the main stakeholders involved. Their	Highly relevant literature and a well-chosen variety of complementary sources are used to explore the perspectives, values and worldviews of all involved stakeholders. Their influence and power on the issue are discussed throughout.

					values or worldviews of stakeholders are not considered.	involved. Some attempt to discuss their influence or power on the issue.	on the issue are discussed in some places.	influence and power on the issue are discussed in most places.	
Critical thinking skills: Analysis, evaluation, and synthesis **20%**	No work submitted	Descriptive account with no analysis, no synthesis, and no evaluation.	Descriptive account of the literature. No analysis of the information collected from site visits.	Descriptive account with limited analysis of the literature and the information collected. Does not identify challenges, barriers, or alternatives to the implementation of solutions to the problem.	Primarily descriptive account with some analysis of the literature and the information collected from site visits. Some attempts to synthesise and evaluate the challenges, barriers, and alternatives to the implementation of solutions to the problem, with marked lapses.	Makes an attempt to identify criteria and assess the information collected (from literature and site visits) but some lapses are evident with respect to generating judgments about the challenges, barriers, and alternatives to the implementation of one or more solutions to the problem. Good analysis and synthesis of evidence, with some evaluation.	Uses valid criteria to assess the information collected (from literature and site visits) and generate judgments about the challenges, barriers, and alternatives to the implementation of one or more solutions to the problem. Good analysis, synthesis and evaluation of evidence in most places.	Uses selected criteria to assess the information collected (from literature and site visits) and generate judgments about the challenges, barriers, and alternatives to the effective implementation of various solutions to the problem. Excellent analysis, synthesis and evaluation of evidence throughout.	Uses well-chosen criteria to assess the information collected (from literature and site visits) and generate valid judgments about the challenges, barriers, and alternatives to the effective implementation of various solutions to the problem. Insightful analysis, synthesis and evaluation of evidence throughout.
Recommendations 10%	No work submitted	No recommendations are made.	Weak recommendations are made that are not based on the analysis of problem, the literature and the judgements made. Feasibility of	Weak recommendations are made and partially based on the analysis of the problem, the literature or the judgements made. The practicality,	Makes relevant recommendations that are based on the analysis of the problem, the literature and the judgements made with some attempt to synthesise and evaluate.	Makes relevant recommendations that are based on a good analysis and synthesis with some evaluation of the problem, the literature, and the judgements made. The practicality, cost-effectiveness and social	Makes relevant recommendations that are based on a good analysis, synthesis and evaluation of the problem, the literature, and the judgements made. The practicality, cost-effectiveness and social acceptance of	Makes relevant recommendations that are based on an excellent analysis, synthesis and evaluation of the problem, the information collected, and the judgements made. The practicality, cost-effectiveness and	Makes relevant recommendations that are strongly based on an insightful analysis of the problem, the information collected, and the judgements made. The practicality, cost-effectiveness and social acceptance for each recommendation are discussed and supported

			the recommendations is described, but this is unclear in most places.	cost effectiveness or social acceptance is discussed but lacks basis in evidence. No synthesis or evaluation.	Attempts to discuss the practicality, cost-effectiveness and social acceptance of each recommendation, with marked lapses.	acceptance of each recommendation are discussed and grounded in evidence in most places, but the quality of arguments may vary across recommendations.	each recommendation are discussed and grounded in evidence in most places.	social acceptance for each recommendation are grounded in evidence throughout.	with robust arguments throughout.
Structure and communication 15%	No work submitted	The text is unclear and poorly structured.	Poorly structured and written. Frequent grammatical and spelling errors.	Unclear and inconsistent structure and writing. Contains grammatical and spelling errors.	Clear structure and writing, but with lapses. The grammar could be more polished.	Well-structured essay with clear writing and good grammar in most places.	Well-structured essay with clear writing and good grammar throughout.	The essay is easy to follow and well-structured. There is clear writing and good grammar throughout.	The essay is compelling and insightful. It is easy to follow and well-structured. Clear writing ensures that it flows throughout.
Referencing 10%	No work submitted	No references are included.	References and citations are missing, flawed or irrelevant.	References and citations contain omissions and errors, including formatting errors.	References and citations contain a few omissions or errors and/or are not appropriately formatted.	References and citations are complete or almost complete, and appropriately formatted in most places.	References and citations are complete and appropriately formatted in most places.	PLEASE DO NOT CLICK HERE	References and citations are complete and appropriately formatted throughout.
Final check not weighted 0%	The work is not submitted or does not include any of the most basic elements to be assessed.	Does not meet the basic requirements of a Master's degree. The work is poorly written, unclear or poorly	Does not meet the basic requirements of a Master's degree. The work is descriptive and does not engage with critical thinking skills. No or weak	Does not meet the basic requirements of a Master's degree. The work is mainly descriptive and contains some analysis. Does not synthesise or evaluate	Meets the basic requirements of a Master's degree. Primarily descriptive and analytical. Shows engagement with synthesis and evaluation of different viewpoints in	Meets the expected requirements of a Master's degree. Demonstrates engagement with critical thinking skills in most places, with some lapses. Descriptive passages still obvious, but makes good recommendations	Exceeds the expected requirements of a Master's degree. Engagement with critical thinking skills in most places. Develops strong recommendations based on analysis, synthesis and evaluation of multiple alternatives and	Goes beyond what would be expected from a Master's student. Uses robust critical thinking skills throughout to develop strong and insightful recommendations or conclusions. Touches on novelty in some places.	Goes well beyond what would be expected from a Master's student constantly and systematically in all aspects.

		structured.	recommendations	viewpoints. Weak recommendations are drawn from the work.	places but the recommendations made do not address clearly the feasibility issues (challenges and barriers).	from the analysis, synthesis and evaluation of multiple alternatives and viewpoints.	viewpoints. Insightful in places.		

Table 2. CEP Marking Rubric: consultancy reports

Performance levels	Poor (F-Fail)				Satisfactory (C-Pass)	Good (B-Merit)	Excellent (A-Distinction)		
Criteria	**0%**	**25%**	**35%**	**45%**	**55%**	**65%**	**75%**	**85%**	**100%**
Problem statement 5% (systems thinking)	No work submitted	No problem definition or representation of the system is developed.	Develops a representation of the system that is inaccurate. The problem statement is very unclear and vague.	Develops a fragmented or incomplete representation of the system. The problem statement is unclear or poorly defined	Develops a descriptive representation of the system (parts, relationships, properties) but with marked lapses and some attempt to define the problem.	Develops a complete representation of the system (parts, relationships, properties) that leads to a good definition of the problem but with some lapses.	Develops a complete representation of the system (parts, relationships, properties) that leads to a concise definition of the problem.	Develops a complete and holistic representation of the system (parts, relationships, properties) that leads to a tight delineation of the problem's contours.	Develops an insightful and holistic representation of the system (parts, relationships, properties) that leads to a tight delineation of the problem's contours.
System analysis 15% (systems thinking)	No work submitted	No factors or actions that affect the system's behaviour are identified.	Factors or actions identified are irrelevant or do not affect the system's behaviour.	Factors and actions identified are relevant, but it is not clear how they affect the system's behaviour.	Analyses and interprets relevant factors and actions that affect the system's behaviour.	Analyses and interprets some but not all the relevant factors and actions that affect the system's behaviour.	Analyses and interprets the most relevant factors and actions that affect the system's behaviour.	Analyses and interprets the main factors and actions (political, economic, social, environmental) that affect the system's behaviour.	Analyses and interprets all the important factors and actions (political, economic, social, environmental) that affect the system's behaviour.
Background analysis 10% (Decision making and value thinking)	No work submitted	No analysis of the situation.	Poor analysis of the situation.	The context of the problem is not described or is based on a poor analysis of the situation with marked lapses throughout.	The context of the problem is described. It is based on partial analysis of the situation.	The context of the problem is described and analysed. It is based on partial synthesis and partial evaluation of institutional, social, technological, and historical contexts.	The context of the problem is described and analysed. It is based on good synthesis and partial	The context of the problem is described and analysed throughout. It is based on good synthesis and evaluation of the	The context of the problem is described and analysed throughout. It is based on excellent synthesis and evaluation of the institutional, social, technological, and historical contexts.

					The perspectives, values, worldviews and influencing power of stakeholders and clients are not considered.	Some attempt to discuss the perspectives, values and worldviews of some relevant stakeholders and clients or their influencing power on the issue.	evaluation of the institutional, social, technological, and historical contexts. The perspectives, values and worldviews of the most relevant stakeholders and clients involved are assessed and their influencing power on the issue are discussed in some places.	institutional, social, technological, and historical contexts. The perspectives, values and worldviews of the main stakeholders and clients involved are assessed and their influencing power on the issue are discussed in most places.	The perspectives, values and worldviews of involved stakeholders and clients are assessed and their influencing power on the issue are discussed throughout.
Methodology & Tools application 30% (critical thinking and research skills)	No work submitted	Descriptive account with no analysis, no synthesis, and no evaluation.	Descriptive account of the literature. No data is generated from decision-making tools or no analysis of the data.	Descriptive account with limited analysis of the data generated from decision-making tools. Does not identify challenges, barriers, or alternatives to the	Primarily descriptive account with some analysis of the data generated from decision-making tools. Some attempts to synthesise and evaluate the challenges, barriers, and alternatives to the implementation of the proposed	Makes an attempt to identify criteria to generate data from decision-making tools but some lapses are evident as to making judgments about the challenges, barriers, and alternatives to the implementation of one or more strategies. Good	Uses valid criteria to generate data from decision-making tools and makes judgments about the challenges, barriers,	Uses selected criteria to generate data from decision-making tools and makes judgments about the challenges, barriers, and alternatives to the effective	Uses well-chosen criteria to generate data from decision-making tools and makes valid judgments about the challenges, barriers, and alternatives to the effective implementation of various strategies. Insightful analysis, synthesis and evaluation of evidence throughout.

				implementation of the proposed strategy.	strategy, with marked lapses.	analysis and synthesis of evidence, with some evaluation.	and alternatives to the implementation of one or more strategies. Good analysis, synthesis and evaluation of evidence in most places.	implementation of various strategies. Excellent analysis, synthesis and evaluation of evidence throughout.	
Strategy, solutions & recommendations 30% **(strategic and future thinking)**	No work submitted	No strategy is developed.	Weak strategy is developed which is not based on the analysis of the problem or the data. No discussion is included of the implementation timescale or the social, financial and environmental impacts of the strategy.	Weak strategy is developed and partially based on the analysis of the problem, the data or the judgements made. The implementation timescale and the social, financial and environmental impacts of the strategy are discussed but lack basis in evidence. No synthesis or evaluation.	Develops a strategy that is based on the analysis of the problem, the data and the judgements made with some attempt to synthesise and evaluate. Attempts to discuss the implementation timescale and the social, financial and environmental impacts of the strategy, with marked lapses. Does not question assumptions, uncertainties or limitations.	Develops a relevant strategy that is based on a good analysis and synthesis with some evaluation of the problem, the data, and the judgements made. The implementation timescale and the social, financial and environmental impacts of the strategy are discussed and grounded in evidence in most places, but some arguments may need further development. Does not question assumptions, uncertainties or limitations.	Develops a relevant strategy that is based on a good analysis, synthesis and evaluation of the problem, the data, and the judgements made. The implementation timescale and the social, financial and environmen	Develops an insightful strategy that is based on an excellent analysis, synthesis and evaluation of the problem, the data, and the judgements made. The implementation timescale and the social, financial and environmental impacts of the strategy are grounded in evidence throughout. Questions assumptions,	Develops a robust strategy that is strongly based on an insightful analysis of the problem, the data, and the judgements made. The implementation timescale and the social, financial and environmental impacts of the strategy are discussed and supported with robust arguments throughout. Strongly questions assumptions, uncertainties, and limitations.

							tal impacts of the strategy are discussed and grounded in evidence in most places. Partially questions assumptions, uncertainties or limitations.	uncertainties, and limitations.	
Structure, referencing & appendices 10% (effective communication)	No work submitted	The text is unclear and poorly structured. No references are included. No appendices.	Poorly structured and written. References and citations are missing, flawed or irrelevant. Appendices are missing, illegible, or contain major errors.	Unclear and inconsistent structure and writing. References and citations contain omissions and formatting errors. Appendices are irrelevant or contain errors.	Clear structure and writing, but with lapses. References and citations contain a few omissions or errors and/or are not appropriately formatted. Appendices are not complete or not mentioned in the text.	Well-structured report with clear writing. References and citations are almost complete, and appropriately formatted in most places. Legible appendices are added but may not be appropriately explained in the text Or some supporting data in the text should go in the appendix.	Well-structured report with clear writing. References and citations are complete and appropriately formatted in most places. All supporting data is presented as appendices that are legible, relevant, and appropriatel	The report is easy to follow and well-structured. References and citations are complete and appropriately formatted throughout. All supporting data is presented as appendices that are legible, relevant, and appropriately explained in the text.	The report is compelling and insightful. References and citations are complete and appropriately formatted throughout. All supporting data is presented as appendices that are legible, relevant, and appropriately explained in the text.

							y explained in the text.		
Final check not weighted 0%	The work is not submitted or does not include any of the most basic elements to be assessed.	Does not meet the basic requirements of a Master's degree. The work is poorly written, unclear or poorly structured.	Does not meet the basic requirements of a Master's degree. The work is descriptive and does not engage with critical thinking skills. No or weak strategy is developed.	Does not meet the basic requirements of a Master's degree. The work is mainly descriptive and contains some analysis. Does not synthesise or evaluate viewpoints. A weak strategy is developed.	Meets the basic requirements of a Master's degree. Primarily descriptive and analytical. Shows engagement with synthesis and evaluation of different viewpoints in places but the strategy developed does not address clearly the feasibility issues (challenges and barriers).	Meets the expected requirements of a Master's degree. Demonstrates engagement with critical thinking skills in most places, with some lapses. Descriptive passages still obvious, but develops a good strategy from the analysis, synthesis and evaluation of multiple alternatives and viewpoints.	Exceeds the expected requirements of a Master's degree. Engagement with critical thinking skills in most places. Develops a strong strategy based on analysis, synthesis and evaluation of multiple alternatives and viewpoints. Insightful in places.	Goes beyond what would be expected from a Master's student. Uses robust critical thinking skills throughout to develop a strong and insightful strategy or conclusions. Touches on novelty in some places.	Goes well beyond what would be expected from a Master's student constantly and systematically in all aspects.

Table 3. CEP marking rubric: oral presentations

Client (Group):

Performance level	F-Fail	Poor (D-Fail)	Satisfactory (C-Pass)	Good (B-Merit)	Excellent (A-Distinction)		Group score
Criteria per group	1	2	3	4	5	6	(1-6)
Slides (15% weight)	The slides lack clarity and structure. Little or no use of graphs/tables/images.	The slides are used ineffectively (i.e. too many slides or too little slides), poorly structured, too wordy or poorly formatted. Little use of graphs/tables/images or these are irrelevant.	The presentation includes some visual aids that complemented the speech, but the slides are poorly designed, too wordy or poorly formatted. Graphs/tables/images are not described, explained or referred to.	The presentation includes visual aids that are engaging in some places. The slides are used to complement the speech in places. Some of the graphs/tables/images are not described, explained or referred to.	The presentation includes visual aids that are engaging throughout. The slides are used to complement the speech throughout. Legible graphs/tables/images are described and explained in most places.	The presentation includes visual aids that are captivating throughout. The slides are used effectively to enhance the speech. Legible graphs/tables/images are described and explained throughout.	
Content (70% weight)	The presentation does not address the client's question, is unclear or contains major errors and inconsistencies.	The client's question is weakly addressed, unclear problem statement, no aims, no methods proposed.	The content is partially relevant to address the client's question with a clear problem statement, but an attempted scoping of the aims and objectives and an attempt to justify the methods proposed.	The content is mostly relevant, addresses the client's question with clearly defined problem statement. The aims and objectives are defined and the proposed methods are justified.	The content is relevant throughout, addresses the client's question with clearly defined problem statement, well-scoped aims and objectives, and well-argued methods.	The content is highly relevant, follows a storyline that addresses the client's question with clearly framed problem statement, precise well-scoped aims and objectives, and well-argued methods.	

Comments_____

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Student Name:

Performance level	F-Fail	Poor (D-Fail)	Satisfactory (C-Pass)	Good (B-Merit)	Excellent (A-Distinction)		Individual score (1-6)
Individual Criteria	1	2	3	4	5	6	
Verbal/non-verbal communication skills + timing (15% weight)	Does not meet the basic requirements of a Master's degree. Poor performance on all criteria considered (clarity of speech, pace, volume, enthusiasm, confidence, eye contact, tone, body language, audience questions)	Does not meet the basic requirements of a Master's degree. Minimal performance on most of the criteria considered (clarity of speech, pace, volume, enthusiasm, confidence, eye contact, tone, body language, audience questions).	Meets the basic requirements of a Master's degree. Speaks clearly at a suitable pace and volume but with some hesitation and no enthusiasm; minimal eye contact or dependence on notes. Attempts to respond to most questions but some responses are inaccurate. Delivers the presentation within allocated time but some points are missing.	Meets the expected requirements of a Master's degree. Speaks clearly at a suitable pace and volume with little enthusiasm or confidence; using sporadic eye contact or body language that maintain the interest of the audience. Attempts to respond to most questions accurately. Delivers the presentation within allocated time.	Exceeds the expected requirements of a Master's degree. Conveys meaning effectively with enthusiasm and confidence, speaks clearly at an appropriate pace and volume; regularly using eye contact and body language to engage the audience. Responds to most questions accurately. The presentation is concise and delivered within allocated time.	Goes beyond what would be expected from a Master's student. Conveys meaning with visible enthusiasm and confidence; speaks at a comfortable pace, clearly and loudly enough to be heard; constantly using eye contact, lively tones, gestures, and body language that hold the attention of the audience. Responds to all questions accurately. The presentation is concise and delivered within allocated time.	

Comments_____

_____

Appendix E Supplementary material for the application of the assessment framework in primary and secondary schools

Primary School

Year 6

Questionnaire

Question 1: Where and when do you use energy? List at least 5 things.

Question 2: Which light bulb saves more energy, A or B? Why?

Question 3: Which of the following energy sources are renewable and which are non-renewable? Put the following words in the correct column: Waves, oil, gas, wind, coal, sun, water, nuclear, biofuels Question 4: Which energy sources are better for the environment and people: Renewable or Non-renewable? Explain why.

Question 5: Where does the electricity you use at your school come from: A. On sunny days? B. On cloudy days? Explain why.

Question 6: When do you use less electricity at school, on weekdays or weekends? Explain why.

Question 7: How can you save energy at school and at home? Give at least 3 tips for each.

Pupil feedback

The pupils mostly felt great and confident about the activities as they had fun, learnt a lot about energy sources, how energy is used at school and how they can save energy and help the environment (empowered to take action and make a difference). Some students felt confused and less confident about their ability to use the ecoDriver tool. They would like their future learning to include: comparing different schools' energy use, exploring the energy challenges in more depth, finding out how much energy and water the world uses, helping their city use less energy, calculating fossil fuel use/year, trying energy saving at home, exploring more types of energy, the financial gain/cost from using solar panels, how much energy solar panels produce, comparing changes of energy use in longer periods, having more time to work with ecoDriver and use it to make their own graphs. They identified as learning worth sharing with others the amount of energy the school uses every day, how to use the ecoDriver tool and that food, water and energy are linked.

Teacher feedback

The teachers enjoyed the entire lesson and felt happy, excited and inspired to be part of it. They felt the most interesting part of it was discussing with the students the pros and cons of different energy sources, which made them consider about the wider argument of energy. They would have liked the activities to be more pupil-led and spread across more lessons, but felt the activities were very relevant to their teaching. They would like this conversation about energy to occur throughout the school. Lastly, they thought the activity was fair and balanced, the content well-organised, the

teaching methods appropriate and the students became engaged and enjoyed it; overall it was successful to a great extent.

Year 5

Pupil feedback

Pupils felt more aware about the water they use every day, learnt about the importance of water, some were sad to know how much water is wasted, but overall they felt excited about doing the activities as they learnt a lot and were surprised about the facts regarding direct and virtual human water consumption. They would like their future earing to include: learning about rives and doing outdoor lessons, setting a water challenge for the whole school, doing robotics related to solving water challenges, helping other people who do not have access to water gain access by reducing consumption in areas where it is high, developing a water re-using building, reducing the amount of water people use to make things, helping save aquatic creatures and inform people about their water use. They identified as learning worth sharing with others: direct water use per day, water used to make the products we use every day such as vegetables and clothes, **we should eat seasonal food**, water, food and energy are linked in many ways, **the tomatoes we buy in the winter come from abroad and grow on more water**, **we use greenhouses to control vegetable growth, tomatoes in Spain are grown all year round and that food production uses a lot of water**. These last student learnings' show their ability to link water use with food production and are worth exploring further.

Teacher feedback

The teachers enjoyed the entire lesson, felt happy, interested and surprised. They believe pupils enjoyed the lesson very much as they liked learning the facts about water use but would have liked more hands-on activity. The content was relevant to their teaching and interesting as it was linked to real life. Their suggestion would be to split it up into more sessions so that the information provided is more manageable for the students. They think pupils developed their thinking, collaborated, explored new topics, came up with new ideas, estimated and linked learning to real life. Overall, the lesson was successful.

Year 4

Questionnaire

Question 1: What is organic food?

Question 2: Why do you think organic food is good for you? Can you think of some problems or challenges with organic food?

Question 3. Can you guess the origin of each fruit (UK or overseas)? Tick under the column you think is the best fit.

Questions 4. Which of the following foods are harvested in the summer and which in autumn? Strawberries, tomatoes, lettuce, pumpkins, carrots, cabbage, apples, pears. Write in the appropriate space below.

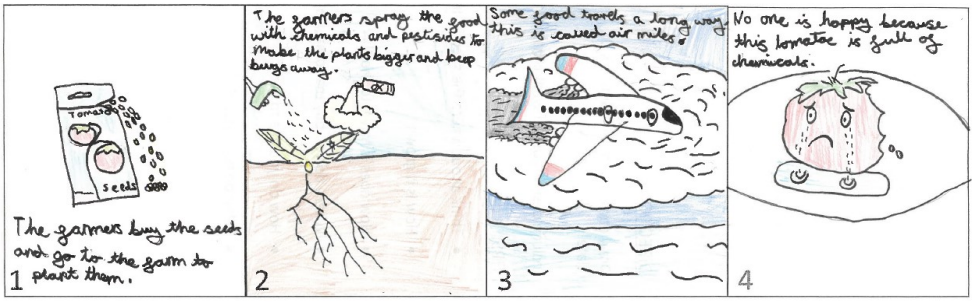
Question 5. Why is it important to recycle our food waste?

Question 6. Circle how much you like eating the following fruits and vegetables.

Storyboard examples

LOCAL ORGANIC TOMATO

CONVENTIONAL TOMATO



LOCAL ORGANIC TOMATO

CONVENTIONAL TOMATO

Secondary School

Year 9

Table 1. Competences assessed and statements used in the self-assessment questionnaire

Competence	Statement
Systems or bigger picture thinking	I can explain both the root causes, and the effects of our chosen problem
	I can explain how the problem affects my school
	I can explain how the problem affects my community
	I can explain how the problem affects my country
	I can explain how the problem affects the world
Metacognitive/reflective thinking/Independent learner	I can explain why we selected the specific problem to work on
	I can explain why the solution selected is appropriate for the problem
	I can identify the limitations of the solution we suggested
	I can evaluate the effectiveness of our solution
Critical thinking	I can identify problems related to the SDGs
	I can link the problem we identified to one or more SDGs
	I can identify sources of information related to the problem we identified
	I can combine information from various sources to understand the problem
	I can select the most appropriate information to include in my work
Self-regulation	I can cope with failure during doing my work for the Global Goals Course
	I can manage my own learning during the Global Goals Course I can reflect on my work and make changes if needed
	I can cope with complex problems
Collaboration	I can collaborate with my team members
	I can understand my team members' needs
	I can work as part of a team
	I can give constructive and helpful feedback to my team members about their work
	I am open to receive feedback from team members about my work
Problem-solving and action/agency	I can mention existing solutions to the problem
	I can propose new solutions to the problem
	I can communicate our solution to other people effectively
	I can develop a plan to implement the solution we suggested

Table 2. Competences assessed and statements used in the team-assessment questionnaire

Competence	Statement
Teamwork	All members of our team have clear roles
	Everyone contributes to the project
	Everyone does their own part of the work
	We have developed a plan about the project
	We plan our project steps together
	We all work to achieve our common goal
	We are able to present and communicate our work effectively
	We work well together
Difficulty coping as a team	We need plenty of support to work as a team
	Some team members are following their own ideas
	Some team members are not committed to the work
	We struggle with project complexity
	We have difficulty agreeing what to do
Team work regulation	We reflect on our project and make improvements
	We divide the work between us fairly
	We show high responsibility doing our work
	We are flexible to consider new directions for our work
	We listen to each other and include all opinions
	We overcome project difficulties by open discussion
	We encourage each other to do the work
	We overcome conflict in a peaceful way

Appendix F Supplementary material for the application of the systemic framework in educator training workshops as part of a WIA

Table 1. Self-assessment rubric for Higher Education Institutions to evaluate the integration of the SDGs as part of a Whole Institution Approach

Integration of the SDGs as a Whole Institution Approach in Higher Education

Self-assessment rubric (please tick in the box that best describes your institution) **Institutional Dimension:**	**Not fulfilled (=0)**	**Partially Fulfilled (=1)**	**Fulfilled (=2)**
1. Outcomes			
1.1 Educational outcomes related to S/SD/SDGs for all courses and modules*			
1.2 Key Sustainability competences for students defined			
1.3 Focusing on community problem-solving and wellbeing			
1.4 Including cognitive, non-cognitive (behavioural, socio-emotional) and meta-cognitive dimensions			
1.5 Promoting knowledge (theory), skills (methods) and attitudes (values and emotions)			
2. Culture			
2.1 Participatory decision-making (including all relevant stakeholders: internal and external)			
2.2 Shared leadership among faculty, non-academic staff and students			
2.3 Sustainability-related leadership as norm (role models and support)			
2.4 Sustainability outreach events (school programmes, conferences, seminars, campaigns and workshops)			
2.5 Sustainability awards or recognitions for faculty, non-academic staff and students			
2.6 Project partnerships at local, regional, national and international level			
2.7 Equality, diversity and inclusion policies implemented and safeguarded			
2.8 Sustainability values agreed and highlighted in every aspect of the Institution			
3. Pedagogy (Teaching and Learning)			
3.1 Active-learning methodology (engaging the students in (inter)action)			

3.2 Learner-centred teaching (teacher as facilitator)			
3.3 Project and problem-based teaching (inter and transdisciplinary projects to solve local and global problems)			
3.4 Collaborative/cooperative learning (group work)			
3.5 Constructivism/social constructivism theory (links new concepts to students' prior ideas and zone of proximal development)			
4. Curriculum			
4.1 Integration of S/SD/SDGs in courses/modules			
4.2 Provision of rich S/SD/SDGs learning experiences to students (on and off-campus activities, seminars, conferences, internships, collaborative projects with various stakeholders, invited talks, campaigns etc.)			
4.3 Fosters the defined Sustainability competences and educational outcomes			
4.4 Content linkages with the SDGs			
4.5 Combination of research-driven and practice-based methodologies			
5. Research			
5.1 Inter and trans-disciplinary research (projects, groups) on S/SD/SDGs coordinated by faculty			
5.2 Students pursuing research in S/SD/SDGs			
5.3 Grants/funding for S/SD/SDGs research			
5.4 Policies for Sustainability research			
5.5 Publications in the area of S/SD/SDGs			
5.6 Ethical guidelines for SD research			
5.7 Professorships/Chairs on SD			

6. Assessment			
6.1 Formative and summative assessment modes (portfolio, reflection journal, interviews, focus groups, personalised feedback, self and peer assessments, etc.)			
6.2 Assessing cognitive, behavioural and socio-emotional objectives			
6.3 Competence based assessment with clear and transparent criteria for the different levels of performance			
7. Governance			
7.1 Integration of S/SD/SDGs in the general vision			
7.2 Signed an existing Sustainability charter/adopted an ESD declaration (Earth Charter, Incheon, Aichi-Nagoya, Brussels, SDGs, ASPnet, UNESCO chairs)			
7.3 Defined a specific S/SD/SDGs mission for the Institution			
7.4 Establishment and implementation of S/SD/SDGs policies (non-research) (related to all aspects covered by the SDGs)			
7.5 Sustainability-related coordinator/champion/committee and office			
7.6 S/SD/SDGs related strategies, monitoring and evaluation			
7.8 Business model aligned with Sustainability principles			
8. Professional practice and development (academic, research)			
8.1 Professional training programmes for research methodologies			
8.2 Professional training programmes for educational methodologies			
8.3 Mentoring programmes for research			
8.4 Mentoring programmes for education			
8.5 Peer support groups for research			

8.6 Peer support groups for education			
9. Infrastructure/resources/operations (human, material, abstract)			
9.1 Allocated funding for (non-research) Sustainability projects			
9.2 Sustainability reporting (quarterly, biannually or annually)			
9.3 Dedicated career advice for Sustainability professions			
9.4 Credit-requirements related to Sustainability courses/projects/initiatives for students and staff			
9.5 Sustainability criteria included in institutional quality assessments			
9.6 Sustainable water, energy and food usage and sourcing, sustainable waste treatment and recycling, net zero emission targets			
9.7 Transparent and democratic information sharing, communication and decision-making processes			
9.8 Student and staff wellbeing programs			
9.9 Sustainable on and off campus transport			
9.10 Sustainable campus and surroundings (building, biodiversity and landscape)			
9.11 Administrative support for Sustainability courses and projects			
9.12 Monitoring and evaluation of S/SD/SDGs integration into curricula, research, culture, governance and operations			
9.13 Student and staff Sustainability, equality, diversity and inclusion survey (needs, feedback, satisfaction, suggestions)			
9.14 Technical equipment for Sustainability education and research activities (classrooms, laboratories, libraries, software etc.)			
9.15 Implementing alternative business models, investing in fair trade and generating social impact			
10. Context (local, regional, global)			
10.1 Alignment to professional demand for Sustainability competences from industry, business and government			

10.2 Implementation of national or international ESD/SDGs policies or agendas			
10.3 Funding opportunities for S/SD/SDGs projects at the national or international level			
10.4 Alignment with SD/SDGs priorities of external stakeholders (industry, business, government, civil society)			
10.5 Collaboration and best practice/expertise sharing with other universities/organisations			

*S/SD/SDGs = Sustainability, Sustainable Development , Sustainable Development Goals

Table 2. Canvas for Higher Education Institutions to implement our systemic framework around linking their educational outcomes to the SDGs

Sustainable Community Change Framework for Higher Education Institutions

1. Vision (visioning)

What is the sustainability vision we would like to achieve for our institution? Imagine an ideal situation and articulate it, be creative.

How does this vision link to the SDGs? Use SDGs handout.

3. Enabling Conditions / Barriers (backcasting)

What do we already have/need to put in place for our vision to materialise? Use the fishbone diagram.

What factors could enable or adversely affect the realisation of our vision? Brainstorm.

5a. Competences

What kind of knowledge, skills, values and attitudes should we develop in our community members so we can achieve our vision? Use the competences handout.

2. Stakeholders (participatory approach)

Who will be involved to realise the vision? Brainstorm various groups.

How will they be involved? Use the stakeholder template handout.

4. Progress Monitoring and Evaluation (indicators)

What are the metrics that will define progress toward our vision? Write at least 3.

1.

2.

3.

5b. Whole Institution Approach

How can we thoroughly integrate sustainability into our institution? Use the self-assessment handout (add score in the brackets).

Research [ ]

Curriculum [ ] and Outcomes [ ]

Pedagogy [ ] and Assessment [ ]

Culture [ ] and Governance [ ]

Professional Practice [ ]

Infrastructure/resources [ ] and Context [ ]

TIMELINE

Actions by the end of 3 months (What, Who, How)

TIMELINE

Actions by the end of 6 months (What, Who, How)

TIMELINE

Actions by the end of 12 months (What, Who, How)