COMMENTARY

WILEY

Embedding environmental sustainability within oral health professional curricula—Recommendations for teaching and assessment of learning outcomes

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Abstract

The FDI World Dental Federation suggests that "dentistry, as a profession, should integrate Sustainable Development Goals into daily practice and support a shift to a green economy in the pursuit of healthy lives and wellbeing for all, through all stages of life." This article reports on the recent activity of the Association for Dental Education in Europe Special Interest Group for Sustainability in Dentistry. Following on from the group's previous activities, which explored current educational practice, this work aimed to reach a pan-European consensus on a number of learning outcomes for environmental sustainability, in order to (i) support institutions in designing and delivering their curriculum, and (ii) to further harmonise the delivery of oral health professional education across Europe. This article presents specific learning outcomes relating to environmental sustainability and recommendations relating to curriculum development, including methods of teaching and assessment.

KEYWORDS
curriculum, dental, dental education, environment, sustainability

1 | BACKGROUND

The oral healthcare sector is not currently considered to be environmentally sustainable; it is a significant contributor to global greenhouse gas emissions, produces other pollutants, and generates unrecyclable waste.[1] In response to the impact of the wider healthcare sector on the environment, multiple national and international stakeholders have produced policy documents in response to the climate emergency. Such examples include the Paris Agreement,[2] the United Nations Sustainable Development Goals,[3] WHO COP reports[4] and NHS England's Delivering a "Net Zero" National Health Service Policy.[5] More recently, there are examples of dental-specific

policy documents, such as the Joint Stakeholder Statement for Consensus on Environmentally Sustainable Oral Healthcare.[6] Here, the FDI recognises the importance of collaborating with all stakeholders in the interests of sustainability—and recommends that dentistry, as a profession, should integrate Sustainable Development Goals (SDGs) into daily practice and support a shift to a green economy.

It is clear that in order to achieve these goals, Environmental Sustainability (ES) must be formally integrated into curricula for Oral Health Professionals (OHPs). In 2019, during the annual meeting of the Association for Dental Education in Europe (ADEE), a Special Interest Group (SIG) reported a consensus view regarding the

importance of ES in dental education, and raised awareness of the fact that academics need support in developing curricula relating to ES. A clear need was established for the creation of teaching materials and guidance for educators and those responsible for curriculum development.[7] Aligning with other ADEE SIG recommendations,[8] the group suggests that learning outcomes, teaching activities and assessment activities should be developed and shared collaboratively. As such, to support educators and to further harmonise the delivery of OHP education across Europe, more formal curriculum elements relating to ES need to be created. This aspiration complements recommendations from the Graduating European Dentist (GED) curriculum task force,[9] which encourage subject matter experts to collaborate and develop discipline-level learning-outcome-based curricula.

Alongside the work of this ADEE SIG, other educational networks are also beginning to report scoping activity within their member institutions. A scoping review by Martin et al.[10] found that "the lack of public and professional awareness is the greatest driver to engage with a positive change of behaviour and attitudes. Awareness through education is key at all levels and this should be the bedrock of future strategies." In 2021, Brynhildsen et al. reported a cross-sectional survey between dental schools in the UK (QMUL) and the USA (Harvard) which concluded that neither school formally taught ES—and major barriers included a lack of understanding and a lack of educational strategy and material. The paper called for training courses and materials for educators.[11] Meanwhile, Gershberg et al. carried out a cross-sectional survey among students at dental schools across the USA to assess their experiences and training in relation to sustainable dentistry.[12] Despite a low response rate (5%, $n = 378$) the data showed that a large majority of students felt that ES in dentistry was important, and yet around 75% of respondents felt poorly educated in this area. Importantly, the students made suggestions for incorporating ES into coursework relating to infection control, practice management and dental public health.

Within the wider discipline of medicine, there has been a similar (albeit more advanced) direction of travel. An Association for Medical Education in Europe consensus statement on planetary health and education for sustainable healthcare[13] recognised that inclusion of climate change in medical curricula in most countries was low (only 15%). Furthermore, the document proposes a number of applicable learning outcomes across a variety of domains that could be included within the curriculum, developed through a Delphi approach involving UK medical educators.[14] Later studies that employed the Delphi inquiry methodology have also been reported, proposing learning outcomes involving input from medical educators in wider networks including the US, India, Australia and Canada.[15] What is needed, however, to facilitate implementation at the institutional level is some guidance regarding *how* these outcomes could be taught, reinforced and observed/assessed within any given professional context.

Therefore, the aims of this consensus article from the ADEE SIG are to:

- report European consensus on suggested learning outcomes for ES in relation to the GED curriculum
- provide recommendations for teaching ES within existing OHP programmes.

2 | METHODS

The consensus was developed using a model similar to that described by Field et al.[8] This consisted of three methodological components, in keeping with Kern's model of curriculum development[16]:

(i) an initial needs analysis (involving a scoping questionnaire and a SIG discussion),
(ii) setting educational goals and objectives (consisting of a separate SIG discussion with pan-European educators to define specific learning outcomes) and, at the same time,
(iii) developing educational strategies (to include methods of teaching and assessment).

The scoping questionnaire and initial SIG discussion are reported in the first paper by the group.[7] This activity took place during the ADEE 2019 Annual Conference in Berlin. Unfortunately, due to the impact of the COVID-19 pandemic, the next annual conference (Strasbourg 2020) was postponed by a year. As such, the SIG activity resumed in time for the ADEE 2021 Annual Conference, which was held online.

2.1 | Session format

Delegates who were responsible for curriculum development in their respective schools, or who led existing elements relating to ES, were invited to attend the SIG workshop. The workshop was planned to run online using Zoom, a cloud-based collaborative video-conference platform (Zoom Video Communications Inc. 2021), chaired by the two SIG leads (JF and BD). Four breakout groups were planned (representing the 4 GED domains) and, as such, two extra facilitators were identified from the team involved in the initial paper (JD, DR). The 4 GED domains comprise (I) Professionalism, (II) Safe and Effective Clinical Practice, (III) Patient-centred Care and (IV) Dentistry in Society.

2.2 | Preparatory work for delegates

Delegates were allocated into one of the 4 breakout groups by the conference organisers to ensure reasonable representation from each geographical area and language across all groups. A week before the session, delegates were sent an email informing them of which domain they had been attributed to, along with the following documents:

- A copy of the relevant GED curriculum domain explaining and listing the existing learning outcomes
- A guide to writing and using learning outcomes
- A copy of the SIGs first paper[7]
- An infographic showing a range of verbs associated with each level of Bloom's taxonomy[17]
- A blank template for formulating some proposed learning outcomes for the relevant GED domain

The template was designed in such a way that it would facilitate constructive alignment[18] by sequentially asking:

(i) What do you intend the students to be able to do?
(ii) What is the best verb to describe this activity?
(iii) How could this be taught or reinforced?
(iv) How could this be assessed or observed?

Delegates were also encouraged to consider the existing GED learning outcomes within their domain, and whether any of these already covered aspects of ES, or whether they could be modified in some way to do so.

2.3 | The live session

The live session was online and used the Zoom video conferencing software (Zoom 2021). Delegates were made aware that the session was going to be recorded and the Zoom platform reminded delegates that this was happening and asked for the participants' consent. Without consent, it was not possible to continue with the session. The purpose of the recording was discussed in the introduction to the session—the primary purpose being that of making the session available to conference delegates at a later date. The session consisted of a brief introduction by the session chairs, which included a breakdown of the SIG activity to date. Time was spent explaining the rationale behind the workshop including discussion around how learning outcomes should be formulated. Delegates were then automatically transferred into their respective breakout rooms by the Zoom hosts (ADEE administrators). Each domain facilitator mediated a 45-min discussion around potential learning outcomes with their delegates, whilst keeping notes. The groups then re-joined the main meeting for summary discussions relating to each GED domain, before a general summary discussion at the end which included the next steps in the project.

3 | RESULTS

A total of 31 delegates, representing 12 different countries, attended the SIG workshop. Delegates were split as evenly as possible across each of the 4 GED domain breakout groups. Following discussion within the breakout groups, a number of suitable learning

outcomes and methods of teaching and assessment were devised for each of the 4 GED domains.

Following the live event, a core group continued to work on reformatting the intended learning outcomes to include information relating to:

(i) the particular GED domain that each referred to
(ii) whether the learning outcome was new or a modification of an existing learning outcome
(iii) specifically, what educators were wanting students to be able to do
(iv) how this could be taught or reinforced
(v) how this could be assessed or observed
(vi) the written learning outcome itself

The ES learning outcomes relating to the current GED domains are represented in Tables 1–4. The tables are created so that educators can see the applied methodology of constructive alignment—and the resultant learning outcomes are labelled as either "new" (if they are additional to existing GED learning outcomes) or "modified" (if they result from amendment of existing GED learning outcomes).

During the live event, the group had a significant discussion about implementation strategies following the breakout groups. These discussions included the themes below and informed the development of the learning outcomes. They are each considered in the discussion:

- Curriculum "load" and ways to avoid further congestion of the curriculum
- Environmental sustainability as a threshold concept and ways to improve understanding
- Adoption of new learning outcomes and the importance of constructive alignment
- Vertical and longitudinal integration of concepts
- The use of case studies and student involvement to support delivery
- The use of novel and innovative methods to teach and assess sustainable dentistry

4 | DISCUSSION

The discussion considers each of the themes emerging from the breakout groups, in turn.

4.1 | Curriculum "load" and ways to avoid further congesting the curriculum

It has long been acknowledged that the overloaded curriculum presents a common challenge for OHP education providers.[19,20] A clear need has now been established to teach ES within OHP curricula,

TABLE 1 Proposed learning outcomes for GED relating to environmental sustainability domain: Domain 1—Professionalism

Sub-domain? New or modified?	What do you intend the students to be able to do?	What are the best verbs to describe this?	How could it be taught or reinforced?	How could it be assessed or observed?
Ethics New	Be aware of the ethical principles relating to sustainable dentistry	List Explain Discuss Apply	• Principles can be introduced using the infographic (ref) • Principles can be reinforced through case discussions and group reflections • Reinforced at key learning events/opportunities across all programmes • Exposure longitudinally throughout a programme • Teachers can be encouraged to use and make reference various infographics to reinforce the principles as part of their teaching (see paper and also https://www.fdiworlddental.org/sustainability-dentistry)	• Students can be asked to list and explain the principles, and their potential application, by written examination • Students can be presented within a scenario (written or practical) and asked to identify/correct current practices, or discuss the impact on the environment • Students can be asked to discuss or describe one change they would make to their current practices to improve sustainability • Students can be asked to reflect on their own, or observed practice in relation to sustainability • Students can be asked to consider sustainability when developing personal development, or action plans
	• Discuss the main principles relating to sustainable oral healthcare • Explain the importance of practising sustainable oral healthcare • Discuss the challenges/barriers to implementing a sustainable approach to oral healthcare • Discuss how the ethical principles of sustainable dentistry can be applied to [present a scenario]			
Regulation Modify 1.2.5	Be aware of the sustainable development goals and current legislation relating to sustainability	Explain Discuss Comply	• A dedicated learning event(s) to introduce the background and potential impact of meeting SDGs, including any relevant legislation	• Students can be asked to research the SDGs and present a summary of how they might impact on dentistry, particularly in relation to use of personal protective equipment (PPE) and digital dentistry (material use, and travel)
	• Discuss the implications of, and be able to comply with, general legislation or regulation in areas such as health and safety legislation, infection prevention and control procedures, data protection, the use of ionising radiation *and sustainability*			
Professional behaviour New	Encourage and promote sustainable approaches within the workplace	Demonstrate	• Tacit learning, by observing teachers or clinicians • Clinical group discussion using a case-based approach • Explicit discussion within the clinical skills learning environment about materials use and environmental impact • Discussion around various lifecycle or impact models • Dissemination and championing of the 8 domains of sustainability across teaching events • Encouraging peers and the wider team to work sustainably	• Students can be assessed in the clinical or clinical skills lab environment (perhaps as part of an overall professionalism grading, or an independent grade as part of an OSCE) • Students can be asked how they would support specific SDGs or local sustainability policies as part of a written exam, or an oral exam • Students can be asked to generate explicit action plans within their academic or clinical environments to support sustainable working
	• Demonstrate a respectful approach to the environment during clinical practice • Critique current clinical practices in relation to environmental impact, and suggest realistic and practical solutions			

but this raises issues in terms of adding further content and the use of additional resources. Simply adding a standalone course for ES will be impossible in most contexts. Additionally, delivering an individual stand-alone course at one point in the curriculum prevents the important integration and longitudinal development of threshold concepts into the programme. Longitudinal integration of ES is considered essential to enable the inclusion of increasing levels of subject complexity as the student progresses. Facilitating this process

TABLE 2 Proposed learning outcomes for GED relating to environmental sustainability domain: Domain 2—Safe and effective clinical practice

Sub-domain? New or modified?	What do you intend the students to be able to do?	What are the best verbs to describe this?	How could it be taught or reinforced?	How could it be assessed or observed?
Team working and communication Modified 2.3.14	Consider environmental impacts (benefits and harm) when offering advice, devising treatment plans, or setting recall intervals for patients	Establish Consider Demonstrate	• Principles can be reinforced through case discussions and group reflections • Reinforced at key learning events/ opportunities across all programmes • Tacit learning, by observing others (peers, or staff) • Explicit discussion within the skills learning environment about materials use and environmental impact	• Students can be assessed in the clinical or skills lab environment (perhaps as part of an overall professionalism grading) • Students can be presented within a scenario (written or practical) and asked to develop a treatment plan whilst discussing the impact on the environment
	• Evaluate the results of treatment and establish an effective *and environmentally sustainable* monitoring and maintenance programme for patients, in cooperation with the wider dental team where appropriate			
Team working and communication Modified 2.4.3	Communicate environmental impacts to the wider dental team and patients, taking steps to minimise these wherever possible	Communicate Manage	• Tacit learning, by observing teachers or clinicians communicating with the team and with patients • A dedicated learning event(s) for the whole dental team, such as a symposium • Inclusion of sustainability within clinical checklists • Clinical group discussion using a case-based approach • Raising awareness of prices of materials, lifecycle analysis and disposal costs	• Students can be assessed in the clinical or skills lab environment (perhaps as part of an overall professionalism grading) • Students can be asked to discuss or describe one change they would make to their current practices to improve sustainability • Students can be assessed communicating with the team, or with patients, as part of an OSCE assessment • Students can be asked to design infographics or create patient resources • Students can be asked to role play discussions with patients and the dental team about environmental impacts

	• Effectively communicate and manage the hazards within the clinical environment including:
	  • cross-infection control
	  • hazardous materials
	  • *packing, procurement and use of resources*
	  • *impact on the environment*
	  • working with ionising radiation			

(Continues)

TABLE 2 (Continued)

Sub-domain? New or modified?	What do you intend the students to be able to do?	What are the best verbs to describe this?	How could it be taught or reinforced?	How could it be assessed or observed?
Evidence-based practice Modified 2.1.3	Evaluate advertisements and claims made by industry so that products, materials and techniques are chosen that minimise environmental impact	Evaluate Critically appraise	• Mediated discussions around real advertisements and claims • Integrating discussions about sustainability into existing critical appraisal sessions • Encouraging sympathetic engagement with industrial partners to discuss environmental impact	• Students can be assessed through case-based discussions or as part of written assessments • Students can be asked to reflect on material/ equipment choice
	• Evaluate the validity of claims made by industry, primarily in relation to the *clinical and environmental* risks, benefits and cost of products and techniques			
Management and leadership Remain unchanged 2.2.6 Modified 2.2.3	Identify areas of concern with current practice, and implement positive change	Identify Implement Manage Plan Integrate	• Tacit learning, by observing teachers or clinicians communicating with the team and with patients • A dedicated learning event(s) for the whole dental team, such as a Symposium • Clinical group discussion using a case-based approach • Elective projects	• Students can be assessed through case-based discussions or as part of written assessments • Students can be asked to reflect on material/ equipment choice • Students can be asked to discuss or describe one change they would make to their current practices to improve sustainability • Students can be assessed communicating with the team, or with patients, as part of an OSCE assessment • Students can be asked to reflect on their current practice within a longitudinal portfolio of practice • Students can be asked to make video diaries to highlight concerns

	• Consider implementing changes within the team and the wider practise environment that will significantly improve efficiency and sustainability of resources
	• Effectively integrate other members of the dental team regarding risk management, for example:
	  • working posture
	  • visual perception
	  • the use of equipment
	  • dealing with stress and burn-out
	  • cross-infection control
	  • working with hazardous chemicals and ionising radiation
	  • environmental sustainability			

TABLE 2 (Continued)

Sub-domain? New or modified?	What do you intend the students to be able to do?	What are the best verbs to describe this?	How could it be taught or reinforced?	How could it be assessed or observed?
Professional education and training Remain unchanged 2.5.1	Be aware of the environmental impact (benefit/harm) of new technology and, where possible, apply the latest technology to reduce the need for material use, patient travel, and to improve efficiencies around patient triage and assessment	Describe Discuss Apply	• Mediated discussions around published papers relating to tele-dentistry • Laboratory and clinical sessions to introduce digital workflows	• Students can be asked about technologies in written assessments • Students can be asked to critically appraise papers relating to remote consultations • Students can be asked to obtain digital records in the skills lab or on the clinic
	• Use contemporary information technology for documentation, continuing education, communication, management of information and applications related to healthcare			
Audit and risk management Remain unchanged 2.4.7	Be aware of any relevant sustainability policies (local or regulatory) and use these to audit current practice	Audit Interpret Plan	• A dedicated learning event(s) for the whole dental team, such as a symposium where audit results are discussed • Group discussion of policy and plans to implement or audit	• Students can be asked to carry out an audit e.g., waste use • Students can be asked to plan interventions based on the results on an audit
	• Interpret, implement and disseminate aspects of audit and clinical governance			

means that ES is more likely to be embedded within the graduating dentist's practices, and they are more likely to implement sustainable solutions and act as advocates for change in the profession.

It is not anticipated, nor feasible, that higher education institutions will completely change their curricula to incorporate ES. However, a curriculum review process, perhaps including curriculum mapping, can allow educators to establish an overview of the current curriculum and to identify any areas where ES could be incorporated, across the whole length of educational programmes. The commonly accepted student-centred approach to curricula, which focuses on and aligns resources to support students in developing fundamental, lifelong knowledge, skills and attitudes, may present more opportunities for educators to embed ES within their curriculum.[21,22]

4.2 | Environmental sustainability as a threshold concept and ways to improve understanding

A threshold concept is defined within the European OHP Education Glossary, Articulate,[23] as "A topic within a curriculum that, when understood, results in fundamental changes in perception and practice of other parts of the subject/discipline." In many ways, introducing and teaching ES is similar in scope to other topics such as Professionalism or Inter-Professional Education. In this regard, it is not sufficient to simply augment existing curricula with additional learning events, and learning outcomes, relating to ES. Instead, there needs to be a school or institutional-wide strategic approach. Gaining a basic understanding has been identified as a strategic need—both in the papers discussed above and also during the work with this

SIG. Teaching materials and resources that allow staff and students to develop a basic and common understanding of ES should be introduced first—and then over time, this can be built on to include other learning and assessment strategies. The suggestion from the group is that as a threshold concept, ES should be considered in everything that is delivered as part of an OHP programme—and some educators discussed the concept of a "virtual course or topic" that spans the whole curriculum. Whilst there are few learning events or materials dedicated specifically to the topic of ES, the aim is to embed sustainable approaches into the rest of the curriculum.

4.3 | Adopting new learning outcomes and the importance of constructive alignment

Constructive alignment is defined within the Articulate glossary[23] as "The design of learning activities and assessment tasks to support the intended learning outcomes of a programme." One of the aims of this SIG was to determine ways in which learning outcomes relating to ES can be taught and assessed within the curriculum. As such, the group is aligning with this approach. Educators can utilise the suggestions provided in Tables 1–4 to construct their curricula carefully—either by working backwards from the intended assessment methods, to decide the best way to deliver the learning material—or by beginning with the teaching methods and then constructing assessments based on the original learning outcomes. Either way, this process avoids the pitfall of introducing learning outcomes, without ever introducing relevant and aligned teaching or assessment activities.

TABLE 3 Proposed learning outcomes for GED relating to environmental sustainability domain: Domain 3—Patient centred care

Sub-domain? New or modified?	What do you intend the students to be able to do?	What are the best verbs to describe this?	How could it be taught or reinforced?	How could it be assessed or observed?
Scientific basis (3.1) New	Recall the evidence base surrounding sustainable approaches to dentistry, and rationalise the methods used to determine the environmental impact of materials and methods	Describe Explain Apply	• Case-based discussion, incorporating cases of a variety of patients, all with different dental histories and oral health needs. Raise awareness of environmental impact of oral healthcare delivery for these different patient groups. • Videos, blogs and podcasts from key stakeholders • Online resources to test and orient the cohort such as SuliTest	• Short answer vignettes • Written reflective reports • Reflective portfolio entries after clinical encounter • Life cycle analyses
	• Apply the scientific knowledge base in relation to the environmental impacts of common treatment methods, and common approaches to the delivery of care • List the main elements of the life-cycle analysis (LCA) process			

Treatment planning (3.3) New	Make informed decisions based on how their choice of treatment or the delivery of care can impact more widely on the environment	Apply Explain Demonstrate	• The use of infographics to demonstrate the environmental impacts of
			  • Importance of planning treatment (including number of appointments)
			  • Repeat or multiple visits
			  • A shift to remote consultation
			  • Antibiotic use
			  • Effective prevention and the need for less intervention
			  • Single use items
			• Case-based discussion
			• Videos, blogs and podcasts from key stakeholders
				• Clinical gradings for treatment planning
				• Case based discussions
				• OSLER

	• Rationalise patient-centred approaches to oral health, that are consistent with maintaining environmental and planetary health			
Establishing and maintaining oral health (3.4) New	Work efficiently and effectively to promote prevention and reduce the need for further oral healthcare intervention in their patient base	Demonstrate Deliver Develop	• Treatment planning and forecasting of the delivery of care (projected treatment plans indicating visits needed, time allocation, material use, etc.) • Case-based discussion • Impact case studies	• As an explicit component of case presentations or written reflective reports • Clinical gradings for treatment planning • Case-based discussion • OSLER
	• Develop effective patient-specific strategies for preventive oral health, reducing the need for recall, operative intervention and material use			

4.4 | Vertical and longitudinal integration of concepts

Whilst it is recommended that the concept of ES should incorporate across the breadth of the curriculum, what does this mean in practice? The suggestion is that ES is incorporated both vertically (integration between the clinical and basic science stages of the curriculum) and horizontally (integrating across subjects in any given year, and across programmes). In essence, the key to curriculum integration is the need to address the learners' knowledge gaps:

• *What is ES?*—Creating awareness through exploration of the environmental impacts of the provision of oral healthcare and normalising the concept at a local level.
• *What can I do?*—Identification of specific actions that can be achieved at an individual level and as part of the larger "oral healthcare industry and associated supply chain" by working collaboratively across all sectors.
• *How can I do it?*—Understanding that the main aspect of the work provided by an OHP is associated with preventable diseases and as such this is where the greatest environmental

TABLE 4   Proposed learning outcomes for GED relating to environmental sustainability domain: Domain 4—Dentistry in society

Sub-domain? New or modified?	What do you intend the students to be able to do?	What are the best verbs to describe this?	How could it be taught or reinforced?	How could it be assessed or observed?
Health promotion and disease prevention 4.2.4 Modified	Advocate for improving population health in general, through public health initiatives, recognising that less individual treatment need is required—and to discuss the potential beneficial impact that this might have on the use of materials and resources and the environment	Discuss Describe Explain Rationalise	• Impact case studies demonstrating the impact on population need, treatment cost, material use and the environment, for various types of public health initiative • Root cause analyses to help students to rationalise cause and effect • Embedded within the Dental Public Health aspects of programmes • Outreach events or symposia with relevant student groups or societies • Introduce the concept of health harm (e.g., in Daily Affected Life Years) for different healthcare interventions • Identify the common values between sustainable development and health promotion such as individual and collective responsibility, respect for others and solidarity, participation of people in decisions that affect them, social justice • Identify the common collective levers for change: advocacy, social commitment, legislative and budgetary measures, organisational changes and individual levers: changes in knowledge, attitudes and individual skills	• Creation of short podcasts or videos • Accounts of reflective practice based on observations within the clinical environment or engagement with wider events relating to ESD • Written case-based scenarios
	• Discuss the importance of behaviour change at a population level, particularly in relation to overall population treatment need, the use of resources and the environment			
Healthcare systems 4.4.4 Modified	Students should be aware of their role, as an oral healthcare professional, in contributing to sustainable development goals. They should be able to describe how the systems within which they will work, can affect these goals	Discuss Describe Explain Rationalise	• Demonstration of remote consultation • Community practice placements • Working with digital workflows, mindful of contrasting material use, potential for error and time • Small group tutorials around SDGs, consider ways dentistry can contribute to these • Discussion around different healthcare system models and potential challenges each possess in relation to ES	• Team-based projects with other OHPs within the school to report how the team can contribute to SDGs • Written papers to assess knowledge of mechanisms of sustainable healthcare delivery • Community practice placements and associated reflections • Competence with using digital workflows for providing patient care, or in the skills lab
	• Discuss the importance of oral health professionals in contributing towards environmental Sustainable Development Goals (SDGs) • Describe the various mechanisms of delivering healthcare, including strategies that improve accessibility and sustainability such as remote consultations, digital workflows and domiciliary/community visits			

impacts are to be gained. A key message is that ES has desirable impacts that reach well beyond the environment; it is good for the patient with whole person-centred healthcare benefits, good for society, good for the profession and good for the wider economy.

Initially, this group suggests a greater emphasis is needed on understanding the fundamental principles of ES in the earlier preclinical years for any healthcare course. As students progress, it is possible to build on these early principles, and introduce new ways of appraising the ES of systems, and how this relates to dental

practice. These models can be revisited and strengthened in future years, becoming increasingly complex and involving more disciplines and areas as time goes by. This model provides an opportunity for the synergistic integration of ES concepts alongside the delivery of good oral healthcare, which must remain the bedrock of all curricula. Initially, as students begin to learn about general medical problems and medicine relevant to dentistry, relevant aspects such as sustainability of patient consultation and travel, or sustainability of prescribing and medication use, can be introduced. As students prepare to move into a clinical environment, ES could be incorporated as a part of key areas such as (but not exclusively) patient care planning, preventive dentistry and decontamination. Beyond the integration of source reduction, there are many opportunities for further integration with core subjects such as public health screening programmes, service delivery models and the co-creation of patient information. The concepts of horizontal and vertical integration are further discussed by Hays.[24] Over time, as the relatively new concept of ES in clinical dentistry evolves, curriculum leads will need to regularly review content and practice to ensure that taught approaches remain valid—examples of suggestions for informing curriculum review include the disciplines of Endodontics[1] and Restorative Dentistry.[25]

4.5 | The use of case studies and student involvement to support delivery

Case-based learning (CBL) has proven to be an effective teaching method in healthcare education[26,27] and this approach is used widely across the profession. As such, OHP students are already often familiar with this method of learning. CBL, by promoting students' critical thinking and decision-making, is a valuable method of choice for developing students' opinions and values in relation to ES. Clinical cases provide real context, and ES is gently encouraged as a normal consideration—eventually becoming part of the range of expected professional attitudes. Some simple examples of fundamental decision-making processes include repairing defective restorations instead of replacing them, and choosing from a range of suitable materials based on factors such as packaging, subsequent waste and procurement journey. Table 5 outlines a case example by which the concept of "source reduction" is explored as the main waste management route to ES[28]—and how its construct is useful as a tool for systematically teaching and reinforcing a sustainable approach to treatment.

In addition to clinical or "dental" case studies, general case studies relating to ES can allow educators to introduce, and students to explore, the key characteristics and implications of particular decisions and interventions. Concrete and contextual ES issues, such as travel issues, waste and energy utilisation can be discussed in order to provide new insights and propose practical solutions to resolve the problems. These "cases" should be co-created with students—but also shared across our educator network as a general resource. Additionally, this will serve as an opportunity for Inter-Professional Education with students from a variety of disciplines (healthcare and beyond). In the same way, students should be encouraged to be "advocates of

TABLE 5 Case study: Source reduction and waste management

Here, the concept of "source reduction" is explored as the main waste management route to ES.[28] At the point of delivery of care, reduction is achieved through the provision of high-quality oral healthcare by engaging with good practice, embodied in four domains (below)[29]:
- *Preventive care*—The assessment and management of systemic and local risk factors with a practical and patient-centred preventive regime.
- *Operative care*—The combination of core knowledge, skill sets, experiential learning and teamwork acting synergistically. The provision of high-quality operative interventions results in durable treatment that will require fewer repairs and replacements.
- *Integrated care*—The integration of services, patient-centred structured treatments and patient participation as co-creators and co-managers of their care.
- *Ownership of care*—Active participation in core and complementary activities that leads to professional development, a passion to excel and the satisfaction of achievement.

The outcome of this integrated approach for the delivery of oral care is two-fold:
- Fewer appointments, with fewer patient journeys and reduced need for professional interventions, results in an overall reduction in CO_2 emissions
- Increased longevity of restorations and a reduced need for procurement, which results in an overall reduction in waste generated.

This construct provides a perfect starting point for the integration of ES into the current curriculum, without the need for separate or independent stand-alone courses. It shows how, through the promotion and implementation of a framework for the management of preventable diseases, we attain good oral health and positive environmentally sustainable outcomes by way of a reduction in CO_2 emissions, waste and pollution.

change"—OHPs who are empowered to drive change—and initiatives that are taken forwards should be shared within the teaching community. Most OHP students are younger professionals, with relatively long careers ahead—and in this regard, they will undoubtedly face impact from environmental pressures that is far more longstanding than their teachers will—at least from a professional perspective. Their interest in changing the existing status of how dentistry and the environment affect each other is therefore very clear, and they could serve as major change agents; our current students are the future. Student-driven (or "student-centred") learning is a well-established concept, which is already shown to give more satisfactory and meaningful learning experiences.[30,31] Examples of students' active involvement in change could include identifying "hotspots" and priority areas to focus on—either in direct liaison with curriculum committees within the school—or as part of their students' society agenda.

4.6 | The use of novel and innovative methods to teach and assess sustainable dentistry

Some of the activities proposed in Tables 1–4 represent a socio-constructive paradigm, where students co-construct their knowledge in a social context within an active learning framework. Active

learning is student-centred, can be challenge-based and collaborative, and is preferably situated in authentic contexts relating to contemporary challenges. Typical activities can include the use of case studies as described above, but we also propose creating other activities where students are forced to actively consider and reflect on context. For example, activities may be designed that allow students to reach out and engage with wider society, and feel a potential immediate impact—these will act as powerful learning experiences. Such learning activities can be designed collaboratively with stakeholders external to the university, or by critically analysing common or frequent societal actions such as the recommendation and selection of oral hygiene products, or by drawing attention to types of packaging or place of manufacture, in relation to ES. With regards to designing learning activities in general, any type of learning activities that students find engaging are likely to be welcomed—and are likely to have more impact—and therefore, educators should consider engaging students with ES concepts through quizzes, flipped learning and reflections on clinical observations. This can be built on further, to develop concrete problem-solving exercises involving more complex cases and collaborative efforts and interactions with society.

Several of the strategies discussed in this article can also be tied together in innovative ways, such as asking the students to keep a reflective portfolio, with elements that relate specifically to sustainable practice—and encourage reflection across a number of activity domains—including areas of competence such as communication skills, collaboration skills, leadership skills, theoretical knowledge, professionalism and an evidence-based approach to practice. Students can be asked to create their own contextual and meaningful links across various facets of OHP education that are relevant to the cases they are involved with—for instance, one such example is where students may identify the significance of how individual patients' travel plans and habits could be linked to care planning.

Of course, assessments that are designed to determine whether students can meet certain learning outcomes, do not always need to be confined to simple question and response arrangements. Co-creation of resources—both between student colleagues and with teaching staff, means that student involvement in the exercise can be assessed, as can the quality of any potential outputs. In this way, resources that are created may be valuable in raising awareness in the wider society—asking students to create materials such as podcasts, or infographics, or considering how they might communicate using social media, all provide excellent opportunities to engage and enthuse students, whilst potentially benefitting wider society. That said, it is possible to build simpler forms of ES assessments into the current curriculum in the first instance. Assessment criteria regarding ES can often be included without major change to the method of assessment. For instance, ES can be added as a mandatory criterion for master thesis writing, or as part of regular clinical skills assessment (e.g., in relation to hygiene routines, prevention perspectives, treatment choices, individualised person-centred care plans, holistic care, treatment planning, appointment scheduling, environmental influences, travel requirements and taking responsibility for a lifelong perspective on treatment choice).

4.7 | Incorporating the learning outcomes into the Graduating European Dentist (GED) curriculum

Open access publication of the original GED curriculum within the European Journal of Dental Education ensured that the original curriculum content, and associated guidance, was accessible to all. Within the spirit of consensus and accessibility, the decision was taken by the GED Taskforce, to evolve GED beyond a series of static documents—and to create an active and dynamic resource for educators and students. As such, the GED suite of documents is accessible through the ADEE website here. ADEE encourages individuals, institutions, educators and industrial partners to leave comments and suggestions on the various domains and learning outcomes—and these are revisited periodically by the GED taskforce. An ADEE-approved French translation of the curriculum is available here. Following the publication of this article, the suggested learning outcomes for sustainability will now be proposed to the GED task force for incorporation into the live online GED curriculum.

5 | CONCLUSIONS/RECOMMENDATIONS

It is clear that in order to meet national and global net-zero pledges and to effectively implement the SDGs into current dental practice, ES must be formally integrated into curricula for OHPs. The SIG established that simply defining ES learning outcomes for educators was not enough. Instead, the group has worked together to reach consensus not only on learning outcomes, but methods in which these can be robustly embedded, taught and assessed within the modern dental curriculum.

The SIG makes the following recommendations for consideration when integrating learning outcomes for ES:

- The integration of learning outcomes should be planned logically and reinforced longitudinally throughout the programme.
- Institutions and educators should encourage and empower students to be ES advocates of the present and future to drive sustainable change.
- Educators should co-create resources with students, inviting student opinion about how they might wish to express their understanding, opinion and motivation for engaging with ES initiatives in dentistry.

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