16 Assessing Learning Outcomes for Sustainability in Primary and Secondary Schools in the UK

Vasiliki Kioupi and Nikolaos Voulvoulis

Abstract

Education for Sustainable Development (ESD) is an integral component of Quality Education as stated in Sustainable Development Goal (SDG) 4 target 4.7. Its main aim is to develop in learners, knowledge, skills, attitudes, values and behaviours conducive to sustainable development. Sustainability was introduced as a curricular topic in primary and secondary schools in the UK after the Earth Summit in Rio in 2002; however, its effectiveness in achieving its learning outcomes (LOs) has not been systematically assessed. In this study, we present the application of a participatory framework for assessing LOs for sustainability. The framework was developed using systems thinking and applied in two case studies conducted in a primary and a secondary school in the UK 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 LOs in their students, while some weaknesses related to their approach were identified. The case studies demonstrated the tool's potential to measure and evaluate students' competences development and support the operationalisation of sustainability competences in primary and secondary education.

Keywords

Education for sustainability · Sustainability competences · Assessment of learning · Systems thinking · Primary and secondary schools

16.1 Introduction

Recent international commitments around sustainability, such as the Sustainable Development Goals and the Paris agreement targeting climate change, highlighted the central role of education in achieving their stated goals and targets (UNESCO, 2018, 2020). The SGDs specifically target education, state that ESD is an integral component of quality education 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 (United Nations SDG4, 2021). This view of education through international agreements coincided with a shift in education policy that showed

V. Kioupi (✉) · N. Voulvoulis
Centre for Environmental Policy, Imperial College London, London, UK
e-mail: v.kioupi17@imperial.ac.uk

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education systems moving towards evidence-based practices. This evidence-based orientation has been associated with the assessment of learning outcomes (LOs) or competences in learners as the means for improving the effectiveness of education offerings (Leutner et al., 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 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/DfE, 2014). The first national strategy regarding sustainable development titled "Securing the Future" was rolled out in 2005 (Department for Environment, Food & Rural Affairs (DEFRA), 2005a), which coincided with the start of the UNESCO Decade for ESD in 2005 (UNESCO, 2014). In Chap. 2 of this strategy, education is 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. 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 (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 they 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, Whales and Scotland, and thus there was a need for a national strategic framework. A few years later, a second report (UK National Commission for UNESCO, 2017) assessed initiatives relating to the Global Action Programme (GAP) on ESD and to the SDGs as well. 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 to be supported, flourish and their impact on achieving sustainable development to 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 LOs for sustainability was developed using systems thinking and described in detail in a previous publication (Kioupi & Voulvoulis, 2019). It outlines five steps as part of a participatory process of selecting and assessing LOs for sustainability and had been applied in higher education programmes (Kioupi & Voulvoulis, 2020).

In this chapter, we present the application of the framework in two case studies around the

assessment of sustainability LOs in school education in the UK during the 2018–2019 school year: the first in a primary school academy, which has an eco-school status, and the second in an independent co-educational secondary school. Both schools have different approaches to curriculum implementation: the former having more freedom to develop its own curriculum being an Academy, satisfying the Education Act (2011) requirements at the same time, and the second being an independent school following the national curriculum but having the flexibility to introduce unique courses for innovative teaching and learning (UK Government, n.d.-a).

16.2 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 researchers to gain insights into the ESD practices employed in the schools (Lapan et al., 2012). It would further help the teachers and researchers 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 LOs 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. For both case studies, we received ethics approval from the Imperial College Research Ethics Committee (ICREC) with reference 18IC4498/14/05/2018 prior to the implementation of the research.

The steps of the applied framework for selecting and assessing sustainability competences can be found in Fig. 16.1. The framework uses a participatory approach, whereby the researchers

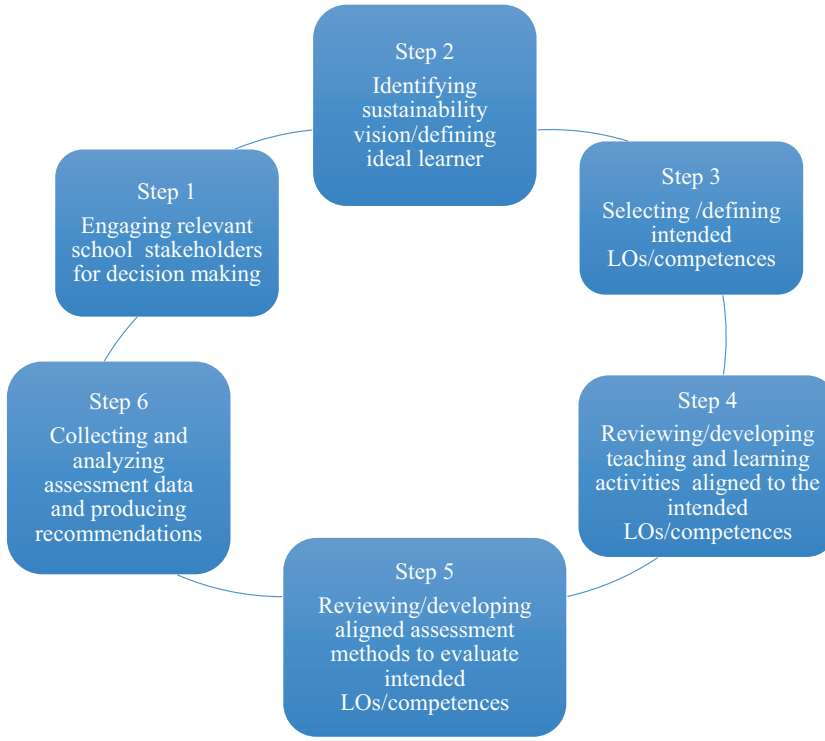

Fig. 16.1 The six steps of the applied framework for selecting and assessing sustainability competences in primary and secondary schools

work with the school stakeholders to implement every step of the framework; have open and meaningful discussions around their values, aims and objectives and 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 on the sustainability vision they would like to achieve. This involved several meetings with the headmaster and teachers of the primary school and with the coordinator and teachers of the Global Goals course of the secondary school. In the next 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, we reviewed those teaching and learning activities and assessment methods against their capacity to develop the selected competences in learners and worked with the teachers to revise them and to develop new ones where needed. In every step, we made sure that the decisions made reflected the realities, aims and needs of primary and secondary school teachers and students.

16.2.1 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 DfE'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 4 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 master). These sustainability themes are interlinked with its curriculum, which follows the Harmony Framework. The Harmony Framework is a unique model of learning that guides how and when curriculum is taught at the school – including the core subjects of English, mathematics, science, 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 the additional subjects such as ESD are 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. Discussing about the vision and mission of the

school with the headmaster and the teachers, we realised 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 our systemic framework's definition of a sustainable state citizen (Kioupi & Voulvoulis, 2019).

As per the adapted framework presented earlier, step 1 was taken to identify and engage the relevant stakeholders. Thus, we 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 about it in our meetings (step 2). Next, we discussed around their intended 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 were analysed to draw insights and make recommendations. The process with 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 for the Year 4, 5 and 6 curriculum for 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 et al., 2019; Opitz et al., 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 goals (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 and 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 LOs regarding sustainability they aimed their pupils to attain. For Year 4 students, they were 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 LOs included knowledge of water usage (direct and indirect), water footprint and how to decrease it, where does water come from and where does it go after we have used it, links between water use and vegetable production and consumption, attitudes towards 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 at school and at home.

The teachers participated in a discussion around the pedagogies and 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 1 day in the life of a farmer and design and create the packaging and marketing material for a healthy snack as part of an arts project. During 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 students engaged in activities around river geography and ocean protection and were responsible for monitoring the school's water use through the Eco Driver tool on a weekly basis as well as measuring how much water is wasted at the end of each lunchtime to ensure maximum savings (personal communication with Year 5 teachers). As these learning activities were not entirely in alignment with the intended LOs, we worked with the teachers and the headmaster of the school to enrich the activities around water to meet the selected LOs. The resulting curriculum engaged the students in activities regarding direct and virtual water use in an average UK household per day. The students calculated their own water footprint and worked in groups to identify ways by which they could reduce their own direct and virtual/indirect footprint. They further examined the link between direct and virtual/indirect 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 headmaster 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 master). 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 Eco Driver, 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 entirely capture the intended LOs. 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, 2017). The questions included a mix of open-ended, select the right choice, classification and Likert-scale questions as we wanted to capture the different types of knowledge, emotions and attitudes the students managed to develop (UNESCO, 2017). Year 4 students were also asked to draw storyboards to assess their attitudes around conventional and organic food. For these storyboards, the students 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 do 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 et al., 2020).

Due to administrative complications, it was not possible to administer the questionnaire developed for Year 5 students, and thus the results are not reported as part of this study. The Year 5 and 6 students 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: a. 31 Year 6 students completed the energy questionnaire and student feedback form and 1 teacher completed the teacher feedback form, b. 26 Year 5 students completed the student feedback form and 1 teacher completed the teacher feedback form, and c. 59 Year 4 students 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 students. The analysis of the quantitative parts of the questionnaires was done using MS Excel software, and the analysis of storyboards and open-ended questions was done with NVIVO for qualitative analysis.

16.2.1.1 Year 6 Energy Questionnaire

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

Almost all students (except for two who did not know or gave irrelevant responses) supported 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 (Fig. 16.2).

Almost one third of the students could correctly identify that the electricity in their school

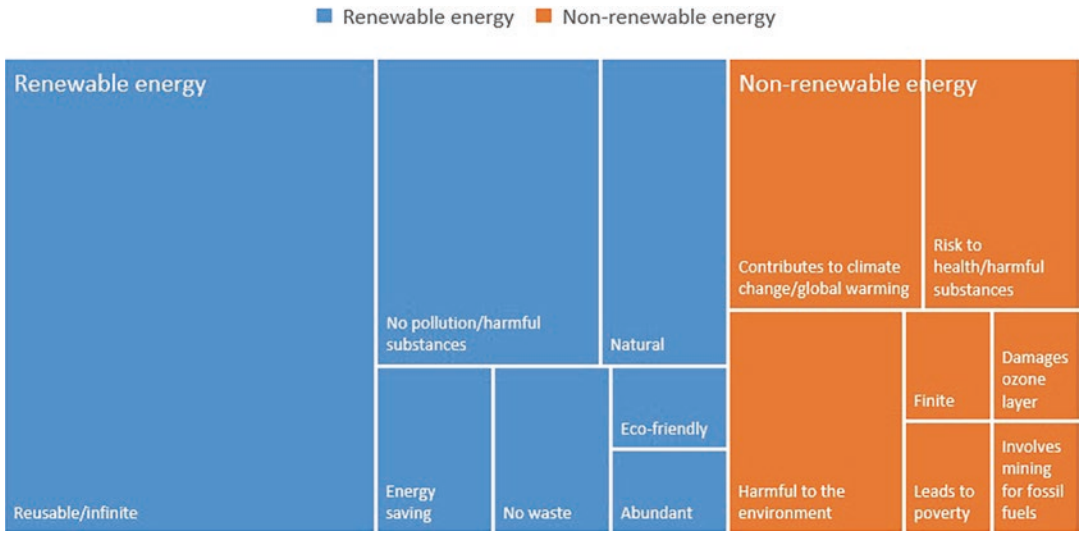

Fig. 16.2 Student responses to Q4: "Which energy sources are better for the environment and people: Renewable or Non-renewable? Explain why" by theme identified. The size of each box is proportionate to the number of students who included the theme in their response

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, fossil fuels and main energy supply as the source of electricity on cloudy days. Out of those, only two were able to explain why. The majority of students thought that the school uses less electricity on weekends than on weekdays and said that this is because of less people in the buildings. Five explained further, giving reasons such as fewer lights are on, no heating, no smartboards and no computers are used, no lunches are cooked and so the kitchen is not in use.

Regarding engaging in energy-saving behaviours, most students mentioned: walking more, turning 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 your 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 suggested (words in italic) were not directly related with energy usage, and some were related with water usage; this shows that students made links between energy and water or energy and its sources. The results from the student and teacher feedback forms can be found in the Appendix (Year 6).

16.2.1.2 Year 5 Water Questionnaire Results

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

16.2.1.3 Year 4 Food Questionnaire

The top five concepts (83% of the responses) linked with organic food in the student open-ended responses were that it is free from chemicals and pesticides and thus better for the environment and human health, it is more expen-

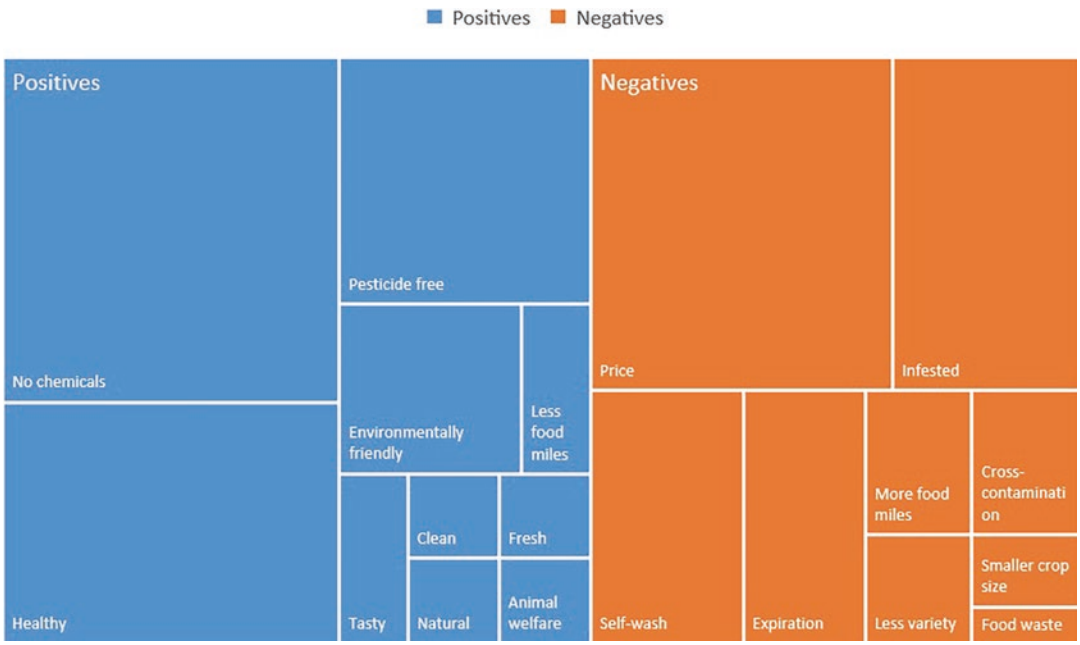

Fig. 16.3 Student responses to Q2: "Why do you think organic food is good for you? Can you think of some problems or challenges with organic food?" by theme identified. The size of the boxes is proportionate to the number of students who included the theme in their response

sive than conventional food and animals are treated better in organic farming. Other less common responses mentioned that organic food is more natural, tastes better and has worse appearance and size than conventionally grown and travels less (food miles) to arrive to the consumer.

Most of the students' responses around the positives of organic food related with the absence of chemicals and pesticides that make it good for the environment and health as in Q2 (Fig. 16.3). Most of the negatives related with high prices that it is or can become infested and thus needs good washing before using or it expires quickly. Other less common responses included that organic food is tastier, 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 was both associated with more and less food miles.

The majority of students managed to identify correctly the origin of at least eight out of ten fruits. Three quarters of the students could categorise correctly four to six of the fruit and vegetable according to harvest season; none correctly categorised all eight of them. Most students 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 (Fig. 16.4).

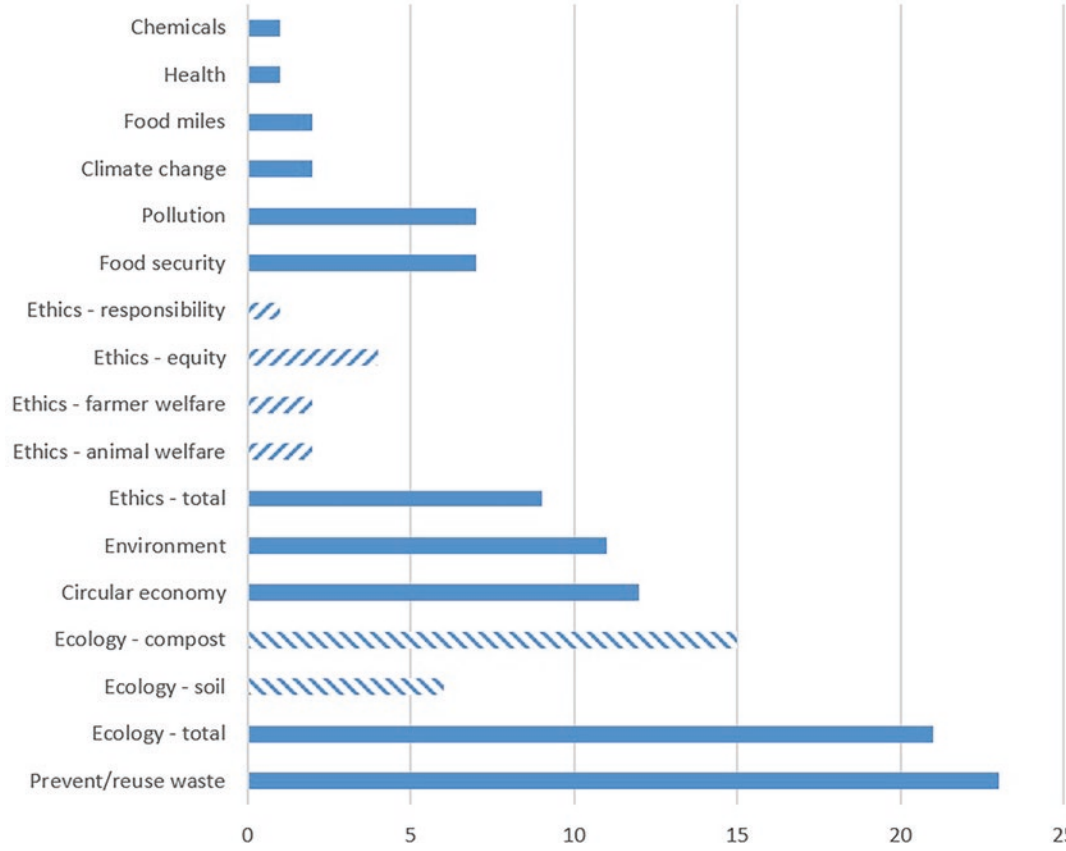

Fig. 16.4 Number of responses per topic introduced by students to respond to Q5: "Why is it important to recycle food waste?" The striped columns represent the sub-topics identified in student responses for the concepts ecology and ethics

16.2.1.4 Year 4 Storyboard Results

We collected 29 storyboards, as only 1 of the 2 Year 4 teachers was able to implement the activity with the students. After reading through the storyboards and analysing the drawings, we used open qualitative coding to record the themes that emerged in the storyboards. Then, we calculated the number of student responses that included each theme. The main themes that were identified in the Year 4 organic and conventional tomato storyboards are shown in Figs. 16.5 and 16.6.

For the organic food storyboard, the most frequently mentioned concept 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 (Fig. 16.6, pesticide confusion). Comparing the two storyboards, it is clear that all students referred to the organically farmed tomatoes as vegetables that grow because of important ecological processes in the soil, because of the sun and water they receive from farmers, whereas the conventionally grown tomatoes grow with pesticides

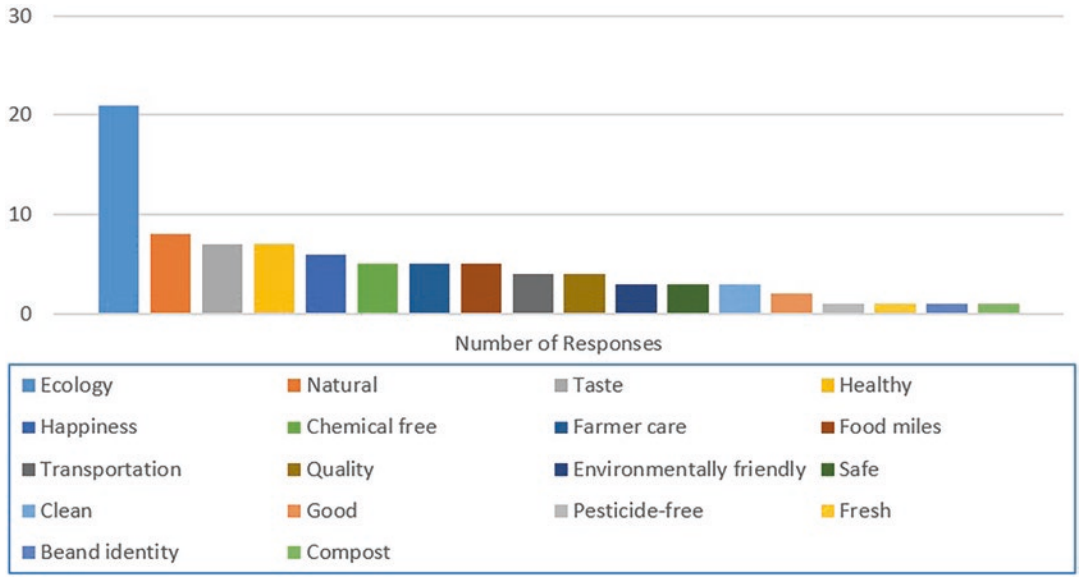

Fig. 16.5 Frequency of the main themes identified in student organic food storyboards

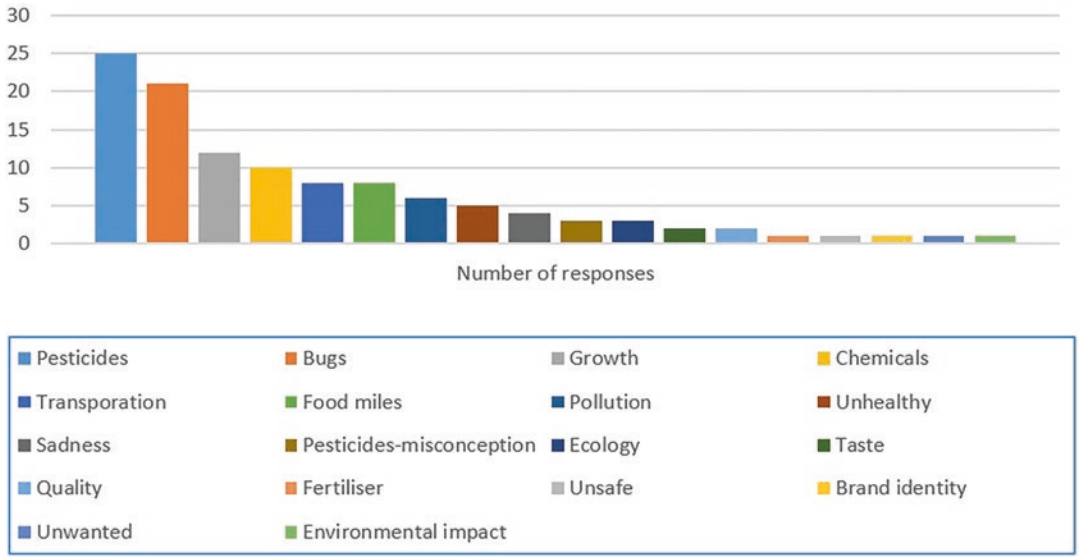

Fig. 16.6 Frequency of the main themes identified in student conventional food storyboards

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 ready for consumption but is harmful for people (Fig. 16.7). In 8 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, being "suspicious" or "secret". Often, the packaging in which the seeds arrive for organic is cardboard and for the conventional plastic, and the planting practices 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. Other differences included transportation of conventional food most often by planes or lorries, which cause pollution, and in one case, transportation by plane is referenced for organic tomatoes. Lastly, the students personified the tomatoes, showing them having faces that 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.

16.3 Secondary School Case Study

The secondary school is a co-curricular independent school located in West London. Independent schools in the UK or 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 towards social inclusivity as it aims to offer opportunities to a well-rounded education to students from various backgrounds and operates a bursary award system (personal

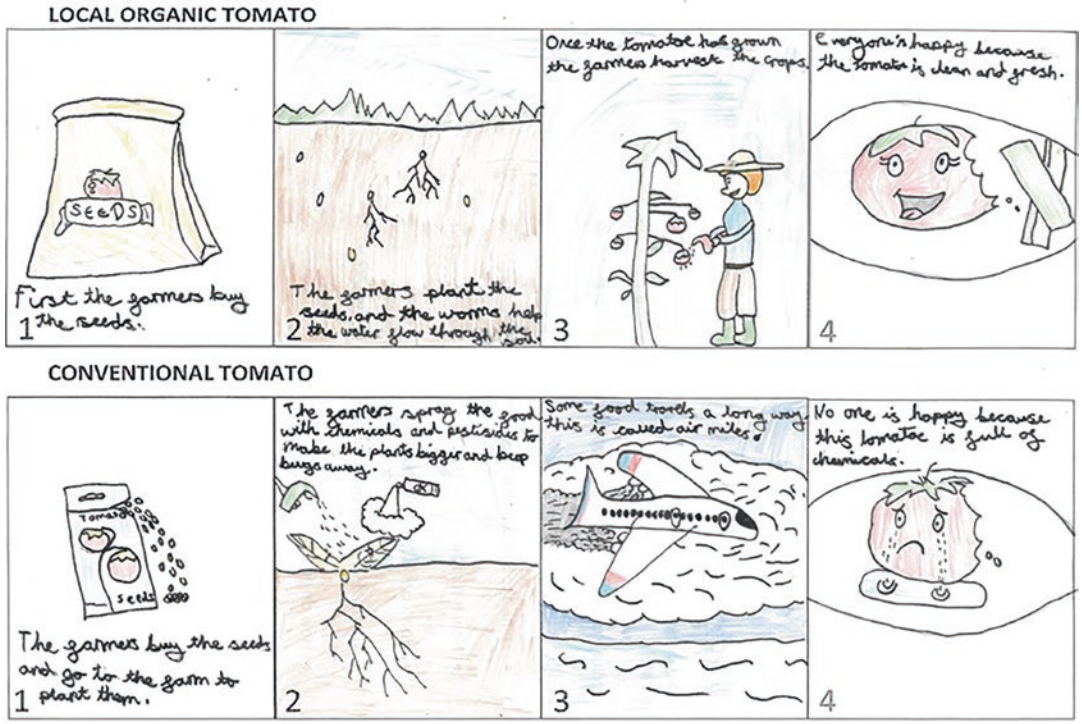

Fig. 16.7 Example of a storyboard drawn by a Year 4 student depicting the journey from seed to table of an organic tomato and of a conventional one

communication with schoolteachers). As an independent school, it follows the UK curriculum and complements it with in-house developed courses to prepare the future citizens of the twenty-first 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. The vision is quoted here:

> 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 teacher coordinator)

Associated with its vision are the set of competences the school aims to develop in all of their students, which are the following:

- 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 (personal communication with teacher coordinator)

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, tolerant and open-minded, critical thinker and resourceful, hardworking and committed to act for a better world (personal communication with 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, 2017; Wiek et al., 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 our research methodology. We specifically worked 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, the students 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 SDGs, but the students look at how problems are manifested across scales. The key is for students 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 towards the targeted SDGs.

As per our framework, we engaged the coordinating teacher team of the Global Goals course (step 1) and worked with them to understand their school's vision towards sustainability and discuss about 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
- 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 for the autumn term analysing problem scenarios, doing literature research around the SDGs and root causes of sustainability problems, learning and using PESTLE (political, economic, social, technological, legal and environmental) analysis to understand problems, engaging in presentations around the outcomes of problem scenarios and discussions to provide feedback to their peer's work. For the spring and summer term, the students mostly engaged in project-based learning, identifying challenges linked to the SDGs and planning, implementing and presenting their projects. This project-based learning was supported by activities for setting SMART (specific, measurable, achievable, realistic and timely) project goals, using the Double Diamond design process for defining problems and developing courses of action and the six hats 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 students (step 4), but there was lack of appropriate assessment methods (step 5).

Regarding the need for assessment of 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" types of assessing the LOs. After organising two meetings with the teachers and the coordinator of the course, the teachers highlighted the importance of empowering the students 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-led. 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 students in terms of how to conduct the assessment and searching in the literature, we 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, 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 students developed.

The self-assessment questionnaire included 27 questions that asked the students 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 1 open-ended question about the role of the student 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 (Year 9, Table A.1, Appendix) comprised 21 statements around how they worked as a group, how they regulated group work and how they coped with difficulties. The students had to read each statement and select Yes, Partially or No to describe to what extent 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 students to assess their peer's final project product/presentation and was based on six groups of criteria. The criteria examined were the research and development that went to 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 in the school fair. The students assigned 1 (for poor) to 5 stars (for top performance in a criterion).

We disseminated the self and peer assessment questionnaires to one class of the Global Goals course of 23 students. We also disseminated the final questionnaire to the entire Global Goals cohort to evaluate the project presentation during the fair and collected 123 completed forms. We analysed the results of the questionnaires 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.

16.3.1 Self-Assessment Questionnaire Results

The reliability of the self-assessment questionnaire was assessed using reliability analysis in SPSS, and the results show high reliability of the measure with Cronbach's a equal to 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 Table 16.1. The analysis of the self-assessment questionnaire produced results that are shown in Table 16.1 as well.

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 score 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. We report cases where the lowest assigned value was 1, which means strongly disagree, as those highlight where the educators should place more emphasis. These statements' values are highlighted in orange in Table 16.1. 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 classroom in terms of the competences assessed are shown in Fig. 16.8.

The students self-assessed higher in systems thinking and collaboration, while they perceive their weakest competence to be self-regulation. The intermediate competences were critical thinking, metacognitive/reflective thinking and problem-solving. There were six groups of students working on six projects around the SDGs in the class and used the team assessment questionnaire to assess their group work. We grouped the statements used in the team assessment questionnaire according to three competences, teamwork, difficulty coping as team and team regulation (Appendix, Year 9). The results of the analysis of the team assessment questionnaire per group of students are shown in Figs. 16.9, 16.10, and 16.11.

The combined results from the three figures show that teams 3, 4 and 6 had the highest teamwork competence, faced the least difficulties in coping with working as a group and had the highest ability to regulate their teamwork. 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, we present below the main themes that were introduced in the students' responses. 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

Table 16.1 Descriptive statistics of the results of the self-assessment questionnaire and categorisation of each statement according to competence

	N	Range	Min	Max	Mean	Std. error	Std. deviation	Variance
I can identify problems related to the SDGs (CT)	23	4.00	1.00	5.00	4.2174	0.19838	0.95139	0.905
I can link the problem we identified to one or more SDGs (CT)	23	4.00	1.00	5.00	4.3043	0.20309	0.97397	0.949
I can explain why we selected the specific problem to work on (MC)	23	2.00	3.00	5.00	4.3913	0.15061	0.72232	0.522
I can identify sources of information related to the problem we identified (CT)	23	4.00	1.00	5.00	3.9130	0.20769	0.99604	0.992
I can select the most appropriate information to include in my work (CT)	23	3.00	2.00	5.00	4.1304	0.19177	0.91970	0.846
I can explain both the root causes and the effects of our chosen problem (ST)	23	3.00	2.00	5.00	3.8261	0.14947	0.71682	0.514
I can combine information from various sources to understand the problem (CT)	23	4.00	1.00	5.00	4.0000	0.18861	0.90453	0.818
I can explain how the problem affects my school (ST)	23	4.00	1.00	5.00	3.8261	0.22363	1.07247	1.150
I can explain how the problem affects my community (ST)	23	2.00	3.00	5.00	4.4783	0.12367	0.59311	0.352
I can explain how the problem affects my country (ST)	23	2.00	3.00	5.00	4.4348	0.13811	0.66237	0.439
I can explain how the problem affects the world (ST)	23	3.00	2.00	5.00	4.4348	0.16426	0.78775	0.621
I can cope with failure during doing my work for the Global Goals Course (SR)	23	4.00	1.00	5.00	3.8261	0.26414	1.26678	1.605
I can manage my own learning during the Global Goals Course (SR)	23	3.00	2.00	5.00	4.0435	0.19355	0.92826	0.862
I can mention existing solutions to the problem (mean) (PSA)	23	2.00	3.00	5.00	4.0652	0.15175	0.72777	0.530
I can propose new solutions to the problem (PSA)	23	3.00	2.00	5.00	3.8261	0.17391	0.83406	0.696
I can explain why the solution selected is appropriate for the problem (MC)	23	2.00	3.00	5.00	4.2174	0.15344	0.73587	0.542
I can identify the limitations of the solution we suggested (MC)	23	2.00	3.00	5.00	4.3913	0.15061	0.72232	0.522
I can collaborate with my team members (CO)	23	4.00	1.00	5.00	4.2609	0.22857	1.09617	1.202
I can understand my team members' needs (CO)	23	3.00	2.00	5.00	4.3913	0.16321	0.78272	0.613
I can cope with complex problems (SR)	23	4.00	1.00	5.00	3.6522	0.18446	0.88465	0.783
I can communicate our solution to other people effectively (PSA)	23	2.00	3.00	5.00	4.1304	0.18117	0.86887	0.755
I can work as part of a team (CO)	23	4.00	1.00	5.00	4.1739	0.20519	0.98406	0.968
I can develop a plan to implement the solution we suggested (PSA)	23	3.00	2.00	5.00	3.8261	0.16215	0.77765	0.605
I can reflect on my work and make changes if needed (SR)	23	3.00	2.00	5.00	4.1304	0.18117	0.86887	0.755
I can evaluate the effectiveness of our solution (mean) (MC)	23	2.00	3.00	5.00	4.0435	0.15372	0.73721	0.543
I can give constructive and helpful feedback to my team members about their work (CO)	23	3.00	2.00	5.00	3.9130	0.16530	0.79275	0.628
I am open to receive feedback from team members about my work (CO)	23	2.00	3.00	5.00	4.2609	0.16890	0.81002	0.656

ST systems thinking, *MC* metacognitive, *CT* critical thinking, *SR* self-regulation, *CO* collaboration, *PSA* problem-solving and action

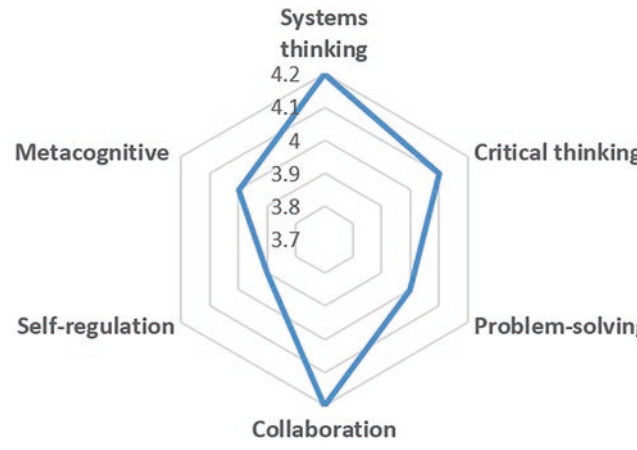

Fig. 16.8 Performance results for the six competences assessed in the secondary school case study

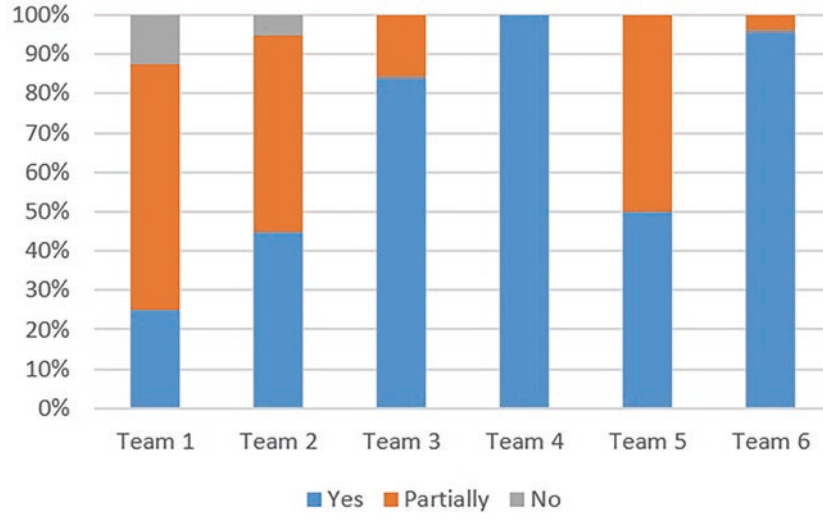

Fig. 16.9 Teamwork assessment results for the six groups of secondary school students (stacked columns)

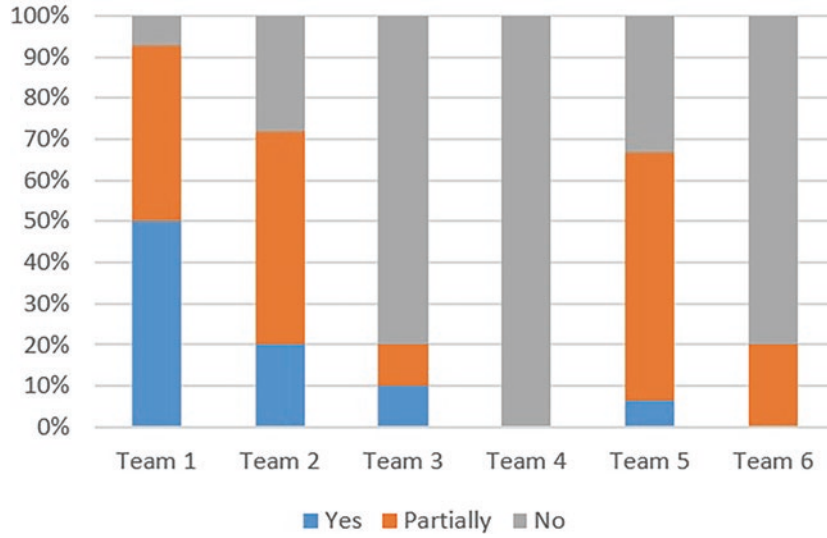

Fig. 16.10 Difficulty coping with the project as team assessment results for the six groups of secondary students (stacked column)

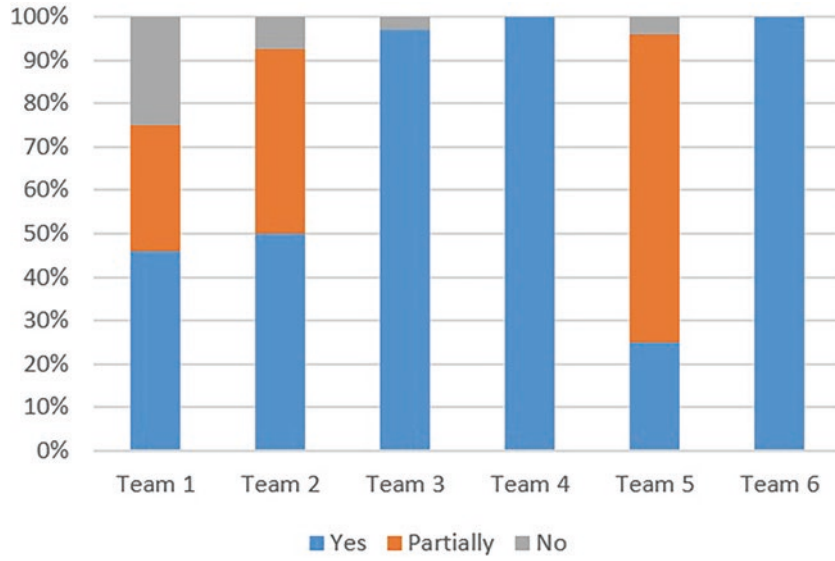

Fig. 16.11 Team regulation assessment results for the six groups of secondary students (stacked columns)

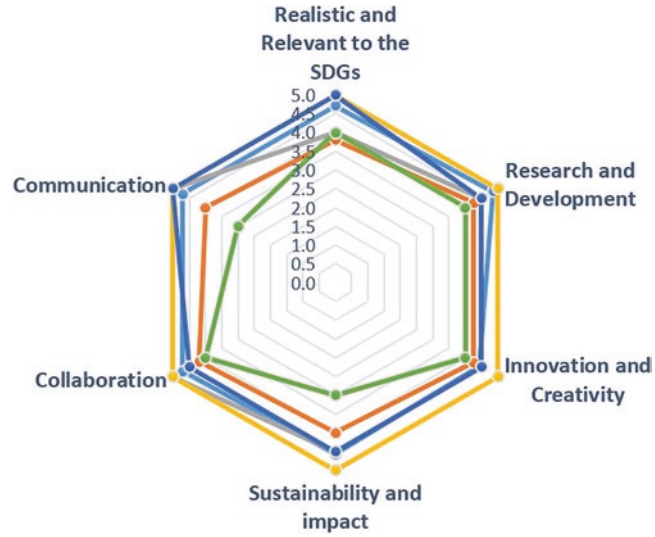

Fig. 16.12 Peer-review assessment results for the six projects of the student groups based on six criteria

mentioned they argued a lot, they had difficulty supporting their opinions with arguments, they were slow as a group, arguing was sometimes fun and if they decided to solve their differences, they could be productive. The groups that had good collaborations mentioned that they discussed about their problems and challenges and listened to each other to help them overcome difficulties, they had chemistry as a group and they were producing a lot of ideas 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's projects, are presented in Fig. 16.12.

The highest score of 5 stars was given to the project safety app, and closely behind were the projects plastic buffet and leftover cookbook; the

lowest scores were given to the website for teen issues and reusable cup projects, which received low scores in sustainability and impact and communication and realistic and relevant to the SDGs, respectively. The open-ended positive feedback the peer reviews gave was around the creativity of the idea that groups went the extra length to develop outstanding prototypes and that the ideas were clear and clever, could be used by everyone and could produce big impact in solving the problems identified.

16.4 Discussion and Suggestions

The primary school results support that, in terms of science literacy, which is the main cognitive LO assessed through the questionnaires, Year 6 and Year 4 students actually seemed 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 and 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 in understanding and reasoning scientifically, and these are the naïve, intermediate and scientific (Pollmeier et al., 2017). Our 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 the 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 were only a few. 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 and were able to use 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 mentioned the positives of renewable and the negatives of non-renewable energy, and in the second case, they equated organic food with positive aspects, emotions and feelings and conventional 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 only consume 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 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 2–3, 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 holistically. 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 at 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 case 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, we recommend that the school should place focus in developing conceptual understanding and scientific reasoning skills to students as well as their ability to think critically. This is important to achieve the energy and environmentally literate citizen that can make sustainable choices that are 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 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, enabling all voices to be heard and all perspectives to be explored would benefit their critical thinking skills (Cotton, 2006; Pauw et al., 2015). 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 for nature from a very young age. Nevertheless, this behavioural predisposition needs to be coupled with a strong foundation of science 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 having discussions with the students, we realised that the open-ended format of the course although being of benefit to them posed come challenges as well. Mostly discussed were the difficulty coming up with realistic projects and completing them within the available time. Other aspects of concern were communicating with external stakeholders and getting them interested to help, redesigning their projects in cases of failure and being responsible for the entirety of their projects. Working as a team and receiving questions and feedback on their proj-

ects from teachers and their peers posed challenges for them as well.

In terms of working together, which was assessed through the team assessment questionnaire, the students showed 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 3–5 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, our results show that these aims were actually 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, national or 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 succeeding in completing their projects was to be responsible of 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 highlight sustainability and real-world impact according to the peer-assessment results. Students felt highly creative throughout conceiving, planning and implementing their projects; however 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 LOs of the Global Goals course, we think 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 et al., 2019).

After discussing some of these challenges with the teachers, we came up with the following:

- The students could 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.
- The students could overcome the identified difficulties by discussing with the previous cohort to identify which problems they tackled, how they coped and which solutions they provided and build on those.
- The teachers 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 thus enhance student engagement.
- Lastly, the students could 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 student's sustainability competences. Thus, primary and secondary schools in general 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 offering flexibility to schools to design their curricula would be an important step in advancing educational policy around ESD.

Acknowledgement The authors wish to thank the headmasters, teachers and students of the primary and secondary schools that participated in this study for their active engagement in this participatory research, their useful guidance and feedback and their collaboration. The authors also wish to thank the students of the master's programme in Environmental Technology Erika Starke and Xiao Zhu for helping with the data collection and analysis.

Appendix

Primary School

Year 6

Student Questionnaire

Question 1: Where and when do you use energy? List at least five 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 three tips for each.

Student Feedback

The students mostly felt great and confident about the activities as they had fun and 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 Eco Driver 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 Eco Driver 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 Eco Driver 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 student-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

Student Feedback

Students felt more aware about the water they use every day and 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 learing 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 informing 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 and felt happy, interested and surprised. They believe students 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 students 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

Student 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.
Question 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.

Secondary School

Year 9

Table A.1 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

References

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71–81). Academic Press.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. S. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307–337). Age Information Publishing.

Barrutia, O., Ruíz-González, A., Villarroel, J. D., & Díez, J. R. (2019). Primary and secondary students' understanding of the rainfall phenomenon and related water systems: A comparative study of two methodological approaches. *Research in Science Education.* https://doi.org/10.1007/s11165-019-9831-2

Baxter, P., & Jack, S. (2015). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544–559. https://doi.org/10.46743/2160-3715/2008.1573

Bobek, E., & Tversky, B. (2016). Creating visual explanations improves learning. *Cognitive Research: Principles and Implications, 1*(1), 1–14. https://doi.org/10.1186/s41235-016-0031-6

Bögeholz, S., Eggert, S., Ziese, C., & Hasselhorn, M. (2017). Modeling and fostering decision-making competencies regarding challenging issues of sustainable development. In D. Leutner, J. Fleischer, J. Grünkorn, & E. Klieme (Eds.), *Methodology of educational measurement and assessment. Competence assessment in education: Research, models and instruments* (pp. 263–284). Springer International Publishing. https://doi.org/10.1007/978-3-319-50030-0_16

Bullock, C., & Hitzhusen, G. (2015). Participatory development of key sustainability concepts for dialogue and curricula at the Ohio State University. *Sustainability (Switzerland), 7*(10), 14063–14091. https://doi.org/10.3390/su71014063

Chambers, C. T., & Johnston, C. (2002). Developmental differences in children's use of rating scales. *Journal of Pediatric Psychology, 27*(1), 27–36. https://doi.org/10.1093/jpepsy/27.1.27

Cotton, D. (2006). Teaching controversial environmental issues: Neutrality and balance in the reality of the classroom. *Educational Research, 48*(2), 223–241. https://doi.org/10.1080/00131880600732306

de Pauw, J. B., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sus-

tainable development. *Sustainability (Switzerland), 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

DEFRA. (2005a). Securing the future – UK Government sustainable development strategy. http://www.defra.gov.uk/sustainable/government/publications/uk-strategy/index.htm. Accessed 16 July 2021.

DEFRA. (2005b). One future – Different paths – The UK's shared framework for sustainable development. http://www.defra.gov.uk/sustainable/government/publications/uk-strategy/framework-for%sd.htm. Accessed 16 July 2021.

Department for Education. (2014). Assessment principles. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304602/Assessment_Principles.pdf. Accessed 16 July 2021.

Dlouhá, J., & Pospíšilová, M. (2018). Education for sustainable development goals in public debate: The importance of participatory research in reflecting and supporting the consultation process in developing a vision for Czech education. *Journal of Cleaner Production, 172*, 4314–4327. https://doi.org/10.1016/j.jclepro.2017.06.145

Dunne, R. (2020). Harmony: A new way of looking at and learning about our world (A teachers' guide). https://www.theharmonyproject.org.uk/product/harmony-a-new-way-of-looking-at-and-learning-about-our-world-a-teachers-guide/. Accessed 16 July 2021.

Huckle, J. (2009). Consulting the UK ESD community on an ESD indicator to recommend to government: An insight into the micro-politics of ESD. *Environmental Education Research, 15*(1), 1–15. https://doi.org/10.1080/13504620802578509

Kioupi, V., & Voulvoulis, N. (2019). Education for sustainable development: A systemic framework for connecting the SDGs to educational outcomes. *Sustainability (Switzerland), 11*(21), 6104. https://doi.org/10.3390/su11216104

Kioupi, V., & Voulvoulis, N. (2020). Sustainable development goals (SDGs): Assessing the contribution of higher education programmes. *Sustainability, 12*(17), 6701. https://doi.org/10.3390/su12176701

Koerber, S., Sodian, B., Osterhaus, C., Mayer, D., Kropf, N., & Schwippert, K. (2017). Science-P II: Modeling scientific reasoning in primary school. In D. Leutner, J. Fleischer, J. Grünkorn, & E. Klieme (Eds.), *Methodology of educational measurement and assessment. Competence assessment in education: Research, models and instruments* (pp. 9–17). Springer International Publishing. https://doi.org/10.1007/978-3-319-50030-0_3

Lapan, S. D., Quartaroli, M. T., & Riemer, F. J. (2012). *Qualitative research: An introduction to methods and designs*. Jossey-Bass.

Leutner, D., Fleischer, J., Grünkorn, J., & Klieme, E. (2017). Competence assessment in education: An introduction. In D. Leutner, J. Fleischer, J. Grünkorn, & E. Klieme (Eds.), *Methodology of educational measurement and assessment. Competence assessment in education: Research, models and instruments* (pp. 1–6). Springer International Publishing. https://doi.org/10.1007/978-3-319-50030-0_1

Loureiro, K. S., Grecu, A., de Moll, F., & Hadjar, A. (2020). Analyzing drawings to explore children's concepts of an ideal school: Implications for the improvement of children's well-being at school. *Child Indicators Research, 13*(4). https://doi.org/10.1007/s12187-019-09705-8

Mickelsson, M., Kronlid, D. O., & Lotz-Sisitka, H. (2019). Consider the unexpected: Scaling ESD as a matter of learning. *Environmental Education Research, 25*(1). https://doi.org/10.1080/13504622.2018.1429572

Opitz, S. T., Blankenstein, A., & Harms, U. (2017). Student conceptions about energy in biological contexts. *Journal of Biological Education, 51*(4). https://doi.org/10.1080/00219266.2016.1257504

Oztas, F., & Oztas, H. (2017). Pupils' understanding of food concept: The assessment of children's preconceptions ideas about food. *Journal of Education and Practice, 8*(7). https://eric.ed.gov/?id=EJ1137571

Pollmeier, J., Tröbst, S., Hardy, I., Möller, K., Kleickmann, T., Jurecka, A., & Schwippert, K. (2017). Science-P I: Modeling conceptual understanding in primary school. In D. Leutner, J. Fleischer, J. Grünkorn, & E. Klieme (Eds.), *Methodology of educational measurement and assessment. Competence assessment in education: Research, models and instruments* (pp. 9–17). Springer International Publishing. https://doi.org/10.1007/978-3-319-50030-0_2

Reynolds, J., & Scott W. A. H. (2011). Sustainable schools in England: Background and lessons learned. *National Association of Field Studies Officers Annual Journal and Review*. ISBN: 978-1-901642-18-6. http://se-ed.co.uk/edu/wp-content/uploads/2012/10/Sustainable-Schools-in-England-background-and-lessons-learned.pdf. Accessed 16 July 2021.

Sarason, I. G., & Sarason, B. R. (1981). Teaching cognitive and social skills to high school students. *Journal of Consulting and Clinical Psychology, 49*(6). https://doi.org/10.1037/0022-006X.49.6.908

Simpson, G. B., & Jewitt, G. P. W. (2019). The development of the water-energy-food nexus as a framework for achieving resource security: A review. *Frontiers in Environmental Science, 7*. https://doi.org/10.3389/fenvs.2019.00008

UK Government. (n.d.-a). Types of school, academies. https://www.gov.uk/types-of-school/academies. Accessed 12 Apr 2021.

UK Government. (n.d.-b). Types of school, private schools.https://www.gov.uk/types-of-school/private-schools. Accessed 12 Apr 2021.

UK National Commission for UNESCO. (2013). Policy Brief 9: ESD in the UK - Current status, best practice and opportunities for the future. www.unesco.org.uk. Accessed 16 July 2021.

UK National Commission for UNESCO. (2017). Good practice in education for sustainable development (ESD) in the UK: Case Studies. www.unesco.org.uk. Accessed 16 July 2021.

UNESCO. (2014). *Shaping the future we want. UN decade of education for sustainable development 2005-2014 final report*. United Nations Educational, Scientific and Cultural Organization.

UNESCO. (2017). *Education for sustainable development goals. The global education 2030 agenda, learning objectives*. United Nations Educational, Scientific and Cultural Organization.

UNESCO. (2018). Issues and trends in education for sustainable development. https://unesdoc.unesco.org/ark:/48223/pf0000261445. Accessed 16 July 2021.

UNESCO. (2020). *Education for sustainable development: A roadmap*. United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.1111/j.2048-416x.2009.tb00140.x

United Nations SDG4. (2021). Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. https://sdgs.un.org/goals/goal4. Accessed 16 July 2021.

Walshe, N. (2008). Understanding students' conceptions of sustainability. *Environmental Education Research, 14*(5), 537–558. https://doi.org/10.1080/13504620802345958

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science, 6*(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6

Yillia, P. (2016). Water-energy-food nexus: Framing the opportunities, challenges and synergies for implementing the SDGs. *Österreichische Wasser- Und Abfallwirtschaft, 68*, 86–98.

Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. *Developmental Review, 27*(2), 172–223. https://doi.org/10.1016/j.dr.2006.12.001

Vasiliki Kioupi has completed her doctoral research in the Centre for Environmental Policy of Imperial College London (ICL) in education for sustainable development (ESD) with special emphasis on the development and assessment of learner sustainability competences from a systems thinking perspective. She received a prestigious President's PhD Scholarship from ICL to fund her research. She is an experienced science teacher, environmental educator, and teacher trainer and has worked for the Greek Ministry of Education as ESD coordinator. She is a fellow of the Schumacher Institute, an independent think tank for environmental, social, and economic issues. She has published her research in scientific and educational journals.

Nikolaos Voulvoulis, BSc (Hons), MSc, DIC, PhD, DMS, is Professor of Environmental Technology at Imperial College's Centre for Environmental Policy and deputy HoD. He is an international expert in environmental management, especially where science and engineering interface with public policy. His research targets the interactions and interdependencies between human and natural systems and focuses on processes and practices across many areas and diverse sectors. His work aims to facilitate policy development, support education initiatives, create an environment for innovation, and engage businesses, industry, and the public in the transformational shift required for our society to reach sustainability.