

REVIEW

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Barriers to learning for sustainability: a teacher perspective

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Abstract

We collectively face a constellation of complex and interconnected problems that threaten human and planetary wellbeing now and into the future. Holistic, multidisciplinary education that integrates the social, environmental and economic pillars of sustainability and enables learners to contribute to more sustainable societies are widely expected to play a crucial role in addressing these challenges. However, transformative learning to foster more sustainable ways of living cannot take place without teachers, who serve as role models for students and are widely acknowledged as key agents of social change. Teachers are called upon to translate international policies for sustainability education into classroom practice, but research shows that many practicing educators feel unprepared to help learners develop the competencies needed to forge more sustainable paths forward. In this commentary, the reflections of a British science teacher provide a first-hand account of the disconnect between international policy on sustainability education and the lived experiences of a classroom teacher and serve as a launch point for comparison with other teachers' perspectives on teaching and learning for sustainability as documented in the literature. Despite significant context-based differences in how sustainability education is implemented, teachers' voices from across the world reveal several common obstacles to multidisciplinary, learner-centered education for sustainability, including disciplinary silos, a focus on high stakes assessments, and inadequate professional learning opportunities for future and practicing educators. These hurdles persist despite repeated calls from policy-makers and researchers to better prepare and support educators as the facilitators of learning for sustainability, underscoring the need to more closely connect top-down Education for Sustainable Development policy to teachers' needs and classroom experiences.

Keywords Teachers, Learning, Learning process, Sustainability, Geoscience, Curriculum, School clubs

Introduction

In the face of complex and interconnected global problems that threaten human and planetary wellbeing now and into the future, little doubt exists that humankind's current trajectory is un-sustainable [1–5]. “Embarking on the path of sustainable development will require a profound transformation of how we think and act” ([6], p. 7). This kind of transformation can only be accomplished

through learning that fosters critical reflection on the prevailing worldviews and systems that promote unsustainable ways of living and that inspires and enables action for change [6–9]. Education has long played a role in the global development agenda and has been said to lie at the heart of the Sustainable Development Goals (SDGs), an ambitious “blueprint to achieve a better and more sustainable future for all” [5, 10]. However, addressing complex and multifaceted challenges to sustainability demands innovative thinking regarding the nature and purpose of education and learning. “Education as usual”, which has been criticized for preparing students for life and work in service of consumption and national economies, will not be adequate for the task [9, 11]. As noted

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by Stefania Giannini, Assistant Director-General for Education for UNESCO, “We are increasingly asking if what people learn is truly relevant to their lives, if what they learn helps to ensure the survival of our planet” [12].

Much has been written about Education for Sustainable Development, a United Nations-led initiative that addresses the knowledge, skills and mindsets that learners need to contribute to a more sustainable society [6, 10]. Because teachers are widely recognized as powerful agents of social change and serve as the translators of Education for Sustainable Development policy into classroom practice, it is crucial to investigate what they understand and think about sustainability and how those perceptions influence implementation of sustainability education at the classroom level [13–18]. In this contribution, the reflections of a secondary-school, British science teacher provide a first-hand account of the lived practice of a classroom teacher and illuminate systemic obstacles to providing both teachers and students with the kind of learning experiences they need to implement for change towards a more sustainable future. This is not a research study, but rather a commentary in which one teacher’s point of view serves as a jumping-off point for a broader examination of teachers’ perspectives on learning for sustainability at the classroom level. A review of teachers’ views in different parts of the world reveal shared obstacles to learning for sustainability and highlight a critical need to help build educators’ capacity to provide transformative learning opportunities for students.

Literature review

A survey of the literature reveals a wide array of terms for sustainability-related education, including Education for Sustainability, Education for Sustainable Development, and Environmental and Sustainability Education [19, 20]. These and other terms are often used interchangeably, although they may be interpreted differently. Education for Sustainable Development (ESD), the goal of which has been described as “learning to live sustainably” ([21], p. 12), is the most widely-used phrase in the international discourse about education, learning and sustainability and is a key component of the Sustainable Development Goals [19, 22]. ESD calls for interdisciplinary, whole-system approaches to learning that integrate curriculum content and organization with school ethos and management, facilities and resource use, and community partnerships (e.g., [6, 23, 24]). ESD provides learners, both teachers and students, with “an inspiring mission – to participate in creating a sustainable future” ([24], p. 43).

Education for Sustainable Development (ESD) is “holistic and transformational and encompasses learning content and outcomes, pedagogy, and the learning

environment itself” ([25], P. 8). Successful implementation of ESD requires a shift in focus from teaching to learning and a multidisciplinary approach that addresses the environmental, economic and social pillars of sustainability. ESD calls both for integration of key topics, such as climate change, disaster risk reduction, health and well-being, equity and sustainable consumption into the curriculum, and for a shift in the teacher’s role, from purveyor of knowledge to facilitator of learning that helps students develop key sustainability competencies [6] (Fig. 1). These competencies represent “the attributes individuals need for action and self-organization in various complex contexts and situations”, and they develop from an “interplay of knowledge, capacities and skills, motives and affective dispositions” as the result of experience, action, and reflection ([6], p. 10).

Rieckmann [6] highlighted three key pedagogies for ESD that draw on ideas developed by Mezirow [26], Kolb [27], and others and facilitate development of sustainability competencies (Table 1).

Teachers have been “singled out as the decisive factor when it comes to success in student learning” ([18], p. 51) and, as translators of ESD into classroom practice, serve as crucial change agents who support learners in developing sustainability competencies [16, 17]. Fostering these competencies requires integration of three inter-related dimensions of learning as described by UNESCO ([21], p. 22):

- Cognitive learning (builds knowledge, understanding, and critical thinking)
- Social and emotional learning (develops the awareness and social skills needed to positively and respectfully relate to others)
- Behavioural learning (fosters the ability to act effectively and responsibly from local to international levels to contribute to a more sustainable world).

However, a recent global survey of 58,000 primary and secondary teachers conducted by UNESCO and Educational International shows that teachers feel more comfortable with teaching cognitive skills than with facilitating the crucially-important social emotional and behavioural learning needed for collaborative problem solving and taking action [21].

Researchers working in different educational contexts in both developed and developing nations and in diverse locations, including Europe [13–16], Asia [15, 19, 29], Africa [15, 30], and the Caribbean [17], have investigated teachers’ perspectives on ESD. These studies emphasize the real need to consider teachers’ voices in assessing how effectively holistic, learner-centered sustainability education is being implemented “on the ground” (i.e.,

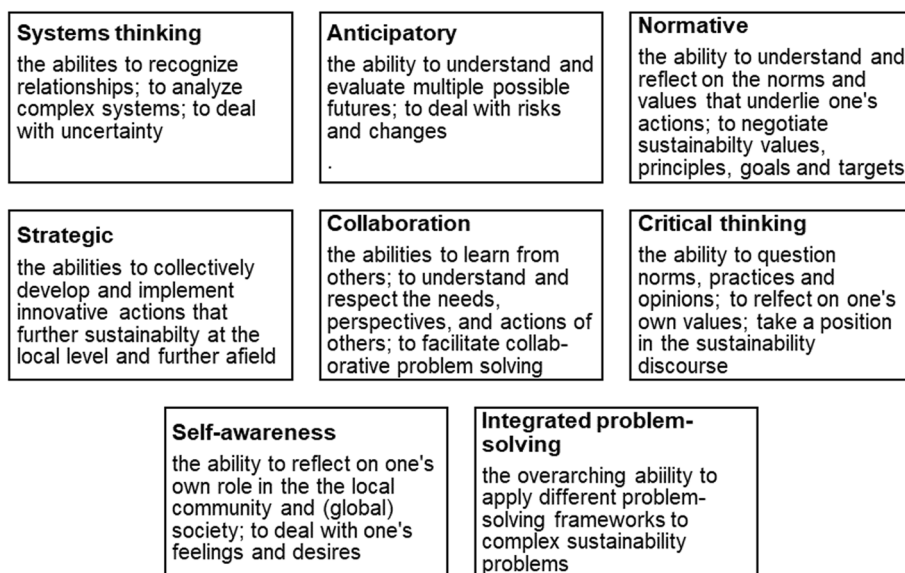


Fig. 1 Key competencies for sustainability (abbreviated). Source: ([6], p. 10)

Table 1 Key pedagogies for implementing ESD. Modified from ([6], p. 55)

Pedagogy	Description
A learner-centered approach	emphasizes the active development of knowledge through learning experiences that require learners to reflect on their own knowledge and learning processes
Action-oriented learning	draws on Kolb's experiential learning cycle with the following stages: 1. Having a concrete experience, 2. Observing and reflecting, 3. Forming abstract concepts for generalization, and 4. Applying them in new situations [27]
Transformative learning	empowers learners to question and change the ways they see and think about the world in order to deepen their understanding of it [26, 28]

at the classroom level). Despite considerable within and across country variations in how ESD is implemented [21, 31–33], these studies show that several obstacles to learning for sustainability transcend location. These include organization of learning into disciplinary silos, a widespread focus on high-stakes testing, a severe lack of training and support, and overworked and underpaid teachers (Fig. 2). The need for a multi-disciplinary approach to address the interconnected environmental, social and economic pillars of ESD is an additional barrier, arising from the fact that the professional preparation of teachers in most countries typically addresses just one of these pillars [32]. A less commonly-recognized obstacle, in the precollege curriculum, is the poor

representation of geoscience education, which provides learners with a holistic understanding of Earth system processes and evolution.

The following investigation of teachers' perspectives on teaching and learning for sustainability begins with first-hand reflections from first author Parry, a British science teacher with a geoscience background. These contemplative observations, which grew from Parry's poster presentation at the 2019 European Geosciences Conference [34], serve as an illustrative case study of the constraints faced by classroom teachers and furnish an opportunity to consider gaps between international ESD policy documents and the everyday realities of teaching within the limitations of current education systems. Parry's reflections:

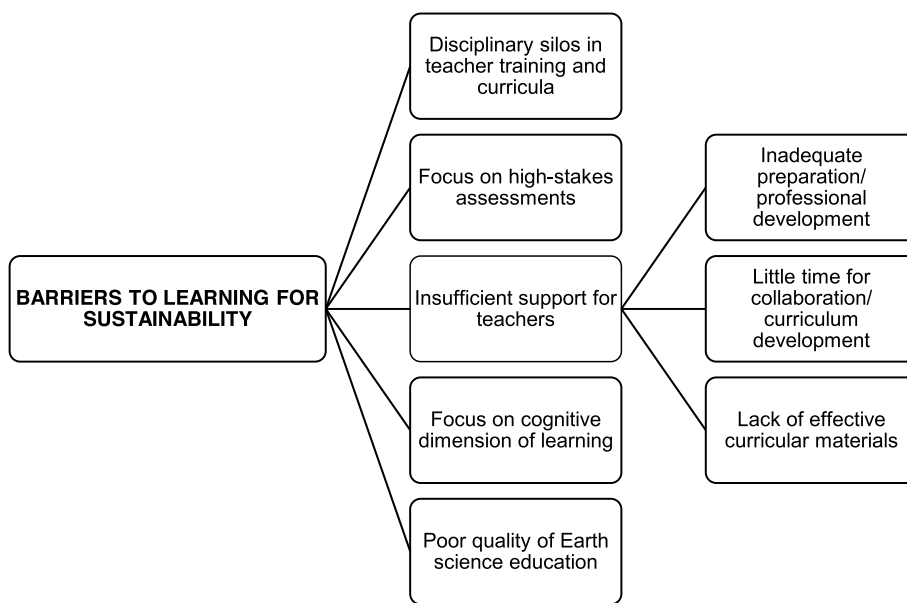


Fig. 2 Barriers to learning for sustainability

1. Supply a point of comparison with findings from the literature about how educators across the world view teaching and learning for sustainability.
2. Identify common barriers that limit teachers’ capacity to engage students in transformative learning for sustainability.
3. Highlight the need to strengthen Earth science education as part of holistic, multidisciplinary approach to sustainability education.

- How the school and the government could capitalise on students’ motivation to help shape more sustainable societies.

Reflections on learning for sustainability: a view from the classroom

I (Sally Parry) have been thinking about sustainability, what it means to students and whether we are adequately equipping our young people with the information and skills they need to understand the underlying drivers of unsustainable choices and take action to affect meaningful change. This is not a research study, but rather a collection of thoughts and observations from my daily life in the classroom, in which I consider:

- The place of sustainability in England’s National Curriculum.
- What is being taught about sustainability, how it is being taught, and how student learning for sustainability could be strengthened.
- What the students appear to think about sustainability issues and how this compares to my own ideas and preconceptions.

These observations were made at my previous school, a larger-than-average comprehensive school for girls with 1,500 students located in the outer suburbs of London. The school is in an affluent area and the proportion of pupils supported by extra funding for disadvantaged students or who have special educational needs and/or disabilities is much lower than the national average. Despite the dearth of funding, in the last Ofsted (Office for Standards in Education, Children’s Services and Skills) inspection in 2017 the school was rated as “outstanding” in all areas. Academically, it is a high achieving school and the 2019 Progress 8 score (the chief measure of school performance in the United Kingdom) was “well above average”.

In 2012, the Department of Education published guidance on the place of sustainability in United Kingdom schools. According to “Top Tips for Sustainability in Schools” ([35], p. 1):

Sustainable development means meeting the needs of all people now – including protecting the natural habitats that are essential to our survival – without compromising the ability of future generations to meet their own needs.

How are teachers meant to educate about sustainability? Well,

teachers help drive and embed behaviour change through integrating learning about this area into teaching, both at a theoretical and practical level. They can also be role models in changing behaviour, for example, by cycling or walking to school ([35], p. 4).

That is good as I walk to school and all my pens are stored in old biscuit tins, but not all my colleagues are in a position to walk or use public transport. What about helping students understand the fundamental science behind such pressing issues as resource management and climate change? Will a better understanding of the relevant science enable and motivate students to make more sustainable choices and lead by example?

Barriers to learning for sustainability—the curriculum

The assumption amongst many of my non-science-based colleagues is that the curriculum covers everything that the students need to know about sustainability. This is not unjustified as the current textbooks follow the national curriculum, but they are also very restrictive in how the content is delivered. Learning objectives are often narrow and factual content is prioritised over the mastery of competencies that enable students to engage in collaborative problem solving around challenges to sustainability.

In England the National Curriculum [36] includes sustainability topics within science and geography, a common approach in the curricula of other countries [15, 23]. The following topics are to be covered within the science curriculum at KS3 (Key Stage 3; ages 11–14) [37]:

- Earth as a source of limited resources and the efficacy of recycling
- The carbon cycle
- The composition of the atmosphere
- The production of carbon dioxide by human activity and the impact on climate.

At KS4 (Key Stage 4; ages 14–16) sustainability-related content in science is expanded to include [37]:

- Evidence for anthropogenic causes of climate change
- The potential effects of increased levels of carbon dioxide and methane on the Earth's climate
- Common atmospheric pollutants
- Earth's water resources and obtaining potable water
- Life cycle assessments and the viability of recycling.

In the KS3 geography curriculum [38] topics include:

- How human and physical processes interact to influence and change landscapes
- Environments and the climate.
- How human activity relies on effective functioning of natural systems
- Change in climate from the Ice Age to present
- Geological timescales.

Geography is not compulsory at KS4.

As a result of this structure, the core content on sustainability is spread over more than one school department, with a disconnect between (a) teaching the science behind sustainability challenges such as climate change and (b) consideration of the consequences and effects within the geography department.

Several studies have explored how teachers' disciplinary training influences how they approach sustainability [14, 30, 39]. As a science teacher with a background in Earth science, I believe that sustainability education is anchored in understanding the geoscience behind the resources we remove from the ground as well as considering how our electricity is generated. Crude oil extracted from under the sea must seem a long way removed from the average teenager's life in the suburbs. This led me to wonder how much students know about where the things that they use come from. Do the students realise that their phones are ultimately unsustainable? At the current rate of extraction, reserves of indium (used in touchscreens) will be exhausted in ten years [40]. Talking with my students has made me more aware of the importance of putting the topic I am teaching into an authentic context that connects to their world. This is consistent with recommendations from sustainability education researchers that learning be situated in real-world contexts in order to provide students with opportunities to link their learning to issues that matter to them, their families, and their community [41–43].

Teaching some basic geoscience, such as the age of the Earth, the formation of the solar system, and main evolutionary dates and previous mass extinctions could, in my opinion, help to put current rates of greenhouse gas emissions and species loss into context for students. This is important because key Earth science topics (climate change, mineral and water resources, natural hazards) and skills (an understanding of geological time, the ability to work across different temporal and spatial scales, interdisciplinary and systems thinking) connect to the environmental and socio-economic dimensions of sustainability [44, 45]. However, Earth science is not well represented in our National Curriculum and is absent or of poor quality in many of the world's schools [44, 45].

Barriers to learning for sustainability—the education system

A fragmented curriculum is not the only barrier to learning for sustainability; the wider issues of school finances and high-stakes assessments must also be considered. A member of the senior leadership team told me that sustainability-related issues within the school have been discussed at the highest level. It has been relatively simple to implement some basic policies such as having recycling bins in every classroom and reminding staff to make a conscious effort to turn off lights and projectors. Recycling bins have also been placed in the canteen. The school-wide policy of covering books in sticky-backed plastic was also dropped this year over concerns of generating more plastic waste. All this aligns with Department of Education's guidance of staff modelling good behaviour that promotes sustainability [35]. In addition, a senior member of staff worked with a core group of year 11 s (age 15 to 16) to talk over their plans for a sustainability club and help them to get the club up and running.

However, tackling issues such as using plastic cutlery in the canteen (a problem highlighted by the students) is not always straightforward. The canteen has already seen an increase in costs due to the new supplier this year and bringing in biodegradable wooden forks would only increase costs further as they are more expensive than plastic. The use of metal cutlery is equally problematic in that the canteen cannot accommodate all the students who wish to eat there and so they take their food away. The logistics of getting the forks back into the canteen for washing up, particularly during the short break time, is unworkable. In the past, students were leaving metal cutlery on the field, creating many more problems. As with many schools, the buildings are outdated and were not designed for the current number of students. Based on my conversations with the maintenance team, even the newer buildings are not nearly as energy-efficient as they were designed to be. An issue of some kind exists with every building on site with little money to rectify the faults.

This relates to the larger issue of limited school funding and its perceived impact on the ability to promote sustainability-related instruction, facilities and practices. How do you reconcile spending more money on addressing sustainability when the school's budget is so tight that doing so would directly affect day-to-day school operations and ultimately the students' learning? Should the school be put in the position of having to make such a decision? As a senior leader commented:

What are we meant to say to the students? We can be more sustainable, but you'll probably get one grade lower in your GCSEs (General Certificates of Secondary Education). What do you choose?

This is clearly a false choice, however, as studies have shown that education for sustainability enhances student achievement (e.g., [24] and references therein).

The perception that integrating sustainability education into the curriculum will negatively impact student performance is widespread at my school in the midst of a global testing culture and its "focus on standardization and high-stakes testing" and resulting "narrow view of what counts as teaching and learning" ([46], p. 192). This concern is common to teachers in countries as diverse as Norway and China [15]. As one teacher in Norway put it: "We are supposed to ensure good results in tests, not to teach students how to save the planet" ([47]; cited in [15], p. 835). However, a synthesis of studies from 18 countries to investigate the role of ESD (Education for Sustainable Development) in quality education [43] "showed evidence that ESD improves test scores and helps achieve other desired outcomes, such as improved student attendance and problem-solving skills" ([43], p. 233). Although no countries claimed evidence for a cause and effect relationship between ESD and improved test scores, eight countries "reported increased academic performance in ESD schools" ([43], p. 233), with no reports of negative impacts of ESD on student performance. My teacher colleagues and senior leaders in my school have not been exposed to this data.

Student perspectives—the sustainability club

Several students recently approached the head teacher to set up a sustainability club. This is something that the school is extremely willing to support. The Department of Education states that:

being a sustainable school raises standards and enhances young people's well-being. Research supports the idea that this is because sustainable schools engage young people in their learning, thereby improving motivation and behaviour, and promote healthy school environments and lifestyles" ([35], p. 1).

It is easy to make assumptions about what the students need to know and understand in order to make informed decisions about sustainability-related issues. However, my preconceptions are based on my education to postgraduate level rather than on the interest and experiences of the students. Listening and talking to a range of students in the sustainability club and in my general science lessons were needed to give me insight into what we are doing well and what needs further development.

Student observations

Knowing that I have an interest in resource management and sustainability, students from the sustainability club invited me to come along to their lunchtime meetings and were kind enough to allow me to take notes of our conversations. I used the opportunity to chat with them about their views on sustainability and what they wanted to achieve. All names have been changed when quoting their views. The ages of quoted students are given in parentheses.

The students from the sustainability club told me how important the issue of climate change is to them. Jess (14): “It is very important; most adults don’t realise how important it is. They don’t understand the effects.” Beth (14) added that “No teachers care, it is not a pressing issue for them.” So, in their eyes, we are already failing them. This would suggest that the school curriculum is not helping students to learn about climate change and other challenges to sustainability, especially if they do not believe that their teachers have any engagement in the subject. The students must be learning about climate change outside of the formal educational setting.

Information sources

I asked members of the sustainability club where they learn about sustainability-related issues. Amelia (15) remarked that “It is easy to find the information; I just need to watch a David Attenborough programme on TV.” Megan (12) said that “I haven’t learnt anything at school about climate change.” This comment was followed by a description of the ozone problem and global warming, which she claimed she had learned at school, but which is not in the curriculum. Even in year 13 (ages 17 to 18), most students cannot distinguish between the thinning of the ozone layer and greenhouse gas emissions leading to climate change.

Social media

Most students agreed that social media are their main source of information and, apart from Greta Thunberg’s Instagram account, I could not elicit the exact sources. No one said that they visited the main news websites in the United Kingdom on a regular basis.

School assemblies

One older student did mention an increase, over the past eighteen months, in the number of school assemblies that address unsustainable practices. These assemblies featured selected clips from the “Blue Planet” series [48]. Watching videos about plastic pollution clearly shocks the students into thinking about their own habits. However, when talking to the younger students before teaching the relevant section in the curriculum, none could

state how plastic is produced, or name the raw material from which it is made. “What I really need to know is how harmful plastic actually is” (Ellie, 13). She was quite perplexed when I tried to explain that we do not yet fully understand its impact, suggesting that students are unaware of the complexity and uncertainty inherent in the many obstacles to sustainability.

Action

These students are more knowledgeable than their peers in that they could easily list predicted consequences to the planet if no action is taken to address climate change and other pressing hurdles to sustainability. However, they find it difficult to describe how their knowledge could be applied to help mitigate these problems, implying a lack of opportunities for students to engage in the social-emotional and behavioural dimensions of learning. This suggests the importance of modifying the curriculum to include experiences that engage students in collaborative, project-based learning focused on problem-solving and action around sustainability issues that matter to them. I also gained the impression that, despite their keen interest in making more sustainable choices, students are reluctant to be seen as the first to make changes to their lifestyles.

School learning

The students from the sustainability club claim to be happy with the sources of their scientific information, but not with their learning in school as it relates to understanding unsustainable ways of living and taking action to change them. A small group of younger students in the sustainability club declared that “people need to be taught about the power of consumption and the consequences of using resources.” Olivia (14) decided that “we need to teach people earlier and more (about) what’s happening.”

Curriculum

As noted earlier, sustainability concepts are currently scattered across different departments, with the majority residing in science. The students expressed the opinion that sustainability-related learning would be far more effective if connected across the curriculum. The students told me that “We need to learn it in PSHE” (Personal, Social, Health and Economic Education) [49]. Such awareness of the need for a cross-curricular approach is interesting in light of research showing that many teachers and students do not hold a holistic view of sustainability and both are more familiar with the environmental pillar of sustainability than with its socio-economic aspects ([50] and references therein). This is an ideal opportunity for the students to be involved in

planning for curricular change to ensure that we address key topics and issues of importance to them, in accordance with recommendations that students be given a greater voice in how sustainability education is implemented at schools [21]. We could take the opportunity to pull together all the strands into a coherent set of lessons that cover science, history, geography and politics. However, is a more cohesive, interdisciplinary approach to delivering content likely in itself to inspire change towards more sustainable choices? The literature clearly shows that acquiring more information does not guarantee behavioural change (e.g., [51] and references therein). To become agents of change for a better future, students must be given opportunities to engage in action-oriented, experiential learning and to apply their learning in real-world contexts.

The school's sustainably club provides an excellent opportunity to engage students in problem-solving around unsustainable practices at their school such as the use of disposable plastic utensils and energy inefficiencies. We need to encourage the students to make changes themselves and to experiment with which solutions prove most effective.

Politics

The students are aware of the need to look beyond their school to investigate the political and societal dimensions of barriers to sustainability. For example, several club members attended a climate march in London (Fig. 3), although, when asked about what they were protesting, they could not give details. Moreover, students are telling us that they do not understand how the government

works. Only five of my form of thirty 15-year-olds could name the local MP (Member of Parliament), despite his having held cabinet positions and being the subject of international news articles. I would hazard a guess that most adults could not explain how Parliament functions, either. This is something we should address, as a school, to prepare students to make informed decisions in the future and help them to develop a sense of responsible citizenship.

The students I spoke to voiced their frustration that, in their view, the older generations do not appear to acknowledge or to care about their concerns. They want to be led by example and be given actual tasks to do and guidelines to follow. Sarah (16) "Why can't the government have an ad campaign on sustainability, with proper things to do; we never hear anything about it from them." These remarks suggest that students are not confident in their own abilities to lead for change and do not feel equipped to engage in the collective action needed for systemic change. One comment from Abby (16) really caught my attention: "Sustainability is only for the elite – being vegan is for posh people. Privilege is being able to make choices."

As a school, we need to address the fact that we are not providing students with the information that they require and the learning opportunities that they need in an accessible way. Most are turning to social media as their main source of information, are unable to discern the scientific facts from the fiction, and are unsure about how to translate knowledge to meaningful action to counter climate change and other issues that will have profound impacts on their futures.



Fig. 3 Second Youth Strike for Climate Justice, London 15th March 2019. Photo: Steve Eason. Licensed under the Creative Commons Attribution-Share Alike 2.0 Generic license

It must also be noted that not all students are interested in sustainability as a topic and have not been exposed to the concept of sustainability as an aspiration for a more just and sustainable future. Making learning for sustainability a more integral part of the curriculum could help to engage more young people. The students' suggestion of a sustainability-themed module that covers all the strands of science, politics, history and geography is a very good starting point for development of interdisciplinary learning experiences. However, the responsibility of writing the lessons and developing new, sustainability-focused curriculum should not lie with the schools and their already over-worked teachers. The national government, which develops the curriculum, needs to provide a clear policy and give guidance for how to systemically integrate cohesive, interdisciplinary education for sustainability. Of course, funding is a key issue, both for schools overall and in the form of dedicated amounts for each school to introduce a central sustainability policy. However, once implemented, education for sustainability should be no more expensive than education for unsustainability [52].

My observations and experiences as a teacher, as recorded in the reflections above, are consistent with findings from other secondary schools. Based on a review of findings from a number of countries around the world, Taylor et al. (2019) [53] noted that implementing sustainability education in secondary schools presents some unique opportunities and challenges. Secondary students are nearing voting age, affording an opportunity to link their learning to "informed and active participation in democratic processes such as voting, choices, civic and community engagement" ([53], p. 104). However, several obstacles exist to implementing holistic, interdisciplinary education for sustainability at the secondary level [39, 53, 54]:

- The secondary curriculum is commonly partitioned into "disciplinary silos", making cross-disciplinary collaboration and lesson planning difficult.
- Sustainability-related instruction is commonly perceived as an add-on that must compete for time within an already crowded curriculum.
- High-stakes testing narrows the curriculum and promotes teaching to the test.
- Few teachers have training in the content and pedagogy of Education for Sustainable Development/Education for Sustainability.

An additional issue is the lack of quality Earth science education in many schools around the globe [44, 45]. Earth science concepts (climate change, mineral resources, natural hazards) and skills (interdisciplinary and systems thinking, a grasp of geologic time and study of earth

systems across diverse temporal and spatial scales) provide a unique and valuable framework for multidisciplinary investigations of planet Earth and connect to the environmental, social and economic dimensions of sustainability [44, 45].

Discussion

As noted by Anyolo et al. "teachers' perceptions of Education for Sustainable Development (ESD) play a major role in the way they teach and prepare learners for the future" ([30], p. 650), making it imperative to understand how educators translate sustainability education policy to classroom practice. First author Parry's reflections and research concerning educators' perspectives from different parts of the world reveal several obstacles to learning that facilitates transformative change for sustainability. These obstacles include compartmentalized curricula, a focus on factual information and on student performance in high stakes assessments, inadequate learning opportunities for future and practicing educators, and lack of time, funding and curricular materials (Fig. 2). The complexity of the interacting environmental, social and economic pillars of sustainability call for a coherent, multidisciplinary to approach to learning that presents further challenges for educators with in-depth training in a single subject [14, 39]. For example, research shows that in general teachers are most familiar with the environmental dimension of sustainability [50], and a recent examination of policy documents for 10 countries revealed that "ESD is mostly associated with the teaching of scientific knowledge on environment" ([25], p. 9).

Widely-reported roadblocks to learning for change underscore the need to better understand impediments to effective classroom-level adaptation of sustainability education. This has important implications for the design of both initial teacher preparation programs and continuing professional development for educators. The most comprehensive international survey to date of teachers' self-reported readiness to teach ESD (and related Global Citizenship Education), indicates that more than 90% of the 58,000 teacher respondents agreed that ESD-related concepts are important and more than 80% want to learn more about them, indicating "an appetite for learning that is currently not being met" ([21] p. 30).

Conclusions

Learning that enables critical reflection upon current worldviews and systems that perpetuate unsustainability is essential to finding a more sustainable trajectory towards the future. However, as illustrated by first author Parry's personal reflections and supported by findings from the literature, traditional curricula, assessments and teaching methods are ill-suited to the task of providing

learners with transformative learning experiences that support development of the sustainability competencies needed to act as change makers. The widespread absence of quality Earth science education, which is essential to a holistic understanding of complexly interacting planetary and human systems, is another impediment.

Research shows that despite important context-specific differences, educators in different parts of the world experience common barriers to implementing sustainability education. Many teachers have difficulty with the multidisciplinary aspects of sustainability, feel unprepared in both the content and student-centered pedagogy of ESD, and they are not adequately supported in terms of resources, materials, time for collaboration and ongoing professional learning opportunities. The persistence of these obstacles, despite longstanding and widespread recognition of the key role of teachers in facilitating learning for sustainability, highlights the need to more closely connect education for sustainability policy to teachers' perspectives, experiences, and learning needs.

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SP collected, analyzed and interpreted the student and staff statements and wrote the paper. EM reviewed the statements and wrote the paper. All authors read and approved the final manuscript.

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References

- Díaz S, Settele J, Brondízio ES, Ngo HT, Guèze M, Agard J, Arneth A, Balvanera P, Brauman K, Butchart SH, Chan KM. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. 2019.
- Messlerli P, Murniningtyas E, Eloundou-Enyegue P, Foli EG, Furman E, Glassman A, Hernández Licona G, Kim EM, Lutz W, Moatti JP, Richardson K. Global Sustainable Development Report 2019. The Future is Now: Science for Achieving Sustainable Development. 2019. <https://sustainabledevelopment.un.org/gsd2019>. Accessed 20 March 2020.
- Griggs D, Stafford-Smith M, Gaffney O, Rockström J, Öhman M, Shyam-sundar P. Policy: sustainable development goals for people and planet. *Nature*. 2013;495:320–2.
- Steffen W, Richardson K, Rockström J, Cornell SE, Fetzer I, Bennett EM, Biggs R, Carpenter SR, De Vries W, De Wit CA, Folke C. Planetary boundaries: Guiding human development on a changing planet. *Science*. 2015;347(6223):1259855.
- Take action for the Sustainable Development Goals <https://www.un.org/sustainabledevelopment/sustainable-development-goals>. Accessed 2 Jan 2022.
- Rieckmann M. Education for Sustainable Development Goals: Learning Objectives. Paris: UNESCO; 2017.
- Sipos Y, Battisti B, Grimm K. Achieving transformative sustainability learning: engaging head, hands and heart. *Int J Sustain High Educ*. 2008;9(1):68–86.
- Lotz-Sisitka H, Wals AE, Kronlid D, McGarry D. Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction. *Curr Opin Environ Sustain*. 2015;16:73–8.
- Bell DV. Twenty-first century education: transformative education for sustainability and responsible citizenship. *J Teach Educ Sustain*. 2016;18(1):48–56.
- UNESCO. Education 2030: Incheon Declaration and Framework for Action—Towards inclusive and equitable quality education and lifelong learning for all. Paris: UNESCO; 2015.
- UNESCO. Global education monitoring report, education for people and planet: creating sustainable futures for all. Paris: UNESCO; 2016.
- UNESCO. UNESCO Member States map the future of Education for Sustainable Development. 2018. <https://en.unesco.org/news/unesco-member-states-map-future-education-sustainable-development>. Accessed 20 Mar 2020.
- McNaughton MJ. Implementing education for sustainable development in schools: learning from teachers' reflections. *Environ Educ Res*. 2012;18(6):765–82.
- Uitto A, Saloranta S. Subject teachers as educators for sustainability: a survey study. *Educ Sci*. 2017;7(1):8.
- Witoszek N. Teaching sustainability in Norway, China and Ghana: challenges to the UN programme. *Environ Educ Res*. 2018;24(6):831–44.
- Waltner EM, Scharenberg K, Hörsch C, Rieß W. What teachers think and know about education for sustainable development and how they implement it in class. *Sustainability*. 2020;12(4):1690.
- Ferguson T, Roofe C, Cook LD. Teachers' perspectives on sustainable development: the implications for education for sustainable development. *Environ Educ Res*. 2021;23:1–7.
- Timm JM, Barth M. Making education for sustainable development happen in elementary schools: the role of teachers. *Environ Educ Res*. 2021;27(1):50–66.
- Hopkins C, McKeown R. Education for sustainable development: an international perspective. *Education and sustainability: Responding to the global challenge*. 2002;3(2):13.
- Summers D, Cutting R. Education for sustainable development in further education. London: Palgrave Macmillan; 2016.
- Teachers Have Their Say: Motivation, Skills and Opportunities to Teach Education for Sustainable Development and Global Citizenship - UNESCO Digital Library. Accessed 05 December, 2021. <https://unesdoc.unesco.org/ark:/48223/pf000037991473=null&queryId=1a252df5-ceac-440e-9574-e6f5c42c2583>.
- Agbedahin AV. Sustainable development, education for sustainable development, and the 2030 agenda for sustainable development: emergence, efficacy, eminence, and future. *Sustain Dev*. 2019;27(4):669–80.
- Evans N, Whitehouse H, Gooch M. Barriers, successes and enabling practices of education for sustainability in far North Queensland schools: a case study. *J Environ Educ*. 2012;43(2):121–38.
- Cloud J, Jackson M. Education for a sustainable future: Benchmarks for individual and social learning. *J Sustain Educ*. 2016;14:1–29.

25. Education for Sustainable Development: a roadmap - UNESCO Digital Library. <https://unesdoc.unesco.org/ark:/48223/pf0000374802>. Accessed 2 Jan 2022.
26. Mezirow J. *Learning as Transformation: Critical Perspectives on a Theory in Progress*. San Francisco: Jossey-Bass; 2000.
27. Kolb DA. *Experiential Learning: Experience as the Source of Learning and Development*. New Jersey: Prentice-Hall; 1984.
28. Slavich GM, Zimbardo PG. Transformational teaching: theoretical underpinnings, basic principles, and core methods. *Educ Psychol Rev*. 2012;24(4):569–608.
29. Nguyen TP. Education for sustainable development in Vietnam: exploring the geography teachers' perspectives. *Int Res Geogr Environ Educ*. 2018;27(4):341–56.
30. Anyolo EO, Kärkkäinen S, Keinonen T. Implementing education for sustainable development in Namibia: school teachers' perceptions and teaching practices. *J Teach Educ Sustain*. 2018;20(1):64–81.
31. Benavot A. *Education for Sustainable Development in Primary and Secondary Education*. Paris: Background paper prepared for the DESD unit at UNESCO headquarters; 2014.
32. Clément P, Caravita S. Education for sustainable development: An international survey on teachers' conceptions. In: Tiberghien A, Clément P, Bruguière C, editors. *Topics and trends in current science education*. Dordrecht: Springer; 2014. p. 175–91.
33. Leicht A, Heiss J, Byun WJ. *Issues and trends in education for sustainable development*. Unesco Publishing; 2018 Feb 19.
34. Parry S. Engaging Girls in Geoscience Through the School Science Curriculum. In: *Geophysical Research Abstracts 2019 Jan 1 (Vol. 21)*.
35. Department of Education. Top tips for sustainability in schools. Department of Education. 2012. <https://www.gov.uk/government/publications/top-tips-for-sustainability-in-schools>. Accessed 20 Mar 2019.
36. Department of Education. National curriculum in England. Department of Education. 2019a. <https://www.gov.uk/government/collections/national-curriculum>. Accessed 20 Mar 2019.
37. Department for Education. National curriculum in England: science programmes of study. Department for Education. 2019. <https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study/national-curriculum-in-england-science-programmes-of-study>. Accessed 20 Aug 2019.
38. Department of Education. National curriculum in England: geography programmes of study. Department of Education. 2019. <https://www.gov.uk/government/publications/national-curriculum-in-england-geography-programmes-of-study>. Accessed 20th August 2019.
39. Borg C, Gericke N, Höglund HO, Bergman E. The barriers encountered by teachers implementing education for sustainable development: discipline bound differences and teaching traditions. *Res Sci Technol Educ*. 2012;30(2):185.
40. Davies S, Mugglestone F, Richards R, Shelton T. *OCR Geology for A Level & AS*. Cheltenham: Illuminate; 2018.
41. Brundiers K, Wiek A, Redman C. Real-world learning opportunities in sustainability: from classroom into the real world. *Int J Sustain High Educ*. 2010;11(4):308–32.
42. O'Donoghue R. Think piece: re-thinking education for sustainable development as transgressive processes of educational engagement with human conduct, emerging matters of concern and the common good. *S Afr J Environ Educ*. 2014;30:7–26.
43. Laurie R, Nonoyama-Tarumi Y, Mckeown R, Hopkins C. Contributions of education for sustainable development (ESD) to quality education: a synthesis of research. *J Educ Sustain Dev*. 2016;10(2):226–42.
44. King C. Geoscience education: an overview. *Stud Sci Educ*. 2008;44(2):187–222.
45. Stewart IS, Gill JC. Social geology—integrating sustainability concepts into earth sciences. *Proc Geol Assoc*. 2017;128(2):165–72.
46. Koppina H, Meijers F. Education for sustainable development (ESD). *Int J Sustain High Educ*. 2014;15:188–207.
47. Ribeiro Koelch, E. 2014. "Constructing Norwegianness in School: Exploring How School Activities in Nature are Connected to the Development of an Important Facet of Norwegian Identity." Master thesis, Oslo Høyskole.
48. BBC Earth. *Blue Planet: The Collection*. [DVD]. London: British Broadcasting Corporation; 2017.
49. Department for Education. Personal, social, health and economic education. Department of Education. 2020. <https://www.gov.uk/government/publications/personal-social-health-and-economic-education-pshe/personal-social-health-and-economic-pshe-education>. Accessed 20 Mar 2020.
50. Sinakou E, Boeve-de Pauw J, Van Petegem P. Exploring the concept of sustainable development within education for sustainable development: implications for ESD research and practice. *Environ Dev Sustain*. 2019;21(1):1–10.
51. Frisk E, Larson KL. Educating for sustainability: competencies & practices for transformative action. *J Sustain Educ*. 2019;2(1):1–20.
52. Cloud, J. Teachable Moments/Let's Optimize Our Children's Capacity to Be Creative and Smart. 2015. <https://cloudinstitute.org/blog/teachable-moments-lets-optimize-our-childrens-capacity-to-be.html>. Accessed 9 Feb 2021.
53. Taylor N, Quinn F, Jenkins K, Miller-Brown H, Rizk N, Prodromou T, Serow P, Taylor S. Education for sustainability in the secondary sector—a Review. *J Educ Sustain Dev*. 2019;13(1):102–22.
54. Kang W. Perceived barriers to implementing education for sustainable development among Korean teachers. *Sustainability*. 2019;11(9):2532.

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