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Fostering student climate agency and future literacy: a case study of scenario-based teaching

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ABSTRACT

Background: The 21st century has been characterised by fast-paced global societal, scientific and technological challenges. As such, future citizens should be adequately equipped with necessary skills to navigate the high degree of uncertainty that they entail.

Purposes: Utilising the affordances of learning in informal spaces, this study explores the use of a scenario-based teaching approach to facilitate students' agency towards climate change.

Sample: Twenty-four ($n = 24$) secondary school students (Year 12) took part in the study.

Design and methods: A teaching session focusing on possible positive, as well as troubled climate change scenarios, was designed and delivered in a Museum of Natural History in England. Students responded to a paper-pencil questionnaire before and after the teaching session to examine potential gains in their feeling of agency, futures literacy and epistemic emotions.

Results: Results indicated a positive effect on students' climate agency, as well as a significant improvement of students' perceived futures literacy. Moreover, students reported that they felt 'motivated' and 'hopeful' during the session.

Conclusion: The findings of the study highlight the pedagogical value of scenario-based teaching as a strategy that can support student agency and confidence in dealing with uncertainties. As a result, it offers valuable insights on effective teaching strategies aiming at students' empowerment towards the complex challenges of the future.

KEYWORDS

Futures thinking; informal learning; climate change; teaching methods

Background

The fast-paced societal, scientific and technological advances witnessed in the last decade at a global level have highlighted the pressing need to prepare young people for the challenges of the future. Researchers, policymakers and educators have, therefore, argued about the role of education in empowering young people by supporting their active engagement with such topics. In line with this narrative, global competences have featured as the core concept of PISA 2018 framework, demonstrating the need to support

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students in taking action 'for collective well-being and sustainable development' (OECD 2020a).

An example of such challenges, often characterised by a high level of uncertainty, is climate change. The high level of uncertainty and risk involved in predictions and decisions around climate change has been associated with feelings of anxiety and hopelessness about the future (e.g., Clayton 2020). Although there have been efforts towards teaching about climate change and sustainability, students express concerns regarding the quality of climate education they receive (UNESCO 2021). To address this issue, it has been argued that teaching activities should be designed in a way that would promote a 'sense of realistic hope' and an 'active orientation' towards the challenges of the future (Levrini et al. 2021).

This study explores the use of scenario-based teaching as a tool for introducing possible, probable and desirable future scenarios with regard to climate change. In doing so, it aims to support students' feelings of agency and empowerment towards issues of high complexity and uncertainty, such as climate change. The study contributes to a body of literature aiming to introduce future-oriented thinking skills, such as foresight and scenario thinking, in educational settings (Tasquier, Branchetti, and Levrini 2019).

Literature Review

The 21st century has been characterised by rapid advances in technology and science leading to dynamic societal changes. Within this context, an increasing number of researchers and educators argue that education should equip future citizens with adequate skills to address the challenges of the future (Tasquier, Knain, and Jornet 2022). These skills often conceptualised as 'twenty century skills', consist of cognitive, interpersonal and technical skills including systems thinking, problem solving and critical thinking (Ananiadou and Claro 2009; González-Salamanca, Agudelo, and Salinas 2020). In the same vein, global competence was introduced in PISA 2018 assessment as an innovative multidimensional construct that 'requires a combination of knowledge, skills, attitudes and values successfully applied to global issues or intercultural situations' (OECD 2020a).

Many national curricula worldwide have begun adding curricular elements targeting global challenges and solutions (UNESCO 2020b). Given the high complexity of the current and future global challenges, it has been argued that concrete examples of SDGs, such as climate action, can serve as a contextual basis for teaching and learning 21st century skills (González-Salamanca, Agudelo, and Salinas 2020). Pedagogical approaches such as Education for Sustainable Development (ESD) and Global Citizenship Education (GCE) have been introduced in order to equip students with decision-making skills regarding environmental conservation, economic sustainability, thereby benefiting present and future generations.

OECD emphasised the importance of Anticipation (foresight), Action, and Reflection (AAR) as essential dimensions of a framework for navigating the complexities of today's world (OECD 2019a). These dimensions call for the cultivation of skills that enhance the ability to envision the future, take responsibility for active participation in shaping the world, and intentionally influence events and circumstances in a positive direction. Encouraging the development of AAR among students conceptually links futures thinking

to agency, as 'agency involves the idea of projection and implies anticipation' (Cuzzocrea and Mandich 2016).

Futures literacy

Pedagogical frameworks such as ESD promote the concept of sustainability to connote improving and sustaining a healthy economic, ecological and social system for human development (Mensah 2019). They therefore emphasise the conceptualisation of sustainability as temporal *continuity* and *interconnectedness*, as that they highlight ways in which present actions could impact future generations (Mensah 2019). They are also *future-oriented* in that they discuss future goals and relevant actions (e.g., 'ESD for 2030'; UNESCO 2020). The competencies associated with these frameworks have been conceptualised in various ways. Wiek, Withycombe, and Redman (2011) define five key competencies for sustainability: strategic, interpersonal, systems thinking, normative and anticipatory competence. In this framework anticipatory competence is defined as 'the ability to collectively analyze, evaluate, and craft rich "pictures" of the future' (Gardiner and Rieckmann 2015).

Conceptually linked to sustainability competencies, *futures literacy* is defined as 'the capacity to explore the potential of the present to give rise to the future' (Miller 2007, 347). These 'future-scaffolding skills' refer to the ability to structure knowledge in the present while envisioning future possibilities, and to navigate flexibly and deliberately across global and local contexts, as well as between different spatial and temporal dimensions (Tasquier, Branchetti, and Levrini 2019). In terminology, the plural form of 'futures' highlights the consideration of multiple possible scenarios, emphasizing the importance of foresight, anticipation, and imagination in thinking about the future. In this process, scenario building is a central skill, alongside risk assessment and other futures literacy competencies (Levrini et al. 2019; Miller 2015). The European sustainability framework 'Greencomp' features such 'future-scaffolding skills' and 'futures literacy' skills as the ability to 'envision alternative sustainable futures' (Bianchi, Pisiotis, and Cabrera Giraldez 2022). According to this framework, futures literacy is obtained 'by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future' (Bianchi, Pisiotis, and Cabrera Giraldez 2022).

Although only recently explored in educational contexts, these processes have been originally described by Futures Studies as 'forecasting' and 'backcasting' (e.g. Robinson 2003; 2011). During these processes, individuals focus on envisioning different perspectives of the future: what could happen (possible futures), what should happen (preferable or desirable futures), and what is likely to happen (probable futures) (Hicks 2010; Masini 2002; Voros 2003). Voros (2003) explains that possible futures encompass all conceivable scenarios, including highly improbable ones. Plausible futures, on the other hand, represent scenarios that could realistically occur based on current knowledge, including physical laws, sociological models, and technological advancements. Within plausible futures, probable futures are identified as those deemed most likely to occur, often extending current trends. To visually differentiate between plausible, possible, and desirable futures, Voros (2003) introduced the 'futures cone', which builds upon an idea first proposed by Hancock and Bezold (1994), as illustrated in Figure 1.

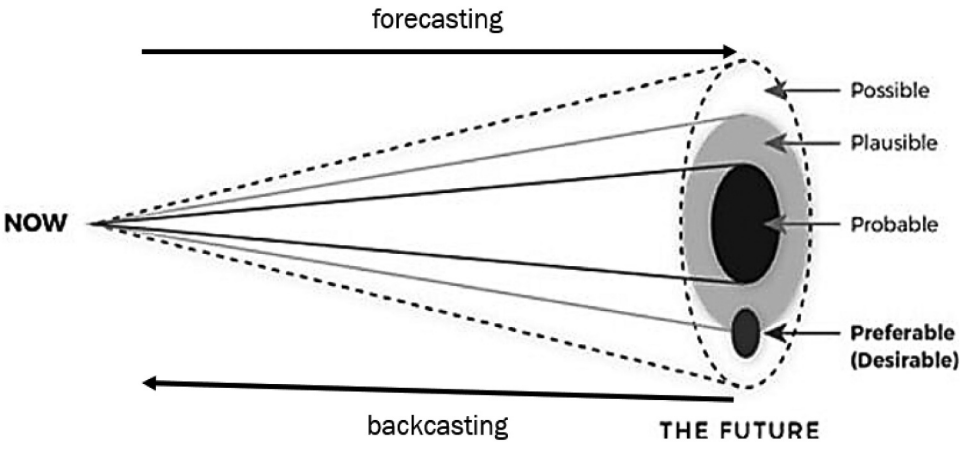

Figure 1. The futures cone (from Voros 2003).

Climate agency

Student agency is a fundamental concept in futures literacy (Häggström and Schmidt 2021) and is prominently featured in influential policy documents (OECD 2019a; 2020b; UNESCO 2020). While student agency has been widely explored in research, it has only recently gained significant attention in policymaking. The OECD's *Learning Compass 2030* (2019a) outlines the essential competencies students need to shape and succeed in their future. Central to this framework is student agency, which is defined as 'the capacity to set a goal, reflect and act responsibly to effect change' (8).

Despite the emphasis put by formal and informal environmental education on knowledge, research in environmental education suggests that climate education should not be limited to presenting the causes and effects of a phenomenon, but it should rather expand to 'systems knowledge' highlighting the dynamic systems and reciprocal actions influencing climate change (Kolenatý, Kroufek, and Činčera 2022). Climate change should be framed within 'a broader emotional and socio-political and cultural contexts, concerns, and values' (Tasquier, Knain, and Jornet 2022). By recognising their position within a wider system of stakeholders (e.g. governments, industry, citizens) and by becoming aware of the impact of their individual actions, students develop their systems thinking competence.

Given that young people are regarded as future citizens and, as such, the driving force behind transformative action for climate change, climate education should, more importantly, promote students' *climate agency* (i.e. students sense of empowerment) by providing 'action knowledge' (e.g. Frick, Kaiser, and Wilson 2004; Mansilla and Schleicher 2022). This includes the necessary sustainability knowledge, skills and attitudes needed to critically think, plan and 'take or request action for sustainability' (SDG 4 Target 4.7). In this context, education should highlight the opportunities that individuals have to contribute to local and global solutions while taking into account their role, characteristics and reach. These opportunities can be highlighted through example actions from the individual (e.g., consumer attitudes), the collective (e.g., climate activism), as well as the political sphere (e.g., active citizenship) (Bianchi, Pisiotis, and Cabrera Giraldez 2022).

Epistemic emotions and climate change

Epistemic emotions refer to how cognitive tasks and activities contribute to generating knowledge. This definition of epistemic emotions, centered on their object of focus, aligns with similar epistemically related concepts such as epistemic cognition, epistemic metacognition, and epistemic beliefs (Pekrun 2016). Positive epistemic emotions, such as hope, curiosity and pride and can play a pivotal role in students' learning (Pekrun 2016).

It has been well-documented that learning about climate change can trigger a variety of emotions (Chapman 2015). Because of the complexity of climate change and sustainability topics, the reported emotions are oftentimes negative and include anxiety, despair, stress, fear, worry, guilt, anger, sadness, helplessness, apathy, and frustration (Corner et al. 2015; Kleres and Wettergren 2017; Ojala 2016; Tasquier and Pongiglione 2017). Young people's emotions, in particular, along with their ability to engage in complex thinking, may play a crucial role in adopting climate-friendly behaviors and perceptions. Kleres and Wettergren (2017) identified emotions such as fear, hope, anger, and guilt as predictors of climate activism and engagement. In contrast, Tasquier and Pongiglione (2017) highlighted fear and other negative emotions as obstacles to behavioral change. Additionally, Ojala (2016, 2017) explored how fear, hope, and anticipation influence learning about climate change.

However, recent studies have highlighted the need to explore the interplay between pedagogical approaches for climate change and epistemic emotions (e.g., Oberauer et al. 2023; Wang et al. 2018). If hope can be broadly defined as a positive feeling about the future (McGeer 2004), teaching activities around climate change should promote 'constructive' hope that is based on action and pro-environmental engagement rather than unrealistic optimism or denial (e.g., Ojala 2012). In this context, the use of future scenarios can be used as a tool to provide a mental visualisation of 'tangible changes', concrete goals and perceived pathways to these goals through the processes of 'forecasting' and 'backcasting' (Ojala 2017). In this way, uncertainty-induced anxiety could be minimised through the development of possible, probable, and desirable climate change scenarios, which might, in turn, foster a sense of agency and hope among young people.

Methodology

Purpose

Although teaching through scenarios has been previously studied in other contexts (e.g. decision-making) (e.g., Eggert et al. 2013), its pedagogical affordances in supporting futures literacy and climate agency have not been sufficiently explored to date (Chan and Erduran 2024). Theoretically framed by education for sustainable development (ESD) (UNESCO 2020) and futures studies (e.g., Hutchinson and Herborn 2012), this study contributes to recent attempts to explore the introduction of future-oriented skills in science education (Barelli et al. 2022; Levrini et al. 2021; Paige and Lloyd 2016; Tasquier, Branchetti, and Levrini 2019).

The aim of this study is to explore the impact of a scenario-based teaching approach on students' climate agency and futures literacy with regard to climate change. To that end, this study followed a participatory approach in designing a teaching session

incorporating elements of formal and informal teaching and learning approaches. The data collection methods were approved by the university's Departmental Research Ethics Committee (DREC) under the procedures described by the University for ethical approval of all research involving human participants (application number ED-CIA-21–046).

Research questions

(1) How does a scenario-based teaching approach influence students' climate agency and their perceived futures literacy regarding climate change?
(2) How does a scenario-based teaching approach influence students' epistemically-related emotions with regard to climate change?
(3) What are students' views on a scenario-based teaching approach regarding climate change?

Context

A Museum of Natural History in England was selected as the informal teaching space for the needs of this study. The museum was selected because of its focus and interest in climate change and biodiversity activities, which would serve as the basis of the designed lesson. For instance, examples of workshops and exhibitions regarding climate change hosted by the museum were presented and discussed during the teaching session. The workshop was organised in the context of a Youth Advisory Board activity, which included a school trip to the museum and a visit to a local university. During the museum visit, one class from two regional schools attended a three-hour workshop that was led by two members of the research team and one museum educator.

Sample

All the participants of this study had voluntarily selected this workshop as their preferred learning activity within the Youth Advisory Board. Therefore, this study followed a convenience sampling method (Onwuegbuzie and Collins 2007). The sample consisted of overall 24 Year 12 students based in England, with a mean age of 16.4 years ($SD = 1.06$).

Participatory approach

The teaching session was developed based on a multi-step process that included a range of stakeholders, such as teachers, policymakers, researchers, as well as educators from informal spaces. Given the breadth of information that was gathered in this phase, a detailed description of these steps would go beyond the scope of this paper. Therefore, this section includes only a short summary of the process of developing the lesson implemented in this study.

The research team initiated the establishment of a network in order to facilitate the collaboration between multiple stakeholders (e.g. teachers, researchers, policymakers) in developing teaching materials about pressing global issues. As part of the network, the research team gathered data on policymakers' views regarding future-oriented skills (Ioannidou and Erduran, 2022), highlighting environmental issues, including

climate change as one of the main challenges of the future. Furthermore, the study demonstrated that policymakers value the inclusion of informal as well as formal forms of science education when teaching about future challenges (Ioannidou & Erduran, 2022). As a result, the research team designed a teaching session in collaboration with science teachers that could be applied in informal teaching spaces, such as museums. The multi-step process is presented in Figure 2.

As illustrated in Figure 2, the teaching session was co-developed by the research team, two science teachers and one museum educator. In order to ensure that the session aligned with the aims of science curriculum in Year 12, the research team conducted two classroom observations. In addition, museum artefacts and teaching materials previously used in the museum involved in this study were reviewed, in order to ensure the coherence between the formal and informal teaching elements of the study.

Description of the teaching session

The outline of the teaching session was constructed based on a conceptual framework developed by Jones et al. (2012) targeting students' futures thinking skills in science education. The framework included five key elements: (a) an understanding of the current situation; (b) identification of key trends; (c) analysis of the relevant drivers; (d) development of possible and probable future scenarios; and (e) selection of preferable future(s). The validity of this framework has previously been examined to establish its suitability for a range of age groups and classroom activities within the context of socio-scientific issues (Jones et al. 2012).

As the primary focus of the study did not lie on students' conceptual understanding of the topic, but rather on students' empowerment through their

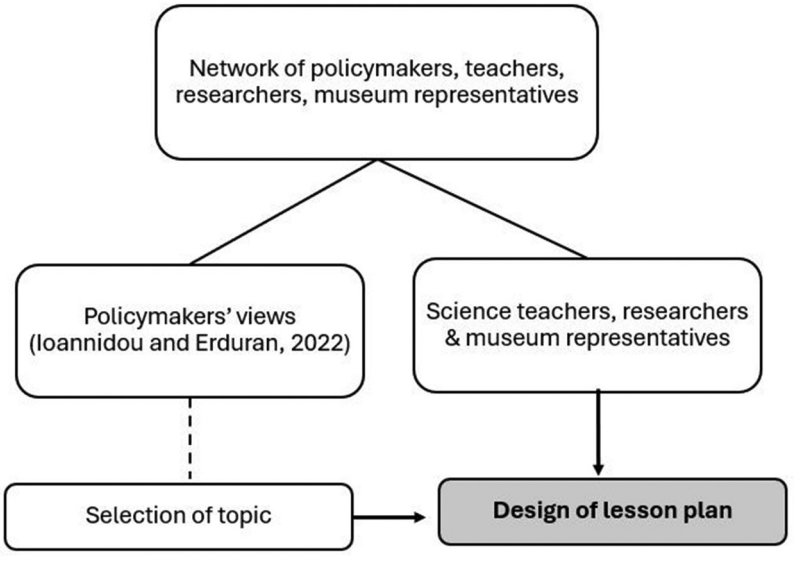

Figure 2. Process developing the lesson plan.

Table 1. Outline of scenario-based teaching session.

Topic	Activity	Mode	Concept (Jones et al. 2012)
What is climate change?	PowerPoint presentation	Teacher-led	(a) understanding of the current situation & identification of key trends
What are the underlying causes and consequences of climate change?	Videos Whole class discussions	Teacher and student-led	(b) analysis of the relevant drivers
Thinking about the possible futures	Group activity	Student-led	(c) development of possible and probable future scenarios
Thinking about the desirable futures	Student presentations	Student-led	(d) selection of preferable future(s)

conceptual understanding, a short introduction of the causes and consequences of climate change was included. As illustrated in Table 1, some key terms (e.g. carbon footprint) were introduced and two short videos were projected depicting a range of scientists, journalists, and other experts discussing an account of the possible causes and consequences of climate change. Students were able to reflect on these ideas during whole-class discussions, which were prompted by guiding questions.

In order to elicit students' futures literacy skills, students were provided with *possible and probable future scenarios through* a set of cards illustrating climate change-related scenarios. The cards were co-developed with two science teachers and were categorised into 'positive' and 'negative'/'troubled' future scenarios (Appendix A). This categorisation was based on whether or not actions would be taken to address climate change in the future. The students were divided accordingly into 'positive' and 'negative' scenario groups of 3 to 5 participants. In order to foster their climate agency, students were asked to *select their preferable future-(s)* ranking the five most important scenarios. During the group discussions students were prompted to consider the importance of the presented scenarios on a collective, as well as on an individual level. Finally, in order to elicit their epistemic emotions, they were also encouraged to reflect on their emotional response during this exercise.

Research design

Since the focus of this study was to investigate the implementation of a future-oriented teaching approach to teaching about climate change, a case study approach was employed. In this study, two classes of Year 12 students were defined as cases (Merriam 2009). The case-study approach would enable the research team to provide a detailed description of the design and implementation of the lesson. In addition, the mixed-methods approach would facilitate the in-depth analysis of both qualitative and quantitative data collected through questionnaires and semi-structured interviews. In order to gain a more comprehensive account of students' views, data was collected at multiple points as displayed in Figure 3.

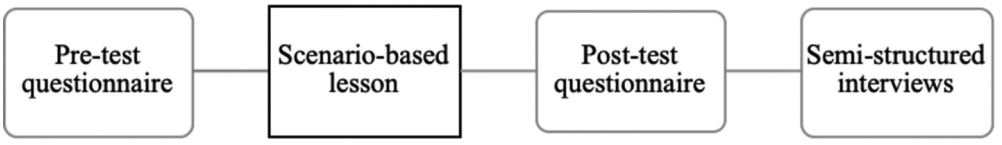

Figure 3. Timeline of data collection.

Data sources and instrument development

Student questionnaires

As llustrated in Table 2, the pre-test questionnaire consisted of overall 27 closed-ended items targeting students' engagement with climate change, as well as their climate agency. Moreover, the questionnaire aimed to capture students' perceived futures literacy and their views on teaching about future challenges.

In order to investigate students' agency regarding climate change, one item was developed and 8 items were adapted from the 'Global Competencies' scale (OECD, 2019b). Four items targeting students' perceived futures literacy were developed based on competencies described in the 'European Sustainability Framework' (Bianchi, Pisiotis, and Cabrera Giraldez 2022). Items referring to students' prior engagement with the topic and their views on teaching were developed by the research team. In order to investigate the effect of the teaching session on students' understanding and views, the same items were repeated in the post-test questionnaires, with the exception of students' prior engagement with the topic. In addition, 7 items investigating students' epistemically-related emotions (Pekrun et al. 2017) and 3 action-specific items referring to students' future actions were included in the post-test.

Table 2. Concepts and example items included in student questionnaires.

Concept	Items (N)	Example questionnaire item
1. Climate agency	9	*Looking after the global environment is important to me.*
2. Perceived futures literacy	4	*I can identify some steps needed to achieve a sustainable future.*
3. Future actions[2]	3	*After the workshop, I am more likely to reduce the energy I use at home (e.g. by turning off the lights when leaving a room) to protect the environment.*
4. Epistemically-related emotions[2]	7	*For each emotion, please indicate the strength of that emotion by circling the number that best describes the intensity of your emotional response. (Motivated, Surprised, Anxious, Bored, Frustrated, Confused)*
5. Views on climate change teaching	4	*I think schools are providing us with the skills to deal with problems such as climate change.*

[2]Items included in post-test only.

Student interviews

In order to investigate students' views on the teaching session, semi-structured interviews were conducted in the two weeks following the teaching session. The interviews were conducted by the first author with 10 out of 24 students in the form of paired depth

interviews (Houssart and Evens 2011). This type of interview would allow interactions between students enriching the dataset with further insights from the students' learning experience. To minimise the effects of potential confounding factors, only students from one participating school were interviewed.

Wilson, Onwuegbuzie, and Manning (2016) highlight the advantages of using paired interviews when researching young people, suggesting that having a peer present can help participants feel more at ease and communicate more openly. This approach can diminish the perceived power gap between the researcher and the interviewees, ultimately fostering deeper and more detailed responses. In this study, participants were not assigned to specific groups but were instead invited to join voluntarily with a peer of their choosing, further enhancing their comfort and willingness to engage in the discussion. The main themes, codes and some examples interview questions are presented in Table 3.

Table 3. Concepts and example items included in student interviews.

Theme	Code	Example interview item
Climate agency	*Individual*	*When you think of global issues, such as climate change, do you think that your actions can make a difference?*
	Career-related	
Views on climate change teaching	*Interdisciplinarity*	*Do you see any links between this topic and other subjects?*
Evaluation of the scenario-based teaching session	*Epistemically-related emotions*	*What was your overall experience of the workshop? How did you feel during the workshop?*
	Pedagogical approach	*Did you find talking about future scenarios meaningful? How did you feel when discussing positive/negative scenarios?*

Data analysis

Student questionnaire

With regard to the quantitative data collected in this study, descriptive statistics were performed and the mean values for each of the closed-ended items included in the pre and post-test questionnaires were calculated. Reliability analyses were conducted for climate agency, perceived futures literacy and future actions as well as future actions, as these measures are central to addressing the research objectives. The scales demonstrated satisfactory reliability; Cronbach's alpha for climate agency (9 items) was .62 and for perceived futures literacy (4 items) was .69 and for future actions (3 items) was .62.

The items measuring participant views on climate change teaching and epistemically-related emotions were included to provide supplementary insights and context to the primary qualitative data collected through interviews. These items were exploratory in nature, capturing distinct or supplementary aspects of the participants' perspectives. As such, their distribution and reliability were not anticipated to mirror those of the core measures (climate agency, perceived futures literacy and future actions). Of the items in the climate agency and perceived future literacy scale, only three met the assumption of normality required for parametric tests, as assessed using the Shapiro-Wilk normality test. For this reason, an alternative non-parametric test, the Wilcoxon signed-rank test was conducted to compare the scale scores before and after the intervention. Although the

data was not normally distributed, we decided to report mean and standard deviation values as these measures are widely used and generally easier for broader audiences to interpret.

Student interviews

The qualitative data from five group interviews involving students from the same schools were analysed using thematic analysis (Braun and Clarke 2022). Coding was conducted using predefined themes derived from established frameworks (deductive coding), which covered concepts already addressed in the student questionnaire. These themes aimed to deepen the understanding of students' questionnaire responses and their overall feedback from the session. New codes were added to capture emerging themes from the interview data. To enhance the reliability of the qualitative data analysis, the deductive coding process was reviewed and discussed with another member of the research team to reach consensus. Discussions focused on ensuring the appropriateness of coding decisions and achieving a shared interpretation of the meaning within the data.

Results and findings

Climate agency

The results from the pre-test ($M = 3.5$, $SD = .51$) and the post-test ($M = 3.8$, $SD = .49$) indicated that the teaching session had a positive effect on students' overall climate agency. A Wilcoxon signed-rank test was conducted to compare pre-test and post-test scores, as illustrated in Table 4. The results showed a significant difference between the pre-test and post-test scores, for Item 2 with a large effect size ($r = 0.65$), suggesting a strong magnitude of change. The results indicated significant differences between pre-test and post-test scores for Item 3 ($r = 0.48$) and Item 5 ($r = 0.50$), with medium effect sizes.

Table 4. Mean values of student climate agency for pre and post-test.

Item[a]	Pre-test M (SD)	Post-test M (SD)	*Z*	*p*
1. Looking after the global environment is important to me.	4.4 (.88)	4.5 (.90)	0.54	.59
2. I can identify some consequences of climate change.	4.2 (.82)	4.8 (.85)	3.09	.002*
3. It is important for me to take some actions to limit my impact on global warming.	4.1 (.88)	4.5 (.90)	2.32	.02*
4. It is the responsibility of certain groups (e.g. scientists or politicians) to take action against climate change[b]	2.2 (1.1)	2.3 (1.1)	0.22	.82
5. I can do something about climate change.	3.5 (.72)	4.0 (.95)	2.40	.02*
6. Personal choices (e.g. consumer behaviours) have an impact on climate change.	4.2 (.98)	4.2 (.95)	0.22	.83
7. I often reduce the energy I use at home (e.g. by turning off the lights when leaving a room) to protect the environment.	3.6 (1.3)	3.9 (.95)	1.10	.27
8. I often choose certain products for ethical or environmental reasons, even if they are a bit more expensive.	3.1 (1.1)	3.4 (.99)	1.61	.11
9. I often sign environmental or social petitions online.	2.3 (1.1)	2.7 (1.1)	2.46	.17

[a]1 = Strongly Disagree to 5 = Strongly Agree.
[b]Reversed item.

The results demonstrated a larger impact on students' confidence in identifying some of the consequences of climate change (Item 2), as well their belief that they can take come actions against climate change (Item 5).

Agency through future careers

During the interviews students could link the themes raised in the workshop to their own lives and particularly to their future career prospects. Their career prospects in their estimation were not only related to science subjects but more broadly in social studies and humanities, ranging from biology to journalism. In some cases, the students noted the element of doing research as part of the workshop tasks which can be useful for all sorts of careers. For example, AM28 who wants to be journalist said that *'the research element'* and discussing *'the effects of like the media on educating people on climate change'* were particularly useful. LH06, in the same pair interview, similar felt *'the research aspect'* was helpful to their aspired career in because in *'cases you have to research quite a lot'*.

Perceived futures literacy

The data analysis demonstrated that there was a significant improvement of students' perceived futures literacy ($M = 4.5$, $SD = .74$) compared to the pre-test ($M = 3.8$, $SD = .74$A Wilcoxon signed-rank test was conducted to compare pre-test and post-test scores. Table 5 presents the mean values, Z scores and p values of student responses for all the items referring to futures literacy. The results indicated significant differences with large to medium effect sizes for Item 2 ($r = 0.67$), Item 3 ($r = 0.59$) and Item 4 ($r = 0.50$).

Epistemically-related emotions

Students' epistemically-related emotions were measured after the end of the session. The mean scores of their responses with regard to seven emotions are presented in Figure 4. The emotional state with the higher mean score was 'motivated' ($M = 4.04$, $SD = .78$), followed by 'hopeful' ($M = 3.36$, $SD = 1.00$), and 'surprised'($M = 3.00$, $SD = 1.17$).

When asked about their overall experience of the workshop, one student said, *'it was actually really positive'* (FP06). This student described entering the workshop *'not really knowing what to expect'* but leaving feeling as though:

Table 5. Mean values of student perceived futures literacy for pre and post-test.

Item	Pre-test M (*SD*)	Post-test M (*SD*)	*Z*	*p*
1. I can imagine some negative scenarios as a result of climate change.	4.3 (1.2)	4.5 (1.2)	1.38	.17
2. I can imagine some positive scenarios as a result of actions against climate change.	3.6 (1.1)	4.6 (.95)	3.21	.001*
3. I can identify some steps needed to achieve a sustainable future.	3.8 (.85)	4.6 (.73)	2.82	.005*
4. I can identify some steps that I, personally, can take to achieve a sustainable future.	3.6 (.93)	4.3 (.82)	2.41	.02*

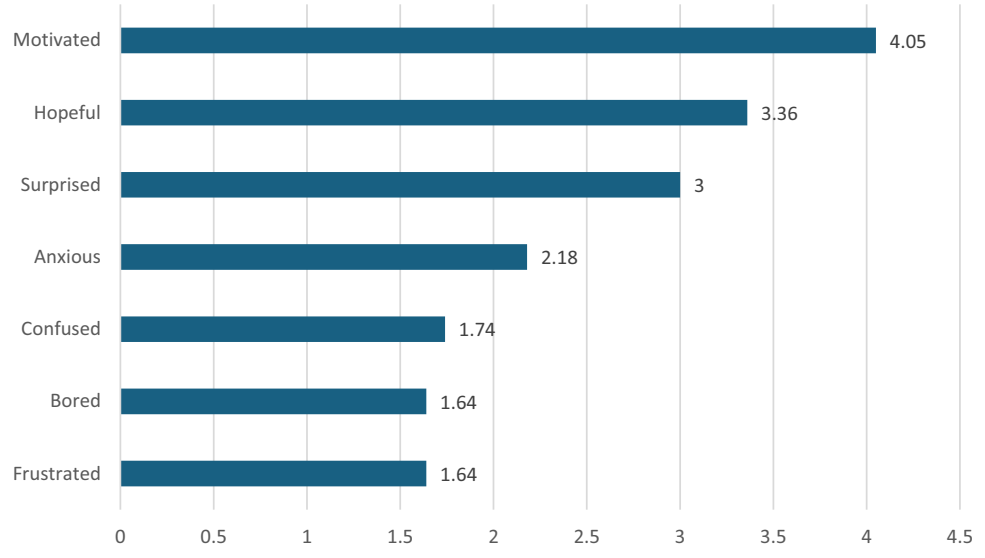

Figure 4. Epistemic emotions reported after the end of the teaching session.

> We done some very good thinking and in our presentations that we did, I feel that kind of forced us to make very good links between different points that we came up with. And it was, it was really insightful. (FP06)

Similar sentiments were offered across the group of interviewees. Student OW13 also felt that they *'quite enjoyed it'*. They felt the workshop was '*offering aspects that we probably wouldn't have known before'* and suggested that it was the multiple perspectives of the workshop which offered this possibility for new thinking, *'like in a political sense . . . , environmental and business-wise'*. The student further reflected that through these activities they *'were able to see the causes and effects of climate change'* and *'where we can try to do [something] to stop it'* (OW13).

Views on climate change teaching

Participants reported a low prior engagement with the topic, as 97% ($n = 24$) of them indicated on their pre-test questionnaire that they have never or nearly never engaged in climate change activities during the year in which the study was conducted. The pre-test questionnaire demonstrated that only 4% of students ($n = 24$) believe that schools provide them with the necessary skills to address global challenges, such as climate change. More than half of the students (63%) held positive attitudes towards informal teaching before the session, which were further increased after the end of the session (83%). Fewer students (21%) indicated a preference towards interdisciplinary teaching, although these views were improved after the end of the session (38%).

Learning through scenarios

With regard to climate change teaching, student interviews targeted participant views on learning through future scenarios. Student FP06 referred to the scenario-based approach followed in the workshop as *'insightful'*, noting *'just how close we are to the edge of where we can't go back and, if I'm honest, it kind of encouraged me to go back to start thinking about it a lot more'* (FP06). This student described how they, upon leaving the workshop, *'the first thing I did was to think . . . how can do some the things that we spoke about earlier . . . how can I apply these into my home life as well?'* They explicitly stated that *'I don't think I've had much of an insight of that quality before'* and described the experience as *'eye-opening'* (FP06). Student JR19 felt talking about future scenarios *'makes you think about what you can do'* and also described a sense of action where *'I went home, and I basically forced people I live with to start turning off lights'* and other such individual and collective environmental actions.

Discussion and Implications

Although the study included a small and relatively homogenous sample, its findings provide useful insights on the pedagogical affordances of a scenario-based teaching approach regarding climate change. Our first research question aimed to explore whether a scenario-based teaching approach for climate change would influence students' futures literacy and climate agency. Findings of this study showed that the scenario-based teaching has significantly improved students' feeling of agency towards climate change, as well as their futures literacy. The session helped students to envision the future possible, probable and desirable scenarios regarding climate change, as well as to identify steps needed to achieve a sustainable future. The projection of alternative futures or 'forecasting' may have helped in developing students' 'backcasting' thinking processes; starting from a desirable scenario, students were able to think what actions should be taken today that could help achieve this future outcome (Bibri 2018). This process may have helped them reflect on the types of actions they can (individually and collectively) take against climate change. Although this study did not highlight any particular types of 'action knowledge', this finding contributes to a growing body of evidence demonstrating that young peoples' sense of agency can be strengthened after completing a climate education programme targeting their environmental impact, as well as ways in which they can improve their communities and the world (e.g., Trott 2020).

With regard to the second research question, the workshop had a larger impact on students' ability to imagine positive scenarios, while students reported that during the session they felt 'motivated' and 'hopeful'. This finding provides useful evidence that a scenario-based teaching approach can elicit positive epistemic emotions, i.e., emotions that are caused by cognitive qualities of task information (Muis et al. 2015). Such emotions include hope, curiosity and pride and can play a pivotal role in students' learning (Pekrun 2016). Given that the design of the task aimed to provide a balanced view of the topic by presenting both positive and troubled scenarios, rather than highlighting an unrealistic account by focusing on the desirable future, this finding demonstrates students' ability to account for both positive and troubled scenarios, while considering the ways in which

they can contribute to possible solutions. This provides useful evidence in support of the use of scenarios as a teaching tool towards cultivating a desired sense of 'realistic hope'.

As the study followed a multi-stakeholder participatory method, students' interviews provided insights on their views on climate change education. Students highlighted the importance of education about climate change from an early age. The need for introducing climate change and other environmental issues in early years education has been well-documented from a theoretical perspective, yet without adequate research interest (Ardoin et al. 2018). Although mentions of climate change are currently included in the UK science, citizenship and geography curriculum from Key Stage 3, the majority of the participants indicated that they have never or nearly never engaged in climate change activities in school while they did not believe that schools are providing them with the skills necessary to address future challenges. The National Curriculum in England does not currently require children to understand the broader impacts of climate change on the environment, economy and society, or to consider issues of social justice in relation to climate change. There is no mandatory requirement for any school students in England to understand or engage with the types of social action most likely to bring about societal change (Howard Jones et al. 2021).

Recent evidence supports these findings; UNESCO (2021) states that nearly half of the national curriculum frameworks of 100 countries had no reference to climate change, while even when young people learn about climate change in school, they express concerns about the quality of climate education they receive (UNESCO,2021). To address this issue, a number of countries, including the UK, have announced educational reforms that would 'put climate change at the heart of education' (Dunlop and Rushton 2022). In this context, the question that arises is what pedagogical approaches can teachers use to teach about climate change? Following a participatory method, this study provides evidence on the use of scenario-based teaching as an innovative teaching tool that can be used to foster students' climate agency and futures literacy skills in order to become co-creators of individual, as well as societal transformation (UNESCO 2021). To that end, it promotes teaching about climate change in a holistic way that would empower students in thinking about their future in a sustainable manner.

While this case study provides valuable insights, it has limitations. The informal setting of the museum, while offering flexibility and engagement, may also pose challenges, as it represents a new learning environment for participants. This unfamiliarity could influence their responses, behaviors, or overall engagement with the study. Additionally, the relatively small sample size limits the generalisability of the findings to broader educational contexts. Future research could explore similar scenario-based teaching approaches in varied settings to assess the broader applicability of the findings. In particular, it would be useful to examine how this teaching strategy could be applied to secondary school classrooms and whether it can elicit opportunities for interdisciplinary collaboration between teachers from various subjects.

Furthermore, with the design and use of a set of items targeting futures literacy, this study contributes to efforts towards translating the concept from a 'buzzword' included in policy documents (e.g. Chan and Erduran 2024; Bianchi, Pisiotis, and Cabrera Giraldez 2022; Rincón and Díaz-Domínguez (2022), into measurable a construct that can be taught and observed. Given that the future is inherently linked to environmental sustainability, further research should refine measurement tools and validate the role of futures literacy

in climate and environmental education (Chan and Erduran 2024). Future studies should further explore the validity and reliability of measures of futures literacy and climate agency, ensuring that these constructs can be effectively assessed and integrated into educational frameworks and policy discussions.

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Appendix A. Example scenarios

Type	Example
Positive	Education: Companies, schools, universities and public institutions commit to carbon literacy training for all.
	Innovation: As business leaders call on their workforce to help them become sustainable, every element of their ethos and process is examined. The result is a 40% uplift in innovation. Brand value increases as consumers enjoy the benefits. Share price increases.
	Dietary overhaul: Historic reduction in meat consumption. Vegetarian and vegan diets widely adopted. Meat alternatives become the major, not the minor.
	Political cooperation: All nations sign or re-enter the Paris Climate Agreement. There is an international commitment to limit global warming to within 1.5-2 degrees Celsius of pre-industrial levels.
Negative	Lack of knowledge: Signs of global warming are scarcely noticeable. People do not understand the complexity or scale of the problem. Huge quantities of greenhouse gasses like carbon dioxide are released into the atmosphere causing the planet to steadily heat up.
	Sea becomes more acidic: The world's oceans absorb millions of tons of extra atmospheric carbon dioxide creating carbonic acid. The resulting acidity bleaches coral and prevents the building of new skeletal material used by aquatic life. Large amounts of coral-reef gone forever.
	Businesses do not change: The cost of change is deemed to be too high or too difficult. Many businesses do nothing to review their carbon output.
	Record number of flights: Globalisation is unstoppable and demand for air-travel sees exponential growth. New airports and runways are built across the world to meet the demand. Billions of tonnes of carbon dioxide are released into the atmosphere as a result.