European Journal of Education

WILEY

ORIGINAL ARTICLE OPEN ACCESS

Climate Change Education in a Secondary School, the I-CHANGE Project Approach

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Received: 27 February 2024 | **Revised:** 22 November 2024 | **Accepted:** 25 November 2024

Funding: The study received partial support from the EU Horizon 2020 under Grant Agreement no. 101037193 and from the EU Horizon Europe Framework Programme for Research and Innovation (2021–2027) under grant agreement no. 101093921.

Keywords: citizen science | climate change | H2020 I-CHANGE

ABSTRACT

Raising the awareness and interest of young generations for climate change phenomena and its impacts is a topic of great importance from a social and cultural standpoint. Along these lines, education plays a crucial role to meet the goals of the EU's Green Deal both through direct interplay with students and information spillover towards families and in general stakeholders at large. Inspired by these ideas, the H2020 I-CHANGE project (Individual Change of HAbits Needed for Green European transition, 2021–2025, https://ichange-project.eu/) aims at engaging and promoting the active participation of citizens for addressing climate change, sustainable development, and environmental protection. By taking into consideration the ongoing fast socio-cultural change, the vertical growth of digital media, and, therefore, the new ways children and young people learn, this paper presents a possible path towards the practical implementation of key EU's Green Deal concepts in a secondary school, building on top of Episode of Situated Learning (ESL) methodology.

1 | Introduction

Ongoing climate change and environmental degradation phenomena are an existential threat for human societies at European and global scale as well as for preserving ecosystems and biodiversity on our planet (IPCC 2023).

Climate neutrality by 2050 has become a priority by turning climate and environmental issues into opportunities to generate a just and inclusive transition (Bäckstrand 2022; Filipović, Lior, and Radovanović 2022). The European Climate Law turns this political will into a legal obligation: the European Union and its member states committed to cutting net greenhouse gas emissions in the EU (2010, 2013) by at least 55% by 2030, compared to 1990 levels. This target is legally binding and based on an impact assessment carried out by the European Commission. Specifically, citizens' participation as individuals and consumers requires a major collective effort including empowerment through actions promoting changes in behaviour and in social practices (Bela et al. 2016). To route these changes, the European Green Deal[1] and the European Climate Pact[2] call for actions to enhance citizen empowerment through personalised education and tools to learn about climate change, effects on biodiversity, and consequences on the environment. European citizens are sensitive about climate change (Eurobarometer 2023): 77% of EU citizens think climate change is a very serious problem at this moment, yet only 35% hold themselves personally responsible.

In this context, there is an urgent call for raising the citizens' awareness of the impacts of climate change through education.

Climate change education can be defined as a component of environmental education and education for sustainable development (Anderson 2012). Its core concept is climate change literacy, which means that students understand the scientific concepts related to climate change and the relationships between them, as well as the effects of climate change and their own activities on the environment (Yli-Panula et al. 2022). Climate change is based on multiple disciplines, and it incorporates elements from a variety of disciplines and study subjects. Therefore, climate change education should include information both on climate change and other environmental issues as well as economic and social issues such as pollution and sustainable consumption and lifestyles (Yli-Panula et al. 2022). Sustainability problems, including climate change, are linked to the complex real world challenges and everyday life of the people requiring a variety of competences to be understood and solved (Wiek, Withycombe, and Redman 2011; Salovaara, Soini, and Pietikäinen 2020).

It has turned out that due to the complexity and uncertainty related to climate change, it is a challenging topic for education (Leve, Michel, and Harms 2023; Núñez-Rodríguez 2021). A review of effective climate change education strategies revealed that there are two main themes that are common in environmental education (Monroe et al. 2019): focusing on personally relevant and meaningful information and using active and engaging teaching methods. Further, four themes specific to climate change education were identified: engaging students in deliberative discussions; interacting with scientists; addressing misconceptions, and implementing school or community projects. Consequently, novel teaching methodologies following these lines for climate change education are introduced, including episodes of the situated learning (ESL), which aims to enhance learning on the topic, but also contribute to awareness raising, and ultimately the behavioural change.

Episodes of situated learning (Rivoltella et al. 2013; Rivoltella 2014, 2016, 2022) is a teaching methodology built on short portions of classroom activities focusing on certain topic or content and "situated", that is, placed within a real and meaningful context to make learning more effective. The overall objective of the ESL didactics is to facilitate a kind of transformative learning (Terrenghi et al. 2019), learning that is able to adjust the learner's thinking based on the new experience or knowledge (Mezirow 2008). The results are by the assimilation of an experience or new knowledge with previous knowledge.

The ESL methodology is divided into three phases (preparatory, operative, and restructural, Terrenghi et al. 2019, Rivoltella 2016 and 2022), through which the student:

1. becomes familiar with a problematic situation;
2. formulates hypotheses and conjectures through the creation of an artefact;
3. devise the strategy to arrive at the solution.

The teacher intervenes only after the event, completing the reworking of the activity developed by the students and specifying which aspects deserve clarifying intervention. The above steps of ESL are presented and discussed below in detail.

In the preparatory phase, students are introduced to the concept of developing their own ideas through an initial individual approach. This anticipates the subsequent work in class, which can be completed independently at home or at school. The teacher then initiates the lesson with a conceptual framework, building upon the work completed by the student and incorporating significant elements to establish the general framework of the problem under consideration. The objective of the framework is to establish a field of knowledge that serves as a catalyst for the activities that students will undertake in class, either individually or in groups. In the conclusion of this preliminary phase, it may be advantageous to select a stimulus for the students (such as a video) that is emotionally evocative and not overly detailed, as it can facilitate the generation of ideas on the topic under discussion and evoke emotions.

The operative phase, which is based on the principle of learning by doing, is the period during which the student, either individually or in groups, gains knowledge through practical experience. The teacher initiates the initial delivery and, during the class work, is attentive to the timing and suggests and guides the activity, with the objective of creating a product, which may be in digital format.

Finally, in the restructuring phase, according to the logic of reflexive learning, a debriefing takes place in which the teacher, in order to understand what has been assimilated during the course, accompanies the students to become aware of what has been done: she/he takes the floor again to analyse the artefacts presented by the students, to clarify the conceptual points to be learnt, to discuss errors or misconceptions.

The methodology indicates that a school working for ESL has the following strengths: it places the learner at the centre of the educational process, enabling them to actively construct their own learning, thus becoming a highly inclusive school; it bases its thinking on the principles of competence; it raises the professionalism of the teachers, as the ESL itself acts as an organisation that encourages teachers to reflect on their work in terms of design, implementation, and evaluation. The curriculum is concise and effective, with content selected according to the criterion of exemplarity and transferability. The ESL also facilitates the professional development of teachers by requiring them to reflect on their work in terms of design, implementation, and evaluation.

This paper presents the results of climate change education applying the ESL approach in the collaboration between the I-CHANGE project with the students of a secondary school of the Mele Municipality, Genoa, Italy. The overall object of the I-CHANGE project (Individual Change of HAbits Needed for Green European transition, 2021–2025, https://ichange-project.eu/) is to engage and promote the active participation of citizens for addressing climate change, sustainable development, and environmental protection in the framework of current European environmental policies (e.g., European Green Deal, the European Climate Pact and the European Biodiversity Strategy for 2030.[3] I-CHANGE wishes/aims to increase the participation of different stakeholders through the concept of quadruple helix) including academic, community, business, and government components through citizen science activities. The key idea is to raise citizens' awareness on climate issues through the direct collection of environmental and socio-economic data with novel and user-friendly tools (sensors, monitoring devices, simplified models, and data resources) managed directly by citizen scientists and supervised by professional scientists. It is expected that this leads to the promotion of a co-designed learning path aiming to improve citizen knowledge on climate change related harmful impacts and understand the role of personal actions and decisions in reducing vulnerabilities and risks. A further step is to empower citizens with targeted and personalised tools (apps and best-practices) enabling behavioural and consumption shifts towards sustainable patterns.

Building on top of the longstanding and fruitful experience of the secondary school of the Mele Municipality, in the application of digital technology and practices for school activities improvement, a rich portfolio of I-CHANGE-project activities has been developed, implemented, and tested. These activities have been ranging from the monitoring of atmospheric phenomena to climate change adaptation and mitigation actions applied on a daily life basis at the local scale. The I-CHANGE-project aforementioned actions have been completed and enriched by the episodes of situated learning (ESL) approach developed by Rivoltella (2014, 2016, 2022) as well as by CIMA initiatives such as "Water & Us" (Munerol et al. 2022) as described in detail in the following.

Section 2 is devoted to presenting the study region and performed in the classroom, and in Section 4, the connections with the I-CHANGE project are deployed. Eventually, in Section 5, we highlight the conclusions of the work.

2 | The Study Context Region: Genoa Living Lab and Mele Municipality

The study area is located in the Genoa Metropolitan area (GMA), where the Mele Secondary School is located. Genoa is the capital of the Italian region Liguria and the sixth-largest city in Italy. In 2015, about 600,000 people lived within the city's administrative limits. As of the 2011 Italian census, the Province of Genoa, which in 2015 became the GMA, had about 850,000 resident persons.

The GMA area is historically affected by flash floods (Acquaotta et al. 2018; Faccini et al. 2016) and severe marine storms (Nissen et al. 2010; Cavaleri et al. 2022) for two main reasons, namely, the meteorological conditions due to the "Genoa Low" (also known as 'Ligurian Gulf Depression') and the city's geographical layout, which is characterised by a narrow coast bounded by steep mountains. The "Genoa Low" is a cyclone that forms or intensifies from a pre-existing cyclone to the south of the Alps with an orographic effect (Jansa et al. 2014) over the Gulf of Genoa, Ligurian Sea, primarily in the autumn–winter and spring periods. This typical circulation is responsible for the large amounts of rainfall distributed over the region surrounding the Ligurian Sea (Sacchini et al. 2012). The morphology of the Ligurian Gulf and the orographic barrier also contributes to rainfall events that may be very intense, especially at the end of the summer or autumn, when Atlantic perturbations may be blocked by the European continental anticyclone. Additionally, the convergence between the air mass stationed over the warm Mediterranean basin and the colder air masses moving from the Po basin may trigger the development of convective systems very intense and localised, namely back-building mesoscale convective systems (Fiori, Parodi, and Siccardi 2011, Rebora et al. 2013). These convective systems have historically affected different locations over the Ligurian Gulf (Portofino 1915, Genoa city 2011 and 2014), causing flash floods arising from rainfall intensities up to 500 mm/6 h or 180 mm/1 h (Fiori, Parodi, and Siccardi 2011; Fiori et al. 2017; Parodi et al. 2017; Faccini et al. 2021).

Among the GMA areas, historically most affected by severe hydro-meteorological events there is certainly the Leira catchment on western Genoa area, which was affected by flash flood episodes in 1833, 1862, 1864, 1867, 1915, 1970, and 1993. At the headwater of the Leira catchment, there is the small village of Mele (16.9 km^2, about 2500 inhabitants), at 125 m above sea level (Figure 1). The Mele area receives on average 1700 mm per year (period 1961–2010) with no significant trend in the period (1961–2010, climatological station data). With reference to the temperature field, the yearly average 2 m temperature, as derived from ERA5 dataset (horizontal resolution of about 30 km), has increased from 1979 to 2022 of more than 2°C, clearly showing also a local effect of climate change phenomena (Figure 2).

Given these conditions, already since 2012, Mele Municipality has developed a large set of learning activities for secondary school students aiming at fostering the development of a high-performing digital education ecosystem as well as enhancing digital skills and competences for the digital transformation, focusing primarily on

- *ability to learn*: find the content that interests the students and how they get there access using the appropriate technological tools to produce results more creative, engaging, and interactive;
- *ability to analyse*: understand the meaning of the message, in general and in its parts, and with reference to the genders and linguistic forms used, the production and distribution methods to which it is subjected, and to the customs of function for which it was designed;
- *ability to evaluate*: express a critical judgement on the message comparing it with personal references;
- *ability to produce messages*: express one's thoughts and experiences with possible and different languages.

In the framework of the I-CHANGE project cooperation, the Mele Secondary School has implemented a series of learning activities inspired by the Episodes of Situated Learning as detailed and discussed in the following section (Figure 3).

3 | ESL Approach and I-CHANGE Project

The interplay between the ESL ideas and I-CHANGE projects has produced the "Mele4future" website.[4] The framework in

FIGURE 1 | Mele area and hydrographic network.

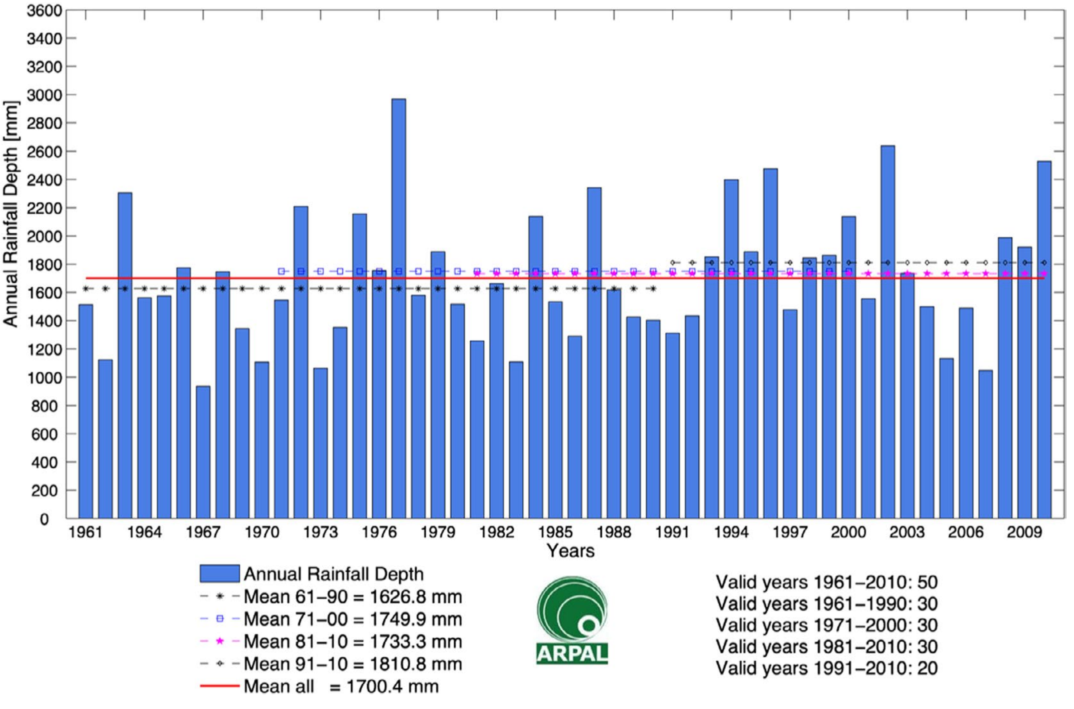

FIGURE 2 | Annual rainfall depth in Mele weather station statistics (courtesy of Agenzia Regionale per la Protezione dell'Ambiente Ligure, ARPAL).

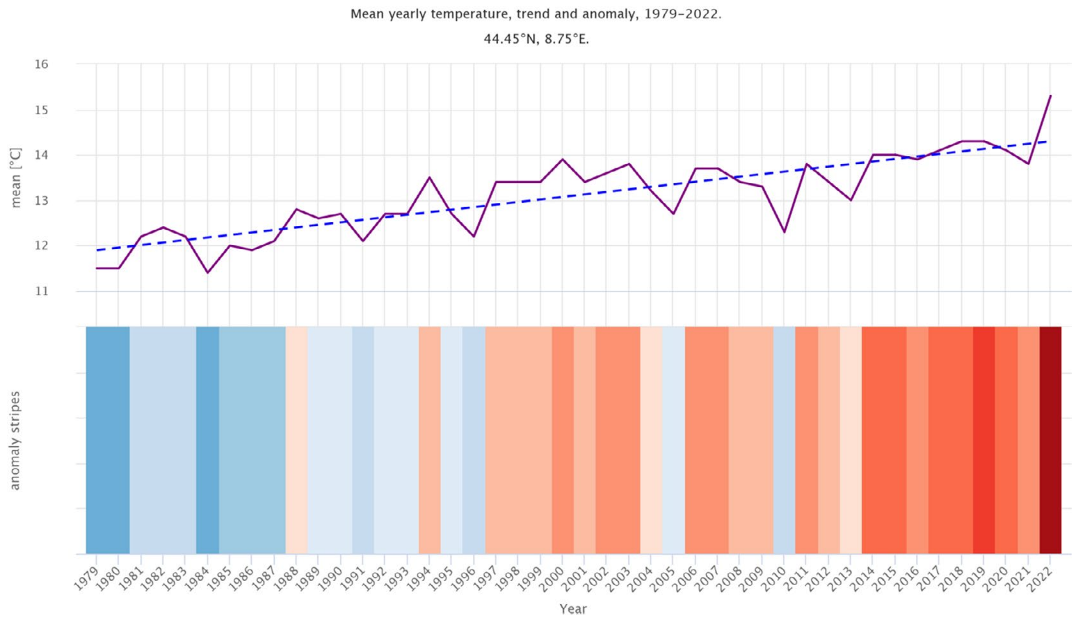

FIGURE 3 | Mean daily 2m temperature annual trend in Mele (courtesy of MeteoBlue, www.meteoblue.com).

which this activity was inserted had the aim of pursuing two of the eight key competences for lifelong learning indicated by the European Union in the Reference Framework annexed to the Council Recommendation of 22 May 2018 on key competences for lifelong learning. They are as follows:

- Citizenship competence, which is based on knowledge of the concepts and phenomena inherent in individuals, groups, society, economy, and culture. Focusing on the aspect of our interest, this expertise concerns the knowledge of sustainable systems, in particular, global climate change and its causes. Citizenship competence requires the ability to engage effectively with others to achieve a common or public interest, such as the sustainable development of society. It includes advocating for sustainable lifestyles and a willingness to be environmentally responsible. As part of the teaching activity carried out, the reference objective for students has been to understand the need for equitable and sustainable development, respectful of the ecosystem, as well as a conscious use of environmental resources that can be known and evaluated in order to critically consider the impact on the environment of their choices.
- Digital competence, which presupposes an interest in digital technologies and their use with familiarity and a critical and responsible spirit to learn, work, and participate in society. In this context, the reference objective is to be able to understand the concept of data; to select correct or incorrect information, even when comparing with a plurality of sources; and to properly use the network to do research and communicate.

As far as digital competence is concerned, the reference goal is to be able to understand the concept of data and to identify correct or incorrect information, also in comparison with other sources, observable and assessable in the dimension associated with it to know the procedures for using the network to obtain data, do research, communicate. The implementation of the activities was possible because the organisation of the work in class, the structure of school time (extended time section), and the digital equipment allowed the students to possess the necessary prerequisites.

It was possible to implement the activities because the organisation, the school time (extended time section) and the digital equipment allowed the students to possess the necessary prerequisites.

The ESL method was fertile ground for implementation of four topics related to climate change: Mele territory flood risk, eco-sustainable practices challenges, historical floods on the Mele municipality territory, and finally tales of climate fiction.

The project involved the entire lower secondary school complex during the second quarter of the 2022/23 academic year (February–June 2023). The activities took place during the afternoon workshops provided for by school time (two afternoons a week of in-depth study lasting a total of 80 min, from 2 to 3.20 pm) and, in the morning, during the "App Hour" lessons, dedicated to the use of digital. The classes involved were composed as follows:

- class 1E: 22 students
- class 2E: 23 students
- class 3E: 18 students
- class 3G: 17 students.

All the students participated in the classroom activities and collaborated in the creation of the digital products; each pupil or group intervened on the basis of her/his/their specific aptitudes and skills. Class 1E, still unfamiliar with digital tools, worked on the simple collection and mathematical analysis (creation of tables and graphs, calculation of the average) of the most recent meteorological data (year 2022/2023) provided by the Acronetwork station installed on the roof of the school. The teachers set up an area of the Google WorkSpace for Education for each class through the Google Classroom application. On this application, the teachers uploaded the materials for the lessons (videos, texts, graphic data processing, etc.). The teachers formulated the assignments to be carried out and, finally, the students uploaded their digital products. By Google Classroom, the students shared the materials and selected with the teachers the most appropriate ones to be published online. The site was created with Google Sites, whose pages were managed by the teachers. The evaluation of individual and/or group products (reality/authentic tasks) was carried out through grids built on specific indicators. It was also included in the final grade proposal of the Civic Education discipline and shared with all the teachers of the Class Council according to current legislation.

In order to assess the ESL in the I-CHANGE project, we applied the ARCS framework (*Attention*, *Relevance*, *Confidence*, and *Satisfaction*), which is a methodology based on the motivational factors in the learning. Motivation is a key issue for learning as it may strengthen the desired behaviour to learn. Motivation can be understood as a process of interaction between the learner and the environment, which is marked by selection, initiation, increase, or persistence of goal-directed behaviour. It can be derived from the quality of the individual, the situation, or the activity in which the individual is engaged (Svinicki and Vogler 2012). In the learning context, the motivation may come from external stimuli or instructional models of learning or from internal motivation. John Keller has developed the ARCS framework enhancing the learners' motivations in the instructional model of learning (Keller 1987, 2010):

- *Attention* is the first factor of the ARCS model, which is regarded as catching the concentration of the learners and embedding the curiosity factor among them to learn. Keller referred to it as the most significant element of the ARCS model of motivation: if attention is not present, the other elements of the model would be difficult to obtain.
- *Relevance* relates to the students' experiences and needs and it consists of contributory elements such as connections to familiar issues and useful goals and matching the students' motivations. Thus, relevance may be developed by using the appropriate examples and language with which the learners are familiar with or by satisfying the needs of the learner in order to meet their personal goals. It is argued that if there is a lack of relevance in the learning process, there will be no attention from the learners' side, and it will become difficult to maintain their attention towards learning.
- *Confidence* refers to the belief in oneself; what one is able to accomplish to achieve the goals. There are three subgroups of confidence: learning requirements, opportunities for success, and personal control. It is important to improve the level of confidence of the learners and let them know what is expected from them at the end of the learning activities.
- *Satisfaction* is defined as the confirmation about the learning experience regarded as relevant with the material of the course and content of instructions helping to enhance the abilities of the learners. Satisfaction aids the learners to increase their motivation level. Here, the aim is to provide learning experiences which create positive and assertive behaviour of the learners towards the goals of the learning.

Below, we describe the work phases and methodologies that characterised the four topics of the activity (Figure 4).

3.1 | Mele Territory Flood Risk

In the ESL preparatory phase, the teacher guided the students to research and understand the key concepts necessary for the activation of subsequent skills (Figure 5):

- the meaning and graphic understanding of the meaning of the elevation contours for the evaluation of the acclivity of a territory (Table A1);
- the analysis of the conformation of the hydrographic network of the territory for the assessment of the flow rate of a watercourse under normal conditions;
- the analysis of land use and the type of vegetation cover to understand what role tall vegetation can play in soil consolidation;

FIGURE 4 | Mele4future website homepage (https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/home).

FIGURE 5 | Mele4future website flash floods section (https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/gli-eventi-alluvionali).

- the analysis of the type of rocks present in the valley and their characteristics in terms of landslides;
- the analysis of the type of interventions that man can make on an urbanised and unstable territory from a hydrographic and geomorphological point of view.

In the ESL operative phase, the students created multimedia products (presentations, video tutorials, infographics, https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/gli-eventi-alluvionali?authuser=0) that evaluated how the steepness, rainfall, hydrographic network, land use, and type of vegetation present, the rocky substrate, and the type of interventions made our territory more or less prone to flooding and/or landslides. In each presentation, the students were asked to identify what—in their opinion—were the more or less risky areas along the municipal territory. To do this, the students compared the knowledge acquired in the preparatory phase with the official data present in the bibliography and reference sitography (maps of various kinds—geomorphological, soil, hydrographic..., data and information—prepared and provided by the teacher). Students took also advantage of the installation of an I-CHANGE weather station at the secondary school premises (Figure 6), whose data of temperature, wind, pressure and relative humidity are available real-time http://www.acronetwork.org/apps/eyes/external_link.html#?uid=067200262847000&h=1243.

In the renovation phase, the artefacts were shared and corrected with the common choice of the most exhaustive to be published on the site. The teacher reiterated the role of the individual factors analysed, associating it with a condition of risk and/or danger. With the class, the teachers chose the emoticon that best described them.

For the evaluation of multimedia products, the teacher refers to the following proficiency evaluation grid with the relevant levels: the table also reports the number of students achieving each dimension of competence (Table 1).

FIGURE 6 | I-CHANGE weather station installation at Mele Secondary School.

3.2 | Eco-Sustainable Practices Challenge

The ESL method was also applied in the implementation of some microlearning activities on challenges, for the choice of eco-sustainable practices feasible in the daily life of students, small pills of good behaviour, indicators of active and responsible citizenship:

TABLE 1 | Proficiency evaluation grid: multimedia products.

Dimensions of competence	Indicators	Initial level (d)	Basic level (c)	Intermediate level (b)	Advanced level (a)
Identify data	He/she identifies curves and their direction of ascent and descent	He/she identifies in a partial way and needs guidance	He/she identifies curves and struggles to find direction	He/she identifies curves and almost all directions	He/she identifies curves and directions completely
Identify relationships	He/she identifies the more or less pronounced slope at critical points	He/she cannot, unless guided, find the slope	He/she identifies more obvious slopes	He/she identifies most critical slopes	He/she identifies critical slopes completely
Describe relationships	He/she creates an effective animation that highlights the danger points in the municipal area	He/she creates an incomplete digital product	He/she creates a correct but not animated digital product	He/she creates a correct and fairly effective digital product in the animation	He/she creates a correct and effective digital product in its animation
Students achievements		3	7	10	3

- Eco-friendly bag challenge to reduce the carbon footprint (Table A2)
- Every drop counts challenge to reduce the water footprint.
- Turn off your mobile phone challenge for fingerprint reduction (Table A3).
- Photocopy paper challenge for a more ecologic backpack.

In the preparatory phase, the lecturer proposed specific websites on the meaning of the various sustainability indicators (carbon footprint, water footprint, fingerprint, and ecological backpack) appropriately chosen in such a way that the web pages analysed did not present possible solutions to the problem. The viewing of the material involved a subsequent individual compilation of an understanding questionnaire on this type of indicator that followed the principle of the 5Ws (who, what, where, when, and why).

The subsequent collective correction of the answers allowed the teacher to focus on the key concepts in the framework. The preparatory stimulus for the next phase was the presentation of short posters, videos, or infographics on the behaviours necessary to reduce the impact of these indicators: this allowed the students to be appropriately motivated to know how sustainably correct their personal behaviours are (Figure 7).

In the operative phase, the students were invited to calculate the value of the various indicators of their family through specific sites (e.g., https://www.arpa.piemonte.it/co2_footprint/#/) in order to have an overall picture of the average value of the class. The next request concerned the calculation of CO2 savings (through checklists prepared by the teacher) by implementing some easily adoptable behaviours (e.g., use of cloth or recycled bags to do the shopping vs. use of plastic bags, saving water by brushing teeth or taking a shower, saving paper by using the tablet compared to photocopies, turning off the mobile phone and not using social media for a defined time, buying local products). The production of advertising banners to be placed on the site has concluded the second phase.

During the renovation phase, the banners were shared and corrected, with the common choice of the most exhaustive to be included in the site. The activity ended with guided comments on the eco-friendly behaviours chosen by the class and related to the rules of behaviour suggested on the web (https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/impronta-ecologica?authuser=0).

For the evaluation of the students' performances, the teacher refers to the following proficiency evaluation grid with the relevant levels: the table also reports the number of students achieving each dimension of competence (Table 2).

3.3 | The Floods of Our Territory—Testimonies and Memories

The aim of this part of the course was to bring to the knowledge of the students some dramatic events of recent memory (the floods in Genoa and Mele in 1970 and 1992) in order to

FIGURE 7 | Mele4future" website environmental footprint section.

understand the importance of assuming responsible and conscious behaviour both to defend one's territory and to protect oneself in case of risk (Table A4).

In the preparatory phase, the students analysed documents and testimonies about the events, such as photographs, memoirs, articles, collected, and proposed by the teacher. The conceptual framework focused attention on the course of events and the places involved; in particular, the viewing of videos was intended to capture the emotional impact that those dramatic situations had on the people who experienced them.

In the operative phase, the students worked in groups in two distinct phases. Outside of school, they interviewed relatives and acquaintances who had been witnesses, direct or indirect, of the flood events and collected a wealth of documentation in paper or audio/video format. Subsequently, in class, they reworked the material into short video-documentaries, structured as news reports or in-depth news broadcasts.

In the renovation phase, the videos produced were viewed in class: impressions of the testimonies were shared and it was observed that the memory of the events that took place is still alive and present among the inhabitants of the area. It was also evaluated which of the videos best responded to the characteristics of journalistic language.

For the evaluation of the students' performances, the teacher refers to the following proficiency evaluation grid with the relevant levels: the table also reports the number of students achieving each dimension of competence (Table 3).

3.4 | Tales of Climate-Fiction

During this activity, the science fiction story was the channel that guided the reflection on what the long-term impact of global warming could be on the territory. The imaginative imagination of "apocalyptic" scenarios was the cue to reflect on the potential environmental, social, and economic consequences of climate change (https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/racconti-di-climate-fiction-a-mele-nel-2523?authuser=0).

The preparatory phase (Table A5) was launched through the reading of an excerpt by Bruno Arpaia, taken from the novel "Something, out there" (Arpaia 2016), belonging to the subgenre of climate-fiction. The author, in the not too distant future, imagines the desperate journey of a crowd of people to Scandinavia, now the only habitable zone in Europe, in search of water and food, hostile to each other. The conceptual framework focused on the analysis of the elements of the narrative typical of the science fiction genre and on those characteristics of the specific piece (description of the desolate landscape, construction of an atmosphere of tension and suspense, reflection on the emotions of the protagonists).

In the operative phase, the groups worked on writing a climate-fiction story, following some guiding questions, such as: what could happen to the territory of Mele in 2053, if the world were devastated by global warming? How would the landscape change? What would happen to the inhabitants? Would there be conflicts, migrations to more liveable lands? After the writing of the stories, the groups created digital audiobooks, accompanied by illustrations and drawings, obtained in some cases by modifying photos of places in the Mele's landscape.

The restructuring phase involved the revision of the drawings, with the evaluation of the most effective on a narrative level and in the digital part. The final reflection focused on the fact that what still seems like science fiction in our latitudes (wars for water resources, flight of climate refugees...) in some parts of the world has now become a dramatic reality.

For the evaluation of the students' performances, the teacher refers to the following proficiency evaluation grid with the

TABLE 2 | Proficiency evaluation grid: eco-friendly behaviour.

Dimensions of competence	Indicators	Initial level (d)	Basic level (c)	Intermediate level (b)	Advanced level (a)
Identify and connect data	He/she identifies data necessary for calculation	He/she identifies in a partial way and with the need for guidance	He/she identifies some data but mistakes conversions	He/she identifies data overall but gets some conversions wrong	He/she identifies all data with correct conversions
Use solving procedure	He/she calculates the request	He/she makes major errors	He/she calculates, committing errors in the procedure	He/she calculates, committing some errors in the measure units	He/she calculates correctly
Estimate the results	He/she estimates the order of magnitude of the results	He/she does not know how to estimate the result	He/she calculates correctly but cannot estimate the result	He/she calculates correctly and partially estimates the result	He/she calculates correctly and justifies the result
Students achievements		7	8	13	7

TABLE 3 | Proficiency evaluation grid: memories.

Dimensions of competence	Indicators	Initial level (d)	Basic level (c)	Intermediate level (b)	Advanced level (a)
Collect information	He/she collects information on flood events through interviews	He/she Collects partial information through some generic questions	He/she collects essential information with general questions	He/she collects fairly complete information, choosing the questions in a reasoned way	He/she collects detailed information, asking targeted and precise questions to the respondent
Select and organise information	He/she selects and organises the interview content to be included in the video	He/she fails, if not guided, to select information	He/she identifies and partially organises some significant information	He/she selects and organises the information in a fairly clear way	He/she selects and organises information effectively and fluently
Make a video-documentary	He/she creates a video documentary that reflects the journalistic style	He/she creates an incomplete digital product	He/she creates a video, that partially reflects the journalistic style	He/she creates a video that is effective enough in journalistic rendering	He/she creates a structured video that is fully consistent with journalistic style
Students achievements		4	6	9	4

relevant levels: the table also reports the number of students achieving each dimension of competence (Table 4).

4 | Results and Discussion

ESL is a functional methodology for laboratory teaching design and stands out as an innovative proposal for schools that want to invest in reflective and meaningful training and in the development of transversal skills. We were able to observe multiple impacts on student learning and their motivation along with the implementation of ESL in the Mele Secondary school with the I-CHANGE project. First, we elaborate the experiences of the teachers and researchers. Then, we describe the experiences of the students based on the assessment utilised ARCS-model.

4.1 | Experiences of the Teachers and Researchers

First of all, the objective of reaffirming the importance of the method, of re-evaluating the profound and contextualised understanding of what is learned, for which the transmission and sharing of contents were subordinated to the problem of their full understanding (ref.?). Starting from these assumptions, students were invited to "do things" and reflect on what they have put into action, working actively on situations; the aim was not simply to acquire and accumulate content, which in ESL comes after the action and is carefully selected. The teacher transformed the content into a problem to be analysed, into an object of research, with the aim of making the class a true "laboratory", a space where students work on culture and produce it. The trigger for teaching work was often represented by current events—Freinet's "living theme"—which links school to life and increases interest and motivation in students.

The ESLS always presented itself as a lesson model capable of communicating with the present through the use of digital media and technologies, which allow the transmission of knowledge and not mere communication (Terrenghi et al. 2019). Digital media and technologies helped the student to connect school with outside school, inside and outside, creating continuity between the different learning environments and the different experiences. The alluvial history of the territory in which the students live, the municipality of Mele, allowed the search for data and testimonies rooted in the memory of the children and their families.[5] Furthermore, the comparison of the data obtained from the challenge with the official data proposed by the internet network,[6] allowed a critical evaluation of the sustainable behaviours adopted by the children in their daily lives. In a methodology where "learning by doing" is the cornerstone of school work, digital is the only language that allows the project to be designed and made factual at the same time.

The ESL accustomed children to widespread assessment. Since the ESL functions at the same time as a teaching activity for the student to carry out and as a verification test, any product of the three phases provides useful information for evaluation purposes. All this diversified the evaluation of the ESL from the

TABLE 4 | Proficiency evaluation grid: fiction.

Dimensions of competence	Indicators	Initial level (d)	Basic level (c)	Intermediate level (b)	Advanced level (a)
Write a plot respecting the canons of a literary genre	He/she writes a climate-fiction novel set in mele	He/she elaborates a plot that is not always coherent and respectful of the characters of the science fiction genre	He/she elaborates a plot that is sufficiently fluent and overall respectful of the climate-fiction genre	He/she crafts a clear and relevant plot	He/she develops an articulated and original plot
Use language and vocabulary	He/she uses the language correctly	He/she makes morphosyntactic and spelling errors, vocabulary is imprecise	He/she writes in a sufficiently correct form and with a vocabulary suitable for the subject	He/she writes clearly, the vocabulary is adequate	He/she writes correctly and fluently, the vocabulary is rich and varied
Make an audiobook	He/she creates an audiobook about the science fiction short story	He/she creates an incomplete digital product	He/she creates an audiobook that lacks in images choice and audio	He/she creates a complete audiobook that is quite effective in communication	He/she creates an effective and original audiobook
Students achievements		2	5	7	3

TABLE 5 | Survey proposed to the students.

ATTENTION Have the activities you carried out as part of the I-CHANGE project aroused your interest and curiosity?	A lot	26.3%	18 students
	Enough	60.5%	42 students
	A little	7.9%	6 students
	No	5.3%	4 students
If you answered yes, what aspects interested you the most? (it was possible to select more options)	Analysis of the causes and effects of climate change	47.4%	33 students
	Research on flood events	26.3%	18 students
	The discovery of facts and memories of our territory	39.5%	28 students
	The presentation of the results at the Foundation's headquarters	7.9%	6 students
	Other	13%	9 students
Which of the topics covered would you like to learn more? (it was possible to select more options)	The study of climate change	15.8%	11 students
	The effects of climate change on our territory	47.4%	33 students
	The collection of meteorological data	18.4%	13 students
	The search for testimonies on flood events	28.9%	20 students
	The study of correct behaviour in the event of an emergency	15.8%	11 students
	Challenges to avoid carbon dioxide emissions	13.2%	9 students
	Writing narrative texts on the topic of climate	7.9%	6 students
RELEVANCE Did you find any links between your activities and your personal experience?	Yes, because I was able to learn more about the environmental and climatic characteristics of my territory	23.7%	16 students
	Yes, because I got to know the history of events and people in my area	34.2%	24 students
	Yes, because I have become more aware of some of the problems of the reality in which I live	31.6%	22 students
	No, I didn't find any links between the activities carried out and my experience	10.5%	8 students
CONFIDENCE: What goals do you think the class has achieved thanks to the project? (it was possible to select more options)	The class has improved my knowledge of my territory	47.4%	33 students
	The class understood the importance of environmentally conscious behaviour	42.1%	29 students
	The class consolidated digital skills with the choice and use of various applications	13.2%	9 students
	The class has consolidated the ability to collaborate and work in groups	34.2%	24 students
What goals do you think you have achieved thanks to the project? (it was possible to select more options)	I have improved my knowledge of my territory	52.6%	36 students
	I understood the importance of environmentally conscious behaviours	42.1%	29 students
	I improved my digital skills	28.9%	20 students
	I learned to collaborate more actively in the group	18.4%	13 students
	I have improved my ability to present a topic in public	23.7%	17 students

(Continues)

TABLE 5 | (Continued)

SATISFACTION Which aspects of the project have given you the most satisfaction? (it was possible to select more options)	Carrying out research on climate change	39.5%	28 students
	Working in a team	28.9%	20 students
	Work with your tablet with various applications	21.1%	15 students
	Present the topic at the CIMA headquarters	42.1%	29 students
In which aspects did you find it most difficult?	Carry out research on topics	44. 7%	32 students
	Working in a team	13.2%	9 students
	Working with apps/software	28.9%	20 students
	Present the topic at the CIMA headquarters	13.2%	9 students

traditional one, eliminating its standardisation and reducing the anxiety of the students, who did not distinguish the moment dedicated to the evaluation from the ordinary activities that take place in the classroom. At every stage of the work of the various sections of the site, the results could be subject to evaluation: one example in particular—during the activities that led to numerical results—was the one in which the students were able to put in place mathematical skills that could be evaluated by the teacher.[7]

In ESL teaching, the educational relationship between the teacher and the students changes (Sadler 2009). In our case, the teacher dedicated herself/himself less to explaining the teaching contents and more to listening to the children, but rather paid attention to them and answered the questions asked, clarified doubts, and expressed appreciation. In this way, the children co-construct the teaching action: they were not themselves passive recipients of the training offer but were able to actively live the learning process. Second, the ESL teacher got close to the class, considerably reducing the proxemic distance that usually separates him/her from the students. This enabled more efficient communication and the interest (also from an emotional point of view) that the student feels in the learning process. This reduction also had a positive impact on the attention of students, who appear visibly more focused on what is proposed to them. For example, during the activity aimed at writing climate-fiction stories and the creation of the related digital audiobook, the teacher carried out exclusively the task of observer and facilitator: it was the students, divided into groups, who independently organised their work, inventing the plot of their story, dividing the tasks independently, and choosing which digital applications to use.[8] This way of proceeding guaranteed greater interest and attention from the class and the involvement of all the members of the groups in achieving the final goal.

4.2 | Experiences of the Students

As a part of the project activities, a survey among the students who participated in the project was undertaken focusing on three aspects of the ARCS-framework: attention, relevance, and confidence (Table 5, see Chapter 2).

Concerning the *attention* aspect, the students found interesting the topics addressed with an overall balance between a major understanding of the climate change causes/effects as well as a deeper understanding of the impacts of historical severe events on the Mele territory. It is worth mentioning that the students were willing to know more about the future effects of climate change on the area where they are living.

With reference to the *relevance* aspect, the students were mostly interested in the links between the school learning activities and the historical severe events of the Mele territory, including possible links with the climate change processes.

The *confidence* criterion mostly highlighted, from a different angle, again the achievements of higher knowledge of their own territory in terms of environmental processes and conscious behaviour. Interestingly, the students perceived the challenges associated with the research activities as intriguing for their own school activities but also complex to achieve. Social aspects of learning (working in a team and giving presentations) were also seen relatively positively.

To summarise, connecting the learning to the local territory and wider global change seems to catch the students' attention and relevance due to its familiarity and matching their motivation to learn turned out to be a successful strategy. It also seems that the ESL did not have a major contribution to the use or development of the digital skills.

5 | Conclusions

In this study, we have described the ESL process carried out as a part of the citizen science activities of the I-CHANGE-project in the Mele School to advance the learning about climate change and potentially contribute to their behavioural change. The results confirm that ESL was successful from the point of view of the teachers and the researchers, and it was well received also by the students. The teachers and the student actively engaged in the construction of the learning process in a different way than what happens in the usual practice. On the one hand, it emerged that the teacher is more committed in the educational relationship progressively developing with the students, devoting less time to the exposition of didactic content (top-down), thus devoting more time to listening to the students, paying attention to them and listen to the questions proposed, to clarify doubts and express appreciation (bottom-up): in this way, the students cocreate the didactic action. On the other hand, we saw how the ESL teacher got close to the classroom, considerably reducing the proxemic distance that usually separates it from the students, thus conveying "Immediacy": the term indicates that type of communication that increases the closeness between interlocutors and the behaviours associated with it express "ease of approach' and willingness to communicate.

From the point of view of students, based on the ARCS-assessment, the process as a whole contributed to the students' motivation to learn about climate change. The topics engaged their attention, they found the content relevant, and they felt mostly confident with their learning and satisfied with the process. Especially, the connection of the learning to their home territory was appreciated.

In conclusion, it is necessary to point out the fact that the ESL method is not miraculous: it is worth little without the subjects who implement it, that is, the teacher who plans, coordinates, and concludes and the students who produce their own knowledge, also taking advantage of the means that technology offers. The integration between the actors and the technologies makes the ESL a valid method for making the school dialogue constructive with its time.

Acknowledgements

We are grateful to the Municipality of Mele (https://comune.mele.ge.it/) for the continuous support and interest in the implementation of the H2020 I-CHANGE project activities.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Endnotes

[1] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

[2] https://climate-pact.europa.eu/index_en.

[3] https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en.

[4] https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/home?authuser=0.

[5] https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/gli-eventi-alluvionali?authuser=0.

[6] https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/miglioriamo-le-nostre-impronte?authuser=0.

[7] https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/think-green?authuser=0.

[8] https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/racconti-di-climate-fiction-a-mele-nel-2523.

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Appendix A

TABLE A1 | From the point of view of acclivity is our territory dangerous?

ESL steps	What the teacher does	What the student does	Time (h)
Preparatory phase	He/she Prepares a geomorphological map of the Melese territory with contour lines indicated and asks the pupil to analyse it	He/she draws the contour lines in different colours (in colour gradation) He/she identifies the points of highest and lowest altitude and areas of ascent and descent He/she recognises the steepest areas (i.e., shorter stretches between curves of different altitudes) and locates them precisely in the terrain	2
Operative phase	He/she requires dynamic visualisation of water or terrain movement based on slope He/she selects the most complete artefact (for next time)	He/she **c**reates a video tutorial highlighting the contour lines of the Mele territory and the direction of any river and/or landslide movements on the basis of greater or lesser slope He/she deposits the work in the classroom folder He/she shares and corrects the artefacts for inclusion on the site(https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/home)	1
Restructuring phase	He/she provides the students with the regional acclivity map found on the Ligurian basin plan site (Leira torrent) and asks them to compare it with the results obtained He/she leads the comparison discussion	He/she compares the qualitative data obtained with the quantitative values of the acclivity map taken from the Ligurian basin plans He/she identifies any differences with the official data, trying to justify them He/she chooses in a shared way the emoticon that best describes the risk of the area	2

TABLE A2 | Eco friendly bag challenge.

ESL steps	What the teacher does	What the student does	Time
Preparatory phase	He/she choose appropriate information on the carbon footprint highlighting the causes of it He/she designs a comprehension questionnaire that follows the 5W principle He/she leads the collective correction of the questionnaire in class and gives a short frontal lesson on the topic He/she selects and proposes a series of posters, videos or infographics on the behaviour needed to reduce the size of the footprint (stimulus) He/she proposes a specific website for calculating the carbon footprint to use at home (https://www.arpa.piemonte.it/co2_footprint/#/)	He/she analyses sites/videos on the significance of the carbon footprint Fills in the questionnaire at home He/she self-corrects the questionnaire and takes notes He/she analyses the effects of various behaviours on the carbon footprint He/she calculates own family's carbon footprint via the website at home with the help of parents	2 h at school + work at home for as long as necessary
Operative phase	He/she requires calculating class savings through a wizard (check list) that takes into account the use of cloth or recycled bags for shopping versus the use of plastic bags He/she requires to digitally produce an advertising banner to be placed on the website https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/home	He/she calculates savings using recyclable bags in the class He/she produces the banner individually	1 h
Restructuring phase	He/she corrects artefacts He/she estimates calculated savings	He/she analyses class products He/she comments on the magnitude of the savings obtained in relation to the behavioural norms suggested online	2 h

TABLE A3 | Turn your mobile phone off challenge.

ESL steps	What the teacher does	What the student does	Time
Preparatory phase	He/she selects a suitable sitography on the digital ecological footprint highlighting its causes He/she designs a comprehension questionnaire following the 5W principle He/she leads the collective correction questionnaire and gives a short lecture on the topic He/she proposes a questionnaire on the main sites/apps/social media used by the children He/she sets up a specific site for calculating the carbon footprint of the class https://www.websitecarbon.com/	He/she analyses sites/videos on the meaning of the digital footprint He/she fills in the questionnaire at home He/she self-corrects the questionnaire He/she expresses own preferences He/she creates a class list with classmates He/she calculates the digital footprint of their class taking into account the time of use of the various apps/socials	2 h at school + work at home for as long as necessary
Operative phase	He/she requires calculation of class savings via a guided procedure (check list) that takes into account certain feasible behavioural choices (no smartphone use for a defined time vs. smartphone use) He/she asks the students to produce some advertising banners to be placed on the site https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/home	He/she calculates savings based on time of use of digital tools He/she produces the banner individually	1 h
Restructuring phase	He/she corrects artefacts He/she estimates calculated savings	He/she analyses class products He/she comments on the magnitude of the savings obtained in relation to the behavioural norms suggested online	2 h

TABLE A4 | The floods of our territory—testimonies and memories.

ESL steps	What the teacher does	What the student does	Time
Preparatory phase	He/she prepares the historical documentation on the floods in the Mele area and shows it to the students (photographs, memoirs, newspaper articles, videos) He/she divides the class into groups (for the next stage)	Together with classmates, he/she examines the materials provided; Reads texts He/she asks the teacher questions about how the events occurred He/she tells the teacher and his classmates some of the incidents he knows about the events that took place	3 h
Operative phase	He/she requires groups to conduct an interview with relatives about the flood events He/she takes a look at the material collected He/she requires the groups to make a journalistic video-documentary starting from the collected material	Together with classmates, he/she identifies the people to be interviewed outside the school and asks questions about flood events; Record or take notes He/she creates a video-documentary that exposes, in the form of a journalistic report, what emerged in the interview He/she shares the work with the class (https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/gli-eventi-alluvionali/le-alluvioni-del-nostro-territorio?authuser=0).	3 h at school + work at home for as long as necessary
Restructuring phase	He/she watches the videos with the kids He/she guides the analysis and comparison discussion	He/she shows the video to the class and review the other groups' videos He/she expresses reflections on how the memory of the events that took place has left a trace in the people of Mele He/she evaluates in a shared way what behaviours can be decisive in extreme situations He/she considers and evaluates in a shared way the elements of journalistic language present or absent in the videos	2 h

TABLE A5 | Science fiction tales about climate.

ESL steps	What the teacher does	What the student does	Time (h)
Preparatory phase	He/she introduces the reading of the passage by Bruno Arpaia He/she guide to reading comprehension and analysis He/she divides the class into groups (for the next step)	He/she reads the passage Together with his/her classmates, he/she carries out exercises to understand the text: he/she identifies the main facts of the action, places, times, characters; research in the text the typical elements of the science fiction genre; analysis descriptive and reflective sequences; trace the elements that contribute to building an atmosphere of suspense	2
Operative phase	He/she requires groups to make an audiobook about a climate-fiction story they invented and set in Mele in 2053 He/she acts as a facilitator by responding to students' requests for explanations He/she takes a look at the material collected	In groups with classmates, he/she: asks questions about what might happen to Mele in 2523—invents and writes the plot of the story, assigns a title—draws illustrations or rework images of Mele and its territory through various apps—records the audio of the reading with the iPad He/she creates a digital audiobook He/she shares the work with the class (https://sites.google.com/icvoltri1.edu.it/ambiente-mele4future/racconti-di-climate-fiction-a-mele-nel-2523)	6
Restructuring phase	He/she watches audiobooks He/she guides the discussion	He/she shows your product to the class and take a look at the other groups' products He/she evaluates which audiobooks are most effective on a narrative and/or digital level He/she reflects on possible future environmental issues and on situations in the world where the climate emergency is already a reality	2