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Backcasting for Youths: Hypothetical and Critical Thinking in the Context of Sustainable Development Education

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Abstract: The growing interest in innovative pedagogies within education for sustainable development (ESD) calls for a renewed set of pedagogical practices. In responding to this challenge, this article draws on backcasting, a future studies method, to support education for ESD competencies among youths. It presents the design, trial, and results of one intervention designed to test the method in the context of secondary education, employing design thinking as an overarching methodology. Using a qualitative descriptive-interpretative approach with a thematic analysis to examine empirical data obtained from participants' perspectives, we present their future visions, how much they were involved in the intervention, what they liked the most and the least, their perceived purpose, ease and adequacy in duration. Our findings show that youths embrace active methodologies such as backcasting. Since the method was new to them, participants experienced difficulties when logically chaining the steps necessary to achieve a desired future from the present state. Nonetheless, the skills underpinning backcasting are relevant to sustainable development, as they involve considering our actions regarding medium- and long-term impacts. In the end, we propose backcasting as a poignant method in the context of secondary education that can promote the development of hypothetical and critical thinking skills central to ESD competencies. While offering a theoretical discussion, a workshop protocol, and future directions for pedagogical practice and investigation, our results apply to researchers, sustainability education professionals, and teachers alike.

Keywords: ESD competencies; planning methods; future thinking; secondary education

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1. Introduction

Positive environmental attitudes tend to dip during adolescence, with a minimum low at 16 [1], making the role of education for sustainable development (ESD) more pressing during this stage of life. While one can identify diverse teaching methods and approaches to ESD in the literature [2], we explore the role of future studies methods such as backcasting in this article. Drawing on previous works such as Ishihara and Valls [3], we tinker with ways in which backcasting "can train imagination and creativity" amongst adolescents, in this case, to think about the future of biodiverse environments. Given the lack of evidence regarding the pedagogical implications and potentials of the backcasting technique within the context of ESD, our contribution aims to fill a gap. Whilst reporting our case study, our goal is twofold. First, to contribute to the ESD literature; second, to put forward reflective and practical guidelines for those involved in ESD with youths who wish to integrate backcasting exercises into their practice. Before presenting our case study, we outline the pedagogical framework that underpins our choice of the backcasting method, we briefly present the method, followed by our research questions.

We set our case study against a backdrop whereby the nature conservation perspective within environmental education has shifted toward an ecological and sustainability one. Accompanying this transformation is a change from a behavioural view of learning toward a critical and emancipatory one. For example, Wals [4] details a nature conservation perspective within environmental education and its underpinning behavioural view of learning. In contrast, the author presents an environmental and sustainability perspective as an emancipatory approach (going back to the work of Paulo Freire 1970), centred on what the author identifies as the qualities of "self-determination, agency, and democracy". In another text, 'Learning Our Way to Sustainability', the author [5] asks: "Should environmental education (EE) and education for sustainable development (ESD) prioritise changing behaviours or focus on capacity building and critical thinking?" To answer the question, the author reminds us that the latter is better suited to prepare learners to become active citizens with the required abilities to contribute toward transformation.

In the above view, ESD should facilitate the development of what Rieckman [6] identifies as vital sustainability-related competencies. Before tapping into such competencies, it is essential to note that ESD is best understood as a "holistic and transformational education" encompassing "learning content, pedagogy, and environment" [6] (p. 40), three interrelated concepts we will return to in the Section 4. ESD often goes hand-in-hand with "innovative pedagogies" [7] to be distinguished from more routine approaches (e.g., transmissive learning and disciplinary learning) in favour of discovery learning, participatory/collaborative learning, problem-based learning, interdisciplinary learning, multi-stakeholder social learning, critical thinking-based learning, systems thinking-based learning [8]. In fact, the literature often details systems thinking and interdisciplinary perspectives [9].

Rieckman [6] emphasises the importance of promoting ESD through key competencies that accompany a shift in education towards a transformative pedagogy centred on self-directed learning and problem orientation. According to the author, ESD includes the following competencies (see Table 1).

The author [6] equally stresses the need for a paradigm shift in education from teaching to learning, emphasising action-oriented transformative pedagogy characterised by self-directed learning, participation, collaboration, problem-orientation, and inter and transdisciplinarity. We will further explore this shift later in the Section 4. In the meantime, what are the suitable methods for ESD anchored on innovative pedagogies?

Jeronen and colleagues [10] emphasise active learning methods that encourage students to be involved in their learning processes through investigation, discussion, critical reflection and co-construction with peers. Georgallis and Bruijn [11] underline case-based in-class debates to foster active learning by exposing students to "practical skills" and "active participation, critical thinking and reflexivity". According to the authors, debates that focus on specific case studies can, in fact, "urge students to consider the complex nature of and multiple viewpoints on sustainability issues" [11]. While the literature on adaptive teaching suggests that different instructional methods are necessary for different students [7], research in ESD highlights the strong presence of constructivist learning methods for promoting comprehensive ESD goals, emphasising self-regulated and self-directed learning of knowledge and problem-solving skills [12]. The connection to place is also evident in the choice of methods such as field trips [13], digital storytelling [14], and outdoor learning more generally [15]. However, methods that enable future thinking are less prominent within the literature, such as backcasting.

Despite the diversity of approaches to the backcasting technique identified in the general literature [16], some essential qualities distinguish it from other future studies methods [17] and make it particularly suitable for the context of secondary education. For example, we take from Quist [18] the view that it is as a method that helps us focus on desirable futures while looking backwards to the necessary steps to achieve such vision. While we further detail the method in the Section 2, here, we add the view from Robinson and colleagues [19], that state that the method's potential to open the way for discussion during the backcasting exercises allows for a 'social learning process' amongst

participants. We position social learning as a potential and essential contribution of the backcasting method to educational contexts, with implications for the ESD competencies highlighted above. Furthermore, we hypothesise that within an educational context, backcasting can support "innovative pedagogies" within ESD [7] that favour discovery learning, participatory/collaborative learning, problem-based learning, interdisciplinary learning, multi-stakeholder social learning, critical thinking-based learning, systems thinking [8]. To test the above hypothesis, we devised a case study to allow us to test the backcasting method in an educational context to understand its pedagogical implications. To guide our research design, we developed the following research questions:

RQ1: *What challenges and barriers do youth encounter when using the participatory backcasting approach in a task involving desired futures? What futures do they imagine? How do they devise ways to reach them?*

RQ2: *What are the participants' levels of engagement with the backcasting exercise?*

RQ3: *How do participants experience the backcasting methodology overall?*

Table 1. Education for Sustainable Development Competencies, adapted from Rieckmann [6] (pp. 44–45).

Competency	Description
Systems thinking	• recognise and understand relationships • analyse complex systems • perceive how systems are embedded within different domains and different scales • deal with uncertainty
Anticipatory	• understand and evaluate multiple futures—possible, probable and desirable • create one's visions for the future • apply the precautionary principle • assess the consequences of actions • deal with risks and changes
Normative	• understand and reflect on the norms and values that underlie one's actions • negotiate sustainability values, principles, goals and targets in a context of conflicts of interests and trade-offs, • negotiate uncertain knowledge and contradictions
Strategic	• collectively develop and implement innovative actions that further sustainability at the local level and further afield
Collaboration	• learn from others • understand and respect the needs, perspectives and actions of others (empathy) • understand, relate to and be sensitive to others (empathic leadership) • deal with conflicts in a group • facilitate collaborative and participatory problem-solving
Critical thinking	• question norms, practices, and opinions • reflect on own one's values, perceptions, and actions • take a position in the sustainability discourse
Self-awareness	• reflect on one's role in the local community and (global) society • continually evaluate and further motivate one's actions • deal with one's feelings and desires
Integrated problem solving	• apply different problem-solving frameworks to complex sustainability problems • develop viable, inclusive and equitable solutions that promote sustainable development • integrate the above-mentioned competencies

2. Research

2.1. Theoretical Background

2.1.1. The Backcasting Method

In line with Quist [18], we draw on backcasting as a method that focuses on looking back from the future to envision a desirable future (see Figure 1); therefore, it differs from forecasting, which looks forward from the present perspective. From the author's perspective, backcasting is helpful for 'complex problems' (p. 271)—sometimes known as wicked problems (for more information on wicked problems see the work of Brown and Russel [20])—that require a view of the future as a long-term horizon where alternatives require long development times. Effective backcasting exercises set 'normative goals' and construct 'desirable futures', making it an effective method for imagining sustainability innovations [18] (p. 11).

According to Bibri [21], in future studies, normative goals are centred on desirable visions essential for strategic planning to accomplish long-term sustainability goals. The author contends that normative goals should be anchored on a vision of "ideal states", a strategy that differs from a focus on current situations and capabilities, which may hinder our capacity to consider desirable futures instead of predictable ones.

Whilst summarising previous work, Bibri [21] presents three categories of future visions, each accompanied by a question.

- Prospective futures—what could possibly occur?
- Probable futures—what is most likely to happen?
- Preferable futures—what we would prefer to happen?

Backcasting works explicitly with preferable futures. As a future design technique, the process often starts by asking participants to identify a "desirable future state" [18] (p. 30). Then, the gap between the desired future state and the current state is identified, and the necessary steps are identified in between [22]. We will come to this last point in the Section 4 when referring to the work of Kerkhof and Wieczorek [23] (p. 741). In the meantime, we detail the procedure in Figure 1. For other complementary images, we suggest consulting the work of Irwin (2018) [24].

Particularly relevant to our case study is the possibility of using backcasting to envision a future for forthcoming generations [25]. As detailed in the Section 2, by asking our young participants to envision the future 30 years from now, we invite them to tinker with what Uwasu [26] (p. 43) details as "the idea of creating future generations in the present to give them the right to speak (. . .)". We can better understand such an approach as a response to what Timilsina and colleagues [27] identify as a Sustainability Dilemma (SD), whereby current generations tend to make self-serving decisions that harm the sustainability of society and future generations. In keeping with the authors, there is a need for innovative social processes that may effectively include the voice of future generations in a choice that the current generation makes collectively; this is the central theme of Future Design by Saijo [28], a practice of future planning that has become essential for the survival of our planet.

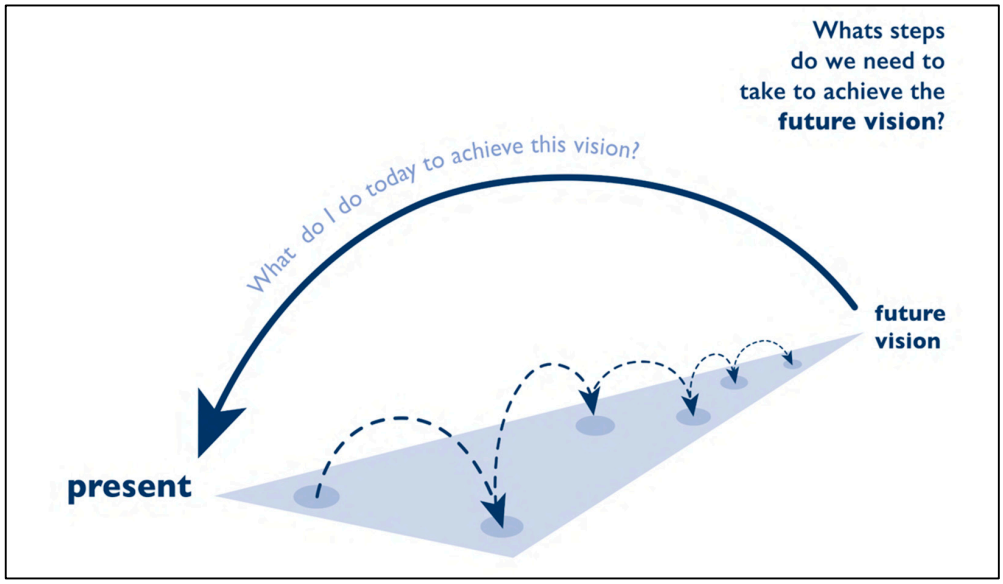


Figure 1. Illustration of the Backcasting development process (by Designer Susana Gomes, based on an image from The Natural Step (Canada) Inc. website, available at: https://old.naturalstep.ca/backcasting, accessed on 18 October 2024).

2.1.2. The Design Thinking Methodology

Quist and Vergragt [29] (p. 1033) provide a five-step framework that illustrates the backcasting process, starting with:

1. Strategic problem orientation
2. Construction of sustainable future visions
3. Backcasting
4. Elaboration and analysis of follow-up actions
5. Embedding results and generating implementation.

The framework devised by the authors aligns with a design thinking methodology (Figure 2) prevalent within educational contexts [30]. In line with the work of Cross [31], design thinking is, above all, a methodology that helps designers (and, to this part, non-designers) focus on ill-defined problems. The design thinking described by Cross is akin to what the British Design Council [32] has come to define as a 'framework for innovation' which is based on four key stages that we summarise below:

1. Discover: This phase involves gaining a deep understanding of a problem. It is about observing, listening, and learning rather than making assumptions.
2. Define: Using the insights gained from the discovery phase, this step is about redefining the challenge in a more informed and nuanced way.
3. Develop: Here, the focus is on generating a variety of solutions to the well-defined problem. This involves seeking inspiration from diverse sources and collaborating with different stakeholders to co-design potential answers.
4. Deliver: This stage is about testing the developed solutions on a small scale, learning from failures, and iterating on the successful approaches to refine and improve them.

Brown and Wyatt [33] further summarise design thinking, which for the authors involves three spaces: 'inspiration', 'ideation', and 'implementation', which overlap rather than evolve sequentially. Inspiration is the problem or opportunity driving solutions, ideation consists of generating and testing ideas, and implementation brings projects into people's lives. The process may loop back through these spaces multiple times for refinement and exploration. While initially chaotic, participants eventually see the sense and results of this non-linear approach compared to traditional milestone-based processes.

We frame "strategic problem orientation" detailed by Quist and Vergragt [29] within the Discovery phase of the design thinking methodology. We place the "construction of

sustainable future visions" in Define. In contrast, we include the actual "backcasting" process in the Develop stage and the "elaboration and analysis of follow-up actions". "Embedding results and generating implementation" can be best understood and framed in the Delivery stage of design thinking. Note, however, that given the speculative qualities of the backcasting technique and the educational context of our intervention, in our protocol (see Appendix A), we did not consider stage 4, 'Deliver'. However, this stage could correspond to some final steps in different backcasting approaches. As detailed by Quist [18] (p. 25), see, for example, the step "Implement research agenda" of the STD backcasting approach and the "Realisation follow-up and implementation" of the SusHouse backcasting approach.

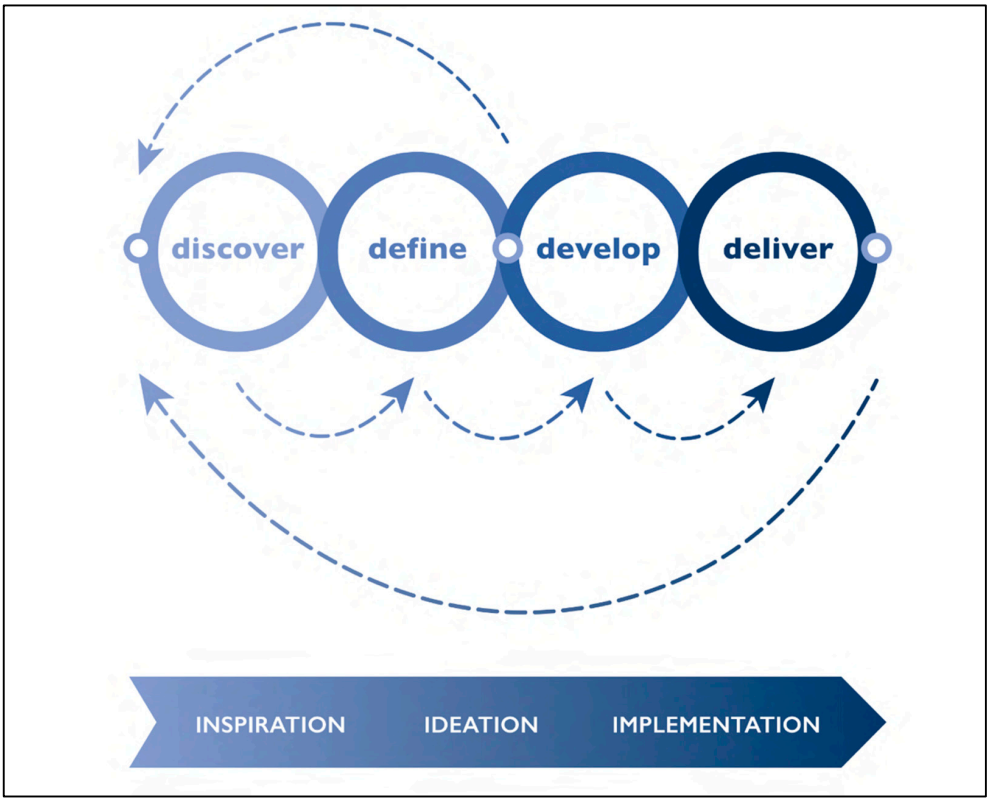


Figure 2. Illustration of the design thinking development process (by Designer Susana Gomes).

We further detail how we combined backcasting and design thinking in Section 2.4. It is important to note that the Deliver or Implementation step of design thinking is less relevant to the backcasting methodology given that it is a speculative tool. Waidelich [34] provides a thorough analysis of 35 models of design thinking that derive from Brown's original proposal and feature ideation and prototyping.

We conclude this sub-section by reiterating the legacy of design thinking within the educational realm. Koh and colleagues [30] highlight the role of design thinking in boosting 21st-century competencies such as creativity, innovation, critical thinking, problem-solving, decision-making, learning to learn, and metacognition (p. 35). In their view, design thinking within educational contexts brings an opportunity to prepare youths for complex and often challenging real-world problems (p. 36), fostering empathy and social consciousness (p. 11) and citizenship (p. 54). Given the methodology's popularity within educational circles, we have opted for a design thinking approach.

2.2. Context

This study integrated a larger project which contemplated the design of interactive and educational materials to support teenagers in their exploration of a local forest of the Azores, the northernmost of the four Macaronesia archipelagos. The Azores features

a Mediterranean hotspot of biodiversity [35], characterised by high levels of endemism, including relict species [36,37] and important areas of native vegetation [38]. Notwithstanding, exotic invasive species (e.g., *Hedychium gardnerianum*, *Pittosporum undulatum*), climate change [39,40], the building of new infrastructures within protected areas (e.g., roads, geothermal facilities), the degradation and fragmentation of habitats due to human activities such as intensive pastures and urbanisation [41], pose significant threats to the conservation of these unique habitats [42,43].

Prior to the backcasting exercise, 18 of the participants visited a local forest with the name Matela, a relic of the primitive natural forest of the Azores [44] (see also Figure 3). As detailed by the local Regional Secretariat for the Environment and Climate Action [45], responsible for managing the forest, the site corresponds to a protected area (part of Terceira Nature Park), spanning 27 hectares and is a preserved natural habitat in the heart of Terceira Island, one of the nine islands of the Azorean archipelago. It is a remnant of the original mid-latitude forest, featuring species such as laurel (*Laurus azorica*), cedar (*Juniperus brevifolia*), and heather (*Erica azorica*). These trees and plants create a dense woodland rich in biodiversity, hosting a variety of endemic flora and fauna unique to the Azores [44].

Figure 3. Participants visiting Matela Forest (Terceira Island, Azores) prior to the backcasting exercise on 21 April 2024.

2.3. Participants

We chose an intentional sampling, combining several criteria related to the geographical proximity to Matela—located within the municipality of Angra do Heroísmo, Terceira Island—the development of the students (secondary education), the availability to participate (curricular year without exams). As a result, we invited two 10th-grade classes from Jerónimo Emiliano de Andrade Secondary School, located in the city of Angra do Heroísmo. This public school offers the 7th to 12th grade and Vocational and Professional training. It has a total of 930 students distributed amongst 63 classes.

At the time of our study, participants were ages 15 to 18, 15 female and 12 male participants, who attended the 10th grade, except for one individual who attended the 12th grade. Among the participants, 22 belong to the Science and Technology Course and five to the Languages and Humanities Course. Therefore, a total of 27 students from the school participated in the research.

On April 21, participants visited the forest for 120 min. They completed the backcasting exercise on 3 May 2023. It is essential to note that on 26 April 2023, we tested the

protocol that underpins our study (see Appendix A) in a neighbouring school, the Basic and Integrated School of de Angra do Heroísmo, with 20 teenagers enrolled in the 9th grade. The session lasted around 90 min. This intervention took place within the scope of the school's Science Week.

Before the sessions described above, The University of the Azores Ethics Committee approved the study, which required informed consent terms and detailed information on data collection instruments. Once we obtained approval, we delivered the consent forms to parents, legal caretakers, and participants. The forms were adapted for each group and included the study's objectives, ethics committee opinion, intervention details, participant questions, duration, data anonymity, withdrawal, and any risks. The consent forms also requested authorization to obtain photographs during the study, transfer of data, and willingness to receive study results.

2.4. Methodology

We combined the backcasting technique within a design thinking methodology that organises the thinking process in the steps detailed above: Discover, Define, Develop, and Deliver. As noted before, we excluded the Deliver stage, considering participants could not implement their ideas in practice, nor was it expected within a backcasting exercise. To guide our investigation, we applied a descriptive-interpretative approach that combines the semantic decoding of students' perspectives on a pedagogical technique, backcasting, with the structural analysis of the logical linkage between the goal and actions, as well as the study of the relevance and adequacy of the strategies proposed to achieve the goals.

Before implementing the protocol of the backcasting exercise (Appendix A), we tested its first version amongst 9th-grade participants regarding the steps to follow, their order and the duration of each of the proposed activities/reflection exercises. Specifically, we invited one 9th-grade class from the Ciprião de Figueiredo School to share their perspectives, knowledge, and experiences about their desired future for nature in the Azores in an informal environment. The school's media library had previously been prepared with two tables to accommodate two groups of nine students and a moderator. We placed a large paper format (roughly 2 × 1 m) and thick markers on each table and followed with a brief reflection using the following question for guidance:

> "Think about the nature of Terceira Island. How do you want nature to be in 30 years?".

After presenting the question, we invited participants to share their ideas, which the moderators wrote on paper so everyone could see. After 10 min of sharing, the ideas were put up for vote. At this moment, each participant received a sticker, which they placed next to the idea they liked most. Once the most voted idea had been selected, we invited participants to apply the backcasting technique to create an inventory of necessary actions to reach the desired future proposed in the concept. Therefore, the moderator assigned to each table asked questions like "What needs to happen for this goal to be possible?" and so on. This approach facilitated the organisation of responses in real-time, from those closest to the goal to the most remote, with the view of creating a retrospective chain, in which the last ones must be closest to the present moment.

Having been motivated by the question "Where would you like to start?" and after organising the chain of thought described above, participants were again invited to vote to plan one of the actions. Stickers were once again delivered to participants, and they applied them to the chosen action. Once the action was selected, participants were invited for further reflection. Three types of action had been envisaged, for which three sheets had been created, with topics for participants to reflect on: Sheet 1 (Stimulate/Convince Others to Act); Sheet 2 (Act/Intervene); Sheet 3 (Raise Awareness) (see Data Availability Statement section). It was not mandatory to use the sheets since they were designed as suggestions. Participants took about 20 min to complete the task, after which groups were invited to present their plans to the class.

After the pilot phase, we invited the participants from the two 10th-grade classes from Jerónimo Emiliano de Andrade Secondary School to consider Matela's desired future, the local forest they had visited before the backcasting exercise (Figure 3). There were no significant changes to the protocol, with both groups focusing on a 30-year perspective.

We worked within the context of the student's regular class schedule. In this case, the teacher freed 90 min for the intervention and was present throughout; she did not participate but was an observer. The teacher found the backcasting method exciting but conveyed that she often resisted these more active problem-solving methodologies because they take up much time and have little to do with specific subjects. She uses digital tools instead to enhance engagement and capture students' attention; this contrasts with the backcasting method, which promotes reflexivity and critical thinking.

To critically analyze the intervention, we collected data from the student's productions, observations of the dynamics developed during the intervention, and from a post-intervention Questionnaire (see Data Availability Statement section). Data collection was guided by a conceptual model designed explicitly for this study (see Appendix B), which focuses on the three research questions. Regarding the first question, we analyzed students' outputs by assessing the richness of their characterization of future scenarios and the direction of the desired evolution. We later examined the logical chains of antecedents in terms of their complexity and the quality of the proposed action plans. For the representations of the backcasting methodology within a design thinking framework, we explored students' perspectives concerning the educational objectives, the working process, and the attractiveness of the activity/methodology. Lastly, we analyzed the engagement, perceived engagement, observed engagement, and inferred engagement dimensions of activity.

To explore the emerging themes in the participants' representations and evaluations, we employed a thematic analysis following the framework of Braun and Clark [46]. Using an inductive approach, we allowed categories to emerge organically from the data based on their semantic meaning. We constructed and refined the categorization system retrospectively and iteratively to ensure comprehensive coverage of all meaning units within the data. We also calculated relative frequencies to complement the description of the categories.

To structurally analyze students' outputs regarding the actions mediating the gap between the desired future and the current state, we undertook the following steps:

- Evaluation of the connections between actions, measures, and strategies.
- Use of flowcharts to illustrate the logical relationships between actions.
- Identification of gaps, logical leaps, and means-ends inconsistencies.

Authors (AMA; RG), each with expertise in Environmental Psychology and Biology, developed the coding process collaboratively; all team members later revised this. Similarly, we calculated relative frequencies to complement the description of the categories.

3. Results

This section presents the participants' responses to their experiences and analyses their engagement with the overall intervention. While we further examine the implications of the gathered data in the Discussion, we present and interpret results and draw some preliminary conclusions. We used a qualitative methodology (descriptive-interpretive) and a thematic approach to guide the data analysis. Our methodology is qualitative, although alternatively—and when it makes sense—we calculate percentages of responses relating to each category. The frequency calculation is subsidiary and plays an illustrative role.

3.1. What Challenges and Barriers Do Youth Encounter When Using the Participatory Backcasting Approach in a Task Involving Desired Futures? What Futures Do They Imagine? How Do They Devise Ways to Reach Them?

In this subsection, we describe how participants approached the design of solutions for the problems they identified via the backcasting exercise (e.g., the relevance, feasibility and complexity of those solutions). Here, we draw on Tables 2–7 to better understand the

symbolic mechanisms they employed during the exercise and facilitate comprehension of the process participants underwent during the workshop.

Table 2. Summary of Group A's productions in the first moment of the intervention: (1) construction of the idealised future.

MOMENT 1 Construction of the Future State
Desired Future for Matela 2054 (+30 YEARS)
Ideal 1: Matela: a restored natural space = 1 vote > New species (plants and animals, insects) > Eliminate invasive plants > More preserved space > Do not destroy nature: =1 vote > Preserve more sensitive areas > Preserve vulnerable species
Ideal 2: Matela: as a centre of cultural entertainment (a type of natural park preserved for recreational and aesthetic uses) = 8 votes > Better use of the area (trails) > Leisure spaces (picnics) = 2 votes > Make it a tourist attraction for children and adults, currently "it's just bush"! = 2 votes > Rubbish bins on the tracks > Fences—delimit the area > Identification of trees with geographic origin, as in the Angra garden > Promotion of activities (cultural entertainment) (e.g., 1 day to observe birds; maze; peddy-paper) = 4 votes > Create an agenda of online activities (description, summary, location, registration forms, timetable, agenda)

Table 3. Summary of Group A's productions in the second moment of the intervention: (2) characterization of the idealised future scenario with a chain of antecedents.

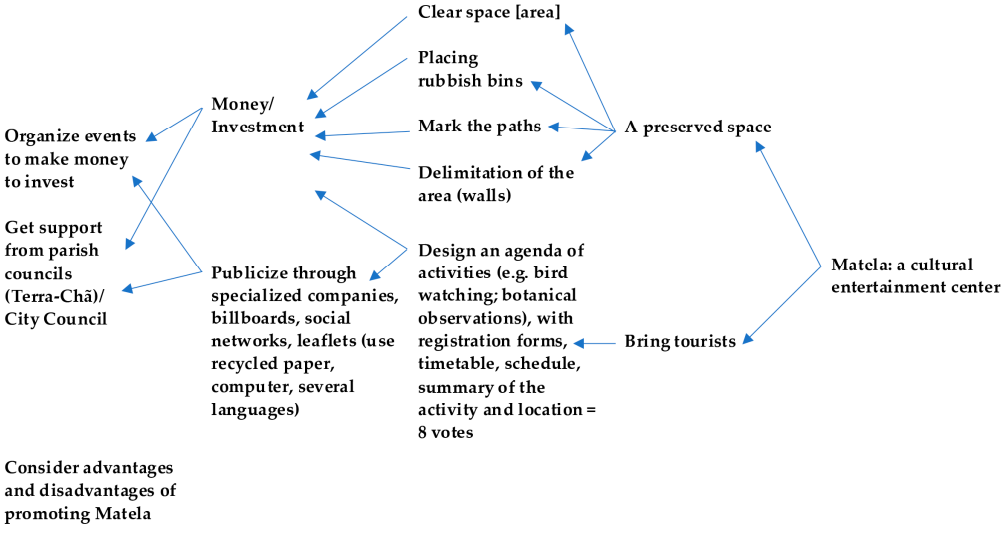
MOMENT 2 Building the Scenario
Desired Chosen Future: Promotion of cultural events and activities in Matela
Description of the Constructed Logical Chain of Events What needs to happen at different times for this future to materialize? 2023----------2053 

Table 4. Summary of Group A's productions in the third moment of the intervention: (3) strategic planning of the chosen action: to develop a cultural agenda for Matela.

MOMENT 3 Strategic Planning
Measure Chosen from the Proposals to be Planned—Persuasion to Act: Develop Matela's cultural agenda
Target Audience—Who do they want to pressure into action? Who has the power to change the situation? > Volunteering (students, elderly people with abilities, unemployed people, . . .)
Objectives—What do you want your target audience to do? > Prepare areas to carry out activities: cleaning, limiting space, building a leisure area)
Identify the Message to be Conveyed—What do you want/need to tell them? > Ensure the conservation of natural spaces
How to Persuade—How can you convince them? How do you think it is best to reach these people? > Promotion of the space by travel agencies (through the creation of) leaflets, social networks, poster advertising
Identify Allies—Who can help? > Get help from PAN (Portuguese 'People-Animals-Nature' political party)
Material Resources—What things and services do you need? > Wood, paper, paint, electronics, etc. SCHEDULING—time frame > about 1 year, more or less
Evaluation—How do you know whether or not you were successful? What strategies could be used to assess efficacy? > If several people join the project (depending on the number of people who join the project)

Table 5. Summary of Group B's productions in the first moment of the intervention: (1) construction of the idealised future.

MOMENT 1 Construction of the Future State
Desired Future for Matela 2054 (+30 YEARS)
Ideal 1: Matela: a restored natural space = 8 votes > Healthy > More endemic plants > More endemic animals (cows, birds, rabbits) > Green Matela > Matela full of life
Ideal 2: Matela, a clean space = 1 vote > Clean from litter > More places to put your trash
Ideal 3: Matela, an inhabited outdoor space = 0 votes > Picnic sites > Lighting > Larger trails (to be able to visit) > Parking for cars > Souvenir shop

Table 6. Summary of Group B's productions in the second moment of the intervention: (2) characterization of the idealised future scenario with a chain of antecedents.

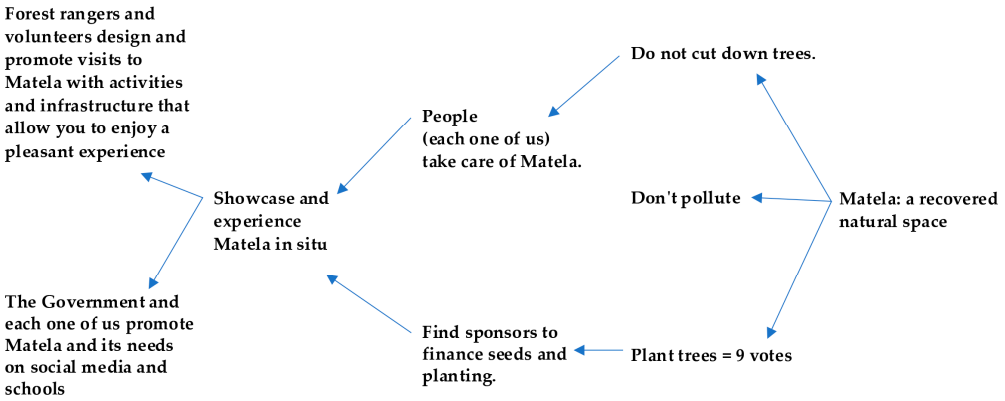
MOMENT 2 Building the Scenario
Desired Chosen Future—More natural life in Matela
Description of the Constructed Logical Chain of Events What needs to happen at different times for this future to materialize? 2023----------2053 

Table 7. Summary of Group B's productions in the third moment of the intervention: (3) strategic planning of an action.

MOMENT 3 Strategic Planning
Measure Chosen from the Porposals to be Planned - Intervention: Planting trees
Objectives—What do you want to achieve? > more endemic plants and animals > exterminate invasive plants (e.g., Cannabis sp.)
Description of the Measure or Action to be Implemented—What do you want to do? > sow and plant endemic plants that serve as food to attract other endemic animals; > planting plants will feed animals—more animals
Human Resources—Do you need help? For what? > ranger, volunteers and school/leisure activities to plant and sow endemic plants
Material Resources—What things and services do they need? > planting needs money from sponsors and government support—to pay people to plant; (and obtain) authorization to (involve) schools and (purchase) seeds and planting
Scheduling—How to organise all the necessary steps over time? > -
Methods of Evaluation—How do you know whether or not you were successful? > -

3.1.1. Group A

This group consisted of nine young participants, seven girls and two boys, all from the 10th grade, seven coming from Science and Technology and two from Language and Humanities.

Two central ideas emerge in how this group constructs the image/scenario of Matela's future in 30 years (Table 2). One highlights the concept of Matela as a well-defined, restored, better preserved natural space, with new species of plants and animals, mainly insects, and the elimination of invasive plants, showing the importance of protecting the most sensitive areas and vulnerable species. In the second, Matela appears as a natural space preserved for cultural, recreational and aesthetic uses. Here, Matela is more focused on human needs, with picnic areas and playgrounds, trails, attracting tourists, becoming a driving force for local development, moving beyond its current state as "just bush".

These two idealizations of Matela, while different, both point towards a positive evolution of the place. This optimistic outlook is in line with our request for the 'desired future', rather than the 'most likely future', for instance. Despite the emergence of only two idealizations, their rich characterization provides us with a vision of Matela that reflects a significant investment in the task.

In the second task, we invited participants to identify the steps necessary for the desired future to become possible, that is, to describe the logical chains of events from 2053 to 2023. Given that this group decided to focus on Matela as a future centre of cultural entertainment, they considered that first, the natural space must be restored, and to do so, it must be cleaned, signposted, delimited, etc. This chain of actions proved relevant to solving the problems diagnosed in Matela, confirming congruence between their chosen steps to achieve a desired future. However, not all actions identified by Group A were discussed, such as the impacts of future interventions in Matela.

The reduced number of steps between the final and initial states, visible in Table 3, reveals some reductionism in understanding the complexity of the problems at stake. For example, making money appears necessary for almost all diagnosed needs in this chain of inferences. This kind of "magic wand" that could change the future is believed to come more from the support of official entities than from individual entrepreneurship. The reduced number of logical antecedents, the power attributed to money as the most crucial resource and the external locus of responsibility for local power in obtaining funds convey a notion of the simplicity of sociocultural change. This position releases citizens from responsibility for the plan's feasibility since its implementation is seen as depending on someone else's power. In this sense, developing a cultural entertainment centre in Matela—the strategy young people chose to plan—is hostage to the subsidies that must be raised.

Out of the proposed actions listed by Group A, participants chose Matela's cultural agenda as the one they wanted to develop and plan, with eight votes out of nine.

During this activity, only three of the nine individuals stood out for their participation, while the overall involvement was weak, with some participants using their cell phones and discussing unrelated topics. One group member focused on creating drawings for the presentation, and another quickly took on the role of leader, despite wanting to avoid presenting orally to the class, due to the presence of their teacher.

This group of adolescents followed the planning sheet for persuasion, answering all the items during the allotted time, providing rather synthetic and superficial answers—as expected. Although the time available for this phase was relatively short, which may explain the superficiality of the planning, this group finished the exercise before the time limit, considering they had nothing more to add. The remaining time was spent beautifying the presentation paper holder, by painting the tree trunk they had drawn.

The participants offered good ideas (Table 4) for developing Matela's cultural agenda. Still, for the planning of the agenda to be feasible, many decision-making processes that were not even considered would have to have been thought out and operationalized. For example, the involvement of volunteers appears to be easy but tricky, especially in Portugal, where associative rates are relatively low.

3.1.2. Group B

This group also consisted of nine young participants from the 10th grade, three from Language and Humanities and six from Science and Technology, four girls and five boys. As we may observe in Table 5, Group B envisioned three future ideas for Matela in 30 years. The first image/scenario of the future presents Matela as "a restored natural space" with many endemic species, plants and animals, greener and full of life; a second idea essentially highlights Matela as a cleaner space than it currently is: "a clean space"; finally, a third idealisation of Matela, sees it as an inhabited outdoor space, prepared to receive people who visit it, with wider trails for better accessibility, picnic areas and other facilities associated with a type of parks prepared to ensure the enjoyment of outdoor space

(e.g., lighting, parking space, souvenir shops). The future scenarios proposed by this group are heterogeneous regarding the investment put into their characterization since the idea of Matela as a clean space was not fully developed.

There is an apparent similarity between one of the visions of the future in the two groups, in this case, Matela as a restored natural space. Although the idea of Matela as a space dedicated to human enjoyment is also evident in both groups, Group A's choice to focus on animation, culture and tourism is more apparent than Group B's. On the other hand, the votes for the most desired future were very different, as eight votes from Group B chose the most natural scenario.

In the second task (Table 6), participants were asked to identify the logical chain of events to make the future feasible, the group opted to operationalize a vision that includes more natural life in Matela, outlining four steps from the future to the present. Focusing on intensifying the nature of Matela, participants linked their preferred future to necessary actions in a systematic and well-thought-out path. For instance, to boost natural life, we need not pollute and protect the space, but to do this, we first need to get to know and experience Matela. Organising visits to Matela, led by volunteers and nature guides, and promoting it in the media and schools are logical antecedents of this chain of events. In addition, this group's focus on individual responsibility for change is much more present than in the previous one.

To help them carry out the "planting" action, which received all nine votes, the group received an action planning form, although they chose not to follow it point by point. Attention to the task could have been more systematic, given the use of cell phones, jokes, and discussions about unrelated topics. One member stood out during the entire activity and was appointed leader and spokesperson of group B at the final presentation.

Focusing on the natural enrichment of Matela, the different measures proposed to be able to plant more trees were planned in some detail, seeking to consider the different decision-making inherent to the plantation, for example, collecting seeds/planting, paying workers, fundraising, etc. (Table 7). On the other hand, the increase in the green spot is not an end in itself, as it is also proposed to be a means of attracting endemic animals to enhance this natural area. Various human and material resources were considered in the planning, although agricultural equipment was not included. Possibly because they had yet to consider the planning guidance form, this group did not present any schedule of measures, parameters, or methods for evaluating the effectiveness of the planting.

The results from both Groups A and B focus almost exclusively on improving physical infrastructure, programming, and information to better disseminate information amongst locals and tourists. Similar points can be found in the use of the backcasting in the work of Groulx and colleagues [47], which focused on the question of accessibility of nature parks. After having conceived several futures for Matela with some ease, establishing the logical sequence of actions needed to make the desired future possible was a considerably more difficult. This difficulty may be due to a lack of experience with problem-solving processes. On the other hand, given that the groups only had 15 min to plan one of the measures they proposed, the level of detail in the planning could not have been much more sophisticated.

Despite this, a thorough analysis of the backcasting step of both Group A and B revealed some of the obstacles encountered by participants; this was visible in the way they had difficulty thinking through the list of actions they proposed to reach a desirable future, the solutions to the problems or gaps they detected as part of the exercise, the division of solutions and strategies when planning the intervention itself (e.g., identifying the different steps) and when planning ways to evaluate whether objectives would be achieved (e.g., planning the evaluation).

Analysing the symbolic mechanisms employed by participants and the results of both groups, it is important to cast light on the difficulties they experienced when activating forms of hypothetical thinking (e.g., visible in their chosen chains of steps leading to a desired future). In line with Amsel [48] who draws on earlier work by St B. T. Evans and polymath Nicholas Rescher: "Hypothetical thinking is defined as the ability to reason about

alternatives to the way the world is believed to be" (p. 87). Amsel contends that it "(. . .) is hard work, requiring the careful and conscious regulation of available beliefs, knowledge, and desires to reason about possibilities in an unbiased manner (p. 89, referencing the work of psychologists Deanna Kuhn and Jonathan St. B. T. Evans). The author highlights that we develop such competence during adolescence, making this stage of life and the contexts that support it, such as education, critical. More precisely, hypothetical reasoning can be hindered because of regulatory constraints with negative impacts on youths' ability to "understand reality in light of possibilities" (p. 98). We will pick up on this point later in the Discussion.

Hypothetical reasoning and critical thinking are deeply interlinked [49]. In fact, we also see challenges with critical thinking (e.g., their ability to consider alternatives) and their difficulty with creative thinking (e.g., visible in their capacity to invent solutions beyond the obvious). The identified challenges reflect a certain reductionism in problem-solving. Moreover, they also open a window of opportunity to work on the ESD competencies summarised in Table 1. Given that hypothetical, critical and creative thinking transverses many of the competencies detailed by Rieckman [6].

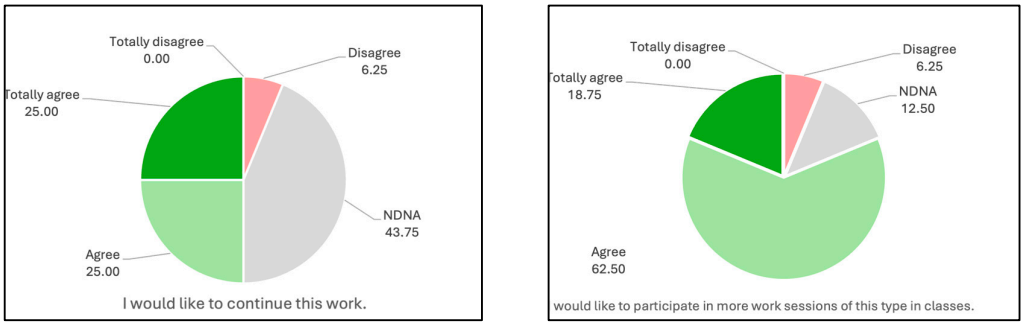
3.2. How Did Participants Engage with the Methodology?

In assessing participants' engagement with the three moments of the intervention, we relied on Questions 2 and 5 of the Questionnaire and the records generated by mediators (see Table 1 for further details). In the case of perceived engagement, we were particularly interested in understanding participants' willingness to continue the work and their willingness to use the backcasting method more often. As to observed engagement, we relied on records of the mediator's observations to determine the type of participation (in this case, the role) adopted by different team members in the various moments of the intervention. In observing team dynamics, we also sought to identify any potential leaders within the group. Finally, we inferred participants' level of engagement by drawing on the data collected from Question 2 of the Questionnaire, in this case, their ability to recall the theme they had worked on two weeks after the backcasting workshop.

3.2.1. Perceived Engagement

Participants assessed whether they would like to continue the work developed during the workshop and if they would like to use the backcasting method again by using a 5-point bipolar scale (1 = 'strongly disagree'; 5 = 'strongly agree').

While the graphs of Figure 4a,b can be read in isolation, the most compelling conclusions can be drawn from their comparison. For example, when comparing participants who would like to continue the work with those who would like to use the methodology more frequently—we can see that engagement with the method is higher than engagement with the topic. The weak adherence to Matela's environmental issues is quite evident since the position of most participants is within the subject's latitude of non-commitment (level 3 on a 5-point scale). The weak engagement on the topic is also reinforced by the fact that none of the participants decided to continue implementing the planned measures, even after the research team volunteered to guide them.



(**a**) (**b**)

Figure 4. (**a**) Pie chart showing participants' willingness to continue working with the theme (Matela forest 30 years from now) (N = 16). (**b**) Pie chart showing participants' willingness to use the backcasting method again (N = 16) (NDNA, neither disagree nor agree).

3.2.2. Inferred Engagement

We can infer engagement in the activity by looking at participants' ability to recall the theme they had worked on in the session four weeks prior (see Question 2 of the Questionnaire). It was exciting to note that all the members of Group A remembered their involvement in creating a cultural agenda for Matela. In contrast, none of the six members of Group B who responded to the post-backcasting Questionnaire remembered having been engaged in planning a strategy to increase Matela's natural life through planting trees.

3.3. How Did the Participants Experience the Backcasting Methodology?

3.3.1. Elements They Liked the Most

After reflecting on their satisfaction with the activity, we asked participants to share positive and negative aspects (Figures 5 and 6, respectively). The most frequently mentioned aspect they were satisfied with related to the characteristics of the backcasting itself, namely "active participation" (six times) and "cooperative group work" (five times), the possibility of thinking and sharing creative ideas" (mentioned three times). In this instance, their feedback reinforces the social learning dimension of backcasting first presented in the Introduction, bringing to light Quist and Vergragt's [29], which also emphasises backcasting and its relationship with learning.

They also appreciated the choice of the forest as the activity's focus, mentioned twice, as well as the freedom given to participants, such as choosing the theme, writing and drawing on large sheets of paper, reflecting on improvement actions for the forest or the environment, and considering environmental issues and the future. Singular mentions included the opportunity to present their work, the pleasant atmosphere, enjoyment of informing the research, eating chocolate, and the value placed on their ideas for change.

Among the aspects they liked most, this work methodology stands out. Its participatory nature, the autonomy and freedom it gives young people, and the cooperation in group work constitute the most prominent elements. However, the possibility of thinking and sharing creative ideas is also mentioned. Elements relating to the theme of the activity appear in second place. The fact it is an unresolved problem for which concrete solutions are sought, the implementation of which could have practical impacts on reality, constitutes a valued aspect. One area that was less mentioned in the evaluation is the knowledge of the concrete context of the intervention. This aspect, while not as prominent, presents an opportunity for growth and improvement in the methodology.

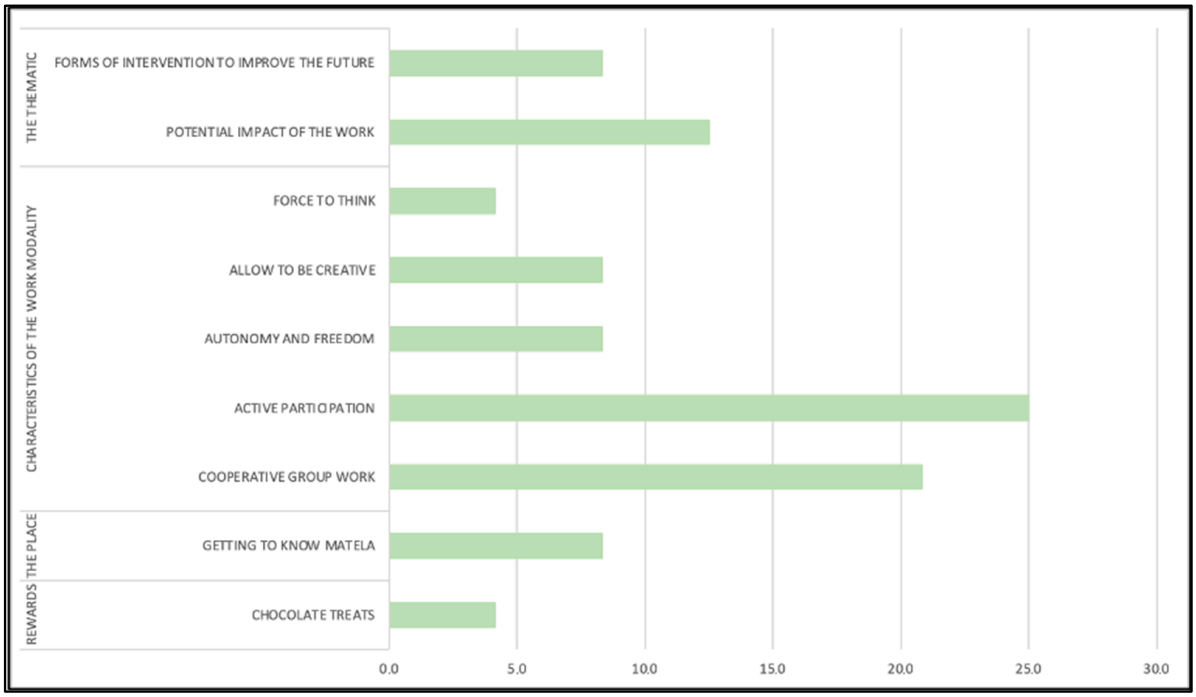


Figure 5. Activity elements participants liked the most (N = 24; %).

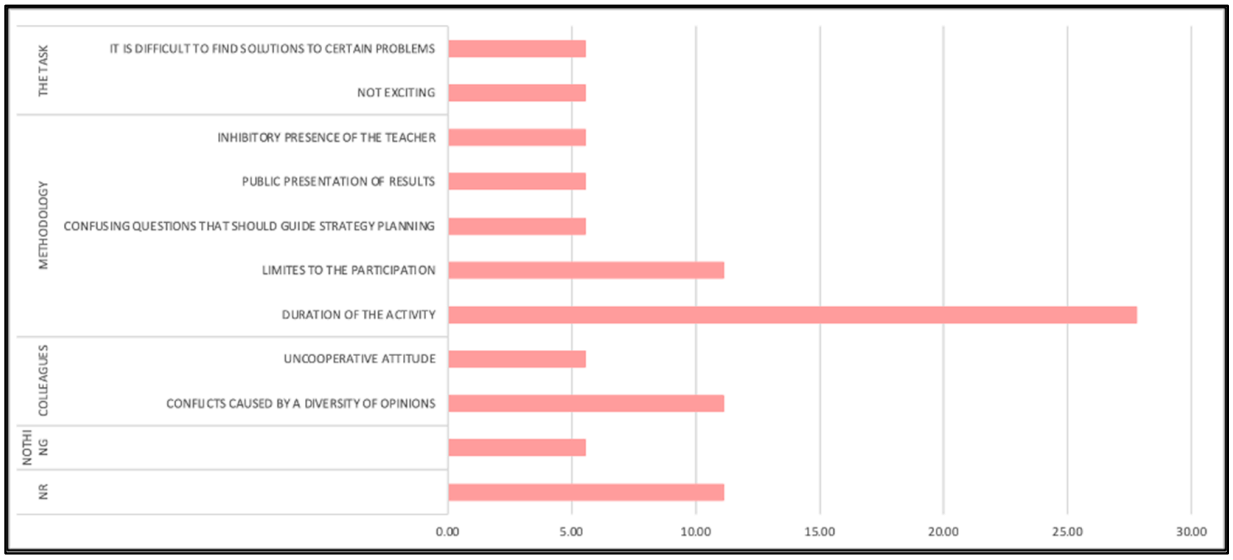


Figure 6. Activity elements participants liked the least (N = 18; %) (NR, no response; NG, nothing).

3.3.2. Elements They Liked the Least

The duration of the exercise was the most criticized aspect, considering that more time would be needed to carry out the various tasks that this activity involved (Figure 6). Other aspects mentioned, although less frequently, were related to the difficulty of dealing with disagreement or lack of cooperation within the group and finding solutions. Three teenagers did not mention any negative aspects.

3.3.3. Perceived Ease of Required Tasks

In observing Figure 7, we note that, for the most part, participants saw the tasks assigned to them as relatively easy. However, item 3, "thinking about solutions to solve the problems/gaps detected", is perceived as the most challenging task, possibly because it involves divergent thinking in search of unknown solutions. For half of the participants,

imagining the future (item 1) and planning the intervention (item 4) was more challenging than backwards listing the actions necessary to achieve a desirable future. It was surprising that 70% of young people considered it easy to plan ways to evaluate the effectiveness of the proposed solutions since none of the two groups planned ways to assess their proposed intervention (item 5).

On first reading, we can interpret 'ease' as a positive attribute of the backcasting technique. However, such superficial examination overlooks some of the difficulties experienced by our participants when challenging their first ideas (or arguments), visible in the lack of complexity and capacity to imagine varied scenarios during the backcasting step identified in Section 3.1.

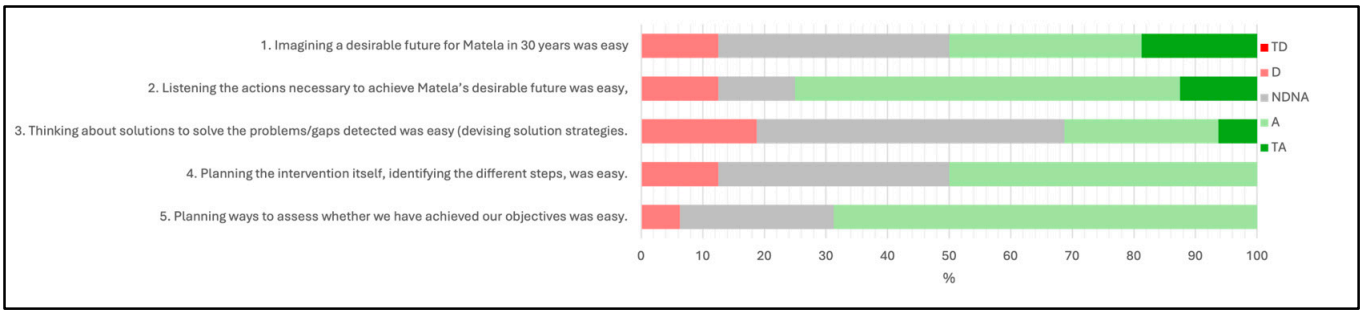


Figure 7. Perceived ease of each task involved in this activity. (D, disagree, NDNA, neither disagree nor agree; A, agree; TA, totally agree).

The perceived ease of the exercise also indicates participants' need for more awareness of the complexity which underpins sustainability issues. It is, however, essential to recognise that sustainability issues are highly complex given the reciprocity between their different ecological, social and economic aspects [50]. Such complexity poses challenges to young participants. Nonetheless, bringing complexity to the forefront is essential to ensure that backcasting can be used to promote the systems thinking competence, highlighted in Table 1. For youths to be able to "analyse complex systems, "perceive how systems are embedded within different domains and different scales", "deal with uncertainty, recognise and understand relationships, "analyse complex systems", "perceive how systems are embedded within different domains and different scales" and "deal with uncertainty" [6] (p. 44) they must rely on dynamic and interactive learning process given that the steps taken from the initial state to the end state, including potential obstacles, are often impossible to know in advance; moreover, purely analytical solutions are not viable [50]. The challenge of interlinking the future and present during the backcasting step provides an opportunity to bring the above-described systems thinking approach to learning [8].

3.3.4. Adequacy of the Duration of the Activity

After evaluating the backcasting exercise, participants were asked about the duration of the group work. Figure 8 shows that most participants found the duration adequate, even though a fifth felt they would have needed more time, as was already mentioned among the least favourite aspects. Therefore, in planning future activities, timing should be carefully considered. Ideally, a whole afternoon/morning should be secured, or even a full trimester, allowing the groups to fulfil their planning.

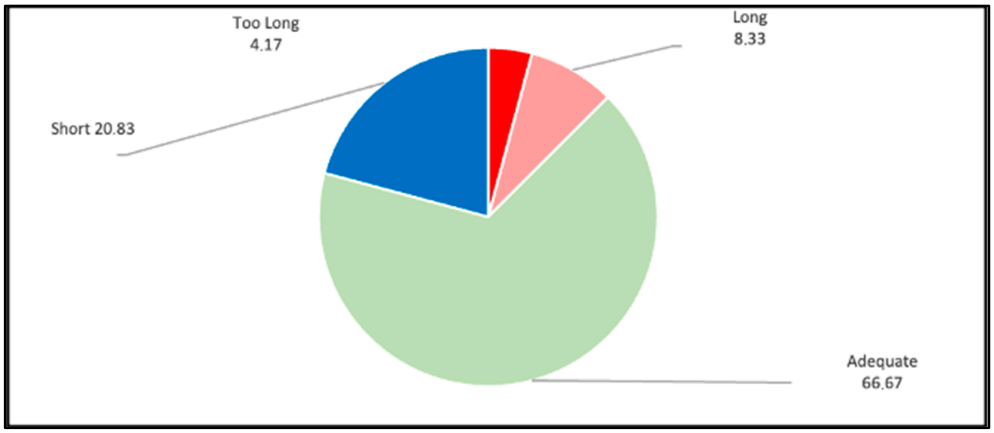


Figure 8. Perceived adequacy of activity duration (N = 24).

3.3.5. Perceived Educational Aims/Purpose

Asked about what they thought was the purpose of this group work, participants presented several different points of view (Figure 9), focusing on Matela forest (12 mentions), nature (6 mentions), young people (3 mentions), and the planet Earth (1 mention). The most popular, mentioned six times, corresponds to the idea that the objective of the work was to understand what young people thought could be done to improve their local natural context. Two other ideas regarding Matela forest were less popular, stating that the purpose of this work would be to understand what young people know about Matela, and how to add value to that forest for the future.

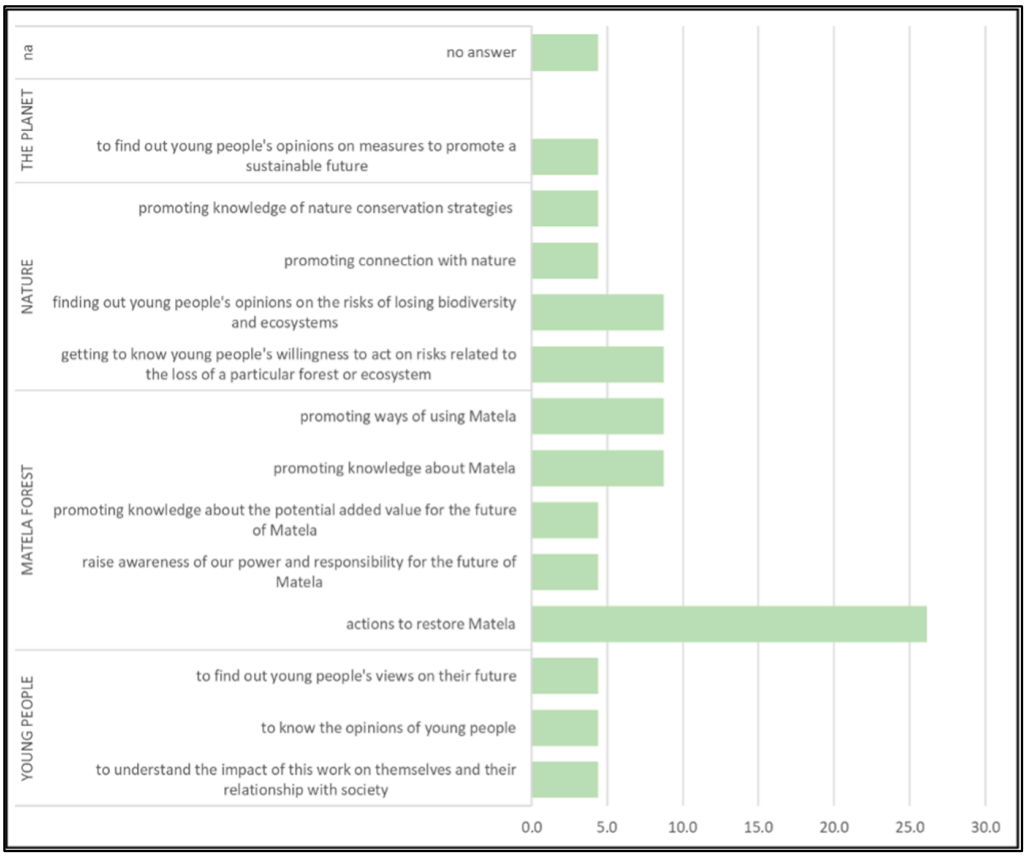


Figure 9. Perceived educational aims of the activity (N = 24).

4. Discussion

In the Introduction, we hypothesised that within an educational context, backcasting could support "innovative pedagogies" within ESD [7] that favour discovery learning, participatory/collaborative learning, problem-based learning, interdisciplinary learning, multi-stakeholder social learning, critical thinking-based learning, and systems thinking [8]. In the Section 2, we presented backcasting as a type of retrospective planning; however, when testing our intervention, it became clear that it is more than that: it is an approach that combines the creativity of imagining desired futures with the practical work of building viable paths to achieving them. The results obtained so far are modest; however, they point toward a view of the backcasting method as a way of promoting some of the competencies highlighted by Rieckmann [6] (pp. 44–45), which we detailed in Table 1. Backcasting has the potential to support students in the development of their ability to:

- "recognize and understand relationships, to analyse complex systems" (systems thinking competency);
- "understand and evaluate multiple futures—possible, probable and desirable" (anticipatory competence);
- "understand and reflect on the norms and values that underlie one's actions" (normative competency);
- "the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield" (strategic competency);
- "learn from others; understand and respect the needs, perspectives and actions of others (empathy) (collaborative competency);
- "question norms, practices and opinions" and "one's values, perceptions and actions (critical thinking competency).

Later, in the Results, we demonstrated participants' positive feedback regarding cooperative work, thinking and sharing creative ideas, the connection to place (in this case a local forest), the freedom to choose a theme, the possibility of writing and drawing on paper, reflection, presentation of the work, the atmosphere of the work, the opportunity to assist the research project, and the importance of the participants' ideas for change.

The above points highlighted by participants hint at the qualities of the backcasting method and its potential to support "innovative pedagogies" within ESD. In addition, we see innovative attributes to the context of our work given the lack of knowledge of the method among teachers and students, the fact that teachers and students expressed appreciation for the opportunity to work in this way and wanted more; the school where we carried out the intervention asked for more sessions using backcasting, and finally, the gaps and difficulties observed reveal the need for this type of process for the development of critical thinking skills.

Drawing on the lessons learned and with the view of furthering our hypothesis, we highlight three steps that can help support the introduction of backcasting in educational settings: (1) balancing the role of the moderator with those of the participants, (2) incorporating exercises via games, fiction and scenarios, and (3) promoting self-regulation in educational contexts. Our proposal responds to the view of ESD as a "holistic and transformational education" process that encompasses not only "learning content" but also "pedagogy and environment" [6] (p. 40).

4.1. Balance the Role of the Moderator with Those of Participants

Our results beg us to consider whether, in the context of youth's education, the development of ESD competencies must be guided by a moderator (e.g., a teacher) who can help students think through the backcasting exercise using a hypothetical and critical thinking processes. In line with the work of Kerkhof and Wieczorek [23] (p. 741), we propose that moderators, or those facilitating backcasting activities amongst youths, should focus on the following six steps:

1. "selection of a vision that is taken as the starting point for the analysis";

2. "definition of milestones and interim objectives that need to be achieved along the way to realise the selected vision";
3. "discussion on the main changes that need to take place in the different domains to achieve interim goals; in this step, the participants indicate the obstacles to be overcome and the opportunities to be taken to realise these changes";
4. "identification of the main actors involved in the transition process and their roles";
5. "discussion on policy instruments and institutions that are needed to bring about the transition";
6. "identification of short-term actions (next 5 to 10 years)".

Note that we exclude step seven, proposed by the authors [23], given the complexity of the "integration and comparison of various pathways and identification of a robust strategy in the given conditions". This would call for an integrated approach, discussing only part of the issues when operationalizing the backcasting actions. It would be interesting to call different teachers, such as philosophy and language teachers, to advise and nurture these thoughts.

Further connecting to the work of Amsel [48], we suggest that moderators guide the process using the design methodology detailed in the Introduction with a particular focus on Discovery, Definition, and Development stages [32]. As detailed by Brown and Wyatt [33], this should be understood as a highly iterative process, whereby inspiration, ideation and implementation sometimes overlap instead of evolving sequentially. We propose that the Definition and Development stages benefit from extensive cross-class presentation to troubleshoot with peers how a given problem and respective answers are defined to promote collaborative and critical thinking competencies. As to the Discovery stage we propose involving external stakeholders with knowledge of a given theme.

While it was difficult to envision the Implementation stage with our participants given the duration and context of our study, we suggest that participants' struggle to evaluate their process can be tackled with more guidance on behalf of moderators when helping participants better understand what type of evidence they might need to assess whether their plan is potentially successful. Despite their perceived ease concerning this point, the difficulty in self-assessment can be particularly crucial for those who would like to consider the Implementation stage of the design thinking process. Here, students need clear guidance on how to propose and evaluate their implementation strategies, underscoring the importance of this skill in the learning process. Namely, we believe that developing evaluatory capacities is related to the Anticipatory Competence identified in Table 1, namely, the ability to "create one's visions for the future and assess the consequences of actions"[6].

The role of a moderator (e.g., teacher) could be crucial in helping students problematise each step of the backcasting exercise and by discussing ideas with students using the ESD competencies [6] as a guideline. While some participants highlighted the teacher's presence during the exercise as an obstacle, we contend that the teacher who takes on the role of facilitator is likely to meet less resistance. The teacher as facilitator is only one of many possible teaching approaches—see, for example the work of Grasha [51] (p. 143); nonetheless, the capacity to facilitate is more likely to lead to the successful steering of "students by asking questions, exploring options, suggesting alternatives, and encouraging them to develop criteria to make informed choices". The teacher as facilitator also starkly contrasts with a standard view of the teacher as evaluator as often perceived by students. While both roles have long been considered necessary [52], the teacher as facilitator is crucial for developing transversal competencies such as those identified in the Introduction.

4.2. Incorporate Games, Fiction, and Scenarios

The challenges posed by hypothetical and critical thinking encountered by participants were due to their inexperience with the backcasting method and the lack of educational experiences promoting such skills. In this sub-section, we propose countering some of these challenges by introducing strategies identified in the literature, such as games, fiction, and scenarios. For example, albeit with adult participants, Andreotti and colleagues [53]

incorporated games within participatory backcasting to engage participants. Given youths' general interest in gaming, it could provide an exciting format. As suggested by the authors, a simple board game can be adapted to examine local conditions, allowing participants to explore the impact of different choices within the backcasting step [53] (p. 4); on a similar note, Ishihara and Valls [3] (p. 337), integrated historical fiction writing as a way to encourage college students to explore "pathways of reaching future visions" during the backcasting step. Moreover, games and fictional writing can boost some of the competencies highlighted in the Introduction.

While participants worked with the concept of desired future states that define the backcasting method, combining participatory backcasting with greater attention to analysing distinct future scenarios could also yield exciting results. A technique derived from future studies, scenario analysis, could offer novel ways for youths to learn from and critically discuss possible future outcomes of current eco-social challenges such as forest conservation and management. Workshop coordinators should lay out scenarios for youths to engage with the complex interaction amongst material or technological, social, and cultural factors directly implicated in such challenges and the obstacles that keep societies from resolving them.

Writing from the perspective of Future Studies, Börjeson and colleagues [54] categorise scenarios along the three following questions: "What will happen?", "What can happen?" and "How can a specific target be reached?". These three questions align with three corresponding scenarios: the predictive, the explorative, and the normative, which includes the backcasting approach. Predictive scenarios are best understood under the umbrella of forecasting and portray the most likely thing to happen given the current circumstances. The authors divide explorative scenarios into external and strategic ones. External ones depend on the evolution of external factors, and strategic scenarios rely on the specific actions of certain actors. Finally, they arrive at Normative scenarios, divided into preserving and transforming scenarios, preserving in the sense that in imagining transformation, participants consider existing structures and transformative (such as backcasting), whereby participants need to consider significant changes to existing systems. For example, de Bruin and colleagues [55] combine participatory backcasting and exploratory scenarios. According to the authors, this combination facilitates the exploration of future scenarios while helping participants focus on short-term actions needed to achieve future goals.

We believe that exposing youths to different types of scenarios (predictive, explorative, and normative) will help them better understand the purpose of backcasting while at the same time promoting modes of discovery learning, problem-based learning, and systems thinking.

4.3. Promote Self-Regulation in Educational Contexts

Beyond the practical suggestions highlighted in Sections 4.1 and 4.2, we believe that our case study, whilst deserving further exploration and retesting, bears theoretical implications, particularly when juxtaposed with the theme of self-regulated learning within the context of education for sustainable development—see, for example, the early work of Martens [56]. Reconnecting to the work of Wals [5], if education for sustainable development prioritises capacity building and critical thinking, then self-regulation is the pillar. Zimmerman [57] describes self-regulation as a learner's capacity to control the learning processes affecting them. Furthermore, the author details how self-regulation encompasses metacognition and motivational and behavioural components that learners activate to gain knowledge and skills (e.g., setting goals, planning, employing learning strategies, self-reinforcement, self-recording, and self-instruction).

The development of self-regulated learning requires teachers to invite students to participate in their learning process; only then will they be motivated to use self-regulatory processes such as "self-observation, self-judgement, and self-reactions" [57]. In addition, Zimmerman asserts that promoting self-regulation is only possible in classrooms where students have control over the "goals, methods, and outcomes of learning", which encourages

responsibility for their educational outcomes in the long run. In self-regulated learning, the teacher must abandon the conventional role of the one who imparts information to one that facilitates knowledge acquisition and the mastering of students' learning processes [58]. On this point, we recall the work of Peterson et al. [7] and the guidelines provided by UNESCO [8], presented in the Introduction. Education for sustainable development is best performed under the guidance of novel pedagogies that foster exploration, collaborative, problem-based, multidisciplinary, multi-stakeholder, critical thinking, and systems thinking-based learning.

If, on the one hand, self-regulation-promoting environments are key to nurturing hypothetical and critical thinking—which is essential for a successful application of the backcasting technique—on the other hand, the technique's qualities make it a viable tool for promoting hypothetical thought processes and down the line self-regulation-promoting environments. While self-regulated learning might appear, first-hand, as a highly individual journey, the literature [59] shows us that self-regulation and peer-to-peer learning are interlinked. This quality could play a crucial ingredient given that the backcasting technique is suited for individual or group work [60], a feature that can also be seen in the data we have collected through our case study and in the sustainability education literature, which emphasises mutual learning and cooperation in solving today's sustainability crisis [61].

5. Conclusions

Given that the ability to think critically about our planet's future and devise alternative modes of living has become essential when attempting to resolve the current eco-social crisis, we emphasize hypothetical and critical reasoning as crucial intellectual qualities that deserve a special place in the context of ESD in secondary education. Our case study has practical implications, given that backcasting is particularly suited for this task, both as an exercise that helps students practise alternative modes of thinking and as a diagnostic tool for teachers to assess students' thought patterns. However, in doing so, teachers need to operate within a curriculum that values transversal skills such as the ones visible in ESD competencies [6].

To conclude our contribution, we point toward future research that should consider incorporating the voices of teachers and students in how to integrate the technique within the existing curricula. In addition, and given that our contribution does not reflect the differences between the two study programs (Science and Technology course versus Languages and Humanities) since students were spread across two groups, we consider it to be necessary to test the method in different areas of the curriculum and schools with distinct pedagogical approaches; this would allow for a more nuanced understanding of how to implement participatory backcasting in educational contexts successfully and to enhance its positive impact on youths' ESD competencies.

Finally, the insights gained from this article must consider the modest sample size. As stated in the Section 3, we have employed a qualitative descriptive-interpretative approach, meaning the study is more intensive than extensive, and therefore the sample is smaller. The aim is not to generalize the results but to show that they can serve as hypotheses for future studies. Nonetheless, testing the method with larger sample sizes would be necessary.

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Appendix A

Backcasting protocol used in the intervention.

Steps	Tasks	Length (min)	Organization
Focus on a desired future.	You recently visited Matela. Now, think about how you want the forest to be in 30 years [1]. If it is difficult to trigger dialogue, you can use the following questions: – What do you see? – What do you hear? – What does it smell like? – What do you feel?	10–15	Work with the extended group.
Focus on previous steps.	For each of step list the previous ones by asking: What needs to happen for this (goal X) to be possible? And so on . . .	15–20	**Divide into smaller groups**. 1. Prepare a table with each future vision (max. 2) written on the top of a large sheet of paper. 2. Each group sits in a "U" shape with a facilitator at the base. 3. Participants vote.
	Place responses organized chronologically, from those closest to the goal to the most remote, so there is a retrospective chain, in which the last ones must be closer to the present moment.		Each group is at a table.
	With the help of group members, the moderator summarizes the chain of actions necessary to achieve the desired future		Work with the extended group.

Steps	Tasks	Length (min)	Organization
Break		3–5	
Focus on youth involvement in conservation [1].	From these actions, what do all of us, including you, can or should start doing to ensure that Matela in the future is as you wish? (so that this happens)	15	Mark the actions mentioned in green (or another suitable colour) on the sheet of paper.
	Where would you like to start?		Vote from the flagged actions using adhesive tags for marking.
	After determining the prioritized action, let's get to work! It's important that participants take responsibility for this task. They should prepare this task independently at their respective tables, engaging fully in the process. However, the moderator's assistance is crucial in transitioning to the chosen action, the co-specific intent, and the form of the intervention measure. Distribute the sheets according to each type of measure.	20	**Smaller Groups** Replace sheets with new ones, with the name of the action they prioritized at the top.
Focus on giving meaning to the actions carried out.	You have been imagining the future you desire. Now, take action. . . if you want! No one can stop you.	3	**Extended Group**
Focus on reflection of activities.	We would love to know what you thought of this work. Give us your opinions use the following link www.florestamatela.com [1] Here you have information, photographs and audios bout some species of the Azores [1].	2	**Extended Group**
Closure	Thank you!		

[1] Adapt to project specific themes and available resources.

Appendix B

Conceptual model comprising constructs, dimensions, sub-dimensions, indicators and sources used in the assessment of the intervention. Note: The acronym QNR stands for Questionnaire.

Constructs	Dimension	Sub-Dimension	Indicators	Source
Evaluation of the Productions	Desired futures	Investment	Number of desired futures	Observation of the written records and notes taken during work process
			Richness of their characterization	
		Direction of the evolution		
	Antecedents for producing the future	Assumed level of complexity	Number of steps anticipated between the desired future and the current situation, as directly proportional to the degree of complexity of the chain of inferences	
		Quality of the action plan	Degree of congruence between the future and successive antecedents	
			Relevance of the proposals to solve the problems	
			Feasibility of the proposals	
			Perceived ease of change	
			Completeness of the planning	
Representations of the Methodology	Attractiveness of the activ-ity/methodology	[Participants perspectives]	Degree of satisfaction with the activity	QNR: Q1
			Elements they liked the most	QNR: Q1.1a
			Elements they liked the least	QNR: Q1.1b
			Comments about the intervention focusing this activity	QNR post-interven-tion: Q11
		[Mediators perspectives]	Observed challenges, obstacles and/or limitations	Records of mediators' observa-tions
	Working process	Adequacy of the duration of the activity		QNR: Q4
		Perceived ease of required tasks	Imagining desirable futures	QNR: Q3.1
			Identifying needs	QNR: Q3.2
			Designing resolution strategies	QNR: Q3.3
			Planning interventions	QNR: Q3.4
			Planning and evaluating the effectiveness of measures	QNR: Q3.5
	Understanding educational aims			QNR: Q6

Constructs	Dimension	Sub-Dimension	Indicators	Source
Activity Engagement	Perceived engagement	Interest in the problem	Willingness to continue this work	QNR: Q5
		Interest in the methodology	Willingness to use this method more often	QNR: Q5
	Observed engagement		Type of participation (role) of different elements in the tasks	Records of mediators' observa-tions
			Emerging leaderships	
	Inferred engagement		Recall of the theme worked in the session after 2 weeks	QNR: Q2

References

1. Baierl, T.M.; Kaiser, F.G.; Bogner, F.X. The supportive role of environmental attitude for learning about environmental issues. *J. Environ. Psychol.* **2022**, *81*, 101799. [CrossRef]
2. Jeronen, E.; Palmberg, I.; Yli-Panula, E. Teaching Methods in Biology Education and Sustainability Education Including Outdoor Education for Promoting Sustainability—A Literature Review. *Educ. Sci.* **2017**, *7*, 1. [CrossRef]
3. Ishihara, S.; Valls, A.M. Back from the Future We Want: Backcasting as a pedagogical practice towards sustainable futures. In *Envisioning Futures for Environmental and Sustainability Education*; Brill | Wageningen Academic: Wageningen, The Netherlands, 2017; pp. 333–344. [CrossRef]
4. Wals, A.E.J. Learning Our Way Out of Unsustainability: The Role of Environmental Education. In *The Oxford Handbook of Environmental and Conservation Psychology*; Oxford University Press: Oxford, UK, 2012. [CrossRef]
5. Wals, A.E.J. Learning Our Way to Sustainability. *J. Educ. Sustain. Dev.* **2011**, *5*, 177–186. [CrossRef]
6. Rieckmann, M. Learning to transform the world: Key competencies in education for sustainable development. In *Issues and trends in Education for Sustainable Development*; UNESCO: Paris, France, 2018. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000261802 (accessed on 16 December 2024).
7. Peterson, A.; Dumont, H.; Lafuente, M.; Law, N. *Understanding Innovative Pedagogies*; OECD Publishing: Paris, France, 2018. [CrossRef]
8. UNESCO. Shaping the Education of Tomorrow: 2012 Report on the UN Decade of Education for Sustainable Development, Abridged. 2012. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000216606?posInSet=2&queryId=dc202864-bded-41bb-9208-ce4080ca5759 (accessed on 16 December 2024).
9. Warburton, K. Deep learning and education for sustainability. *Int. J. Sustain. High. Educ.* **2003**, *4*, 44–56. [CrossRef]
10. Jeronen, E.; Ahonen, P.; Korkeamäki, R.-L. Connections of Transformative Education with Bhutan's Pedagogical Ideas for Promoting Sustainability Education. *Sustainability* **2022**, *14*, 163. [CrossRef]
11. Georgallis, P.; Bruijn, K. Sustainability teaching using case-based debates. *J. Int. Educ. Bus.* **2022**, *15*, 147–163. [CrossRef]
12. Riess, W.; Martin, M.; Mischo, C.; Kotthoff, H.-G.; Waltner, E.-M. How Can Education for Sustainable Development (ESD) Be Effectively Implemented in Teaching and Learning? An Analysis of Educational Science Recommendations of Methods and Procedures to Promote ESD Goals. *Sustainability* **2022**, *14*, 3708. [CrossRef]
13. Yoon, T.K.; Kim, S.; Takano, T.; Yun, S.-J.; Son, Y. Contributing to Sustainability Education of East Asian University Students through a Field Trip Experience: A Social-Ecological Perspective. *Sustainability* **2016**, *8*, 1067. [CrossRef]
14. Lahmidi, M. Field trips and Education for sustainable development. A proposal for youth participation using digital storytelling. *Edmetic* **2021**, *10*, 184–201. [CrossRef]
15. Hill, A. The Place of Experience and the Experience of Place: Intersections Between Sustainability Education and Outdoor Learning. *Aust. J. Environ. Educ.* **2013**, *29*, 18–32. [CrossRef]
16. Kishita, Y.; Höjer, M.; Quist, J. Consolidating backcasting: A design framework towards a users' guide. *Technol. Forecast. Soc. Change* **2024**, *202*, 123285. [CrossRef]
17. Poli, R. A note on the classification of future-related methods. *Eur. J. Futures Res.* **2018**, *6*, 15. [CrossRef]
18. Quist, J. *Backcasting for a Sustainable Future the Impact After 10 Years*; Eburon Academic Publishers: Utrecht, The Netherlands, 2007.
19. Robinson, J.; Burch, S.; Talwar, S.; O'Shea, M.; Walsh, M. Envisioning sustainability: Recent progress in the use of participatory backcasting approaches for sustainability research. *Technol. Forecast. Soc. Change* **2011**, *78*, 756–768. [CrossRef]
20. Brown, V.A.; Russell, J.Y.; Harris, J.A. *Tackling Wicked Problems Through the Transdisciplinary Imagination*; Earthscan: London, UK, 2010.
21. Bibri, S.E. A methodological framework for futures studies: Integrating normative backcasting approaches and descriptive case study design for strategic data-driven smart sustainable city planning. *Energy Inform.* **2020**, *3*, 31. [CrossRef]

22. Timilsina, R.R.; Nakagawa, Y.; Kotani, K. Exploring the Possibility of Linking and Incorporating Future Design in Backcasting and Scenario Planning. *Sustainability* **2020**, *12*, 9907. [CrossRef]
23. van de Kerkhof, M.; Wieczorek, A. Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations. *Technol. Forecast. Soc. Change* **2005**, *72*, 733–747. [CrossRef]
24. Irwin, T. The Emerging Transition Design Approach. In *Design as a Catalyst for Change*; Design Research Society: Limerick, Ireland, 2018. [CrossRef]
25. Kishita, Y. Backcasting for Envisioning Sustainable Futures Across Multiple Generations. In *Future Design: Incorporating Preferences of Future Generations for Sustainability*; Saijo, T., Ed.; Springer: Singapore, 2020; pp. 49–68. [CrossRef]
26. Uwasu, M. Future Generations Correcting Markets and Democracy—Research Needs in Future Design. In *Future Design: Incorporating Preferences of Future Generations for Sustainability*; Saijo, T., Ed.; Springer: Singapore, 2020; pp. 37–48. [CrossRef]
27. Timilsina, R.R.; Shahrier, S.; Kotani, K. Capitalism and Sustainability Dilemmas. In *Future Design: Incorporating Preferences of Future Generations for Sustainability*; Saijo, T., Ed.; Springer: Singapore, 2020; pp. 151–167. [CrossRef]
28. Saijo,T. *Future Design Incorporating Preferences of Future Generations for Sustainability*, 1st ed.; in Economics, Law, and Institutions in Asia Pacific; Springer: Singapore, 2020.
29. Quist, J.; Vergragt, P. Past and future of backcasting: The shift to stakeholder participation and a proposal for a methodological framework. *Futures* **2006**, *38*, 1027–1045. [CrossRef]
30. Koh, J.H.L.; Chai, C.S.; Wong, B.; Hong, H.-Y. *Design Thinking for Education: Conceptions and Applications in Teaching and Learning*, 2015th ed.; Springer: Singapore, 2015. [CrossRef]
31. Cross, N. *Design Thinking Understanding How Designers Think and Work*; Berg: Oxford, UK, 2011.
32. British Design Council. Framework for Innovation. The British Design Council Website. Available online: https://www.designcouncil.org.uk/our-resources/framework-for-innovation/ (accessed on 17 July 2024).
33. Brown, T.; Wyatt, J. Design Thinking for Social Innovation. *Stanf. Soc. Innov. Rev.* **2009**, *8*, 31–35. [CrossRef]
34. Waidelich, L.; Richter, A.; Kölmel, B.; Bulander, R. Design Thinking Process Model Review. In Proceedings of the 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), Stuttgart, Germany, 17–20 June 2018; pp. 1–9. [CrossRef]
35. Myers, N.; Mittermeier, R.A.; da Fonseca, G.A.B.; Kent, J.; Mittermeier, C.G. Biodiversity hotspots for conservation priorities. *Nature* **2000**, *403*, 853–858. [CrossRef]
36. Borges, P.A.; Costa, A.; Cunha, R.; Gabriel, R.; Gonçalves, V.; Martins, A.F.; Melo, I.; Parente, M.; Raposeiro, P.; Rodrigues, P.; et al. Description of the terrestrial and marine Azorean biodiversity. In *A List of the Terrestrial and Marine Biota from the Azores*; Princípia Editora: Cascais, Portugal, 2010; pp. 9–33.
37. Gabriel, R.; Coelho, M.; Henriques, D.; Borges, P.; Elias, R.; Kluge, J.; Ah-Peng, C. Long-term monitoring across elevational gradients to assess ecological hypothesis: A description of standardized sampling methods in oceanic islands and first results. *Arquipel.-Life Mar. Sci.* **2014**, *31*, 45–67.
38. Gaspar, C.; Gaston, K.J.; Borges, P.A.V.; Cardoso, P. Selection of priority areas for arthropod conservation in the Azores archipelago. *J. Insect Conserv.* **2011**, *15*, 671–684. [CrossRef]
39. Patiño, J.; Mateo, R.G.; Zanatta, F.; Marquet, A.; Aranda, S.C.; Borges, P.A.V.; Dirkse, G.; Gabriel, R.; Gonzalez-Mancebo, J.M.; Guisan, A.; et al. Climate threat on the Macaronesian endemic bryophyte flora. *Sci. Rep.* **2016**, *6*, 29156. [CrossRef] [PubMed]
40. Ferreira, M.T.; Cardoso, P.; Borges, P.A.V.; Gabriel, R.; de Azevedo, E.B.; Reis, F.; Araújo, M.B.; Elias, R.B. Effects of climate change on the distribution of indigenous species in oceanic islands (Azores). *Clim. Change* **2016**, *138*, 603–615.
41. Borges, P.A.V.; Santos, A.M.C.; Elias, R.B.; Gabriel, R. The Azores Archipelago: Biodiversity Erosion and Conservation Biogeography. In *Encyclopedia of the World's Biomes*; Goldstein, M.I., DellaSala, D.A., Eds., Elsevier: Oxford, UK, 2020; pp. 101–113. [CrossRef]
42. Borges, P.A.V.; Lamelas-Lopez, L.; Amorim, I.R.; Danielczak, A.; Boieiro, M.; Rego, C.; Wallon, S.; Nunes, R.; Cardoso, P.; Hochkirch, A. Species conservation profiles of cave-dwelling arthropods from Azores, Portugal. *Biodivers. Data J.* **2019**, *7*, e32530. [CrossRef]
43. Norder, S.J.; de Lima, R.F.; de Nascimento, L.; Lim, J.Y.; Fernández-Palacios, J.M.; Romeiras, M.M.; Elias, R.B.; Cabezas, F.J.; Catarino, L.; Ceríaco, L.M.P.; et al. Global change in microcosms: Environmental and societal predictors of land cover change on the Atlantic Ocean Islands. *Anthropocene* **2020**, *30*, 100242. [CrossRef]
44. Sousa, M.A.; Lamelas-López, L.; Elias, R.B.; Gabriel, R.; Borges, P.A.V. A multitaxa approach to biodiversity inventory in Matela protected area (Terceira, Azores, Portugal). *Biodivers. Data J.* **2024**, *12*, e121884. [CrossRef]
45. Azorean Regional Secretariat for the Environment and Climate Action. Matela: Protected Area for the Management of Habitats or Species. Available online: https://parquesnaturais.azores.gov.pt/en/parques/8/areasprotegidas/92 (accessed on 19 October 2024).
46. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
47. Groulx, M.; Lemieux, C.; Freeman, S.; Cameron, J.; Wright, P.A.; Healy, T. Participatory planning for the future of accessible nature. *Local Environ.* **2021**, *26*, 808–824. [CrossRef]
48. Amsel, E. Hypothetical Thinking in Adolescence: Its Nature, Development, and Applications. In *Adolescent Vulnerabilities and Opportunities: Developmental and Constructivist Perspectives*; Amsel, E., Smetana, J., Eds.; Interdisciplinary Approaches to Knowledge and Development; Cambridge University Press: Cambridge, UK, 2011; pp. 86–114. [CrossRef]

49. Stanovich, K.E.; Stanovich, P.J. A Framework for Critical Thinking, Rational Thinking, and Intelligence. In *Innovations in Educational Psychology: Perspectives on Learning, Teaching, and Human Development*; Springer: New York, NY, USA, 2010; pp. 195–235.
50. Steiner, G.; Posch, A. Higher education for sustainability by means of transdisciplinary case studies: An innovative approach for solving complex, real-world problems. *J. Clean. Prod.* **2006**, *14*, 877–890. [CrossRef]
51. Grasha, A.F. A Matter of Style: The Teacher as Expert, Formal Authority, Personal Model, Facilitator, and Delegator. *Coll. Teach.* **1994**, *42*, 142–149. [CrossRef]
52. Bolding, J.T. Evaluator or facilitator. *J. Thought* **1978**, *13*, 250–253.
53. Andreotti, F.; Speelman, E.N.; Van den Meersche, K.; Allinne, C. Combining participatory games and backcasting to support collective scenario evaluation: An action research approach for sustainable agroforestry landscape management. *Sustain. Sci.* **2020**, *15*, 1383–1399. [CrossRef]
54. Börjeson, L.; Höjer, M.; Dreborg, K.-H.; Ekvall, T.; Finnveden, G. Scenario types and techniques: Towards a user's guide. *Futures* **2006**, *38*, 723–739. [CrossRef]
55. de Bruin, J.O.; Kok, K.; Hoogstra-Klein, M.A. Exploring the potential of combining participative backcasting and exploratory scenarios for robust strategies: Insights from the Dutch forest sector. *For. Policy Econ.* **2017**, *85*, 269–282. [CrossRef]
56. Martens, H. *Decision-Making Strategies and Self-Regulated Learning: Fostering Decision-Making Competence in Education for Sustainable Development*; Georg-August-Universität Göttingen: Göttingen, Germany, 2012. Available online: https://ediss.uni-goettingen.de/handle/11858/00-1735-0000-0006-AE41-0?locale-attribute=en (accessed on 7 March 2024).
57. Zimmerman, B.J. Self-regulated Learning. In *International Encyclopedia of the Social & Behavioral Sciences*; Smelser, N.J., Baltes, P.B., Eds.; Pergamon: Oxford, UK, 2001; pp. 13855–13859. [CrossRef]
58. Karlen, Y.; Bäuerlein, K.; Brunner, S. Teachers' assessment of self-regulated learning: Linking professional competences, assessment practices, and judgment accuracy. *Soc. Psychol. Educ.* **2024**, *27*, 461–491. [CrossRef]
59. Bozzkurt, F. Teacher candidates' views on self and peer assessment as a tool for student development. *Aust. J. Teach. Educ.* **2020**, *45*, 47–60. [CrossRef]
60. Bibri, S.E. Backcasting in futures studies: A synthesized scholarly and planning approach to strategic smart sustainable city development. *Eur. J. Futures Res.* **2018**, *6*, 13. [CrossRef]
61. Heinemeyer, C.; Reason, M.; Quatermass, N.; Wood, N.; Adekola, O. Mutual learning through participatory storytelling: Creative approaches to climate adaptation education in secondary schools. *Res. Educ.* **2024**, *118*, 87–107. [CrossRef]