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Nature-Based Solutions and the Decline of Pollution: Solving Problems to Learn Sustainable Development Goals

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Abstract: The Sustainable Development Goals (SDGs) are important issues that should be learned about in school, particularly those related to sustainable cities and communities. Target 6 of the 11th Goal mentions the special attention that should be paid to air quality. Nature-based solutions are a current theme that should be learned in school to empower students to contribute to planetary sustainability. In this context, a pedagogical intervention was developed through problem-based learning addressing air pollution. After two lessons of 50 min each, students presented a worksheet answered in groups, a group snapshot reflection, and the results of filling out a digital mural before and after the intervention. After a content analysis, the results of this evaluation study were reflected in the 105 students' increasing knowledge about nature-based solutions to improve air quality. A positive appreciation of problem-based learning as an active methodology that motivates and increases students' participation was also referred to.

Keywords: sustainable development goals; nature-based solutions; problem-based learning; air pollution

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1. Introduction

Nature-based solutions (NBS) provide an all-encompassing and sustainable approach to resolving the most pressing societal and environmental problems by working harmoniously with nature. Given the ongoing research and/or innovation investments in this field, the growing number of publications is apparent and is anticipated to rise over the following ten years [1]. Over the past 50 years, there has been a noticeable increase in the desire for the genuine involvement of citizens in creating public policies and making decisions, particularly in sustainability. The extent to and various ways in which citizens actively participate in nature-based solutions (NBS), and how their involvement influences the paths these solutions take, are receiving growing interest [2]. However, the complexity of NBS calls for more innovative and transdisciplinary practices, including collaborative governance and genuine engagement with diverse local communities [3,4].

The Earth system integrates five adaptative subsystems (atmosphere, biosphere, cryosphere, geosphere, and hydrosphere) with delicate dynamics that are essential to promote sustainable development and guarantee humanity's survival, as well as being essential for the maintenance of the bio- and geodiversity of our planet [5,6]. As such, it is not surprising that the need for cities worldwide to adopt NBS is growing significantly. NBS can address various issues, including reducing the risk of natural disasters, improving human well-being in urban and rural settings, enhancing biodiversity, enhancing air and water quality, and mitigating climate change. NBS initiatives include the creation of urban green areas, the adoption of natural stormwater management techniques, and the introduction of environmentally friendly transportation options. Their contribution to the development of climate change resilience and ability to assist communities in adapting to its effects is becoming more widely recognised. By preserving or restoring natural habitats,

they can also significantly contribute to biodiversity conservation by promoting wildlife and enhancing the general health of ecosystems.

NBS are becoming more globally well-known within agreements, which are frequently seen as essential tools for accomplishing the sustainability goals of the entire planet. Nevertheless, although there are increasing calls for collaborative governance support of sustainability transitions, there is little empirical evidence regarding the contribution of diverse citizen participation to achieve sustainability objectives [3,4]. This is reflected in the teaching and learning processes of NBS and Sustainable Development Goals (SDGs) at all levels of schools and higher education institutions.

A systematic literature review [7] showed that working memory, cognitive flexibility, and attentional control improve after exposure to the natural environment. Namely, outdoor green spaces in the school context contribute to increased concentration and attention [8,9]. However, NBS is a cutting-edge strategy that has not yet been fully included in schools' curricula and higher education programs. Developing a good curriculum can achieve success in the learning and teaching processes in schools, since the curriculum is a set of learning experiences that the students obtain during the teaching process [10]. To improve teaching and learning experiences in NBS, academics and students from various disciplines urgently require methodologies, strategies, and resources.

As sustainability gains ground as a crucial component of growth and economic advancement, there is an opportunity to incorporate environmental plans and policies into economic and social agendas [11]. Research on NBS's capacity to promote long-term socio-ecological sustainability is of the utmost importance in academic and policy circles [4,12]. This implies that NBS can be incorporated into the curriculum alongside the Sustainable Development Goals. The implementation of SDGs teaching is already well documented in the literature [13–15].

Numerous teaching methodologies and strategies can be employed to teach students in NBS and SDGs. The literature refers to some of these methodologies and strategies, which encompass, for example, hands-on experiences [16], case-based teaching [17], field trips [18,19], STEAM approaches [20,21], and the particularly active approach of Problem-Based Learning (PBL) [22,23]. The latter methodology is active, making students the protagonists of their learning rather than just passive information-receivers [24]. According to some authors [24,25], in this modern approach, students are at the centre of the activity and actively participate in the teaching process, encouraging students to learn about natural and social phenomena.

PBL is acknowledged for its capacity to foster various competencies in students while empowering them to control their learning process. In this approach, the teacher assumes the role of a facilitator, although he or she might encounter challenges. Several PBL implementations demonstrate those difficulties, such as the teacher's inability to organise and conduct lessons or the time it takes for students to become independent and solve problems autonomously.

However, critics contend that Problem-Based Learning (PBL) can be time-consuming and is frequently embarked upon by individuals who may not fully grasp its intricacies [26]. Some authors even state that some facilitators feel that their purpose is only to observe the process and tutorial dynamics and lose the control and authority that they had as a teacher. Nonetheless, its effectiveness in enhancing learning is widely acknowledged across multiple academic disciplines [13,27–30].

Within this theoretical framework, this study aimed to assess whether teaching students about reducing pollution through NBS and employing the PBL methodology could enhance their understanding and competencies in SDGs. The two objectives are encompassed: (i) advocating for the adoption of the PBL methodology in SDGs education and (ii) furthering the integration of NBS instruction, specifically through the application of PBL. Additionally, the study shed light on the PBL facilitator's role and the challenges students faced in initiating questions during PBL.

2. Materials and Methods

2.1. Method

The research methodology applied in this investigation was an evaluation study supported by the qualitative method. An evaluation study is characterised by the gathering of data that can be used to determine the relevance or need for improvement of a resource (book, task, activity, lesson plan, etc.). We employed an evaluation research methodology that aimed to examine if and how interventions, particularly those based on PBL and NBS, can bring about changes in the world of education and, if so, why and how. Given the absence of prior learning about the NBS topic in the participants' curriculum, no prerequisites were identified, and no comparative study was conducted between existing findings and the findings after the intervention. The focus was on determining whether Problem-Based Learning (PBL) and incorporating NBS could positively impact students' learning. Consequently, the study was conducted with qualitative data and some descriptive statistics.

2.2. Sample

The sample comprised 105 students (n = 105) from an urban public school, which integrated five 9th-grade Natural Sciences classes. Class 1 (C1) had 23 students, 12 boys and an average age of 14.7. Class 1 (C2) had 20 students, 13 boys and an average age of 14.5. Class 3 (C3) had 22 students, of both genders (male and female), with eleven students and an average age of 14.8. Class 4 (C4), with an average age of 15, had 12 girls, totalling 25 students. Finally, class 5 (C5) had 12 girls, a total of 20 students, and an average age of 14.7. The total sample had ages between 14 and 16, with an average age of 14.7. Most of the students were males (53.34%), and the second author of this article, a Natural Science Teacher, was the facilitator.

2.3. Research Techniques and Instruments

The techniques used during this evaluation study were registers, usually defined in the literature as artefacts. The instruments were of three types: (i) a register in a digital visual board using Padlet software (Version 207.0.6), (ii) a worksheet/monitoring sheet containing the main problematic scenario, and (iii) a snapshot report. Only the monitoring sheet containing the main problematic scenario underwent validation, as the other two resources were developed by the students. The validation of this tool involved its being drafted by the facilitator after conducting a literature review. The instrument was created following the references of Ann Lambros [31]. After elaboration, it was analysed and discussed by a panel of three experts in PBL and modified until a consensus was reached.

A pilot study determined the reliability of the three evaluation tools with 18 students from another school's 9th-grade Natural Sciences class. Students were presented with the problematic scenario and followed the same procedure, which was designed to apply to the present study group. They used three instruments, and the technique of spoken reflection was employed to enhance the formulation of the tools, ensuring they were fully comprehensible to participants of the same age group as the present evaluation study. After gathering all the comments and suggestions from the students, the same panel of PBL experts discussed and improved the instruments until a consensus was reached.

2.4. Procedure

This study was conducted during two consecutive lessons on Natural Sciences of 50 min each.

The students completed the three tasks in Table 1 during the two PBL lessons. The application of the instruments was not timed, but the average response time is also shown in Table 1.

Table 1. Tasks and research instruments of the study.

Task	Research Instrument	Duration (Minutes)
1 Elaboration of a digital visual board.	Padlet Board register	10
2 Raising questions and answers.		
Part I: Raising questions.	Worksheet	40
Part II: Answering in the digital visual board.	Padlet Board register	35
3 Development of a group report.	Snapshot Report	15

During the two lessons of the evaluation study, the students were invited to complete the following tasks:

Task 1—Elaboration of a Digital Visual Board

In the first assignment, students were required to envision themselves as members of their local town hall assembly. They were instructed to access a Padlet link using the Google Classroom platform. On this platform, they were tasked with proposing actions to diminish environmental air pollution within their municipality, aligning with target 6 of the 11th SDG (particular attention should be paid to air quality). Due to urbanisation and related mortality, air quality is becoming a more significant issue, and NBS solutions are utilised to reduce pollution [32,33]. The solutions proposed by students were expected to minimise their ecological footprint while embodying nature-centric solutions. The solutions were written on the Padlet digital board.

Task 2—Raisin Questions and Answers

Task 2 (part I)—Answering a worksheet

The worksheet followed the PBL structure outlined in some published works [22,31]. It involved the students engaging with a problem scenario that, in this study, included a dialogue between a father and his son regarding the quality of the air and a recent United Nations report regarding the long-term impacts of air pollution in Europe and North America. In this task, students were required to: (i) identify the facts presented in the problem scenario, and (ii) compile essential driving questions to be answered with problem-solving strategies. The facilitator was pivotal in guiding students towards extracting the most pertinent facts from the scenario. Subsequently, students utilised digital resources, such as websites recommended by the facilitator, to explore nature-based solutions. The websites were mentioned in the worksheet and accessible to all participants via the Google Classroom platform, streamlining the research process. Notably, the provided websites were sourced from reliable and reputable outlets. Following this, students formulated "driving questions". In the end, students had to deliver the worksheet with the essential questions they would like to be answered and write them in the worksheet. Afterwards, the driving questions were gathered, submitted to a content analysis technique and analysed regarding the cognitive order based on the work of various authors [34]. This task was guided by recommendations registered in the literature [35].

Task 2 (part II)—Continuing the elaboration of the digital visual board (Padlet)

Following their analysis and discussion of the website information, students working in small groups were tasked with selecting the most relevant questions. This collaborative sharing of findings with other groups occurred in part II of task 2, and students utilised a Padlet link available on the Google Classroom platform for their presentations. During this process, the facilitator provided feedback to each group, empowering them to take greater ownership of their learning compared to traditional classroom settings where teachers primarily disseminate information [36]. Consequently, the online visual board, Padlet, was employed in two distinct phases: (i) the first phase, undertaken before the application of the problem scenario (Task 1); (ii) the second phase (Task 2—part II), conducted after the discussion of the problem scenario and raising of questions.

Task 3—Development of a Group Snapshot Report

A snapshot report is considered a brief report to provide a "snap" of the work that has been carried out. In this study, in a collaborative work, each group of students developed

one over fifteen minutes. The snapshot report had three main topics: (i) a reflection on the problematic scenario that was presented, (ii) what was learned during lessons, and (iii) a self-assessment of the work carried out by the group. Creating these snapshot reports represents a metacognitive effort by the group members to synthesise information, collaborate, enhance their critical thinking competencies, and improve their written communication. Additionally, they assess students' perceptions of the assigned task and gather constructive feedback to help facilitators enhance their performance using Problem-based Learning and digital tools.

2.5. Ethical Considerations

In the present study, ethical procedures implicit in the field of social sciences were employed. Data protection for the participants was ensured in accordance with specific legislation in the country in which the study took place. Initially, informed consent was obtained from the director of the urban public school to guarantee access to the school and the facilitator's participation (the second author of this article). Subsequently, as the students were minors, informed consent was sought from their legal guardians—the parents or other legal persons. Lastly, their assent was obtained to ensure the participants' voluntary and informed collaboration in the study. It was established from the outset that the study would not influence the evaluation of the students, and those who chose not to participate would face no form of retaliation. It should be noted that all students from the five classes agreed to participate. Due to ethical reasons, such as maintaining anonymity and confidentiality, an identifying code was assigned when processing the data from each student and class.

3. Data Analysis

This qualitative study employed a content analysis technique to analyse data. Content analysis is used for making replicable and valid inferences from the data to the study's context [37]. It is a well-suited technique for analysing qualitative data and provides valuable insights into the study's results. This technique is suitable for condensing information, transforming the extensive content of a text into a concise set of content categories following coding rules. This study categorised and coded students' records following a fluid reading of the obtained results. The analysis was conducted by three PBL experts who came together to discuss and reach a consensus after individually analysing the records filled out by the students. The results will be presented separately for each task and instrument.

3.1. Results of Task 1: Elaboration of a Digital Visual Board

It should be recalled that the students completed this task before the presentation of the problem-learning scenario. To determine which examples could be considered NBS, answers given by students were classified as having reference to the work of some authors [38]. Regarding the results from the Padlet digital board, students' proposed solutions to diminish environmental air pollution within their municipality were inserted into two categories: (i) Nature-based Solutions (NBS) and (ii) not Nature-Based Solutions (all other types (Not NBS)) (Table 1). Unfortunately, the measures referred to by students were mainly considered in the category "Not NBS". After the authors' reflection, the solutions from both categories were divided into subcategories—"arboreal", "transportation", "industry", and "rules"—as their content was convergent in these matters. To enhance the solutions that contributed most to reducing air pollution, the online tool "NBS performance assessment" [39] expresses the top 15 measures for improving air quality by resorting to NBS. Those top 15 measures are vertical-made gardens, (wet)retention ponds, creating and preserving habitats and shelters to biodiversity green corridors, green facades, green wall systems, heritage gardens, infiltration basins, intensive green roofs, large urban public parks, pocket gardens/pocket parks, semi-intensive green roof, street trees, urban forest, and the use of pre-existing vegetation. Examples of those solutions are presented in Table 2.

Table 2. Results from categorising the five classes' answers in the Padlet digital board (quotes translated from the original text).

Categories	Subcategories		Examples/Quotes of Solutions Presented by Students	Classes
NBS	Spatial arboreal		Reforestation Municipal Day, where reforestation will occur in the municipality. Tree planting The planting of trees of native or regional species and the expansion of the municipal garden network. More planting of trees to increase O_2 and decrease CO_2. Vertical Gardens do not occupy horizontal space and help reduce CO_2 in the atmosphere	C1 C2 C5
	Not Arboreal	River intervention	Promote the cleaning of rivers: Strategic planning of cities to make the most of river or lake areas.	C3
		Soil intervention	Recycle household waste: Composting	C4
Not NBS (Others)	Transportation		Decrease the price of/free public transportation: Increased use of public and/or electric transportation. Limit car use by increasing the use of public transport.	C1 C2 C4
			Sustainable transportation Build more bike lanes. More cycling or walking, as driving is more polluting for the environment. Assign people electric scooters.	C2 C3 C4
	Industry		Eco-friendly solution: Use filters in factory chimneys. Decrease of excessive production in factories	C1, C2, C3, C4, C5 C4
	Legislation		To legislate: Applicate fines for those who do not comply with the rules. Prohibit the use of fire in danger zones. Tax benefits for individuals who have solar panels.	C1 C1, C5

Analysing the results allows for us to ascertain that students from all classes have limited knowledge about Nature-Based Solutions. Furthermore, most solutions tend to focus on pro-environmental behaviours for sustainability. These findings underscore the necessity for school curricula to incorporate NBS as an integrated theme across various disciplines. It is worth noting that NBS can be linked to Education for the SDGs, enhancing urban citizens' well-being, and investing in circular cities. Integrating green initiatives into urban areas represents an innovative and pressing issue at present. Consequently, teaching NBS is also a way to teach the SDGs.

3.2. Results of Task 2: Raising and Answering Questions

3.2.1. Part I: Raising Questions

The student groups from the five classes answered the worksheet, and the main questions that were raised are presented in Table 3. This task had a high level of supervision from the facilitator as the literature reconises how difficult it is for students to know how to write questions of a higher cognitive order. As such, driving questions raised by students were classified according to [40] five categories: encyclopedic, meaning-oriented, relational, value-oriented, and solution-oriented. Table 3. Questions raised in the worksheet and categorisations of the cognitive level of the questions. The results reveal students' uncertainty regarding NBS. Consequently, the question "What are nature-based solutions?" was raised repeatedly in all five classes. Another joint inquiry was "What are nature-based solutions for reducing air pollution?" This highlights the importance of the PBL

methodology because problematisation encourages students to contemplate the most crucial questions to solve the problem presented in the scenario. This approach ultimately leads to a deeper understanding of the meaning and utility of NBS for society. Once again, this activity underscores that students need guidance in learning to pose questions, especially those of higher cognitive levels.

Table 3. NBS categorisation (categorisation based on the top 15 NBS for improving air quality).

Categories of NBS		Subcategories	Examples of Solutions Presented by the Students	Classes
NBS Units	Spatial units	Spatial Arboreal units (street trees, urban forest)	Planting of trees.	C1
			Planting of trees that allow for the native species' expansion.	C2
			Planting trees of native species.	C3, C4
		Spatial Mixed Vegetation Units (large urban park, pocket garden, heritage garden, green corridors)	Creation of green areas with specimens of native plants.	C1
			Municipal gardens with aquaponics techniques.	C2, C4
			Increase the network of municipal gardens.	C3, C4, C5
			Construction of green spaces in urban areas.	C3, C4
	NBS Technological Unitsr	Technological vertical units (green wall system, green façade, vertical mobile garden)	Creation of green walls	C1, C2, C3, C4, C5
		Technological Horizontal Units (infiltration basin, wet retention pond, intensive green roof, semi-intensive green roof)	Creation of green roofs	C1, C2, C3, C4, C5
NBS Interventions		Biodiversity Interventions (create and preserve habitats and shelters for biodiversity, use of preexisting vegetation)	Reforestation	C1, C3, C4
			Using natural or environmentally friendly integration of buildings in the surroundings	C2
			Restoration or management of natural and semi-natural ecosystems.	C3, C5
			Creation of natural habitats.	C3
			Preservation of natural forests.	C4
			Avoid the use of pesticides, giving preference to biological control.	C4, C5

3.2.2. Part II: Answering in the Digital Visual Board

As mentioned earlier, the responses provided by each class post application of the digital visual board, completed after the problem-solving second lesson, were recorded and are presented in Tables 4 and 5. A similar procedure was conducted to evaluate the outcomes after implementation of the first digital visual board intervention during the first lesson (Table 1). The NBS mentioned by students' classifications was based on the hierarchical classification scheme in previous work [38]. After some reflection, the authors ended up setting two content categories: (1) Nature-Based Solution Units (NBS Units) and (2) Nature-Based Solution Interventions (NBS Interventions). Again, the top 15 measures for improving air quality by resorting to NBS were essential to analyse the solutions presented by students. This content analysis is expressed in Table 3.

Table 4. NBS advantages (categorisation made after Watkin, 2019 [39]).

Categories of NBS Benefits	Examples of NBS Benefits Presented by Students. (Quotes)	Classes
Nature (environmental features of soil, air, and vegetation)	Improve air quality.	C1, C3, C4
	Mitigate some of the effects of climate change.	C1
	Moderate impacts of heat waves.	C1, C3, C4
	Reduce global warming and heat islands.	C1, C4
	Reduce air pollution.	C2, C3, C4, C5
	Contribute to the promotion of biodiversity.	C1, C3, C4, C5
	Increase the existence of native trees and plants.	C2, C3
	Value soils.	C3, C4, C5
	Increase carbon storage capacity.	C4
	Mitigate the heat island effect.	C5
People (cultural, education, recreation and economics)	Provide social and economic benefits and help to build resilience.	C1
	Move economies and societies into a sustainable path.	C1
	Improve citizens' quality of life.	C1, C3, C5
	Benefit mental and physical health.	C1, C2, C4
	Reduce health problems, especially respiratory problems.	C2, C3, C5
	Adopt solutions that contribute to the reduction of energy consumption.	C2, C3, C4, C5
	Improve the energy efficiency of buildings.	C2, C3
	Make the city more pleasant and more comfortable.	C4
Water (flood mitigation, drought and flood resilience, water storage and reuse, and groundwater and surface water quality)	Optimise rainwater management.	C4
	Strategic planning of cities to take full advantage of river or lake areas.	C5
	Enhancement of aquifer recharge.	C5

Having other reference research in the field [40], the benefits of the NBS appointed by the students' classes were also divided into three topics—"nature", "people", or "water" These were organised as follows: (i) "nature" benefits mentioned the soil, air, and vegetation as environmental features; (ii) "people" benefits focused on cultural, education, recreation, and economic benefits; (iii) the "water" benefits were all those answers related to water storage and water reuse. This content analysis is displayed in Table 4.

Notably, after the problem scenario presentation, students referred to more NBS, which were learned during the problem-solving lessons. However, Nature-Based Benefits continued to focus on pro-environmental behaviours for sustainability, which is highly positive since it is recommended that school curricula also align with Agenda 2030 for SDGs. Once more, these findings emphasise the crucial need for educational curricula to seamlessly integrate NBS into various disciplines. Incorporating environmentally sustainable practices into urban environments is a forward-thinking and urgent challenge in contemporary society. Therefore, it is imperative to introduce these concepts into middle and secondary education.

3.3. Results of Task 3: Development of a Group Snapshot Report

At the end of the PBL methodology application, the students wrote a snapshot report in 4–5 groups in each class. This snapshot report allowed for the researchers to gather information regarding the PBL methodology. Table 5 presents a content analysis of the snapshots based on relevant quotations provided in the snapshot reports.

The content analysis of the snapshot reports revealed that, in all classes, the problem extracted from the scenario presentation was remarkably similar. Students consistently addressed the issue of air pollution and potential NBS. Across all classes, students mentioned that they had learned that nature-based solutions are vital for ensuring planetary sustainability and improving air quality. Group work proved beneficial for learning, making classes more dynamic, although not all group members consistently contributed at a high level. Consequently, the PBL methodology is seen as a positive approach, enhancing

the teaching process and enabling students to develop the necessary content. It is important to note that collaborative work competence, written communication, digital competencies, and critical thinking were all developed through the proposed activities.

Table 5. Content analysis of the snapshots (quotes translated from the original text).

Classes	The Problem Raised as Understood by the Students	What Students Say That They Have Learned	Self-Assessment of the PBL Group Work
Class 1	What are Nature-based Solutions that reduce air pollution, and what are their advantages?	To reduce atmospheric pollution, vertical gardens, green roofs, reforestation, and expansion of vegetable gardens should be built.	Not everyone collaborated similarly; however, all members did well in consolidating the matter.
	The problem was presented to us digitally, which motivated us to work more sustainably and with less paper use.	We learned numerous solutions to pollution and how to combat it sustainably.	We were a rather talkative and distracted group.
Class 2	The main problem is air pollution, which decreases the amount of oxygen in the air, which causes more people to develop breathing problems.	We learned that the air is polluted and about nature-based solutions and their consequences.	Everyone contributed to the completion of the work. We share tasks with everyone.
	It was easy to understand and conclude. It was presented in a way that occurs in everyday life, facilitating the understanding of the subject matter.	How to prevent air pollution and the importance of solutions based on nature.	We enjoyed working together, and everyone learned something.
Class 3	The problem presented is "The air that surrounds us". We enjoy learning more about this issue, which motivates us to learn about Nature-based Solutions.	We learned that we must preserve our planet.	We work better in a group, and these classes are better.
	In our opinion, the problem helped us understand the mistakes that society makes and some of the advantages of having a better quality of life in the future	These nature-based solutions helped us to understand the problem in a more specific way.	We find it interesting since we can cooperate and combine ideas to obtain the best possible result.
Class 4	Decreased air quality. Cardiorespiratory problems. Atmospheric pollution.	We learned measures to reduce atmospheric pollution and general advantages of solutions based on nature.	We performed well as a group. The group work was more dynamic, and there was more interest in doing the work.
	The presented problem motivates us to learn about the problems that occur in the atmosphere caused by humans.	With this experience, we learned that we must adopt measures to reduce pollution to obtain better living conditions and to have a better planet.	This work was creative, different and more about learning how we look for information.
Class 5	The problem was related to what we can do in our daily lives, to reduce atmospheric pollution, presenting solutions based on nature.	We learned the importance of Nature to save our planet and also the consequences of our actions.	Our working group worked well, although some elements were more participatory than others.
	In this group work, the problem presented was atmospheric pollution, and through the theme, we became aware of how human beings affects the environment.	We learn and know new measures for the implementation of a better environment, such as, for example, the creation of green roofs and walls.	Our working group has a healthy environment, and we work well together.

4. Discussion

The results from the first task, expressed in Table 2, show that almost all the measures appointed in the five students' classes had three main focuses: promote the use of transportation with less environmental impact (such as building more bike lanes), act through the implementation of legislation (particularly taxation) or limit pollution by industries (mainly through the filtration of polluting gases). This observation is consistent with the idea that industry is frequently appointed as bearing a responsibility for air pollution in students' minds [41]. Therefore, students, in general, were not familiar with the concept of NBS.

Suggestions of NBS measures to reduce air pollution were scarce and focused on spatial arboreal units, favouring "tree plantation" (although two more types of NBS measures were appointed, these were not directly implicated in the decreasing of polluted air, but in river management and soil conservation). This finding might be related to the fact that the NBS concept is not officially mentioned in the Natural Sciences syllabus in Portuguese schools from the 7th to 9th grades. Another reason is possibly related to the scientific literature, in which NBS is a relatively recent issue [42,43]. For example, considering the bibliometric analysis of some authors [43], the first articles mentioning NBS as an issue are dated from 2012. It is also noted that discourse on NBS is not yet totally embedded in the decision-making processes. In 2013, the European Commission tried to establish the NBS concept within the range of ecosystem-based approaches, and the calls for projects in this field were launched approximately seven years ago [42]. In this line of thought, it is plausible to assume that this time frame did not allow for the effective empowerment of citizens about this matter.

In employing the PBL, it is noteworthy that, following the intervention, students demonstrated a relevant awareness of the NBS that aligned with what they had learned during the problem-solving sessions. While there were some variations among classes, it is striking that the questions raised by students exhibited similarities, possibly due to the consistent scenario and the facilitator's experience. This could also be due to the nature of the exercise and the fact that it was uniformly applied, reflecting a thought-out instructional design.

The consistent success of PBL as a methodology across all the classes to which it was applied is a significant observation that is worth highlighting. Nonetheless, an extensive body of literature attests to the efficacy of PBL as a constructive approach for facilitating students' comprehension of scientific concepts and nurturing the diverse competencies essential for success in the 21st-century job market [44,45]. It is equally notable that the literature frequently highlights students' challenges in formulating questions, particularly those of moderate or advanced complexity [34]. This underscores the critical requirement for a skilled facilitator who can actively stimulate and bolster the development of self-confidence and autonomy within the student's learning journey [46,47].

The digital board utilised within the PBL methodology received positive feedback from students, significantly contributing to the success of this methodology. Through PBL, students engaged with the subject matter and integrated the acquisition of digital competencies, which are increasingly relevant. This approach bridges the gap between the teaching process and students' real-world experiences, but can also aid them in becoming proficient in using digital tools [48].

5. Conclusions

This study has provided valuable insights. It revealed that, when implementing the PBL methodology, students significantly improved their understanding of NBS and their role in reducing pollution. Equally important is the connection made between the study's objectives and the 2030 Agenda for SDGs. This highlights how the presented problem aligns with global sustainability goals. The research underscores the pivotal role of the facilitator in guiding students' learning journeys, ultimately enhancing their performance and helping them attain academic success. These findings support the existing literature

on the development of diverse competencies fostered by this methodology and emphasise the urgency of integrating PBL, the sustainable development objectives, and the theme of nature-based solutions into educational curricula. While the positive impact of the PBL methodology is evident, there is still room for further refinement and expansion of its application across various disciplines. Moreover, it can be effectively integrated into different approaches, such as the STEAM approach. This approach is particularly noteworthy as it fosters competency development and promotes greater inclusivity, especially for underrepresented groups like girls, in fields where they are not yet adequately represented. It can also assess success when applied to current scientific content, such as the SDGs and NBS, as in this evaluation study. Being an active methodology, despite originating in the 1960s, it remains relevant in promoting the development of competencies necessary for employability in the 21st century, such as cooperative work, problem-solving, and the development of knowledge, digital competencies, and critical thinking.

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