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The BioS4You European Project: An Innovative Way to Effectively Engage Z-Generation Students in STEM Disciplines

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Abstract: In this contribution, we present the BioS4You project and analyse the results obtained in the first 18 months of its activity. The "Bio-Inspired STEM topics for engaging young generations" (BioS4You) Erasmus+ KA2 Innovation project aims to bridge the gap between STEM national curricula (which include Science, Technology, Engineering, and Mathematics) and the needs of Z-generation students, uninterested to basic themes, but enthusiastic in issues related to environmental, social, and health concerns. The BioS4You project engages young learners in STEM subjects, starting with current issues of interest for them, as the social and environmental impact of new technologies, connecting STEM concepts to real-world technologies that are supporting on facing environmental, social, and health current challenges. Novel fields such as Bioengineering, Bioscience, Biotechnology can be implemented into classroom teaching, integrating academic disciplines, and stimulating the academic and social growth of young people. The knowledge of new STEM contents makes the students feel an active part of the technological innovation (and not just passive users) and help them to build a better future, bringing them closer to the STEM world and enabling them to make more informed choices for their future careers.

Keywords: STEM education; active learning; biomimicry

1. Introduction

Recent reviews about the state of education in STEM fields has determined that most of the students finds the courses dull and unwelcoming; consequently, many students end the school journey showing very low interest in STEM disciplines, ill-prepared in problem solving. The National Science Foundation recommends that a student's educational experience should "build inquiry, sense of wonder, and excitement of discovery" [1]. Current trends in education emphasise the need for a progressive switch toward student-centred approaches that differentiate from conventional teaching models. Accordingly, recent research assumes that the students should participate actively in the learning processes [2]. School atmosphere changed a lot in the last decades. School education started introducing new technology, such as tablets, 3D printers, interactive whiteboards, apps and scaffolds, and other various ICT education instruments. Schools are challenged to suggest curricula which are closer to the interests of the new generations, flexible to the place and time of the learners, which incorporate and discover the potential of new technology and empower students to take control and awareness of their learning, to grow and move onwards. This challenge should be met by educators and schools as early as possible. There is no doubt that schools should form a new vision of learning services adapted to needs, complexity, connectivity, and velocity of the new knowledge society [3–7]. Schools should provide their learners, the Z-generation, with such learning experience which would open the doors to the best academic achievement, would ensure economic growth, social and civic engagement. Today, students need to be goal-oriented, creative, and able to solve problems and come up with innovations, in order to be future responsible European citizens and workers [8–10]. Recent studies evidenced the need to engage students at all levels in science to boost the supply of a skilled scientific workforce and knowledgeable citizenry [11]. Young students (Z-generation) are more connected and more careful regarding environment and social issues as well as to psycho-physical wellbeing, compared to "millennials".

The main goal of the "Bio-Inspired STEM topics for engaging young generations" (BioS4You) project, is to engage European young learners in STEM subjects, starting with current issues of interest for them, as the social and environmental impact of new technologies, connecting STEM concepts to real-world technologies that are supporting facing environmental, social, and health current challenges. Therefore, in BioS4You-based curricula STEM subjects that could be considered abstract by the students are put into a context more "congenial" to them, more connected with their everyday and future life [12,13].

The right to quality and inclusive education, training, and life-long learning that develops key competences and basic skills are fundamental rights to which all individuals should have equal and fair access. Key competences and basic skills are needed by all for personal fulfilment and development, employability, social inclusion, and active citizenship. BioS4You education integrates academic disciplines and stimulates the academic and social growth of young people; it can represent an important tool to promote awareness of shared values, having an impact on student everyday life. Furthermore, BioS4You project can act as a vehicle to inspire the Z-generation of students, and in particular young girls, to pursue a scientific career.

The purpose of this paper is to present the European project Bios4You to a wide educational audience, reporting the activities performed in the first 18 months of the project. In particular, here we describe how to create the STEM curriculum, using Moodle as a platform, based on topics of interest to the students and teachers. During the first months of the project, the consortium established mixed working tables (teachers and students) for the identification of "hot" topics in biotech scientific innovation of interest to the younger learner generations and useful in making students feel an active part in building a better future. Selected topics not only may develop basic STEM skills but also foster students' identities as capable persons and citizens in a global, fragile, and changing world. Moreover, the paper also addresses the pedagogical requirements for the BioS4You educational material (focused on the school) identified by the partners, on the base of STEM national curricula, available literature sources, and teacher interviews. The teaching/learning unit characteristics to be adopted to increase student ability to solve real-life problems and contribute to the enhancement of STEM education at school are described, together with the adopted methodology.

2. Materials and Methods

2.1. The Bios4You Project and Its Added Value in STEM Education

The "Bio-Inspired STEM topics for engaging young generations" (BioS4You) project, funded by the European Union within the Erasmus+ KA2 Innovation program, involves five partners from four different countries (Germany, Italy, Lithuania, Turkey). Figure 1 show the logos of the consortium partners, Figure 2 the project logo.

The BioS4You project aims to bridge the gap between STEM national curricula (which include contents of Science, Technology, Engineering, and Mathematics) and the needs of Z-generation students, apathetic/uninterested to basic themes, but enthusiastic in issues related to environmental, social, and health concerns. Novel fields such as Bioengineering, Bioscience, Biotechnology can be implemented into classroom teaching under the umbrella of BioS4You education, integrating academic disciplines and stimulating the academic and social growth of young people; it can represent an important tool to promote awareness of shared needs. The BioS4You project aims to increase the interest of new generations in STEM subjects by introducing them to the bioinspired technologies, to both the biologically inspired engineering and the scientific innovations, new treatments, technology, and processes that could make a real difference in improvement of life and environment. The knowledge of these contents makes the students feel an active part of the technological innovation (and not just passive users) and helps them to build a better future, bringing them closer to the STEM world and enabling them to make more informed choices for their future careers [14]. However, in order to obtain successful results with young learners by nourishing their positive attitudes towards STEM subjects and strengthening their basic skills and key competencies, very motivated and trained teachers are needed. For this reason, another relevant objective of the BioS4You project is to support upper secondary STEM school teachers and implement teacher collaboration in promoting intensive dissemination of new teaching strategies and innovative ideas in the field of Bio-inspired Sciences education. In the project, teachers also benefit by exploring new designed-based learning/training approaches and producing interdisciplinary learning modules. They strengthen their ICT competence and have open access to modern research and teaching facilities. The educational material available in the BioS4You e-learning platform improves educator day-to-day teaching, making it more effective and student-oriented. Specific bio-inspired STEM educational scenarios, OERs, teaching/learning tools, and best practices provided by European school educators over the BioS4You e-learning platform impact on teaching process and inspire pedagogical innovation and modernisation. In order to help students to improve critical thinking skills, and demonstrate alternative approaches in STEM education, teachers are expected to create learning modules. The project will focus not only on how teachers could learn to build Bios4You based educational modules but also on how they could develop effective STEM activities in formal, non-formal, and informal environments.

Figure 1. Logos of the BioS4You project partners.

Figure 2. Logos of the BioS4You project.

The specific results and impact for students are:

- to allow students to connect their learning in Science, Technology, Engineering, and Math together with concerns related to environmental, social and health issues, creating a direct connection between what students are learning and how it is applied in the real world;
- to enhance project-based learning experiences that expose students to the critical thinking skills necessary for success in the 21st century;

- to create wonder, critique, inquiry, and innovation in students' learning, improving student interest and satisfaction.

With the aim to achieve these tasks, as planned in the BioS4You proposal, the first Intellectual output IO-1 (*Research on how technology and engineering bring STEM to life and vice versa*) has been devoted to a Research Phase aiming to clarify some aspects relevant to the project. In particular, the first phase of IO-1 has been devoted to the identification and discussion of STEM panorama, need analysis in the four countries of the project Consortium and research that supports best practice in STEM education. The analysis of teacher and student need and awareness was conducted on the base of the available literature sources (https://bios4you.infoproject.eu/).

2.2. The Bios4You Methodology

The methods and the training procedures used in the didactic approach are elements of a didactic strategy. Although many other structural elements of educational strategy are equally important, field practitioners tend to focus especially on didactic methods as the visible part of the didactic iceberg [15]. The method is a term of Greek origin "methodos" ("metha" translating to through and "odos" meaning direction, road), namely it can be translated by the phrase "the way to". The didactic method is a way through which the teacher conducts and organises the training of the trainees. The method is defined as "the assembly or the system of processes or modes of execution of the operations involved in the learning process, integrated into a single flow of action, in order to achieve the objectives proposed" [16], p. 46.

Bios4You with the core contents including environmental education can be considered as sustainable development education which is based particularly on environmental and ecological sciences. It encourages students to critically reflect on the ideas of sustainable development and the values that underlie them, and to create solutions to achieve concrete goals in a variety of unpredictable situations. These kinds of contents exist especially in the fields of ecology, biodiversity, conservation, and system biology. According to Palmberg et al. [17] the ability to identify species is important for a better understanding of biodiversity and issues concerning the environment and sustainability, not only for comprehension of certain branches of biology (e.g., ecology, evolution, genetics). However, taxonomy is often a forgotten field in school curricula. Biological phenomena connected to socio-scientific issues, such as climate change, need to have an integrative and interdisciplinary approach to be thoroughly taught and learned. When biology education is given in connection with SE (Sustainability Education), teaching methods such as experiential, collaborative, process-based, and problem-based experimental learning and computer-assisted methods can be useful [18]. Biodiversity, climate change, the sustainable use of natural resources, health, cultural heritage, multiculturalism, and global welfare are important contents in the planning of a sustainable future. The effects of students' own behaviours should be discussed and sustainable actions practiced in local surroundings. An important goal is to learn negotiation, problem solving, and decision-making skills through discussions about ecological, social, economic, and ethical principles concerning local and global responsibility in their own life. Through memorable, experiential, and active processes, students learn to discuss their own value selection and to evaluate phenomena and sources of information critically [19]. In biology education, selected teaching methods should support learning biology, learning to do biological science, and learning about biological science [20]. Several biological topics require approaches promoting experimental problem solving and process-based skills [21]. The focus is on science investigation processes and the goal is to reach valuable learning results, and students therefore need crucial science content knowledge as well as autonomous learning [22]. This, however, seems to create difficulties for the so-called working memory, which again impairs the self-regulation competencies [23]. Therefore, it is important to implement teaching methods including both autonomous learning and instructional activities, and to vary the level of openness of experimental tasks. The implementation of problem-based active learning models has positive effects on students' academic achievements and their attitudes to science courses [24–26], while implementation of problem-based learning and group investigation encourages students to think critically through planning, arguing, stating questions and problems, and providing solutions to environmental problems [27]. Biological field-based activities, e.g., fieldwork and field trips, provide students with authentic and interactive experiences and experiential learning opportunities, which increase students' interest and enhance their learning. Students' engagement in field-based activities plays an essential role in learning biological issues. Fieldwork provides students with a chance to observe nature and the environment and to use scientific inquiry to test ideas and concepts they have learned in the classroom. According to Hart and Nolan [28], fieldwork had a positive effect on students' knowledge, attitude and behaviour, crucial factors also in promoting sustainability [18]. In fact, BioS4you follow-up programs can incorporate the following:

(i) Giving teachers direct access to experts in the practice of scientific method resources in the classroom;
(ii) Instruction in project-based framework, presenting students with real-life problems (questions) for them to examine and seek answers to;
(iii) The training introduces teachers to the most current and best materials available for supporting 2-E instruction;
(iv) The training is integrative, showing teachers how to use and incorporate various technologies and electronic media, including educational gaming, into the instructional mix so that teachers can engage students using tools they understand and value;
(v) The program culminates in classroom demonstration projects in which teachers and students deploy the scientific method to solve real-life problems, engineering experimental designs and products, and report findings as actual scientists might.

BioS4You started its training program using Material World Modules (MWM) produced at Northwestern University as the main instructional tool for showing teachers how to use I&D (Inquiry and Design) like 2-E (Explore and Execute) to teach scientific subject matter from a student-centre point of view. Focusing on materials that we use every day, a team of NU professors, high school science teachers, professional editors, and designers, created a series of nine modules each featuring a separate materials topic. The modules are designed for use in middle and high school science, engineering, and technology classes. They have been extensively field-tested by teachers in a wide array of subjects, including chemistry, physics, biology, earth science, technology, engineering, and mathematics (https://mwm.northwestern.edu/). Students who used MWM related a perceived improvement in their science process and technological design skills in key areas such as working as a team, connecting science to the real world, planning a design project, and analysing data and understanding science concepts to name a few. Student surveys indicated that after using MWM there was a positive change in their perceptions about science. They related that: science classes are interesting; they talked about science among friends; they looked up science information on their own; and they considered going into science as a career. Similarly, also in the BioS4You project, module development should be driven by the needs of students and teachers. Students need modules to enhance their learning of science and engineering concepts, build their confidence in applying these concepts, and prepare and inspire them to enter science and technology-related careers. Teachers need modules to be safe for use in the classrooms, inexpensive, relevant to concepts taught in physical and biological curricula and closely linked to the national science standards and benchmarks. The inquiry (explore) and design (execute) methodology has proven very effective in meeting these needs. Students gain exciting hands-on experience working as scientists (inquiry) and engineers (design) that stirs their natural curiosity and motivates them to learn. Teachers receive help in linking science and engineering concepts to real-world applications that students can appreciate. The module development process is very rigorous. Great care is taken to ensure that content is relevant and up-to-date, and that student have a "wow" experience. 2-E emphasises both Explore and Execute. Explore entails investigation in one or more area of science and Execute relies on engineering principles and practices to devise solutions to real-life problems. In turn, science and engineering depend on mathematics and technology. From this point of view, the various STEM areas are integral to a coherent problem solving process. Based on the core contents in BioS4You categorised in sustainable education which needs problem solving methods and works with STEM education curriculum, it is expected that the teachers present a brief explanation about Bio-inspiration definitions and discuss a main question related to Bio-inspiration in terms of STEM education works curriculum driving problem solving, collaboration, and creative thinking skills to ensure student success in the workforce [29].

2.3. The Bios4You Moodle Platform

In this paragraph we present the Moodle platform, adopted according to the requirements of the project BioS4You in order to achieve its results. Additionally, project partners are expected to create positive experience of both sides: teachers and students. We chose a Moodle platform because it provides several benefits:

(1) the flexible toolset. Moodle administrator can configure Moodle by enabling or disabling core features, and easily integrate everything needed for a course using its complete range of built-in features, including external collaborative tools;
(2) open source;
(3) accessible;
(4) user-friendly;
(5) the Moodle platform was formed in all partners languages (Lithuanian, German, Italian, Turkish) as well in English; other languages are possible, if there is a need. A possible further step is to put it in Spanish, since approximately 577 million people speak it and Spanish is the third most used language on the internet (after English and Chinese);
(6) different tools integration (tests, quizzes, discussions boards, etc.);
(7) different sources integration (files, folders, links, pages, video, etc.);
(8) different types of activities for students' engagement into active study processes available (forums, glossaries, wikis, assignments, choices (polls), SCORM players, databases, etc.);
(9) interactivity;
(10) gamification tools (badges, competency, completion progress, etc.);
(11) tools for monitoring and assessing progress;
(12) communicating and self-reflection tools;
(13) course management tools (access restrictions to learning materials, automated assessment or testing, reports, managing work submissions);
(14) use anytime, anywhere, on any device; Moodle app provides possibility to download the content and to use it without internet;
(15) global community support (online support documentation, strong support for security and administration).

The BioS4You Moodle platform users will be teachers and users, therefore we prepared two guides for the users: one guide provides for teachers understanding of how to use the platform and upload all the training material; the second guide helps students to enrol in the platform and consume the training material as well as to do different activities. The purpose of the teacher's guide is to make teachers' experiences related with the teaching content creation simple and positive and to provide all the basic information, which is required for course creation. This platform should inspire pedagogical innovation and modernisation as well it will have an impact on the teaching process. In every section of the guide, we presented the main tasks, what the teacher should do in order to create the course in the Moodle (see Table 1).

Table 1. Teacher guide main elements and description of them.

No.	Section Name	Task Description
1.	Log in	Main information how to login into the course.
2.		Explanation about the form necessary to fulfil to create a new course and/or test it; information, how to contact the "Moodle" administrator (the contacts of the administrator will be seen at the bottom of the webpage and near the login information). The administrator can manage all the areas of the "Moodle", solve problems, and provide technical help.
3.	Create a course (the role of course creator)	Instructions how to fulfil the form in order to create a new course. This can be done by those who are assigned the content creators role.
4.	Course settings	Instructions how to change course settings to a teacher, or other user with the update course settings capability. Explanation on how to add a course summary and image, change course format, appearance, and other.
5.	Course homepage	Explanation about "Moodle" course main blocks, i.e., visual layout of the content.
6.	Capability to change course details	Main information, how to fill in the course form.
7.	Course editing	The information about tools, which can help to create or edit new units; capabilities to add activities or recourses and the description of activities. Explanation how to add other additional information into the course.
8.	Activity completion	The directions related to the icons for activity completion; the options, how to see that students have finished his/her activity; capabilities to evaluate students for the finished activity.
9.	Interactive content—H5P	Short instructions how to integrate the tool H5P into the course used content bank. Instructions how to create interactive content (course presentation).
10.	Quiz activity application	Short instructions, how to add the quiz for the students' evaluations.
11.	Students' enrolment	Short instructions about students' self-enrolment and teachers' manual enrolment of particular students.
	Course layout	The course layout is based on the methodological part of the project. Every unit consist of two parts: explore and execute. Basic level consists of introduction and basic principles lessons; advanced level is related to two advanced material lessons.

With the purpose to help students' easier enrolment in the project courses and easier Moodle usage, we prepared a student guide, which consists of 12 sections. In every chapter we presented the main information, useful for the student studying in the "Moodle" course (see Table 2).

Table 2. Student guide main elements and a description of them.

No.	Section Name	Description
1.	Introduction information about "Moodle"	Main information about Moodle.
2.	Log in information	Main information how to log into the course.
3.	Homepage and Dashboard	Explanation how to navigate in site, how to use personal dashboard and homepage.
4.	User settings	Instructions how to change user settings and other preferences; how to edit user information, set the forum preferences and the message or the notification preferences.

Table 2. *Cont.*

No.	Section Name	Description
5.	Enrolling into a course	Explanation how to search course, to preview course summary and to enrol or unenroll into a course
6.	Course homepage	Explanation about "Moodle" course main blocks, i.e., visual layout of the content and how to study in a Moodle course. Explanation of where resources for reading or activities are.
7.	Progress tracking	Information about the conditions of course activity completion. Explanation of where it is possible to see progress bar and how to track your completion.
8.	Quiz or self-evaluation task	Information about the self-evaluation task, which can help to understand the content or check on own. Explanation how to start and complete quiz.
9.	Grades	Explanation where to find your grades.
10.	Forum discussion	The information about forum activity. Explanation of how to discuss online, to post messages, or to ask questions for teachers or for other students.
11.	Messaging	Short instructions on how to send private messages for teachers or other participants.
12.	Help	The additional information about "Moodle" and where to go for help.

3. The Results of the First 18 Months of Activity of the Project

3.1. The Identification of "hot" Topics in Biotech Scientific Innovation

According to the project proposal, the second phase of IO-1 focused on the identification of "hot" topics in biotech scientific innovation which could effectively engage the young learners by increasing their interest in STEM subjects, with the final aim to establish which subjects of technological innovation are of interest to the younger learner generations and useful in making students feel an active part in building a better future. We would like to select topics that not only develop basic STEM skills but also foster students' identities as capable persons and citizens in a global, fragile, and changing world. Appendix A is the list of 25 subjects in biotech innovation of great interest in STEM education obtained by mixed working-tables—teachers and students, organised in each country by partners in the first months of the project. After the identification of these 25 topics, we created two surveys with the aim to assess awareness and needs of the two target groups (teachers and students) and identify the "hottest" topics. In total, 50 teachers and 244 students from the four Consortium countries participated in the study. In Appendix B we can see the 15 more interesting subjects in education selected by our students for insights; in Appendix C the more interesting subjects selected by the teachers and chosen, together with the number of who selected them and the percentage. As we can note, teacher selection is different from student selection and, in particular, the list chosen by the teachers seems to contain much more conventional themes. In accordance with the innovative nature of the project proposal, the consortium partners decided to use the choice of the students as the 15 "hottest" topics in biotech scientific innovation which could effectively engage the young learners by increasing their interest in STEM subjects. The 40 national (10 in each national language) and 5 transnational teaching/learning modules should be created on these topics. More important, teaching/learning paths should be multidisciplinary and incorporate two or more of these subjects.

3.2. The Pedagogical Requirements for the BioS4You Educational Material (Focused on the School)

As the main group who were observed through this project were the school students between 14 and 18 years old, and according to the research from the cognitive and learning sciences, it confirms observations that good learning involves direct experience, "deep immersion in a consequential activity". It confirms that learning works best when young people can focus in-depth on a few things at a time; when they see a clear purpose in learning activities; and when they have an active role-co-constructing, interpreting, applying, making sense of, making connections. Research confirms that, though sometimes fragile, motivation is a powerful engine for learning, and that it can be fostered under the right conditions. Motivation to learn is stronger when driven by the young person's prior knowledge and interests; when it is located, not in rewards and punishments, but in the task itself; when it is driven by a desire for mastery and by identification with mentors and teachers.

According to the HPL (How People to Learn) which emphasised some key findings from decades of research on motivation to learn:

- People are motivated to develop competence and solve problems by rewards and punishments but often have intrinsic reasons for learning that may be more powerful.
- Learners tend to persist in learning when they face a manageable challenge (neither too easy nor too frustrating) and when they see the value and utility of what they are learning.
- Children and adults who focus mainly on their performance (such as on gaining recognition or avoiding negative judgments) are less likely to seek challenges and persist than those who focus on learning itself.
- Learners who focus on learning rather than performance or who have intrinsic motivation to learn to tend to set goals for themselves and regard increasing their competence to be a goal.
- Teachers can be effective in encouraging students to focus on learning instead of performance, helping them to develop a learning orientation [30].

Biomimicry is a rich framework for teaching that can be used to address a wide range of topics in science, engineering, and environmental literacy—all with a hopeful message that encourages students to be positive agents for change in the world [31–38]. As the growing field of biomimicry attests, there are countless opportunities to learn from the natural world around us and doing so may indeed be the key to a liveable future on this planet. However, to get there, today's young people must learn not just how to live and succeed in a complex world made by other humans but to see and appreciate the complexity of the natural world around us, and how we are interconnected with it.

Students should be able to "read" a tree as effortlessly as they would read a book. That is, to see that a tree is not just a source of fuel, or wood to build a house, but also an amazing technology in its right—one that stores energy from the sun, moves gallons of water a day without motorised pumps, creates materials out of carbon in the air, and provides countless ecosystem services. When we learn to see technology in nature this way, our eyes are opened to the sustainable world that already exists, embodied in the plants, animals, and other organisms all around us [39].

Using bio-inspiration for the development of new products and devices requires the students to acquire new educational tools, in principle based upon the appropriate selection of design and manufacturing technologies, but not limited to these. In addition, a renovated and more multidisciplinary curriculum would also be needed, including a wider knowledge of materials science, chemistry, and biology [40]. However, the most significant part of this renovation is likely to be centred on an increased interaction between the disciplines. This would enable the student not only to elicit some information from the relevant branch of science but especially communicating with experts using appropriate technical definitions, so as to apply the above knowledge to the specific design issue, as explicated in Table 3 [41].

Table 3. Forms of bio-inspiration and related examples [41].

Level of Analogy	Meaning of the Analogy	Typical Biological Contexts
Architectural	Mimicking the organisation of structures built by living creatures, e.g., in buildings or in systems	Typical biological contexts
Morphostructural	Mimicking biological microstructures to obtain specific properties	Cells, bones, shells
Biochemical	Observation of biochemical mechanisms (e.g., photosynthesis, bioluminescence)	Plants, fireflies, some fishes
Functional	Understanding and repeating the logic of specific features aimed at some function	Super-hydrophobic surfaces (e.g., shark skin, lotus)
Behavioural	Transfer of some behavioural modes, e.g., protection, reaction to environment	Exoskeletons, armour-like skins
Organisational	Transfer of organisation strategies, e.g., redundancy, self-adaptation, autonomy, self-organisation	Sensory and neural systems

Generally, all efforts in biomimicry education, regardless of age, should also aim to impart to students a new way of viewing and valuing the natural world. Students should come away feeling and understanding that nature is full of ideas about how to solve our challenges, and that they are empowered to address those challenges to improve the world. What is the main role of STEM education to help this aim or what should STEM education look like now and in the future? This pedagogical process in BioS4You requires students to be aware of some information:

- Identifying bio-inspired principles in the functions and strategies of living things to stimulate innovative solutions.
- Causes and effects of the problem which lead them to find the solution.
- Applying the technical process (STEM) to reach a bio-inspired solution for the problem.

Some Teaching Strategies

Imagine Being as Part of Nature:

This is the basis for why biomimicry makes sense: humans need to do many of the same things those other organisms do. For example, acquiring resources, making and breaking down materials, processing information, and reproducing.

The more we understand about how our planet-mates have leveraged the resources and constraints of this place, over billions of years, the better equipped we are to create technologies and systems that will enable all life to flourish long into the future.

In this way, teachers can take students out and encourage their innate curiosity and affinity for nature, incorporate sensory exploration into outdoor experience, and ask the students about closing their eyes and noticing what they can detect about their surroundings through the environment.

Using Function and Strategy:

The students need to understand the concept of function as it relates to both biological strategies and design solutions. Function, by definition, is the purpose of something. In the context of biomimicry, function refers to the role played by an organism's characteristics or behaviours that enable it to survive. Importantly, function can also refer to something you need your design solution to do. Once a student can identify the functions being served by biological elements, they can begin to relate those biological solutions to human technological challenges.

Recognising Matters of Scale:

Scale is a conceptual framework that can help students understand, apply, and describe biomimicry. There are two ways we can talk about scale in biomimicry: (1) we can use scale in a literal sense to describe the relative size of organisms, physical parts, or other components of a biological strategy or technological design, and (2) we can use scale to describe increasing levels of complexity in the application of biomimicry.

In this way, teachers encourage the students to consider how functions and strategies in biological and designed systems may change with scale.

System Thinking:

Our world is composed of systems-from ecosystems in nature to organisations and technologies in human society. Systems thinking means thinking about the whole system and its interacting parts. The good news is that children have an intuitive sense of systems. Learning to see, understand, and think in systems is essential to biomimicry. In this case, teachers can engage the students in conversations about the relationships between things in nature or design and discuss cause and effect relationships [40].

3.3. Didactic Sequence and Characteristics of Learning/Teaching Units

Since the BioS4You project aims to increase the interest of new generations in STEM and to help prepare students with a more conceptual understanding of technology and engineering and its place in society, great attention is paid to the training platform, tools, and didactic sequence, which would use innovative modern technologies and methods. Figure 3 presents an exemplum of the methodological approach which was used for the creation of the learning units.

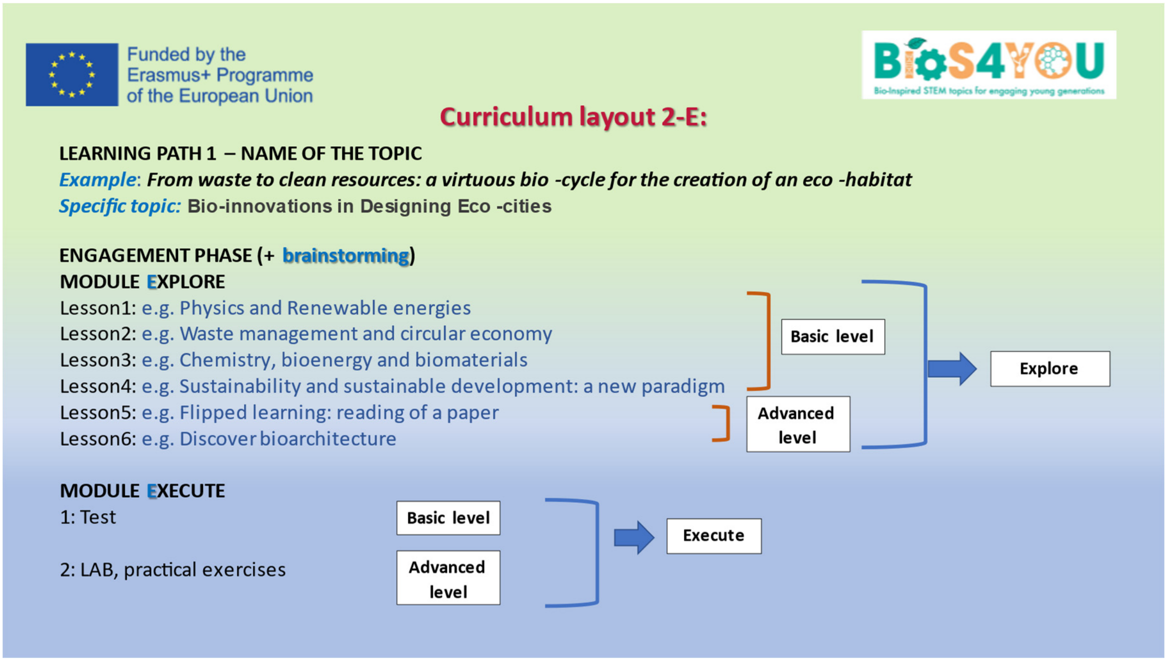

Figure 3. Main structure of the teaching/learning units.

There, we can see that every unit was divided into an 'explore' part and 'execute' part. The exploration part has two levels: the basic level and the advanced level. The execution part aims to improve students' activities in the online system (based on Moodle) and let the students grasp practical aspects of the presented topic while gaining more understanding and practical abilities related to the topic.

In particular, the BioS4You learning unit Moodle structure consists of:

- ✓ Identity card of the learning unit with a brief description of the learning path.

- ✓ Engagement phase (brainstorming activity with driving questions).
- ✓ Explore phase (includes "theoretical" activities eventually split up in basic and advanced level).
- ✓ Execute phase (includes planning and realisation of hands-on activities, virtual or remote lab activities, flipped activities, solutions to real-life problems, etc., eventually split up in basic and advanced level).
- ✓ Evaluation and assessment phase (include tests, exercises, questionnaires, open problems, etc., for both teacher evaluation and student self-evaluation).

More important:

- Engagement should inspire inquiry;
- Exploratory activities should provide background and concept information central to the topic object of the study;
- Practical activities should challenge students to apply what they have learned.

The topics of the learning units are selected based on the analysis of questionnaires and information collected from schools on the topics of most interest among teenagers. This analysis was carried out within the BioS4You project. The learning units are expected to be in all the project partners' languages and English. Currently, there are five learning units presented in English:

(1) 'From waste to clean resources: A Virtuous Biocycle for the Creation of an Eco habitat'.
(2) 'Biomimicry: Innovation and Design Inspired by Nature'.
(3) 'Global Climate Change'.
(4) 'Arduino and Coding'.
(5) 'Robotics in Biotechnology'.

All learning units are intended for teenagers aged 14–18 years and all units of the Bios4You project aimed at encouraging students to explore different STEM directions and put them together. The study materials are prepared as interactive H5P presentations, containing pictures and videos, or seamlessly changing links to information on the Internet. There are self-assessment questionnaires at the end of each topic. To make the material more attractive and engaging for teenagers, Bios4You project partners used a wide range of H5P capabilities, allowing for a drastically increased interactivity of the learning material. Among most useful interactive content type items, we could note: Interactive Video; Course Presentation; Branching Scenario; Drag and Drop; Virtual Tour (360); Image Hotspots; Drag the Words; Timeline; Multiple Choice question; Fill in the Blanks; True/False; Image Sequencing; Mark the Words; Image Slider; Guess the Answer; Image Pairing; Single Choice Set; Advanced Fill in the Blanks Tutorial, and other tools.

Let us illustrate the learning sequence in the last learning unit "Robotics in Biotechnology".

The quite complex problem of building the bionic hand and making it move is broken down into a set of separate tasks:

(a) 3D modelling of body parts,
(b) 3D printing of body parts,
(c) Realising the motion of bionic hand fingers by servomotors,
(d) Controlling Servomotors by the Arduino UNO Microcontroller.

The general didactic pathway might be described as the following sequence:

(a) Overview of the topic,
(b) Advanced Study of the Topic,
(c) Virtual simulation from elementary 3D shapes or hardware actions up to bionic body parts and computer-controlled movements,
(d) Self-assessment,
(e) Experiments in laboratory settings.

The strongest point of the modules in the Bios4You project is the extensive use of virtual tools for the students' activities on the path from theory to practice. Regarding the unit "*Robotics in Biotechnology*" the 3D printers, servomotors, and Arduino UNO hardware might be of limited availability for all students, but this shortcoming could be easily compensated for by web-based virtual tools for 3D modelling such as Tinkercad or others. The same could be said about hardware and software simulation of servomotors controlled by Arduino UNO (single-board microcomputer of a credit card size). The advantage of such tools as Tinkercad is a graphical environment for software development. Compared to a native Arduino UNO development environment, designed by enthusiasts and aimed at such users, Tinkercad offers graphical programming in 'Code Blocks'. These are much more pupil-friendly and extremely similar to SCRATCH, a graphical programming environment, widely used to teach programming at schools (also in Lithuania).

The general advantage of virtual simulation tools is an opportunity to avoid costly losses (mostly in hardware) due to human errors while learning. Teacher-supervised simulation allows students to learn potential breaks and failures, as well as measures to prevent them in the real world. Therefore, the students after passing the simulation phase will become reasonably better prepared for real experiments.

To support the didactic process for teachers, as an intellectual output, the project partners created the document 'Pedagogical requirements for the Bios4you educational material'. With the help of this material, teachers will learn how to effectively engage new generations by incorporating biologically inspired engineering and scientific breakthroughs into their courses using an e-learning platform. In Table 4 we list examples of driving questions together with both teacher and student requirements which can be useful in the building of the teaching/learning units.

Table 4. Examples of driving questions together with both teacher and student requirements.

Examples of Driving Questions	**How Can We Learn from Nature?**	**How Can Nature Impact on Our Future?**	**What Do You Think about Bio-Inspired and Global Warming?**	**How Can We Find a Solution in Nature for the Global Warming in Future?**
Teacher requirements	- Identifying bio-inspired principal - Making a question related to the environment and future of life (strengthen the student's dream about their future life) - Considering some causes and effects of the questions (helps to encourage the students to find a solution) - Expanding the bio-inspired identifications in the STEM topics (interpreting some kinds of questions or problems including bio-inspired information related to Science, Technology, Engineering and Mathematics) - Consolidation of professional competence(s), didactic competence(s), methodological competence(s) - Independent further development of social and personal skills; sensitisation for ethical aspects of the subjects and for critical handling of media - Development of role clarity and teacher personality development in order to strengthen or change students' attitudes and behaviour and to encourage them to reflect on their attitudes, views, and behaviours and to convey the importance of the sustainability of their own actions in a personal, school, regional, and global context - Design and support of individual learning processes, school career counselling, and individual educational counselling - Acquisition of diagnostic skills for the differentiated support of students and appropriate design of examination situations - Reliable classification and assessment of oral, written, and other services - Active and continuous readiness for continuous in-service training and further education in the specialised sciences, specialised didactics, and educational sciences - Openness and willingness to implement new findings in one's own teaching practice according to the situation - Active constructive participation in school quality assurance and development processes STEM-Media: Whether podcasts, virtual reality glasses, wikis, chats, or shared learning platforms. Science lessons with digital media are fascinating and inspire students and teachers alike. However, modern technology must be used in a pedagogically and didactically meaningful way if it is to have a positive impact on school learning processes			

Table 4. *Cont.*

Examples of Driving Questions	How Can We Learn from Nature?	How Can Nature Impact on Our Future?	What Do You Think about Bio-Inspired and Global Warming?	How Can We Find a Solution in Nature for the Global Warming in Future?
Student requirements:	- Professional requirements: They describe the competencies that students should achieve in the respective subject and can be awarded by a STEM certificate. Subject requirements are divided into three requirement fields. Requirement field 1 represents the theoretical foundation (either two Abitur subjects at an advanced level with at least four hours per week or two advanced courses or three courses, of which at least one Abitur subject at an advanced level with at least four hours per week or one advanced course). Requirement field 3 describes all additional STEM activities in and outside of school. - Project weeks with scientific content - Working groups within the framework of the open all-day schools, for example the school pond project, the school garden project, bicycle workshop, etc. - School laboratories - Networking of student research centres - STEM Academy - Competitions (presenting their project as a team or individually)			

4. Discussion and Conclusions

The aim of this work was to share with a wide educational community the BioS4You project philosophy. As we discussed, BioS4You aims to exchange good practices and develop innovative methodologies and activities with the purpose to engage new generations in STEM topics by introducing them to the bioinspired technologies, to both the biologically inspired engineering and the scientific innovations, new treatments, technology, and processes that could make a real difference in improvement of life and environment. BioS4You project Intellectual Outputs represent an important tool to raise awareness on the environmental and on the sustainability, having an impact on learner behaviour and everyday life by connecting STEM topics to human concerns on environmental, economic, and social systems.

BioS4You-trained educators could produce a skilled scientific workforce and knowledgeable citizens who are prepared to design and choose bio-inspired products safe for human health and the environment, moving our society towards more sustainability. Bios4You-based education represents an ideal way to integrate academic disciplines, stimulate the academic and social growth of young people, and of young women in particular, and promote the conservation of the natural environment. Furthermore, bio-inspired technologies draw students toward STEM-related pathways and careers and inspire them to pursue a career or further educate in STEM fields.

The BioS4You project proposes a new and innovative way to help schools to transform their curriculum emphasising academic excellence. The implemented model can help educators to organise digital resources while designing and delivering personalised instruction in school learning environments, engaging students through the student-centred learning and personalised feedback, and share developed learning units with teachers on a European landscape. Within the BioS4You project, a European network of teachers may compare ideas, practices, and methods in order to develop innovative learning paths for students, starting on the specific themes of bio-inspired technologies, disseminate and put them into practice.

In this frame, it needs to be pointed out that a considerable amount of STEM instruction takes place in a detached laboratory setting, causing students to think of science as an entity separate from the world around them. By engaging students in place-based lessons that incorporate their local communities and environments into STEM learning, these activities build on concepts and experiences with which they are already familiar. In some cases, the activities help to develop a genuine sense of place in students who are uninterested in their locales and communities, and in others, the activities help to nurture and strengthen learners' extant connections to the community. Developing this sense of place has been found to increase interest and engagement in science among learners [42]; has been cited as important for developing a willingness and intent to change [43]; and can make science more personally relevant, especially for underrepresented groups [44]. Students glean valuable information about their community while gaining experience in research methods and the scientific method in the process. The two aspects become mutually reinforcing: the spatial element makes the STEM learning experiences relevant and helps to sustain interest and engagement while focusing on local environs through a STEM lens increases connection to the landscape.

After introducing the project BioS4You educational material as a technical learning project, the further goal to be pursued in a future study should be answering the following questions [14]:

(i) How can technology-supported learning help to move beyond content delivery and truly enhance science, technology, engineering, and mathematics (STEM) education so that students develop a broad mix of skills?
(ii) Could innovative teaching and learning approaches spark thinking and creativity, enhance student engagement, strengthen communication, and build collaboration?
(iii) Would they make STEM teaching and learning more effective, more relevant, and more enjoyable?

These educational issues will be addressed and explored in a subsequent research work by following an experimental design that tests the hypothesis regarding these research questions.

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Appendix A

List of topics in biotech innovation of interest in STEM education (as obtained by mixed working-tables—teachers and students—organised in each country by partners)

1. From Pythagorean tables to bio-inspired computing: a journey to discover biological-inspired computational algorithms.
2. From waste to clean resources: a virtuous bio-cycle for the creation of an eco-habitat.
3. Biomimicry: innovation and design inspired by Nature.
4. Bio architecture and bio-design: a multidisciplinary path across Art, Engineering and Science, driven by Nature.
5. Coronavirus emergency and biotechnology: from the thermo-scanner to the possible vaccine.
6. Home automation and bio-sustainability.
7. Bioengineering and artificial intelligence systems: what can we learn from natural behaviours?
8. From leaves photosynthesis to fuel cells.
9. Bio-inspired/smart health medicine.
10. Environmental education and biotechnology.
11. Agricultural/food education and biotechnology.

12. Marine (sea) education and biotechnology.
13. Electric and magnetic phenomena in bioengineering
14. Processing of big data, signals, and images in bioengineering.
15. Bioengineering and tools for the study and design of medical devices and systems, natural and artificial materials, fabrics, apparatuses, and agents.
16. Methods of analysis of the characteristic structure–property link of biomaterials and biomechanical structures.
17. Climate change.
18. Industry 4.0 and biotechnology.
19. Computer and information sciences (cryptology, programming, artificial intelligence, etc.).
20. Genetic engineering.
21. Neuroscience.
22. Bioengineering and Internet of Things.
23. Robotics in biotechnology field.
24. Biotechnologies driven change.
25. Game theory, Arduino, and coding.

Appendix B

List of topics in biotech innovation of interest in STEM education selected by the students.

	Selected Topics	Student Number	Percent
1	Coronavirus emergency and biotechnology: from the thermo-scanner to the possible vaccine	86	35.2
2	Computer and information sciences (cryptology, programming, artificial intelligence, etc.)	84	34.4
3	Game theory, Arduino, and coding	77	31.6
4	Neuroscience	62	25.4
5	Genetic engineering	59	24.2
6	Bioengineering and artificial intelligence systems: what can we learn from natural behaviours?	58	23.8
7	Robotics in biotechnology field	57	30
8	Marine (sea) education and biotechnology	57	28
9	Bio-inspired/smart health medicine	56	23
10	Home automation and bio-sustainability	55	22.5
11	Climate change	53	21.7
12	From waste to clean resources: a virtuous bio-cycle for the creation of an eco-habitat	50	20.5
13	Electric and magnetic phenomena in Bioengineering	48	19.7
14	Biomimicry: innovation and design inspired by Nature	47	19.3
15	Environmental education and biotechnology	41	16.8

Appendix C

List of topics in biotech innovation of interest in STEM education selected by the teachers.

	Selected Topics	Teacher Number	Percent
1	Climate change	18	36
2	Robotics in biotechnology field	17	34
3	Coronavirus emergency and biotechnology: from the thermo-scanner to the possible vaccine	16	32
4	Computer and information sciences (cryptology, programming, artificial intelligence, etc.)	16	32
5	From waste to clean resources: a virtuous bio-cycle for the creation of an eco-habitat	15	30
6	Biomimicry: innovation and design inspired by Nature	15	30
7	Game theory, Arduino, and coding	15	30
8	Bioengineering and artificial intelligence systems: what can we learn from natural behaviours?	14	28
9	Environmental education and biotechnology	13	26
10	Home automation and bio-sustainability	12	24
11	Electric and magnetic phenomena in bioengineering	12	24
12	Genetic engineering	9	18
13	Neuroscience	9	18
14	Bioengineering and Internet of Things	8	16
15	Bio-architecture and bio-design: a multidisciplinary path across Art, Engineering and Science, driven by Nature	8	16
16	Processing of big data, signals, and images in bioengineering	8	16

References

1. NSF Report. *Shaping the Future: New Expectations for Undergraduate Radication in Science, Mathematics, Engineering, and Technology*; Education and Human Resources Directorate: Washington, DC, USA, 1996; pp. 96–139.
2. Altbach, P.G.; Reisberg, L.; Rumbley, L. Trends in global higher education: Tracking an academic revolution. In *Report for the UNESCO 2009 World Conference on Higher Education*; UNESCO: Paris, France, 2009; pp. 113–121.
3. Alizadeh, M.; Parmelee, D.; Overman, I.; AlJasem, M. Preparing learners for learning in the engaged learning classroom. *MedEdPublish* **2019**, *8*. Available online: https://corescholar.libraries.wright.edu/med_education/100 (accessed on 15 October 2021). [CrossRef]
4. Roche, J.; Murphy, C. Changing Values in Science Education and the Emergence of Science Gallery. In *Values in Science Education*; Springer: Cham, Switzerland, 2020; pp. 91–104.
5. Cedere, D.; Birzina, R.; Pigozne, T.; Vasilevskaya, E. Perceptions of today's young generation about meaningful learning of STEM. *Probl. Educ. 21st Century* **2020**, *78*, 920. [CrossRef]
6. Pizzolato, N.; Persano Adorno, D. Informal physics teaching for a better society: A mooc-based and context-driven experience on learning radioactivity. *J. Phys. Conf. Ser.* **2020**, *1512*, 012040. [CrossRef]
7. Kelley, T.R.; Knowles, J.G.; Han, J.; Trice, A.N. Models of Integrated STEM Education. *J. STEM Educ. Innov. Res.* **2021**, 22.
8. Moore, K.; Jones, C.; Frazier, R.S. Engineering Education for Generation Z. *Am. J. Eng. Educ.* **2017**, *8*, 111. [CrossRef]
9. Miller, A.C.; Mills, B. If They Don't Care, I Don't Care: Millennial and Generation Z Students and the Impact of Faculty Caring. *J. Scholarsh. Teach. Learn.* **2019**, *19*, 78–89. [CrossRef]
10. Hernández de Menéndez, M.; Escobar, C.A.; Morales-Menendez, R. Educational experiences with Generation Z. *Int. J. Interact. Des. Manuf.* **2020**, *14*, 847–859. [CrossRef]
11. Shuell, T.J. Learning theories and educational paradigms. In *International Encyclopedia of the Social and Behavioural Sciences*; Baltes, P.B., Ed.; Elsevier: Oxford, UK, 2001; pp. 8613–8620.
12. Canbazoğlu Bilici, S.; Küpeli, M.A.; Guzey, S.S. Inspired by nature: An engineering design-based biomimicry activity. *Sci. Act.* **2021**, *58*, 77–88.
13. Snell-Rood, E.C.; Smirnoff, D.; Cantrell, H.; Chapman, K.; Kirscht, E.; Stretch, E. Bioinspiration as a method of problem-based STEM education: A case study with a class structured around the COVID-19 crisis. *Ecol. Evol.* **2021**. [CrossRef]
14. Kärkkäinen, K.; Vincent-Lancrin, S. *Sparking Innovation in STEM Education with Technology and Collaboration: A Case Study of the HP Catalyst Initiative*; OECD Education Working Papers 2013, No. 91; OECD Publishing: Paris, France, 2013. [CrossRef]
15. Landøy, A.; Popa, D.; Repanovici, A. Teaching Learning Methods. In *Collaboration in Designing a Pedagogical Approach in Information Literacy*; Springer Texts in Education; Springer: Cham, Switzerland, 2020. [CrossRef]
16. Cerghit, I. *Metode de Învățământ*; Editura Polirom: Iaşi, Romania, 2006.

17. Palmberg, I.; Berg, I.; Jeronen, E.; Kärkkäinen, S.; Norrgård-Sillanpää, P.; Persson, C.; Vilkonis, R.; Yli-Panula, E. Nordic–Baltic student teachers' identification of and interest in plant and animal species: The importance of species identification and biodiversity for sustainable development. *JSTE* **2015**, *26*, 549–571. [CrossRef]
18. 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]
19. Maina, F.W. Authentic learning: Perspectives from contemporary educators. *J. Authentic Learn.* **2004**, *1*, 1–8.
20. Spörhase, U. Welche allgemeinen Ziele verfolgt Biologieunterricht. In *Biologie Didaktik, Praxishandbuch fur die Sekundarstufe I und II*, 5th ed.; Spörhase, U., Ed.; Cornelsen Verlag: Berlin, Germany, 2012; pp. 24–61.
21. Ehmer, M. Förderung von Kognitiven Fähigkeiten Beim Experimentieren Im Biologieunterrichtder 6. Klasse: Eine Untersuchung zur Wirksamkeit von Methodischem, Epistemologischem und Negativem Wissen [Promoting Cognitive Abilities with Experimenttion in Grade Six BiologyTeaching. An Investigation of the Effectiveness of Methodological, Epistemological, and NegativeKnowledge]. Ph.D. Thesis, University of Kiel, Kiel, Germany, 11 July 2008.
22. Hof, S. Wissenschaftsmethodischer Kompetenzerwerb durch Forschendes Lernen. Entwicklung und Evaluation einer Interventionsstudie [Science Methodical Acquisition of Competency by Inquiry Based Learning. Development and Evaluation of an Intervention Study]. Ph.D. Thesis, Universität Kassel, Kassel, Germany, 2011.
23. Kirschner, P.A.; Sweller, J.; Clark, R.E. Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educ. Psychol.* **2006**, *41*, 75–86. [CrossRef]
24. Akınoğlu, O.; Tandoğan, R.Ö. The Effects of problem-based active learning in science education. *Eurasia J. Math. Sci. Technol. Educ.* **2007**, *3*, 71–81. [CrossRef]
25. Persano Adorno, D.; Bellomonte, L. Active learning in a real-world bioengineering problem: A pilot-study on ophthalmologic data processing. *Comput. Appl. Eng. Educ.* **2019**, *27*, 485–499. [CrossRef]
26. Persano Adorno, D. Inquiry-based Environments for Bio-Signal Processing Training in Engineering Education. *Int. J. Mech. Eng. Educ.* **2021**, 03064190211026207. [CrossRef]
27. Asyari, M.; Al Muhdhar, M.H.I.; Ibrohim, S.H. Improving critical thinking skills through the integration of problem-based learning and group investigation. *Int. J. Lesson Learn. Stud.* **2016**, *5*, 36–44. [CrossRef]
28. Hart, P.; Nolan, K. A critical analysis of research in environmental education. *Stud. Sci. Educ.* **1999**, *34*, 1–69. [CrossRef]
29. Persano Adorno, D. The BioS4You project: How Science Education can enhance student capacity to be participatory citizens in a transforming world. In Proceedings of the XIX IOSTE SYMPOSIUM: Transforming Science & Technology Education to Cultivate Participatory Citizens, Daegu, Korea, 1–5 February 2021. Online.
30. Board of Science Education. *How People Learn 2: Learners, Contexts, Cultures*; National Academy Press: Washington, DC, USA, 2018; ISBN 978-0-309-45964-8. [CrossRef]
31. Pauls, S. Biomimicry a "natural lesson" in STEAM. *STEAM J.* **2017**, *3*, 33. [CrossRef]
32. Chongsrid, R. Biomimicry: An Approach for Innovative STEM Projects in High School. In *Conference Proceedings. New Perspectives in Science Education*; libreriauniversitaria. it Edizioni; Pixel: Padova, Italy, 2017; p. 362.
33. Nagel, J.K.; Rose, C.; Beverly, C.; Pidaparti, R. Bio-inspired design pedagogy in engineering. *Des. Educ. Today* **2019**, 149–178.
34. Sanne, F.; Risheim, I.; Impelluso, T.J. Inspiring Engineering in the K12: Biomimicry as a Bridge between Math and Biology. In *ASME International Mechanical Engineering Congress and Exposition*; American Society of Mechanical Engineers: New York, NY, USA, 2019; Volume 59421, p. V005T07A015.
35. Gencer, A.S.; Doğan, H.; Bilen, K. Developing biomimicry STEM activity by querying the relationship between structure and function in organisms. *Turk. J. Educ.* **2020**, *9*, 64–105.
36. Fried, E.; Martin, A.; Esler, A.; Tran, A.; Corwin, L. Design-based learning for a sustainable future: Student outcomes resulting from a biomimicry curriculum in an evolution course. *Evol. Educ. Outreach* **2020**, *13*, 1–22. [CrossRef]
37. Coban, M.; Coştu, B. Integration of biomimicry into science education: Biomimicry teaching approach. *J. Biol. Educ.* **2021**, 1–25. [CrossRef]
38. Stevens, L.; de Vries, M.; Mulder, K.; Kopnina, H. Biomimicry education as a vehicle for circular design. In *Circular Economy*; Routledge: Abingdon-on-Thames, UK, 2021; pp. 174–198.
39. Biomimicry Institute. *Sharing Biomimicry with Young People an Orientation for K-12 Teachers*. 2017. Available online: www.Biomimicry.org (accessed on 15 October 2021).
40. Vincent, J.F.V. Biomimetics—A review. *Proc. Inst. Mech. Eng. Part H J. Eng. Med.* **2009**, *223*, 919–939. [CrossRef] [PubMed]
41. Santulli, C.; Langella, C. Introducing students to bio-inspiration and biomimetic design: A workshop experience. *Int. J. Technol. Des. Educ.* **2010**, *21*, 471–485. [CrossRef]
42. Gruenewald, D. Teaching and learning with Thoreau: Honoring critique, experimentation, wholeness and the places where we live. *Harv. Educ. Rev.* **2002**, *72*, 515–554. [CrossRef]
43. Krasny, M.; Tidball, K. Community gardens as context for science, stewardship and advocacy learning. *Cities Environ.* **2009**, *2*, 1–18. [CrossRef]
44. Calabrese Barton, A.; Berchini, C. Becoming an insider: Teaching science in urban settings. *Theory Into Pract.* **2013**, *52*, 21–27. [CrossRef]