COMMUNITY SCIENCE PROJECTS TRAINING TOOL-KIT

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Community Science Projects Training Toolkit

Prepared by the Open: Wide Minds will Find Eco Virtual STEAM Solutions towards Climate change! (Wi-Mi) consortium.

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Wi-Mi wants to promote virtual cooperation, collaboration, and communication culture amongst students, teachers, schools, associations, and further multipliers to fight against climate change and strengthen the profiles of these entities.

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1. Introduction

In our rapidly evolving global landscape, cultivating a profound understanding of climate change among young learners is not just a pedagogical necessity but an ethical imperative. This introduction unveils a comprehensive and expansive toolkit meticulously crafted for primary school educators, harnessing the transformative potential of STEAM education (Science, Technology, Engineering, Arts, and Mathematics) to instill environmental consciousness and activism. As we embark on a detailed exploration of the toolkit's various facets, we will underscore the importance of each section, drawing connections between the theoretical frameworks and practical, real-world applications.

The heightened likelihood of conflicts stemming from human-induced climate change, characterized by a rise in the occurrence and the exacerbation of disparities in natural resource distribution, is perceived as a significant security concern by numerous communities. To comprehensively address this issue, multidisciplinary perspectives and approaches, integral to the nature of STEAM, play a vital role in fostering awareness. These approaches can be broadly employed across the extended timeline of history, enabling an exploration of the intricate relationship between humanity and the environment, delving into both the impact humans have had on the environment and the reciprocal effects on human societies (Ludlow & Travis, 2018).

In Europe, STEAM practices are getting more advanced, and groups of schools and teachers with a lot of experience are looking closely at how they work, especially when it comes to things like climate change and big arts/science education projects. As we mentioned earlier, research should focus on helping teachers and students get better at using digital STEAM methods. We also need to think about how going digital might make it harder for schools and students who don't have a lot of money to access these activities. This became really clear during the Covid-19 pandemic, especially when it came to getting basic access to technology (Chappel & Herherington, 2023).

In general, the main skills that STEAM skills and activities bring to their beneficiaries can be categorised as follows (Hurlet & Roche, 2023):

Exploratory practices	Meaning-Making Practices	Critiquing practices
• Noticing and questioning • Exploring materiality • Defining the problem space	• Producing tentative representations • Conducting principled iterations or revisions • Engaging multiple modalities • Finding relevance	• Critical historicity; Hacking the ideas of others • Cultivating dissent • Holding commitments to the standards of the field • Sharing results/"audiencing"

In the realm of climate change education, the NFL model emerges as a beacon of innovation. By intricately weaving together the principles of STEAM education and Community Science Projects, "**NFL Learning and Teaching Model in Climate Change Education Adapted STEAM and Community Science Projects**" section seeks to redefine the learning experience. Professional examples will illuminate instances where this model has been successfully employed, demonstrating its efficacy in cultivating not just knowledge but a profound sense of environmental stewardship among young minds.

The evolution of educational methodologies is evident in the paradigm shift towards blended/hybrid learning approaches. "**Blended/Hybrid Learning and Teaching Approaches, STEAM Integration and Community Science Projects to Fight Against Climate Change**" delves into the strategic integration of STEAM principles and Community Science Projects, showcasing professional examples that highlight the successful fusion of technology and experiential learning. These examples serve as practical blueprints, illustrating how educators can seamlessly incorporate these approaches into their classrooms to enhance climate change education.

Nature, with its inherent capacity to captivate and educate, becomes a powerful ally in the fight against climate change. "**Natural and Adventure-Based Learning to Fight Against Climate Change**" section explores how natural and adventure-based learning experiences can be harnessed to create lasting impressions on young minds. Through professional examples, we will demonstrate the tangible impact of outdoor education in fostering a deep connection between students and their environment, transcending traditional classroom boundaries.

Empowering students to not just understand but actively address climate change is a cornerstone of the toolkit's philosophy. The integration of STEAM activism becomes a powerful catalyst for change. Professional examples will spotlight instances where students, armed with STEAM principles, have become agents of positive environmental transformation. These examples about **STEAM Activism and Climate Change Education** will elucidate the impact of student-led initiatives in addressing climate change on both local and global scales.

The toolkit recognizes that addressing climate change requires more than just knowledge; it demands the development of critical skills. "**21st Century Skills Development Strategies and Tools through the Use of STEAM and CSPs**" section explores how STEAM and Community Science Projects contribute to the development of 21st-century skills such as critical thinking, problem-solving, creativity, analysis, analytical thinking, design, and effective communication. Professional examples will showcase the tangible benefits of integrating these skills into climate change education, preparing students for the challenges of a rapidly evolving world.

Moving beyond theoretical concepts, the toolkit offers practical visual tools. **Visual Tools for Analyzing and Managing Environmental Behavior Patterns** will enable users to analyze and manage individual and organizational environmental behavior patterns. Drawing from professional examples, this section will illustrate how these tools serve

as invaluable instruments for educators, providing a structured framework to assess and modify environmental behaviors.

The toolkit's final section serves as a repository of **Environmental Tips with Authentic Examples.** These real-life instances offer practical suggestions for teachers, drawn from successful cases of addressing environmental problems. By grounding advice in professional examples, this section becomes a rich resource for educators, offering insights into effective strategies for fostering environmental responsibility in students.

In essence, this comprehensive toolkit transcends traditional pedagogical boundaries, offering primary school teachers a multifaceted approach to climate change education. By infusing STEAM principles and drawing from professional examples, the toolkit becomes a dynamic and practical resource, empowering educators to shape environmentally conscious citizens who are not only knowledgeable about climate change but actively engaged in its mitigation. As we navigate this extensive exploration, the toolkit emerges not just as an instructional guide but as a transformative force in cultivating a generation of environmentally literate and proactive global citizens.

2. NFL learning and teaching model in climate change education adapted STEAM and Community Science Projects

2.1. Introduction

Introduction Non-formal education is the learning process that occurs outside the traditional education system, that is, it involves activities organized outside the formal system, in a holistic and sociocultural dimension, being a complement to it. In this sense, students experience different information, realities and supports and can develop their autonomy in accessing information and its systematization. It is, therefore, a structured and planned process, centered on the student, which must consider their profile, with the mission of making them autonomous and participating in social life. In this way, the student assumes a central role, becoming an active subject in the development of their learning.

This chapter aims to show a teaching and learning model in non-formal education about climate change adapted to STEAM projects and Community Science Projects, developed with students from 10 to 14 years old.

Activity proposal: Construction of a model of a green and smart city.

2.2. Community Science Projects

Project based learning (PBL), research and action allows students to solve concrete problems and involve the school community, while enabling learning.

It is also important to highlight the importance of action partnerships between the school and the community. From an interdisciplinary perspective, students should be guided to:

- View videos about environmental problems and develop debates to exchange ideas, raise awareness, raise awareness, and encourage active citizenship.
- Research lifestyles (transport, clothing, food…) and environmental degradation in the region where they live.
- Identify environmental problems in the region where they live by identifying the ecological costs of modern economic growth.
- Present solutions to the problems listed.
- Construction of a model of a green and smart city.

2.3. Examples of Activity Plans For Climate Change Education

a. The problem of climate change and social change

With this activity, students could develop environmental and social awareness, explain some dimensions of the problem of climate change, relate social action and solving the problem of climate change, identify new forms of social action linked to the problem under analysis and identify factors of resistance to change.

For that, students will work with desk research, interviews/surveys and at the end there will be a debate.

All the activity is developed in the subjects of Sciences, Mathematics and Technological Education.

Tasks:

- Research on the problem of climate change and the social actions developed in the city/country/in the world**.**
- Prepare an interview guide or questionnaire to apply in: companies, city council, organizations, and school.
- Analyse the information collected.
- Draw conclusions.
- Present the results of the work to the class in PowerPoint, for example.

- Discuss the problem of climate change and social change.
- Recording the findings.
- Make a proposal for behaviour change.
- Publish the findings on the school's website.

b. The Sustainable Development Goals in the municipality

Students will work in groups and must choose one of the topics to investigate:

- Environmental problems present in the municipality, what possible solutions?
- Economic problems present in the municipality, what possible solutions?
- Social problems present in the municipality, what possible solutions?

Then, they will collect information on one of the selected aspects (e.g. photographic survey, desk research, survey application); they will conduct documentary research on the implementation of the 2030 agenda and the Sustainable Development Goals in the municipality, accompanied by an interview with a representative of the municipality and they will Proceed with the selection and processing of the information collected. After that work, students will present the products obtained to the class, followed by discussion and synthesis of the conclusions and then there will be a dissemination of the products obtained to the school community, for example, through the class blog.

This work aims to raise awareness among the school community about the importance of the 2030 Agenda, to disseminate to the school community the progress regarding sustainable development in the municipality and to make students aware of the implementation of the 2030 Agenda in the municipality where the school is located.

2.4. Interactive Learning

Working with projects breaks with the more classic teaching approach, characterized by being linear and unidirectional, little interactive and with little stimulus for students. The Project Work Methodology places the student at the center of learning, unlike

what happens in traditional teaching, in which the student is a mere recipient of content. For this reason, it becomes increasingly important to give students the opportunity to build their knowledge, and teachers need to find strategies that meet the motivations and interests of their students. The project work methodology is considered a pedagogical approach, which promotes the active participation of students by involving them in an in-depth study of a given theme or topic. It is, therefore, centered on students, promoting their total involvement, and giving greater meaning to learning spaces. In this sense, work cannot be imposed on students, as only then will there be active and motivated adherence and participation on the part of everyone, promoting the acquisition of new learning. This approach is a work method that requires the participation of each member of a group, according to their capabilities, with the aim of carrying out joint work, decided, planned and organized by mutual agreement. As this methodology promotes collaborative work between students and teachers, some benefits associated with educational practice stand out, namely, teamwork to reach a final objective, increased student responsibility, conflict management, cooperation and autonomy, enabling the construction of learning at the same time. The use of this methodology correlates with non-formal learning environments. These environments represent spaces that include various activities favorable to the acquisition of knowledge and development of practices in the teaching-learning process and point to the multiplicity of areas and forms of learning available, outside the formal education system. In teaching, a project is a work methodology that has research as its starting point and, consequently, leads to the acquisition of knowledge. Basically, it is important to highlight that the project work methodology presupposes that students become increasingly autonomous, that they carry out certain tasks on their own and that they develop their critical capacity regarding their paths and their learning.

a. Outdoor Education: Study Visit

In order to integrate and develop learning process in outdoor activities and in contact with the community, students will be in touch with the Sustainable Development Goals and with Some solutions to environmental problems.

For that, students will have the opportunity to develop environmental and social awareness; to know possible actions taken by companies in the defense of the environment; to understand the importance of business development in the implementation of the SDGs at the local level, to collect information for group work; and to promote the spirit of observation.

All the activity is developed in the articulation with the subjects of Sciences, Mathematics and Technological Education.

b. Questionnaire

1. Identify

1.1. The name of the company

1.2. The industry to which the company belongs.

1.3. The main activity carried out by the company.

1.4. The number of employees in the company.

1.5. Other relevant data

2. Does the company use (produce or market) eco-friendly products?

3. What is the destination of the company's waste from its main activity?

4. What is the concern with energy efficiency? What type of energy is most used by the company? How do you heat the premises?

5. What is the concern about water consumption? And how do you manage it?

6. What are the concerns about the recycling of office supplies (computers, photocopiers, telephones, paper, ink cartridges, plastic packaging...)? And what are the concerns about reducing, reusing, and recovering?

7. Does the company encourage its employees to share transport to the company with each other?

8. Does the company encourage its employees to make a sustainable transition?

2.5. Assessment and Evaluation

Assessment is an essential component of the educational system and one of the key points that regulates the teaching and learning process of students. It is a moment and an opportunity to check whether students managed to achieve the defined goals and allow a new direction to pedagogical actions so that the objectives are achieved. The interaction established between the teacher and the student motivates them to make efforts and surpass themselves to develop their learning. Assessment must be continuous, diverse, and integrated into the development of activities and requires monitoring of the student at different moments of the educational process.

Initial moment – the diagnostic assessment must inform about the sociocultural diversity of the students, as well as the different styles and ways of learning – questionnaire in Forms.

Intermediate moments – formative assessment should provide feedback on students' progress, helping to understand each student's needs – using Kahoot.

Final moment – the summative assessment, to be formalized at the end of the project, should result from the analysis of performance levels, considering the processes and products resulting from the learning experiences.

In addition to assessing knowledge, particular attention must be paid to the skills, attitudes and values demonstrated throughout the work carried out. The assessment must also consider elements relating to the civic, cultural, and social involvement and participation of students in the educational community. - Verification of knowledge through a teacher made questionnaire.

2.6. Accessibility and Inclusivity

Nowadays, it seems consensual to understand that children learn in different ways and at different rates. Some learn faster than others, some learn better with the expository method, others achieve it with other, more self-directed methodologies. Since this diversity is the nature of a teacher's group, it is important to consider that the school must value the student's much knowledge, providing them with activities and strategies that highlight their real potential, allowing them to acquire learning in the most effective way, according to your style. Centering the teaching and learning process on the student, pedagogical differentiation constitutes the appropriate response to the requests that the heterogeneity of students who attend school today requires. To this end, it is during the teaching and learning process that it makes sense to think about adapting to the characteristics of the different participants in the educational process, carrying out reflective and flexible management, which bears in mind that students do not all learn in the same way, nor that their difficulties and interests are the same. This humanistic and democratic approach sees and understands the individual and their singularities, to develop responses to their personal needs and their needs as an individual and active citizen in the social sphere. Within this framework, the entire teaching and learning process must be thought out, considering the specificities of each child and their capabilities, trying to reach everyone indiscriminately.

2.7. Sustainability

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, and which officially came into force in 2016, defines the priorities and aspirations of global sustainable development for 2030 and seeks to mobilize global efforts around a set of common objectives and goals. The specific objective on climate action (SDG 13) refers to the urgency of adopting measures to combat climate change and its impacts. This objective highlights the importance of improving education,

increasing awareness and human and institutional capacity on mitigation, adaptation, impact reduction and early warning measures regarding climate change.

There are several environmental problems in today's world caused by the increasing pressure exerted by human beings, but if we are the origin of the problem, we are also the origin of the solution.

The environmental issue concerns all of us, which is why it is necessary to join forces – citizens, companies, schools, the State – to find the path of sustainability and leave a planet in good living conditions as a legacy to future generations. For this to be possible, students must become aware of the impact that their behaviors may have on changes in the environment. This sensitization and consequent change may be possible by putting into practice field classes and the development of projects in the community.

Thus, in groups, students can:

- explore the 17 sustainable development goals in order to learn about the various goals established by the 2030 agenda with a view to promoting sustainable and supportive human development.
- research relevant information about concrete strategies to achieve the SDGs.
- observe images to make students reflect on the problems of human development that arise on a global scale.
- investigate environmental problems with global impact, such as disturbances caused by the natural greenhouse effect, the reduction in the thickness of the ozone layer, the reduction of biodiversity, among others, anchored in work guides prepared by the teacher and in interdisciplinary coordination.

2.8. Feedback Mechanism

In education, the term feedback is used to designate a complex set of components that relate to different procedures, whose presence and complementarity become

indispensable to achieve a real effect on the improvement of students' learning. It is one of the core and most powerful skills that the teacher must master to ensure a formative assessment with a positive impact on students learning: on the one hand, on the cognitive level, it provides students with the information they need to understand where they are and what they need to do next; On the other hand, on the motivational level, it develops a feeling of control over its own learning and, therefore, increases the degree of involvement of students through increasingly effective processes of self-regulation. In other words, it is the response that is given to the student in the face of a performance, or a work carried out (e.g. test, portfolio, project work, oral presentation). From this point of view, feedback focuses on the different ways in which students evidence their learning and materializes in the provision of useful and pertinent information related to the defined objectives. Feedback is, therefore, information (oral or written, as we will see below) that results from the evaluation of students' progress and, consequently, suggests the actions they should take to achieve the intended objectives.

To be consistent, feedback demand that the teacher is available to create new possibilities for learning and highlighting them, otherwise its main purpose would be seriously compromised. When a teacher gives feedback to the student, the student trusts and has the legitimate hope that, in their learning journey, there will be other opportunities to apply the information they have received. In this context, the following activities and tools can be used to develop this stage of self-awareness of learning:

Quizizz

Digital mural (Padlet, Wakelet) where students present results of actions carried out with information in diverse media (images, videos, audio, texts...)

3. Blended/Hybrid Learning and Teaching Approaches, STEAM Integration and Community Science Projects to fight against climate change

3.1. Introduction

Traditional classrooms are no longer the only places of learning. Educators and institutions worldwide are embracing blended and hybrid learning as a flexible and dynamic approach to education. The confines of traditional classrooms are a thing of the past. Educators and institutions all over the world are breaking boundaries with blended and hybrid learning, a dynamic and adaptable approach to education. A recent global surveys unveiled a fascinating trend that more than 35% of students now desire a perfect blend of in-person and online learning.

Climate change forces all educational institutions to reconsider their traditional ways of teaching and organizing education. This implies that they should reduce their impact on the environment and provide sustainability-oriented education. Blended and hybrid learning (fusion of on-site and online learning) may provide an appealing solution to achieve both objectives. It may reduce climate impact by reducing student travel to and from institutions and support the development of students' sustainability competencies.

The acronym of STEAM stands for Science, Technology, Engineering, Arts and Mathematics, and it refers to the study and education of these subjects and related fields. Climate change is perhaps the greatest challenge human beings have ever faced. In order to overcome it we require a generation of scientists, inventors and creative thinkers. And for that we need STEAM education in schools. Children who learn about sustainable development and green technology from an early age will eventually grow up to implement them.

Also Community science projects in schools are an important tool in teaching and addressing climate change. They allow students to actively engage in and contribute to scientific research that can help us better understand the impacts of climate change on our communities and the environment because they require interdisciplinary collaboration between science, technology, engineering, art, and mathematics, providing students with opportunities to develop a wide range of skills and knowledge and expand their interdisciplinary skills to contribute to solutions.

3.2. Hybrid and Blended Learning Strategies

The way we learn has changed in increments for decades, but it's really just in the past few years that the majority of people have really started to take notice. The ease of new technology, the availability of resources and being forced to stay at home is driving this learning evolution. There's also a good amount of confusion regarding what these new learning methods actually are. Two effective methods of learning that have puzzled people are hybrid learning and blended learning. As with many terms used in e-learning, blended and hybrid learning are not used to mean the same thing.

- Hybrid learning is an educational approach where some individuals participate in person and some participate online. Instructors and facilitators teach remote and in-person learners at the same time using technology like video conferencing.
- With blended learning, instructors and facilitators combine in-person instruction with online learning activities. Learners complete some components online and do others in person.

Both types of learning involve a mix of in-person and online learning, but who differs in the two scenarios. With hybrid learning, the in-person learners and the online learners are different individuals. With blended learning, the same individuals learn both in person and online.

It's important to note that the teacher in hybrid learning is providing instruction to their in-person and virtual learners at the same time — virtual learners aren't watching recordings or participating on their own time. To teach remote and in-person at the same time, the instructor will employ video conferencing tools to assist the virtual learners. To ensure everyone has the same opportunity to get the most out of the course, hybrid classes need to be well thought out in advance, especially having a strong wifi connection and the right technology to support the session.

The online components of hybrid learning are designed to replace face-to-face classroom time without losing the appeal and effectiveness of in-person learning. The remote students should still have the opportunity to interact with the teacher and the rest of the students in the class, and the synchronous design of hybrid learning allows them to do just that.

Blended learning is a bit more understood, in a universal sense, than hybrid learning, because we've been doing it on a larger scale for much longer. Blended learning starts with the classic, in-person learning, then supplementing the time students spend in a physical classroom with online learning material. This combination of physical classroom attendance and tech-driven, online learning goes a long way toward engaging learners of all types along the multimodal learning spectrum.

The in-person classroom setting of blended learning is where your learners can gain valuable experience from face-to-face feedback, as well as work with you during hands-on training exercises or in role-playing opportunities.

The online portions of these classrooms are becoming more interactive as the average person becomes more comfortable with more advanced content creation, like video and audio. The course content comes in many forms, such as an online activity that needs to be completed or a well-reviewed instructional video, or reading materials, games, quizzes and more. Whether passive learning or interactive experiences, the

online learning aspect of blended learning gifts personalized educational opportunities to students in a manner that is self-paced.

Blended and hybrid learning share some key elements, and at face value, they don't sound all that different from each other. In fact, the two terms are frequently — and mistakenly — used in place of each other. And that confusion is understandable. Both take advantage of the benefits of in-person learning, as well as technological advancements that enable online learning. The main difference between the two is the manner in which in-person and online learning are used.

In hybrid learning models, the in-person attendees and the remote learners are all experiencing the same class at the same time. The instructor teaches them all at once, and the video conferencing technology is used to ensure the remote learners are receiving the same experience as the in-class learners.

Blended learning, on the other hand, finds all learners attending in person. The online portion, of course, is designed by the instructor to be supplemental — it's a way for students to learn on their own away from the classroom setting.

Essentially, hybrid learning is designed to maintain an equilibrium between online and offline learning, while blended learning is designed to give in-person students online material to complement their in-class experience.

To see the difference here are two examples of both blended and hybrid learning:

Blended learning:

- Before attending a class about engaging in difficult conversations, learners are asked to view a video on body language.
- Once they complete a self-paced online module on design thinking, learners are paired with a mentor who oversees their work on a pitch for a new product idea, before they regroup in an online meeting to debrief what they learned through the project.

Hybrid learning:

- At the annual conference, roughly 80 percent of registrants watch the keynoter from seats in front of the stage in the hotel ballroom, while the others catch her remarks via a livestream.
- The facilitator moves through the exam prep content, answering questions from learners raising their hands in the classroom and from learners submitting questions through online video conferencing software.

Benefits of Hybrid and Blended Learning

Both hybrid learning and blended learning come with their own benefits, which should be fully explored and understood in order to determine the way you want to design your specific learning process.

Benefits of Hybrid Learning

Ease of Accessibility: Because hybrid learning gives in-person and remote learners equal access to the class, more people have the opportunity to engage in the curriculum. If a person can physically attend, then great. But if location, illness or personal circumstances make it impossible for a learner to attend in person, they can still get the full experience by attending online.

Lower Cost: It can be expensive to logistically get all of your customers, employees, or partners into one place at the same time. Hybrid learning reduces costs by eliminating travel expenses, printed materials and more, allowing you to maximize the provided learning experience while staying on budget.

Health & Wellness Safety: If a student is ill, or they fear for their health due to something like, say … a global pandemic, the hybrid model allows them the opportunity to still attend class along with their fellow learners without putting their wellness or personal safety at risk.

Benefits of Blended Learning

Easily Incorporate Multimodal Learning: Not everyone prefers to learn in the same way. Some thrive with visual information. Others do best when listening. Some excel through reading and writing exercises. Still, other people do their best when given a hands-on learning environment. A blended learning course allows a teacher to prepare sessions that cater to all these things, ensuring each person is given the type of instruction they need to do their best.

Personalization: While all learners in a blended course get the same instruction during their in-person meetings, the instructor can customize (or give options for) the online exercises and activities to best meet the learning needs of the different students.

Improved Engagement: We live in a technological world, and giving access to information through different technological means has been shown to drive engagement.

Hybrid vs Blended Learning: Which to Use and When

The choice between hybrid and blended learning depends on various factors, including the learning objectives, the nature of the course, and the needs of the students.

Hybrid learning is best used when you need a mix of in-person and virtual interaction. It's suitable for courses where real-time communication and simultaneous instruction are important. On the other hand we should choose blended learning for courses that benefit from a balance of self-paced online content and in-person interactions. It's excellent for subjects where students require hands-on training or have diverse learning preferences.

As a general rule, Hybrid learning is better suited to formal education. Blended learning is more flexible and adaptable, in addition to being used in formal education it is a great choice for professional development, micro-skills, an alternative to webinars, and most modern learning situations.

Hybrid and Blended Learning in Climate change education

Teaching Climate Change's concepts are hard and challenging to impress in the minds of younger learners in a traditional classroom environment. Designing appropriate instructional strategies with the best visual experiences enable learners to grasp the complex principle behind the concept and stimulate their interest.

Several studies were conducted to explore views on learning Climate Change with a blended/hybrid learning approach. An active participation of the learners during the face-to-face session demonstrated that through blended learning, they had a clearer understanding and they appreciated the concept with a larger improvement in learners performance. Hence, this active and constructive learning strategy encouraged collaboration and cooperation, and celebrated the autonomy of the learners. Moreover, learners were motivated to take action and address problems in the community, developing their civic responsibility for sustainable development.

3.3. STEAM Integration in Hybrid/Blended Learning

The world is facing complex challenges, from climate change and resource scarcity to pandemics and technological disruption. To navigate these challenges, we need a generation equipped with not just scientific knowledge but also the ability to apply it creatively and collaboratively to solve real-world problems. This is where STEAM education comes in, and blended or hybrid learning has emerged as a powerful tool to enhance its effectiveness.

In a world driven by innovation, teachers are turning to blended or hybrid learning as a powerful tool to equip students with the critical thinking and problem-solving skills they need to tackle 21st-century challenges. This model, seamlessly merging online and offline learning activities, is revolutionizing STEAM education by immersing students in authentic problem-solving scenarios and fostering a passion for real-world impact.

Blended and hybrid learning combines the strengths of traditional classroom instruction with the flexibility and personalization of online learning. Students engage in face-to-face interactions with teachers while also exploring concepts and applying skills through online activities, simulations, and projects. This dynamic approach caters to diverse learning styles and paces, fostering deeper understanding and a more active learning environment.

Here's why it works for STEAM education:

a. Real-World Problem-Solving

Blended learning facilitates project-based learning, where students tackle authentic challenges that connect STEAM concepts to real-world applications. This could involve designing earthquake-resistant structures, building solar-powered cars, or analysing local environmental data. After conducting a meta-analysis of 66 empirical research papers, researchers found that the project-based learning intervention is known to improve students' learning outcomes and has a profound impact on engineering and technology disciplines.

b. Active Learning and Collaboration

Online platforms provide opportunities for individual exploration and practice, while classroom sessions allow for collaboration, discussion, and teacher guidance. This combination promotes critical thinking, communication, and teamwork – crucial skills for future STEAM professionals. It has also been found that a combination of digital technology and collaborative tools in a blended learning environment acts as a facilitator, mediator, and results-oriented framework.

c. Personalized Learning

Blended learning allows for differentiated instruction, tailoring the learning experience to individual student needs and learning styles. Online resources and live solutions can

offer adaptive learning paths, remedial activities, and additional challenges, ensuring each student progresses at their own pace.

d. Engaging Technology

Blended learning leverages the power of technology to engage students and make learning more interactive. Virtual labs, simulations, and immersive experiences bring STEAM concepts to life, fostering curiosity and a desire to explore further. The STEAM (Science, Technology, Engineering, Arts and Mathematics) approach with blended learning has one major advantage - an intriguing learning strategy to teach children how to reason logically before having them solve actual world problems and master technology.

Illustrative Examples of Blended Learning in Action

Here are some examples of how blended learning can engage students in real-world problem-solving:

a. Engineering Earthquake-Proof Structures

Imagine students collaborating in a virtual lab, testing different building materials and designs using simulations of earthquake tremors. They can then build and test miniature structures in the classroom, comparing their virtual models with real-world results. This project not only teaches them engineering principles but also fosters critical thinking, teamwork, and communication skills as they analyse data, discuss solutions, and present their findings.

b. Building a Sustainable Future

Blended learning can empower students to become environmental stewards. Online platforms can offer access to real-time data on local air and water quality, while offline activities involve field trips to collect samples, analyse the data, and design solutions for environmental challenges. Students could create awareness campaigns, propose

policy changes, or even develop sustainable energy solutions, all while putting their scientific knowledge into practical use.

c. Combating Food Insecurity

Food security is a global issue, and blended learning can equip students with the tools to address it. Through virtual simulations, students can explore different agricultural practices and the impact of climate change on food production. In the classroom, they can conduct experiments on plant growth, design hydroponic gardens, or even develop mobile apps to connect local farmers with consumers, learning valuable lessons about agriculture, technology, and social responsibility.

d. Preserving Cultural Heritage

From analysing historical artifacts using 3D scanning technology to designing virtual tours of ancient landmarks, blended learning allows students to delve into the past and connect it with the present. They can research historical figures and events, translate ancient texts, or even develop educational games to share their learnings with others, using technology to bridge the gap between the past and the future.

By addressing critical avenues, teachers can cultivate a thriving blended learning environment that ignites students' passion for STEAM, equipping them with the skills and knowledge needed to face the challenges of the future.

3.4. Community Science Projects in Hybrid/Blended Learning

Community science projects are a great way for kids to experience what it's like to be a scientist and for teachers to illustrate the kinds of real-world problems scientific research can solve. Also they help students develop a sense of ownership and responsibility for their local environment and community. By working on projects that address local environmental issues, students can see the direct impact of their efforts and develop a sense of agency and empowerment. Community science projects can

help raise awareness about climate change and its impacts, promoting greater understanding and concern about this critical issue.

Through community science investigations, students partner with scientists and resource managers in real scientific research to understand local ecosystems and climate change. Community science empowers students as it builds their curiosity, connection to local ecosystems, science knowledge, and understanding of data and data analysis. They learn alongside their teachers and peers as they explore questions that have not yet been answered and data that they are the first to see and share.

Nowadays using blended or hybrid learning makes community science projects even easier to do in schools or other educational settings. Here are some examples of community science projects that can be implemented into learning process:

- https://education.nationalgeographic.org/resource/citizen-science-projects/
- https://www.experientiallearningdepot.com/experiential-learning-blog/20-citizen-science-projects-for-students-of-all-ages
- https://sciencelessonsthatrock.com/citizen-science-projects-html/
- https://www.plt.org/educator-tips/earth-day-citizen-science-projects
- https://www.teachstarter.com/au/blog/citizen-science-in-the-classroom/

3.5. Technology tools that enhance hybrid/blended learning

Finding the best educational tools to support blended and hybrid learning is now more crucial than ever because it combines the greatest aspects of both learning experiences — online and offline.

The term "blended learning tools" describes a variety of resources and technologies in the delivery of blended learning, which mixes conventional in-person instruction with online learning. With the help of these resources, learners will be able to access and interact with educational content more easily and with greater freedom. Some

examples of blended learning tools include personalized learning software, interactive multimedia, learning management systems (LMS) and video conferencing software.

In contrast, hybrid learning tools are the technology that supports hybrid learning and blends traditional face-to-face instruction with online learning, but with a different emphasis. Unlike blended learning, when online learning replaces face-to-face training, hybrid learning often uses it to extend and augment it. Tools like lecture capture, which captures classroom lectures for later viewing, or online discussion boards, which enable students to carry on their discussions outside class time, are examples of hybrid learning technologies.

Here are some online learning tools for a blended or hybrid approach:

a. Educational games

People of all ages play games. But besides recreational fun, games are a great way to infuse your training with new life. Gamification in training is another blended learning tool to keep students learning and remaining active participants during a training session.

b. Digital badges

Digital badges are another great blended learning tool to consider implementing. They can be used in a few ways. One is it can help designate one type of course from another; making it easier for students to locate within a learning management system. Secondly, digital badges are a motivator for students to successfully complete a task or a series of tasks. You can assign different tasks with badges and track to see which students are earning the most badges. Not only is it a great analysis tool, but digital badges can be used to award top performers.

c. Webinars

Webinars are a great way to bridge the gap between in-person training and online training. It is a happy medium and therefore an ideal fit for your blended learning

environment. Students can ask questions, and message peers, and webinars can be recorded for employees who can not attend the day of.

d. Simulations

The worst part about the training is you teach your students new skills and then they soon forget these skills once they return to their desks. Or, worse, they convert to their old methods. In order to avoid this situation, you want to teach skills, but more than teaching skills, you want these skills retained and used by your employees. That is where simulations come in. Simulations reinforce what was learned and help with changing students' habits. In order to begin, you first want to teach students key skills in whatever format you want. Then, you want to set up a simulation highlighting these key skills along with any pre-existing knowledge your employees may have. This will help tie new skills with what they are already using.

3.6. Student Engagement Strategies

Learning to engage students in the classroom is a crucial teaching strategy because student engagement is a prerequisite for learning and a strong predictor of student success. It allows your students to thrive in the class because they are actively participating which leads to higher mastery of the course material.

Here are five things you can do to increase student engagement in blended or hybrid learning environments:

a. Adequately prepare your students

To engage your students from the very beginning, you need to ensure they are briefed on how the hybrid learning environment will function. Start off by taking the time to demonstrate how any online learning platform or application will be utilized in the class. Don’t assume that the students will know how to use a website or program for their education—even if it is common.

b. Structure your class for both asynchronous and synchronous learning

You want your students to be actively engaged regardless if they physically attend class, come for a livestream, or watch the recorded lecture later. Copying the structure of a purely face-to-face or online class will usually not be sufficient for ensuring success in a blended learning environment. Relying solely on traditional methods for those modalities is unlikely to optimize student engagement. The way you ultimately structure your hybrid class is up to you, but keep your varied students in mind while you design your course.

c. Have a reliable instructor presence

Your students should feel supported by you whether they are a face-to-face, a synchronous, or an asynchronous student, which will ensure they stay engaged throughout the semester. Regularly communicate with your students and provide a forum through which they can get responses to their questions or concerns as quickly as is feasible.

d. Assign meaningful activities

To drive student engagement in a hybrid learning environment, create assignments that are both interesting and inline with the students' learning outcomes. Students learn best and are much more likely to engage with their education if they find interest in it. As the instructor, you should be creating an environment where students have agency and autonomy in driving their own learning.

e. Create a reliable method for student to student interaction

Even though many hybrid learning models offer accessibility for students, it has its drawbacks. For example, a student who never steps foot inside the classroom may feel disconnected from their fellow peers. Such challenges of the hybrid model can be overcome, and one way to accomplish that is by designating a way for students to build an ever-present online community.

3.7. Advantages of Hybrid/Blended Learning in Climate Change Education

1. Students are free to go at their own speed. Others who are comfortable with the subject can move through the online material more quickly, while those who are less confident can pause and re-watch the difficult sections.
2. Teaching in several situations. Teachers care about the blended learning curriculum design to make it possible to use a variety of resources to deliver learning materials in a variety of situations. When teaching a certain topic, they might, for example, employ lectures, tutorials, and practical situations.
3. Material is always available. When a student works best, they may log in and access the lessons, lectures, and other resources they need to study.
4. Students can prepare ahead of time. When considering blended learning for practical work, students can examine essential ideas and subjects online prior to face-to-face demonstrations. This gives students some familiarity with the topic, allowing them to spend more time on intriguing and engaging activities.
5. It may help with retention. Several studies conducted in the 2000s showed that blended learning assisted learners in remembering more knowledge. Although further research is needed, it may be useful.
6. It can aid in self-directed learning. Students are given self-advocacy and the flexibility to take charge of their education in many blended learning approaches. This can help them prepare for future schooling and the workplace.
7. Different instructional techniques can be aided by technology. Blended learning may promote active learning, utilization of real-world settings, social learning, and application of knowledge to new contexts.
8. It is the introduction of new technology. Blended learning allows students to experiment with new software and technology. Learning how to use such technologies can help students prepare for future activities.

9. Set objectives and keep track of your progress. Many blended learning solutions enable teachers and trainers to monitor their students' progress. This can provide instructors with a better understanding of which techniques are most effective.
10. Educators may then focus on adapting their face-to-face class time to the requirements of their students by providing online materials.

As technology allows increased options when it comes to how we implement learning and development programs, we find ourselves at the crossroads of tradition and innovation. Hybrid and blended learning stand as beacons of change, guiding us toward more learner-centric and adaptable methods. These models offer unique advantages and limitations, each with its own place in climate change education.

4. Natural and adventure-based learning to fight against climate change

4.1. Introduction

The purpose of this chapter is to focus on raising awareness among students about the dangers of global warming and on them becoming environmentally conscious.By experiencing outdoor activities, students become aware that learning and development take place everywhere, laying the foundation for lifelong learning and personal responsibility for their own development, while also being a very effective way to meet the changes of the contemporary world. When we hear learning, the first word that is associated with learning should be reflection. When we hear experiential, we realise that it should be about an activity that we experience with our whole body and all our senses.

In schools, nowadays, environmental education can serve as a critical tool in countering environmental problems as it strives toward the goal of environmental protection and conservation. It aims to intrinsically motivate young students to perform appropriate real-life behaviours. This is why education is regarded as an indispensable requirement if we want to promote sustainable development successfully. Nature-based learning involves using the natural environment as a context for education. It's about getting children outside and engaging with the world around them, fostering a sense of wonder and curiosity.

This approach is grounded in the belief that children are innate learners, and the natural world offers endless opportunities for discovery, creativity, and problem-solving.It is highly important that our students are connected with nature because they can understand better the impact of global warming on the environment they study outdoors. It is required that they get familiarized with all the elements of nature from an early age. As imagination thrives outdoors, the unstructured,

open-ended nature of outdoor play encourages creative thinking and innovation. Early exposure to nature instils a deep appreciation and respect for the environment, cultivating future stewards of our planet. Taking part into activities like school gardening projects, participation in local conservation efforts, and field studies in natural habitats, students develop a sense of connection and commitment to the environment that can last a lifetime.

4.2. Understanding Natural and Adventure-Based Learning

Natural and adventure-based learning is an approach to curriculum that engages students into the outdoor natural environment, with a focus on exploration, adventure, and fostering a sense of care and responsibility for our planet.

When students have nature as a classroom, like **forests, parks, or even city areas**, outdoor education creates an active and engaging setting for exploration and climate change awareness. Students are encouraged by this hands-on approach to see how what they learn in class about the changes generated by global warming relates to the **real world**, making them more involved and motivated to learn how to fight against climate change.

Through this toolkit, we encourage both students and teachers to take an active role in caring for the environment and making a positive impact. We recommend that schools incorporate sustainability into their curriculum, teaching students about eco-friendly practices and encouraging them to become responsible global citizens.

This approach is all about **learning through action**. Instead of just listening or reading about something, students actively engage in hands-on experiences. It allows them to not only understand theories and knowledge taught in class but also see how they apply to **real-life situations**. By doing and reflecting on what they have learned, students can make stronger connections and gain a deeper understanding of the

subject matter. Natural and adventure-based learning is a powerful tool that benefits both teachers and students in their educational journey.

Adventure -based learning is considered a hybrid distance education approach that provides students with opportunities to explore real-world issues through authentic adventure-based learning experiences within both face-to-face and online collaborative learning environments.

By experiencing outdoor activities, students become aware that learning and development take place everywhere, laying the foundation for lifelong learning and personal responsibility for their own development, while also being a very effective way to meet the changes of the contemporary world. We believe that outdoor education has obvious advantages in mobilising children's physical and mental resources, helping them to develop in a balanced way, in harmony with nature.

In response to the climate crisis and other sustainability challenges, there is an urgent need to empower learners with knowledge, skills, values and attitudes to take informed decisions and responsible actions for environmental integrity. Bringing nature into the centre of education and allowing learning through active exploration and discovery activates learners' creative capacities and sense of being part of, and not separate from, nature. At a moment when our planetary boundaries are being crossed and planetary systems are changing, demonstrating less resilience, it is imperative that education, at all levels, fosters planetary citizens who can think, visualise, and act in resonance with life.

Natural and Adventure-Based Learning is an ecosystem of blended educational strategies encompassing environmental education, indigenous ways of knowing, climate and biodiversity education, education for sustainable development, outdoor education and experiential education, mindfulness, and socio-emotional learning, among others. Natural and Adventure-Based Learning is a holistic approach that integrates the living systems approach into all forms of education to inspire and

re-establish a deep connection between humans and the rest of nature. Through nature-based learning, individuals learn about and from nature, including the environment, the climate and water systems, biodiversity, and humans as a key species on our planet. It can be incorporated in formal, non-formal, and informal education, training, and capacity building among others, and recognizes the importance of systems thinking, problem-solving learning, and cultural diversity. Place-based and project-based instructional approaches are a natural fit for this ecosystemic approach.

4.3. Adventure-Based Learning for Climate Action

Adventure-based learning is a form of experiential learning that uses outdoor activities and challenges to develop teamwork, communication, problem solving and leadership skills. It takes students out of their confer zones and encourages them to work together towards a common goal: climate change awareness. One of the key benefits of adventure-based learning is that it provides a unique and memorable experience for the students. By taking part in adventure-based learning activities, the students are engaged into thinking creatively and finding innovative solutions. This not only strengthens their problem-solving abilities, but also encourages them to think outside the box and explore new perspectives. Furthermore, adventure-based learning enhances communication skills. Effective communication is essential for successful teamwork and adventure-based activities provide a platform for students to practice and improve their communication skills. Whether it's true through verbal instructions, nonverbal cues or active listening, students learn how to effectively convey their thoughts and ideas. Leadership development is another significant aspect of adventure-based learning because through various challenges and activities, students have the opportunity to step into leadership roles and practice their decision-making skills.

Examples of adventure activities:

a. **Community Clean-up**

Organize a community clean-up day where students gather in local parks, beaches, or natural areas to collect litter and learn about the impact of pollution on ecosystems. This hands-on activity fosters a sense of responsibility and teaches students the importance of keeping our environment clean.

b. Native Plant Gardening

Establish a native plant garden on the school grounds or in a nearby green space. Students can learn about the benefits of native plants, their role in supporting local wildlife, and the importance of preserving biodiversity. This project allows students to actively participate in creating and maintaining a sustainable ecosystem.

c. Waste Reduction Campaign

Launch a waste reduction campaign within the school community. Educators can work with students to implement recycling programs, encourage the use of reusable water bottles and lunch containers, and educate peers on the impact of single-use plastics. This project raises awareness about the importance of reducing waste and instills eco-friendly habits.

d. Energy Conservation Challenge

Create an energy conservation challenge where students learn about energy consumption and ways to reduce it. Students can conduct energy audits within the school, develop strategies to conserve energy and track their progress over time. This project empowers students to make a tangible difference and understand the connection between their actions and environmental sustainability.

e. Nature Journaling

Encourage students to keep nature journals during outdoor excursions. Students can record their observations, sketches, and reflections about the natural world. This activity not only deepens their connection with nature but also promotes creativity and

mindfulness. Teachers can guide discussions about the importance of preserving natural habitats based on students' journal entries.

By incorporating practical ideas and projects like these into outdoor education, educators provide students with **hands-on experiences** and empower them to make a positive impact on the environment. These initiatives deepen students' understanding of sustainability and conservation, fostering a lifelong commitment to caring for the Earth.

4.4. Outdoor Education

In order to integrate and apply learning processes in outdoor activities, the teacher uses elements based on situation analysis and consideration of the children's learning potential and conditions, contextual elements, goals and objectives, content, learning and assessment processes.

The teacher must know how to choose the right strategies to integrate outdoor education into the curriculum. For this it is good to take into account:

- Children's learning prerequisites and potential: age, resources, cognitive level, language, social skills, knowledge of gardening or agriculture and cultural and social context.
- Context issues: physical space as an actor in the learning process, resources, what equipment and materials are needed. Have rules and restrictions on outdoor activities been taken into account? Are the conditions of the outdoor environment, the surrounding area taken into account: means of transport, water supply, free time, light conditions (sun/shade), temperature, soil conditions?
- Aims/objectives: are defined by the culture and society, but also by the teacher. Each culture and society has specific and different goals for children of different ages.

- Content: what content is relevant and necessary? These are often detailed in school curricula. What do children need to learn? Science, cooperative mechanisms, language or art?
- Learning processes: What are the underlying principles, actions and methods used to implement learning processes? The teacher chooses the principles or a combination of them and is able to present them to partners (colleagues, parents).
- Evaluation: the teacher has to consider and decide how to evaluate and reflect on learning processes. Assessment can be formal or informal. Thus, the teacher can discuss informally with children about their experiences and ask them questions about their learning, experiences and feelings. The teacher can also use formal assessment methods. It is important to consider the purpose of the assessment.

Outdoor activities in science foster a deeper understanding of **natural phenomena and ecological systems**. Consider the following examples:

- **Field studies**: Take students on nature walks or field trips to local ecosystems, such as forests, wetlands, or coastal areas. Encourage them to observe, collect data, and analyse various aspects like biodiversity, population dynamics, or environmental factors. Align these activities with specific science standards or learning objectives related to ecological concepts, scientific inquiry, or data analysis.

- **Citizen science projects**: Engage students in collaborative research projects that contribute to real-world scientific data collection. They can participate in bird counts, water quality assessments, or phenology studies, allowing them to contribute to scientific knowledge while learning about environmental stewardship. Align these activities with standards related to scientific investigations, data collection, or environmental awareness.

- **Experiment-based learning**: Design experiments that can be conducted outdoors, such as investigating the effects of sunlight on plant growth, the impact of different soil types on water retention, or the behaviour of animals in their natural

habitats. Connect these activities with standards focused on experimental design, data analysis, or scientific explanations. Some examples of outdoor activities that promote environmental awareness.

4.5. STEAM Principles in Natural Learning Environments

In order to apply STEAM Principles in Natural Learning Environments, it is very important to take into consideration the next aspects:

1. Depending on the predominant level of development that the outdoor activity proposes:

a) Knowledge (cognitive): develops especially knowledge about things;

b) Skills (psycho-motor): develops in particular specific skills that can be used in a life context;

c) Attitudes (affective): develops in particular attitudes, values that can be used in a school context but also in everyday life;

2. Depending on the context of implementation of the activities:

a) Curricular- focusing on the development of competences by school subjects - and taking place during classes (multi, trans, interdisciplinary);

b) Extra-curricular - focusing on competences complementary to the school curriculum - and taking place outside school hours;

c) Combined - activities that take place both during and outside school hours.

3. Depending on the objectives/learning outcomes developed- competences complementary to those per subject:

a) Enthusiasm and eagerness for learning manifested by: student's enjoyment of being outdoors, student's motivation to participate and persevere showing resilience in the face of proposed challenges/adventures, encourages others to participate, ability to

reflect on own experiences and describe own experiences and use them to inspire other aspects of life, ability to work as a team with others, ability to adapt and find solutions depending on the situation/challenge, ability to lead.

b) Health and wellbeing manifested by: a desire to be healthy, well proportioned and interested in outdoor activities, a positive self-image, understanding the link between emotional and physical wellbeing, identifying and adopting a healthy lifestyle.

c) Environmental awareness/responsibility towards the environment manifested by: consciously experiencing different natural environments and its various conditions, understanding the impact of human activities on the environment, demonstrating care for the environment through one's actions, appreciating nature and learning from it, experiencing the state of revelation and inspiration from nature (aha moment).

d) Social awareness/skills manifested by: recognising own and others' strengths and weaknesses, understanding the impact of own and others' actions, respecting others, developing confidence in self and others, developing and valuing relationships with others, building trust in others, being able to work in teams with others.

e) Personal qualities manifested by: building self-confidence, broadening comfort zone and overcoming personal fears, identifying risks and pushing boundaries to achieve personal goals, developing autonomy and initiative, communicating effectively, responding in a positive way to challenging situations.

f) Physical skills manifested through: development and use of physical and technical outdoor skills such as: packing a bag, building a tent, setting up a fire pit, using specific equipment, cooking in nature, etc.

Examples of how nature-based exploration can enhance STEAM learning:

By using different types of resources

a) resources easily accessible at classroom or school level: e.g. strings, sheets, balls, easily accessible nature resources (writing sheets, pen, stones, leaves, branches, etc);

b) more elaborate resources that are also required outside the school context: such as transport, perhaps minimally special equipment such as compasses, QR code with information, insulation, tents, ropes, etc;

c) specialised resources that require external collaborations such as those with travel agencies, specialised NGOs, outdoor specialists and very specific equipment for activities such as: orienteering, kayaking, ropes courses, thematic trails on specialised themes, guided tours, etc.

By scheduling them according to the right time:

a) activities that happen seasonally: for example, every year the 6th graders take a guided tour of the riverbank in spring to observe beaver activity;

b) activities that happen regularly: for example, at the beginning of each year each class has a day of outdoor teambuilding activities in the forest organised by parent educators. Or, at the end of the school year, the whole school takes part in a picnic to celebrate the end of the school year;

c) activities - homework - that students have to do as individual team tasks for home, but happen outdoors. For example: making a documentary (written, drawn, filmed or photographed) about the stages of dandelion growth or the position of the sun in the sky, or tasks they have to do on the way to school (calculate the diameter of a tree trunk that is at x).

There is always a pedagogical intention behind a teaching activity, the teacher must reflect on his/her professional practice in order to justify his/her pedagogical decisions. In outdoor education, several objectives and intentions can coexist in a lesson.

For example, for the Science curriculum area, the learning process can use as resources the living things found in the outdoor environment (plants, insects, animals), highlighting the functions they perform in the natural environment in relation to natural phenomena or natural elements, such as earth, wind, fire, the calorific value of

wood, rain, sunlight, temperature, environmental challenges and sustainability, ecological cycles, etc. For the social sciences, the pedagogical process can focus on a learning experience through which children get to know the world sensory. Thus, outdoor education aims at both knowledge of the real world and children's sensory experiences. Therefore, the fact that learning takes place outdoors is a strong motivating factor. The teacher chooses a topic related to everyday life and the children's knowledge and practical experiences of a plant, for example, potatoes that can be prepared in the traditional way."

4.6. Suitable STEAM Outdoor Activities

Consider these activities:

- **Plein air painting**: Take students outside with easels and art supplies to create landscape paintings en plein air. Encourage them to observe the colours, textures, and lighting conditions in the natural environment while expressing their artistic vision. Align these activities with art standards related to observation, composition, or expression.
- **Nature-inspired sculptures**: Provide materials like clay, found objects, or natural elements for students to create sculptures that reflect the forms, patterns, or concepts found in nature. Encourage them to consider sustainability and environmental aesthetics in their creations. Align these activities with art standards related to three-dimensional forms, craftsmanship, or creative expression.
- **Photography expeditions**: Equip students with cameras and guide them on outdoor photography expeditions. Encourage them to capture images that showcase the beauty and uniqueness of the natural world. Incorporate discussions about composition, lighting, or storytelling through visuals. Align these activities with standards related to visual communication, aesthetics, or digital media.

4.7. Discussion on the benefits of learning in natural settings

Learning in natural settings promotes nature-based education as an integral and multi-beneficial way to address climate change, biodiversity loss, and social inequities, bringing nature to the centre of learning and introducing a living systems approach to education. It enhances collaboration and coordination among stakeholders and sectors involved in nature-based education and nature-based solutions and it ensures that climate and biodiversity education are not treated as separate from each other.

The benefits of outdoor education for students' personal, social, cognitive, emotional and behavioural development

Cognitive and behavioural:

- promotes understanding, bringing real life closer;
- theoretical knowledge learned in the classroom can be applied or taken from concrete experience, making conceptualisation easier;
- deductive and inductive thinking is stimulated;
- it helps to form concepts and notions through direct contact with objects, beings and natural phenomena, which are an absolutely necessary intuitive support in the development of thought;
- the pupil becomes an active agent of knowledge, thus being motivated to (re)know, understand, solve situations, problems;
- they relate previous knowledge and experience to present events, generating new concepts, ideas, algorithms, original working schemes;
- provides support for various analogies, which stimulate imagination and creativity (solar system - structure of the atom, leaf - lungs, rivers - blood circulation, movement of stars - different life cycles), thus making problems easier to solve;
- intellectual fatigue is reduced, thanks to the pleasant atmosphere and intrinsic motivation;

- their unusual, novel character and the fact that they correspond to the pupils' interests and concerns, stimulates memory;
- experiential learning contributes to the vividness of the memory, to longer retention;
- the imagination has more diverse material for its combinatorics;
- increases concentration and productivity.
- develops respect for nature (land, water, plants and animals);
- interpersonal and social skills;
- develops creative imagination, creativity, sense of responsibility and positive thinking;
- promoting spirituality and the responsibility to protect nature, establishing a closer relationship with the environment.

4.8. Assessing Learning Outcomes

A valuable outdoor learning experience is one in which:

- the content of the outdoor experience/activity is connected to other ideas and especially to everyday life;
- the content of the learning experience is personal, relevant, interesting, useful and meaningful to the experiencer;
- the participant is present in the activity, not just a spectator of the activity, or at least finds him/herself in the activity;
- the participant learns at the same time from others and also contributes to the learning process of others;
- the beneficiary of the outdoor learning experience can set learning targets for him/herself and evaluate whether he/she has achieved them;
- the outdoor learning experience is at least fun, engaging, arouses curiosity and generally feels good;

- the learner gains a better understanding of themselves, others and the world around them.

Assessment of learning can be done for outdoor activities to improve the learner's learning. This can take place on the ground where the activity takes place or back in the classroom. Preferably the assessment should also be outdoors to be as relevant as possible. It is quite difficult to find the best method to assess both the activity and the learning and the participants. Whether we use a practical assessment, oral or written, with short-answer items, gaps, graphs or charts, any technique can be used, the disadvantage being that there is no opportunity to correct, to show the learner again, what has been done outdoors. Even if it is part of the ongoing assessment, it should be accompanied by descriptive, individual feedback where needed, possibly feedforward.

Ways of assessing the activity:

- Quantitative evaluation - e.g. material resources used, number of pupils involved, number of teachers;
- Qualitative evaluation - e.g. degree of pupils' involvement in the activity, skills acquired.
- evaluation methods and tools used - example: questionnaire, focus group, discussion, debate, observation, interview
- feedback is one of the essential aspects of outdoor activities, as it gives us an overview of pupils' opinions, complaints and proposals; - for an outdoor activity to be successful, it must be based on constant cooperation, communication, giving those involved the opportunity to express themselves.

Ways of giving feedback - some examples:

a. Complete (at the end of an activity)

I was surprised to learn that...

I liked it... I didn't like it...

I want to learn more about...

b. In the "Positive Diagram" (Jim Thompson) the teacher makes a list of all team members and records 3-5 positive points about each student's performance during a team game or outdoor activity. These points are given as positive feedback at the beginning of the next session.

c. We ask questions about what happened, how it worked, facilitating reflection;

- What did you notice happened?
- What did you think when...?
- What did you feel when...?
- What caught your attention during the exercise?
- How did you arrive at the solution, how did you react during the exercise at time X?
- What did you like about this activity? What steps did you take, in what order?
- What did you discover/learn from this experience?
- Is there a lesson here to note, to remember?
- Is there anything new you discovered about yourself, about others, about the topic etc?
- What similarities could you find between the elements, the steps of the game, the way you react and real situations in your everyday life: in your family, at school, with colleagues etc?
- Have you experienced similar situations in your everyday life? How did you react?
- Next time, what would you pay attention to if you were in a similar situation;
- What would you do differently/otherwise next time?
- What advice would you give a friend/extraterrestrial about this topic? etc.

Outdoor activities have a strong experiential component, putting the learner in the middle of the action, active agent and subject of their own learning. Dealing with new, challenging and difficult situations transforms learning into an authentic and productive process, leading students to change their climate change behaviour.

5. STEAM Activism and Climate Change Education

5.1. Introduction

It is widely acknowledged in today's educational landscape that educational experiences should be meaningful and applicable to the actual world (Coates, 2010; Wilson et al., 2019). This part is dedicated to utilizing STEAM to tackle one of the most threatening problems of our era which is climate change with emphasis on increasing student engagement in climate change projects. This project does not only encourage more student participation, but also critical thinking skills and a sense of social responsibility.

Climate change, a global issue that requires urgent attention for the sake of our planet, is a complicated and diverse problem that is in remarkable need of multidisciplinary approaches and creative solutions. By dedication themselves to finding solutions to this menacing problem, students can equip themselves with critical thinking skills, problem-solving ability and a sense of environmental stewardship. Here, we can observe a compromise with STEAM education which undertakes integrating science, technology, art, engineering and mathematics as a duty to find a resolution to complex issues as well as stimulating creativity and innovation.

Furthermore, the principles of problem-based learning (PBL) are on the same page with climate change. (Savery, 2015) defines PBL as an instructional technique that presents students with complicated, authentic problems and encourages them to actively explore and propose solutions. Student can resort to obtained STEAM skills in order to analyse data, conduct research and propose new solutions to fight against the climate change.

Through empowering students, we mean to help them to become change and to build an individual and collective feeling of environmental responsibility. As the students are integrated in climate change mitigation activities, they might gain a feeling of global

citizenship and responsibility with the help of educators. Moreover, students will not reach to a better understanding of scientific ideas, but they will also gain the abilities required to face & tackle global challenges as they will become problem solvers of the future as well as global citizen. Community engagement and the application of STEM principles in tackling climate change provide a tremendous platform for students to develop a profound awareness for the environment and a sense of stewardship that extends beyond the classroom (Maspul, 2024).

5.2. Understanding STEAM Activism

Since 1990, employment in STEAM has grown by nearly 80%, and it won't stop growing as it is expected that number of STEAM jobs will continue to increase by 8% over year for next 7 years. What is interesting to discover about STEAM is its intersection and link with activism. Young people around the world keep making themselves notices through their STEAM discoveries, inventions and advocacy and hence paving the way for future generations.

However, for vibrant activism journey students need robust STEAM education and opportunities provided to them. That's main requirement behind the STEAM activism: equal access to resources to thrive.

STEAM is the pioneer of leading innovation and finding solutions to global problems, and that means perfect alignment with activism. Let's check how:

a. Promoting diversity and inclusion

Alex Stutzman, a Ph.D. student in Genetics and Molecular Biology at the University of North Carolina at Chapel Hill School of Medicine, is leading efforts to promote diversity in science through inclusive language. Through her efforts, she is drawing attention to importance of intentional language in her field, in particular with interpretations of ethnicity and race.

Alex is a fabulous example of someone changing the STEM world for the better from the inside out. Without her activism in the field, harmful language would continue to further marginalize certain groups.

b. Shared experiences to build community

When Abinaya Dinesh was diagnosed with pelvic floor disorder, she used her smarts to create an app called Gastro at Home, which "help(s) others with gastrointestinal disorders learn more about their diagnoses and find at-home treatments and pain management for their disorders."

Abinaya, who is a Girls Who Code alumna, is an example of how solidarity and creativity around our shared experiences can break barriers in the tech world by providing equitable resources to everyone who needs them. Before using her coding skills to develop Gastro at Home, robust solutions like the app didn't exist for people with her diagnosis.

c. A field representative of you and your peers

Sejal Mehra, who uses art and engineering to raise awareness about harmful plastics in the ocean and their harmful effects on sea turtles.

Recently, she created a Save the Turtles flag out of plastic straws, plastic bags, and tape to raise awareness about the harmful effects of plastic on the environment, especially for sea turtles. Her mission to "change the face of STEM through art" was the first of its kind, which created a ripple effect of young people wanting to change the world themselves.

d. Combat bias in STEAM

When it comes to demanding equitable resources and opportunities in STEM, change happens from the inside out. That means supporting initiatives to diversify STEM often trickles down into diversifying other fields and setting an example for all kinds of career opportunities.

For example, let's look at the Algorithmic Justice League. They are leading a cultural movement toward equitable and accountable AI (artificial intelligence). Right now, AI systems can perpetuate racism, sexism, ableism, and other forms of discrimination. The Algorithmic Justice League was founded by Dr. Joy Buolamwini, who came face-to- face with discrimination through AI. While in grad school, facial recognition software struggled to detect her face; yet her peers with lighter skin had no issues. It wasn't until she added a white mask over her face that she was detected. Dr. Buolamwini's personal story exemplifies the need to combat bias in the field and remove the remnants of prejudice in technology.

e. Using STEAM to impact policy-making

In recent years, the movement of scientists as engaged citizens has picked up even greater steam, as they think more critically about the roles they play as activists in critical social, political and environmental issues. In many ways, the STEM community is leading the charge in providing trustworthy information about important topics such as climate change, in order to motivate more people to act.

Groups like the Union of Concerned Scientists and People's Climate Movement, use science and information to spread awareness on issues impacting our like the climate crisis, transportation system, fossil fuels and many more. Their work brings awareness to those in charge, with the ultimate goal of enacting policy change. Because STEM professionals are such trusted providers of reliable information, we look to them to inform our advocacy, which is also true for policymakers who are in charge of making the systematic changes we are pushing for.

f. Innovative solutions to complex problems

The world of STEM is vast and full of people who tackle tough problems like gender inequality, education equity, mental health, and more with curiosity and the ability to think outside the box.

Take Nastasia Efremkina, for example. She's a student at the University of Pennsylvania who patented her own technology for a firearm tracker in an effort to promote gun safety. If implemented, her invention could prevent mass shootings from happening, saving countless lives.

Overall, the partnership between STEAM and activism gaining pace recently as our world is changing rapidly and constantly and students will be the ones that decide the direction of STEAM. Whether it is for climate or for intentional language, there is not limit to the ways that STEAM and activism cooperates and drive a change or movement in our society.

5.3. Student-Led Climate Initiatives

In general, STEAM project's objective is to provide students with novel educational experience which goes above and beyond typical classroom learning. Within the project framework, students are empowered to become responsible agents, climate agents in this case. They will develop a profound grasp of the interdependence of science, technology, engineering, arts and maths by concentrating on climate change and its broad impact on our lives. And how can students take initiatives?

First strategy they can follow is being immersed in fieldwork, so that they can engage with different stakeholders. Additionally, they will have an opportunity to observe natural events, gather information and keep tally of effects of climate change in their neighbourhood over time. Fieldwork is a hands-on and immersive activity that allows students to establish a stronger connection with their surroundings and a clearer understanding of the value of environmental care (Al-Azawi, 2019).

Another one is data analysis. Through climate data, students will learn how to gather and interpret scientific evidence on climate change. To this end, they need to investigate a set of data sources, i.e. climate records, temperature readings, precipitation data, biodiversity surveys.

Moreover, students should not neglect the power of technology to tackle the climate change problem. As they harness this power, they will learn how to model climate scenarios, assess the impact of various initiatives and analyse large data sets using computational tools and software. Therefore, they will develop their logical reasoning, algorithmic thinking, and problem-solving abilities which are imperative to address climate change problem. Let's take a look at some of the examples of student-led initiatives.

Climate change affects numerous sectors, including the food sector. The agricultural sector is simultaneously a major contributor to Canada's greenhouse gas (GHG) emissions and itself highly vulnerable to climate change. Student-led food initiatives like campus gardens, food waste diversion projects, and community food security partnerships are on the rise and are a proven way of localizing climate action and transforming food systems. These initiatives of the students may not be certain solution to the fundamental issues related to climate change, however; they can definitely transform students' mindsets, develop their skills and confidence who will become change agents in the future. The research with McGill University students participating in student-led campus- and community-based initiatives shows how these activities can support transformative opportunities for learning about, and acting on, food security and climate change. Students have long reported that education about food and environmental issues like climate change feels abstract and disempowering within the confines of classroom walls.

The lack of real-world engagement makes it challenging for learners to discern how and where they can contribute to building solutions. Student-led food initiatives are one way that students engage with these issues through experiential learning.

Additionally, under the body of Be the Change Earth Alliance, there are some initiatives that can generate an inspiration. For example, Student Leadership for Change is an education curriculum that inspires youth to connect, understand, and respond to the

environmental and social challenges facing our planet. This comprehensive suite of experiential, project-based curriculum materials help students connect global issues to local solutions by taking specific, measurable actions with their classmates and family. Also, Youth Climate Ambassador Workshops is a collaborative project with the UBC Climate Hub to offer free workshops to empower Vancouver high school students to take action on climate change. These workshops aim to supplement existing resources with information about how high school students can become “Climate Ambassadors” and encourage their local communities to take action on climate change. By empowering young people to act and demonstrating how effective their actions can be, these workshops aim to foster a sense of agency and purpose.

5.4. Design Thinking for Climate Solutions

Some problems cannot be solved with a linear solution, and climate change is among these problems. It is too complex, too intertwined with our daily lives and it requires input from different fields. Hence, a design thinking approach might play a huge role in solving problems surrounding climate change and sustainability.

And what exactly is that design thinking? It is a creative problem-solving approach that makes it possible to solve problems that are ill-defined or not very well known. It is uniqueness derives from its human centred approach that directs its focus on truly understand people’s needs comparing to other standard methods.

There is no regular process to start implementing design thinking, however it usually starts with a question that addresses a specific pain point or a need. According to this solution-based approach, the next steps consist of prototyping, iterating, and testing as many times needed to ensure that the product is ready. When applied properly, design thinking can be a powerful tool to change how the humans interact with the world and each other.

Design thinking can be applied in multiple ways to fight against climate change in various sectors. For instance, let's assume that you are a new start up founder trying to raise the fundings of your green tech company that aims to reduce food waste. You can implement following steps, in no particular order:

a. **Start approaching climate-based issues with an open mind**

Instead of assuming that our food system is full of waste and inefficiencies are caused by consumers buying too much, dive into the topic and do a lot of research. Listen to podcasts, reach out to people working in agriculture/food industries, talk to your local grocery store manager- literally anything to get your brain thinking about all the possible reasons and systems in place that could make food waste occur. Once you interact with these people, you will understand that there are alternative solutions.

b. **Question current systems and think about how we can improve them. It's always easier to build off from what we currently have**

One of the more daunting walls we face while trying to solve climate change issues, is that oftentimes the problem feels too large and systemic to completely change. However, with design thinking, you don't have to start over from scratch if a solution is not working. Instead, the beauty of this approach is that you can build off and refine current systems to improve them that way.

c. **Come up with an innovative solution back by real research data to fill the gap of a certain need**

Upon completing the proper research, now is the time to support your solution with real experiences and data. Quantitative and qualitative data allows you to find the reasoning behind all your strategy-based decisions and increase you capability to back them.

Also, although you may have more than one solution initially, it is always important to come back to your original question and focus on a route you want to go towards.

Once you have a solution, don't forget to then test this solution to the people who need it the most and get their feedback.

d. Iterate, Iterate, Iterate

This one is pretty obvious. Keep working on your solution to make sure it maintains its competitive edge and solves the problem as it continues to evolve.

e. Implementing and scaling the sustainable solution

Once the solution has been refined through testing and iteration, the next step is implementing it on a larger scale. This involves working closely with stakeholders, developing implementation plans, and ensuring the necessary resources are in place.

That's whole for the design thinking approach, which is a key to understand complex problems, in that case climate change, and find innovative solutions. Design thinking offers a robust framework for creating sustainable solutions that address today's complex challenges. By embracing empathy, creativity, and rationality, organizations can develop innovative products, services, and systems that solve problems and contribute to a more sustainable future. Whether designing eco-friendly products, developing sustainable business models, or tackling social challenges, design thinking can revolutionize how we solve problems and impact our world.

José Valencia is a smallholder tenant farmer in Colombia's Valle del Cauca region. He has realized that his soil's productivity is diminishing, and keeping records of input quantities and costs is not common practice for first generation farmers, a group that José Valencia is a part of. Instead, Valencia's working assumption is that more inputs better his odds of a big harvest of large-sized onions, the kind most sought after because they create perfect rings for topping burgers, Colombia's favourite food.

Experts have reached a consensus on the negative impact of chemical inputs on soil regeneration. Despite the governments advises to adjust the chemical inputs according

to soil needs, the ambiguous climate change problem makes it unlikely that farmers change their conventional ways of cultivating.

The Rare-d.school suggests that the specific question is “which lived experiences allow communities to better understand and assess their own environments? How can communities be empowered with the right data-driven tools to manage their resources?” rather than teaching the communities the proper way to cultivate in climate friendly manner.

By utilizing the design thinking approach, the team launched their research process based on farmers’ experiences. During the process, they have discovered that farmers did not own the land they cultivate, so they abstained themselves from making any investments into soil unless it improves their livelihood which comes before the environmental benefits of any investments or change of methods. They did not want to face the financial risks of new methods without being able to see the benefits ahead. The team’s approach was therefore to take as much ambiguity as possible out of farming and do so in the language farmers understand. For example, farmers speak in the language of “good” or “bad” years. But the joint effort led to a realization that a tactile, visual guide could help farmers better understand their soil, alongside an easy-to-use tracker to account for how monthly fertilizer use correlates with success.

Students generated multiple directions to generate a solution which is beneficial to both environment and farmers. For that purpose, they created crop planner customized for farms, soil health card which breaks down soil into its texture, smell and humidity.

In conclusion, one small action can create an enormous impact. When the common way no longer works it is time to look into new tools, instruments and utilize design thinking approach for different solutions.

5.5. Activism through Environmental Science

Ever since the beginning of first environmental movements, there has been an interdependent relationship between with science; utilizing scientific aspects to drive community wide environmental action.

Even though the core link is still there, the interdependency can be interpreted as a relationship which is less direct. Science is now one of the fundamental sources of knowledge to fight against climate change along with indigenous knowledge, communication insights, and lived experiences.

Sometimes, as we encounter, the environmental sciences are not good allies for environmental sciences suggested by SOS-UK activist El Andrade May at the IES' Burntwood Lecture in 2022. Campaigns require clear and consistent messaging to reach its objectives, and in that manner, science might be inconvenient as it can be too complex to summarise to draw attention within limited attention spans; and it can distract from the solutions which activists seek. Correspondently, scientists can be indecisive between a desire to support action on the natural systems they work with and a hesitation to link their work with activism due to getting involved in political conversations.

There are no distinct lines between environmental scientists, activists, communities and those engaged in politics. These terms are often overlapping and the people who consider themselves as activists can also be scientists. And those lines can be even more blurry in the future as environmental issues become global and major problem for our future.

In order to find the balance between the environmental science and activism, we must embrace openness, transparency and collaboration. We should put some effort into breaking down the barriers between the sciences while improving the relationship

between science, public and policy. Discussions about environmental issues should unite us and different sectors rather than dividing.

Similarly in every sector and field, involvement of technology changed the way things work and climate activism is no exception. The emergence of the internet and the growth of social media platforms registered a monumental impact on social activism movements. Thanks to online communication and social media tools environmental activists gathered and organized easily and effectively. They managed to circulate information to remarkable number of people, communities and supporters and find a ground for like-minded persons to connect. With the introduction of abovementioned tools, geographical and temporal barriers were limited.

On the other hand, benefits enabled by digital technologies for the environmental movement, namely more effective organization and communication, are outweighed by the tendency of online activism to be low-risk and lacking real engagement, due to echo chambers and 'slacktivism' (Jacqmarcq, 2021). Wider audience might mean higher impact, but also the loss of meaningful engagement and impactful activism according to Jacqmarcq, 2021.

Along with science and technology, the arts have a significant role in addressing climate change. Without a doubt, scientific reports and policy developments play a substantial part in fighting against climate change, but we can neglect the power of art when it comes to raising awareness and mobilizing individuals. Art can be a powerful tool to evoke emotions, spark conversations, and create a profound connection between individuals and the environment. Through visual tales, art may communicate complex climate science and challenges. Inspiring images, artworks, visual stories, infographics, and illustrations can help increase public understanding of climate concepts, statistics and their impacts on people and ecosystems.

Climate change art is a form of artistic expression that aims to address topics related to climate change and its impact on the environment, society, and the world as a whole. (Zoë Lescaze 2022).

As the problem of climate change became a global issue that requires global solutions, artists used their creative talents in raising awareness and provoking thought on the subject. Even though, there is no specific starting point for the utilization of the climate change art, it has started to increase with 2000s. Climate change art takes many different forms, each offering a unique medium for expressing the urgent need for action. These forms include visual storytelling, geospatial maps, visual arts, performing arts, film and media, and street art and installations.

Moreover, in addition to other fields, mathematics is also very helpful for us to tackle the problem of climate change. From glacier retreat to extreme weather events, either in a major way or in a major way, we face challenges set by changing climate which is a long-term phenomenon.

Mathematicians can resort to data and modelling to evaluate the consequences of global warming. In order to predict future trends, scientists look to the past. For instance, ice cores from the Arctic show how carbon dioxide levels have changed over time.

The UK Met Office Hadley Centre set the Earth's climate to that at the start of the twentieth century and ran it through a model to predict trends in the following century, once with stable carbon dioxide levels and again with the actual measured increase. This showed that the Earth ought to be cooler than it is today, proving that this enhanced greenhouse effect is solely due to human activity (Budd, 2018).

In recent years, the momentum for climate activism has reached a peak, and the pressure on politicians to act is mounting. To design international policies that fit the agendas of individual nations, and which have a high chance of preventing serious

damage to the environment, we turn to mathematicians to design mathematical models on supercomputers that generate accurate predictions.

6. 21st century skills development strategies and tools through the use of STEAM and CSPs, such as critical thinking, problem-solving, creativity, analysis, analytical thinking, design and effective communication

6.1. Introduction

The development of 21st-century skills is essential for preparing students to navigate and succeed in a complex, ever-changing world. Through STEAM (Science, Technology, Engineering, Arts, and Mathematics) education and Community Science Projects (CSPs), students cultivate critical thinking, problem-solving, creativity, analysis, analytical thinking, design, and effective communication. These educational approaches provide hands-on, real-world experiences that not only enhance academic learning but also foster essential life skills. By integrating methods like inquiry-based learning, interdisciplinary projects, and digital tools, students are equipped to tackle global challenges with confidence and innovation. Effective communication within these projects ensures that ideas and findings are clearly articulated, promoting a collaborative and innovative culture.

6.2. Critical Thinking in STEAM Education

Critical thinking is a foundational skill that STEAM education aims to develop through hands-on learning and real-world applications. Here's a deeper look into how critical thinking can be promoted in STEAM activities, along with examples of projects that engage students in analysis and decision-making:

Strategies for Promoting Critical Thinking through STEAM Activities

a. **Inquiry-Based Learning:**

- **Approach:** Encourage students to ask questions and explore the answers through experiments and research. This method helps them to not just accept facts but understand the processes behind them.
- **Implementation:** Set up a scenario or a problem and have students formulate questions that lead to hypothesis-driven research.

b. Problem-Based Learning (PBL):

- **Approach:** Present students with a complex problem that doesn't have a straightforward solution. This fosters analytical skills as they must consider various factors and approaches.
- **Implementation:** Students could work on finding sustainable energy solutions for their school, integrating technical, economic, and social considerations.

c. Interdisciplinary Projects:

- **Approach:** Combine elements from different STEAM fields to create more complex and realistic challenges that mimic real-world problems.
- **Implementation:** Projects like designing a garden that requires knowledge of biology, chemistry, art, and mathematics.

d. Collaborative Learning:

- **Approach:** Promote teamwork where students share ideas, challenge each other, and jointly develop solutions. This exposes students to diverse perspectives and enhances critical thinking.
- **Implementation:** Use group projects where students must build a small-scale model of a sustainable urban neighbourhood.

e. Use of Technology and Digital Tools:

- **Approach:** Integrate modern technology to simulate real-world problems and solutions, allowing students to experiment with scenarios that would be otherwise inaccessible.
- **Implementation:** Utilizing software for coding robots or simulations that model ecological systems.

f. Reflection and Revision:

- **Approach:** Encourage students to reflect on their findings and the effectiveness of their solutions, and consider how they could improve them.
- **Implementation:** After completing projects, students can present their results and receive feedback, then revise their work based on this feedback.

Examples of projects that foster critical thinking:

a. Eco-Friendly Architecture Design:

- **Project:** Students design a model of an eco-friendly house that uses renewable energy, efficient materials, and innovative technologies to minimize environmental impact.
- **Skills:** Analysing energy needs, researching sustainable materials, and integrating technology effectively.

b. Water Quality Assessment:

- **Project:** Students collect water samples from local sources and test them for pollutants and biological indicators to assess water quality and suggest methods for improvement.
- **Skills:** Gathering and analysing scientific data, making informed decisions about public health and safety.

c. Robotics Challenges:

- **Project:** Students build and program robots to solve specific tasks, such as navigating a maze or sorting objects by colour and size.
- **Skills:** Applying principles of engineering and computer science, testing and refining the programming and design.

d. Art and Technology Integration:

- **Project:** Create a digital art installation that responds to environmental stimuli (like light or sound) using sensors and programming.
- **Skills:** Combining creative design with technical programming and sensor integration.

e. Mathematical Modelling for Disease Spread:

- **Project:** Use mathematical models to predict the spread of a hypothetical disease and develop strategies to mitigate its impact.
- **Skills:** Utilizing mathematical concepts to simulate real-world issues, interpreting models to make predictions.

These activities not only enhance students' ability to think critically but also prepare them to tackle complex problems with confidence and creativity. By engaging in such diverse and challenging projects, students develop a toolkit of skills that are applicable in both academic and real-world contexts.

6.3. Problem-Solving Approaches in CSPs

Community Science Projects (CSPs) offer an invaluable opportunity for applying problem-solving methodologies to real-world challenges. These projects not only engage communities in scientific inquiry but also solve practical problems affecting those communities. Here's an exploration of how CSPs use various problem-solving approaches and some case studies highlighting their implementation.

Problem-Solving Methodologies in Community Science Projects

a. **Design Thinking**

- **Approach:** Employs empathetic and creative problem-solving that begins with understanding the human needs involved.
- **Application:** In CSPs, design thinking can be used to develop solutions for issues like community health or urban planning. The process involves defining the problem, ideating solutions, prototyping, testing, and iterating based on feedback from community stakeholders.

b. **Systems Thinking**

- **Approach:** Looks at problems as parts of an overall system, focusing on the interactions and relationships between different system components.
- **Application:** CSPs apply systems thinking to environmental issues, such as water management or ecosystem restoration, where the impact of solutions on various parts of the ecosystem needs consideration.

c. **Scientific Method**

- **Approach:** Involves forming hypotheses, conducting experiments, and analyzing data to draw conclusions.
- **Application:** This method is fundamental in CSPs that deal with data-driven issues like air quality monitoring or species population studies, where empirical evidence is crucial for decision-making.

d. **Participatory Action Research**

- **Approach:** Combines research with action and involves community members in the research process to encourage practical change.
- **Application:** Used in CSPs for social issues, such as community development or educational improvements, ensuring that solutions are culturally relevant and community-driven.

Case Studies Highlighting Community Science Projects

Here are detailed case studies that illustrate how Community Science Projects (CSPs) effectively address real-world challenges without specific geographic references:

a. **Urban Air Quality Monitoring**

Background: Many urban areas face deteriorating air quality due to increased vehicle emissions and industrial activity, affecting public health.

Community Science Project: Community groups and local schools collaborate to deploy air quality sensors throughout the city. Participants, including students and local residents, collect data on particulate matter and other pollutants using these sensors.

Impact: The data collected helps to map pollution hotspots and identify times of high pollution levels. This information is used to advocate for better air quality regulations and urban planning practices that prioritize environmental health.

b. **Community-Based Water Resource Management**

Background: Regions with scarce water resources face challenges in managing and distributing water sustainably.

Community Science Project: Local communities implement systems to collect rainfall data and monitor water usage and levels in community wells. This collaborative effort includes training residents to use and maintain monitoring equipment and analyze the collected data.

Impact: The project leads to improved water management practices, ensuring sustainable water use and better preparedness for drought conditions. It also fosters a greater sense of community ownership and responsibility over local natural resources.

c. **Wildlife Conservation through Community Tracking**

Background: Human-wildlife conflict is an issue in areas where expanding human settlements encroach on animal habitats.

Community Science Project: Communities involved in wildlife conservation use tracking systems to monitor animal movements. This project includes setting up camera traps and tracking devices, which are managed and monitored by community volunteers.

Impact: The data gathered helps in creating effective conservation strategies and reducing conflicts between humans and wildlife. It also informs better land use planning to accommodate the needs of both wildlife and local communities.

Each of these case studies exemplifies how CSPs can be designed to address specific local issues effectively while empowering communities with the skills and knowledge needed to tackle future challenges. This integration of community engagement with scientific inquiry not only resolves immediate problems but also builds a foundation for ongoing community resilience and scientific literacy.

6.4. Fostering Creativity in STEAM

Fostering creativity within the context of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education involves integrating artistic and innovative approaches into traditionally analytical disciplines. This enhances not only student engagement but also problem-solving skills and overall understanding. Here's a look at strategies to promote creativity in STEAM education and why it's beneficial.

Strategies to Foster Creativity in STEAM

a. Interdisciplinary Projects

Combine subjects like art and science or math and music to show students how creative thinking applies across different fields. For example, students could design an art installation that incorporates geometric principles or create musical compositions based on mathematical sequences.

b. Design-Based Learning

Encourage students to engage in hands-on projects where they must design and build solutions to specific challenges, such as building a bridge from unconventional materials or designing a user-friendly device for people with disabilities.

c. Use of Digital Tools

Integrate technology that allows for creative expression, such as digital drawing tablets, 3D modelling software, or coding platforms for creating games and animations. Projects might include using CAD software to create 3D models of their science fair projects or developing an educational app as a class project.

d. Idea Generation Techniques

Teach methods for brainstorming and ideation, such as SCAMPER (Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, Reverse), mind mapping, or sketch noting. This can be applied to brainstorm solutions for a community issue, leading to a project proposal that incorporates elements from multiple STEAM disciplines.

e. Role Models and Guest Speakers

Invite professionals from diverse STEAM fields to share how creativity impacts their work, demonstrating real-world applications. This could be a guest lecture series featuring architects, game designers, scientists, and artists who discuss their creative processes and the role of innovation in their careers.

f. Flexible Learning Environments

Create spaces that are conducive to creative thinking, such as collaborative workspaces, areas for quiet reflection, and resources for hands-on activities. The classroom could be redesigned to include areas with art supplies, building materials, and technology stations that encourage students to experiment and explore.

6.5. Analysis and Analytical Thinking in CSPs

Community Science Projects (CSPs) provide a practical platform for fostering analysis and analytical thinking, which are crucial in understanding and solving real-world problems. Analytical thinking in CSPs involves breaking down complex issues into manageable parts, understanding underlying patterns, and using logical reasoning to arrive at solutions. Here's how CSPs cultivate these skills through various approaches.

Analytical Approaches in Community Science Projects

a. Data Collection and Interpretation:

CSPs often start with data collection, which is fundamental to any scientific inquiry. Participants learn to collect accurate data, whether it's water samples for quality analysis, surveys on community health, or observations of local wildlife. The critical part comes next: interpreting this data. This requires analytical thinking to identify trends, anomalies, or correlations that inform the community about potential issues or the outcomes of implemented solutions.

b. Problem Definition and Hypothesis Testing:

In CSPs, defining the problem correctly is as critical as solving it. Participants use analytical skills to understand the scope and nature of the issue. This often involves distinguishing between symptoms and causes. From there, they develop hypotheses on potential solutions. Testing these hypotheses then involves structured experimentation, further data analysis, and refinement of solutions based on empirical evidence, all of which rely heavily on analytical thinking.

c. Systems Analysis:

Many community problems are systemic, meaning they are part of a larger interconnected system. Analytical thinking in CSPs involves understanding these connections and how changes in one part of the system affect others. For example,

reducing traffic in one area might decrease air pollution but could increase it elsewhere or affect local businesses. Participants learn to predict and analyse these outcomes, which is crucial for developing sustainable community interventions.

d. Resource Allocation and Project Management:

CSPs require effective project management, including resource allocation. Participants must analyse what resources (time, money, manpower) are necessary for various project phases. This involves creating and analysing budgets, schedules, and logistic plans to maximize the impact of the project. Analytical thinking ensures that projects are feasible and set up for success.

Implementing Analysis in CSPs

Projects such as local environmental clean-ups, educational outreach initiatives, or health awareness campaigns all involve significant analysis. For instance, an environmental clean-up project would require participants to analyse geographical data to identify the most polluted sites, assess the types of pollutants involved, and understand their sources and impacts on the community.

Moreover, in a health awareness campaign, participants might collect and analyse data on community health metrics, determine areas of concern, and analyse the potential impact of various intervention strategies. Each of these steps not only requires data analysis skills but also the ability to think critically about how to apply findings in a practical, impactful manner.

In summary, analytical thinking in Community Science Projects equips participants with the skills to tackle complex challenges thoughtfully and systematically. These projects not only solve immediate problems but also empower communities with a deeper understanding of how to apply analytical skills to a wide range of future challenges, promoting sustained community development and resilience.

6.6. Design Thinking Principles in STEAM

Design Thinking is a user-centric methodology used widely in the field of design and increasingly across all areas of STEAM (Science, Technology, Engineering, Arts, and Mathematics). It focuses on understanding the user's needs and rapidly prototyping solutions to solve complex problems. This approach is particularly effective in STEAM education as it fosters creativity, encourages experimentation, and promotes a hands-on approach to learning. Here's a breakdown of the core principles of Design Thinking and how they integrate into STEAM education.

Core Principles of Design Thinking

a. Empathize

Understanding the needs, motivations, and emotions of the people for whom you are designing is crucial. In STEAM, this means students learn to consider how their projects affect others and to design with the user's needs in mind. For example, when engineering a new tool, they would first seek to understand how it will be used and the challenges the user faces with current tools.

b. Define

This stage involves clearly articulating the problem. In STEAM projects, this could involve defining a specific scientific problem or a design challenge based on the insights gathered during the empathy stage. Clear problem definition helps to guide the focus of the project and ensures that the solutions developed are relevant and targeted.

c. Ideate

Ideation in Design Thinking involves generating a wide range of ideas and solutions without judgment. This encourages creativity and divergent thinking among students. In a STEAM context, this could involve brainstorming different ways to solve a scientific

problem, design a product, or interpret a data set. This stage is crucial for fostering innovation and out-of-the-box thinking in students.

d. Prototype

Prototyping is about creating quick, early versions of a product to visualize an idea. This allows designers to explore ideas before committing significant resources to them. In STEAM education, prototyping might involve creating models, simulations, or mock-ups. For instance, students might build a scale model of a mechanical device, code a basic software prototype, or sketch out a scientific experiment setup.

e. Test

Testing involves trying out prototypes with users or within a real-world context to gather feedback and identify shortcomings. In the STEAM framework, this might mean conducting experiments to test a scientific hypothesis, using a technology prototype in its intended environment, or gathering user feedback on a new design. Testing is critical for iterative development, allowing students to refine their ideas based on real-world data and feedback.

Integration of Design Thinking in STEAM Education

Integrating these principles into STEAM education transforms the learning environment by making it more interactive and focused on real-world applications. Design Thinking encourages students to engage deeply with content, apply their knowledge in practical settings, and think critically about the implications of their work. It promotes a culture of learning by doing and iterative improvement, which are essential for both academic and personal growth.

For example, in a STEAM project aimed at creating sustainable urban transport solutions, students would follow the Design Thinking process to empathize with users (commuters), define key issues (such as pollution and traffic congestion), ideate

solutions (like bicycle-sharing systems), prototype (develop a small-scale operational model), and test (evaluate efficiency and user response).

Here are examples of projects across various domains that effectively utilize a Design Thinking approach to find solutions:

a. Educational Tool Development

Project Goal: Design an educational tool that helps children learn complex scientific concepts through interactive play.

Design Thinking Process:

- **Empathize:** Observe and interview teachers and students in classrooms to understand their challenges and needs.
- **Define:** Identify that students struggle with abstract scientific concepts that are not contextualized in real-world applications.
- **Ideate:** Brainstorm ideas such as interactive games, mobile apps, or physical devices that could make learning these concepts engaging.
- **Prototype:** Develop a prototype of a mobile app that uses augmented reality to bring scientific concepts to life.
- **Test:** Bring the prototype back into classrooms for feedback and observe how students interact with it, refining the app based on observations and suggestions.

b. Healthcare Improvement for Remote Areas

Project Goal: Improve healthcare accessibility and efficiency in remote areas.

Design Thinking Process:

- **Empathize:** Conduct field visits and engage with local communities, healthcare workers, and patients to understand their experiences and limitations.

- **Define:** Discover that lack of timely information and remote access to doctors are key issues.
- **Ideate:** Generate solutions such as telemedicine services, mobile health clinics, and community training programs.
- **Prototype:** Set up a pilot telemedicine service that allows patients to consult with doctors via video conferencing.
- **Test:** Evaluate the service based on user satisfaction and health outcomes, making adjustments as necessary to scale up the solution.

c. Sustainable Urban Transportation

Project Goal: Create a sustainable urban transportation plan that reduces traffic congestion and pollution.

Design Thinking Process:

- **Empathize:** Survey residents and analyse traffic data to understand commuting patterns and attitudes towards transportation.
- **Define:** Find that inadequate public transit options and reliance on private vehicles cause congestion and pollution.
- **Ideate:** Develop ideas for improving public transit, creating bicycle-sharing programs, and implementing carpool incentives.
- **Prototype:** Launch a small-scale bicycle-sharing program in a congested neighbourhood.
- **Test:** Monitor usage rates, environmental impact, and public satisfaction, iterating on the program based on feedback and data.

d. Waste Management System

Project Goal: Design a waste management system that maximizes recycling and minimizes landfill use.

Design Thinking Process:

- **Empathize:** Interview residents and waste management professionals to understand behaviours and barriers to effective waste separation.
- **Define:** Recognize that confusion and lack of incentive prevent effective sorting of recyclables.
- **Ideate:** Propose solutions such as clearer labelling, community sorting incentives, and educational campaigns.
- **Prototype:** Implement a new labelling system on bins and launch a community workshop on recycling practices.
- **Test:** Assess changes in recycling rates and gather community feedback to refine the system further.

These examples showcase how the Design Thinking process can be applied across different sectors to address complex problems. By empathizing with users, clearly defining problems, ideating innovative solutions, prototyping, and testing these solutions, projects can achieve meaningful and sustainable outcomes.

6.7. Effective Communication Strategies

Effective communication is critical in STEAM (Science, Technology, Engineering, Arts, Mathematics) and Community Science Projects (CSPs) as it enhances collaboration, ensures that ideas and findings are well understood, and supports the dissemination of project results to a broader audience. Here are some guidelines for promoting effective communication within these contexts:

a. Create a Communication-Centric Culture

Encourage Open Dialogue:

Foster an environment where team members feel comfortable sharing ideas, challenges, and feedback. Regular team meetings and open-door policies can help facilitate this.

Value All Perspectives:

In interdisciplinary teams, each member brings a unique viewpoint. Encourage members to share their perspectives, highlighting how each contributes to solving complex problems.

b. Develop Clear Communication Protocols

Establish Roles and Responsibilities: Clearly define communication roles within the project team. Specify who is responsible for internal communications, who will communicate with external stakeholders, and who will handle documentation.

Use Effective Tools: Utilize tools that match the team's needs, such as project management software, collaborative documents, and communication platforms like Slack or Microsoft Teams. This ensures that information is easily accessible to all team members.

c. Train and Educate

Communication Skills Training: Provide training in both verbal and written communication. This could include workshops on public speaking, technical writing, and interpersonal communication.

Feedback Mechanisms: Teach team members how to give and receive constructive feedback. This can improve project outcomes and individual performance.

d. Practice Inclusive Communication

Adjust for Audiences: Tailor communication strategies to the audience's knowledge level and interests. This is particularly important when conveying complex STEAM concepts to non-experts or community members.

Promote Language Accessibility: Use clear, jargon-free language, when possible, especially when communicating with non-specialists. Consider translations or other adaptations for non-English speakers within the community.

e. Leverage Visual and Digital Media

Visual Communication: Use visual aids like diagrams, infographics, and videos to communicate complex information more effectively. Visuals can help bridge understanding and make abstract concepts more tangible.

Digital Storytelling: Employ digital storytelling techniques to share project progress and results. This can be particularly effective for engaging community members and stakeholders through social media, blogs, or project websites.

f. Encourage Reflective Communication

Document Processes and Learnings: Encourage regular documentation of project processes, changes, and outcomes. This not only aids in project management but also helps in reporting results to stakeholders and funding bodies.

Reflective Discussions: Hold sessions where team members can discuss what went well and what could be improved. This reflection can enhance learning and performance over time.

g. Regularly Review and Adapt Communication Strategies

Evaluate Communication Effectiveness: Regularly assess how well communication strategies are working. Surveys, feedback forms, and informal conversations can provide insights into areas for improvement.

Adapt Strategies Based on Feedback: Be flexible and ready to adapt communication methods based on team and stakeholder feedback to improve clarity and effectiveness over time.

By following these guidelines, teams engaged in STEAM and CSPs can improve their communication effectiveness, leading to more successful collaborations and better project outcomes. Effective communication not only supports the logistical aspects of project management but also enhances the sharing of knowledge and the building of relationships among project stakeholders.

Incorporating presentation and collaboration skills into project-based learning (PBL) is essential for preparing students to succeed in diverse and teamwork-oriented environments. These skills not only enhance students' ability to communicate their ideas clearly but also enable them to work effectively in teams. Here's how educators and facilitators can integrate these crucial skills into PBL settings:

h. Strategies for Incorporating Presentation Skills

Regular Presentations:

Integrate regular presentation opportunities into projects. This can start with informal presentations in small groups and progress to more formal presentations for the whole class or external audiences. Each presentation can focus on different aspects of the project, such as the planning phase, progress updates, and final results.

Diverse Formats:

Encourage students to present in various formats, including digital slideshows, posters, videos, and live demonstrations. This variety helps students develop flexibility in how they convey information and adapt to different contexts and technologies.

Peer Feedback:

Implement structured peer feedback sessions following presentations. Provide guidelines on how to give constructive feedback focusing on both the content and delivery of the presentation. This process helps students refine their communication skills and learn from each other.

Presentation Workshops:

Offer workshops or sessions that focus on developing presentation skills, such as how to structure a presentation, use visual aids effectively, and engage an audience. Practicing these skills in a low-stakes environment can boost confidence and competence.

i. **Strategies for Enhancing Collaboration Skills**

Defined Roles and Responsibilities:

At the beginning of a project, help students define their roles and responsibilities within the team. This structure encourages accountability and ensures that all aspects of the project are covered. Roles can rotate throughout the project to give students experience in various aspects of teamwork.

Collaboration Tools:

Teach students how to use collaboration tools effectively. These might include project management software like Trello or Asana, communication platforms like Slack, or document sharing tools like Google Drive. Familiarity with these tools is crucial for modern teamwork and helps students manage projects more efficiently.

Conflict Resolution Training:

Equip students with conflict resolution skills. Offer training or workshops that cover strategies for resolving disagreements and maintaining positive team dynamics. This training can help prevent conflicts from derailing projects and teach valuable interpersonal skills.

Reflective Group Discussions:

Schedule regular check-ins where teams can discuss their progress, challenges, and strategies. These discussions should be structured to allow every team member to

voice their thoughts and concerns. Reflective practice helps teams stay on track and learn from their experiences.

Incorporating presentation and collaboration skills into project-based learning not only enriches the educational experience but also prepares students for professional and personal success beyond the classroom. By actively integrating these skills into PBL, educators can help students develop into effective communicators and collaborators.

6.8. Assessment of 21st-Century Skills

Assessing 21st-century skills is crucial as education systems worldwide shift focus from traditional knowledge-based standards to skills that prepare students for the dynamic and complex challenges of today's world. These skills include critical thinking, problem-solving, creativity, communication, collaboration, and digital literacy, among others. Effective assessment of these skills requires innovative approaches that go beyond conventional testing methods. Here's how educators and institutions can effectively evaluate 21st-century skills:

a. Performance-Based Assessments

Performance-based assessments require students to perform tasks or projects that demonstrate practical application of their skills. Unlike traditional tests, these assessments allow students to create, perform, or build something, often with real-world applications.

Implementation: Create assignments that require students to solve a problem, conduct a project, or create a product. For example, students could be tasked with designing a sustainable energy solution for their school, presenting their proposals through both written reports and oral presentations.

b. Portfolios

Portfolios are collections of student work that demonstrate learning progress and the development of skills over time. They allow students to reflect on their learning and showcase their best work.

Implementation: Encourage students to maintain digital portfolios that include a variety of work samples, such as written pieces, design projects, and video recordings of presentations. Portfolios can be reviewed periodically to assess growth in key competency areas.

c. Self and Peer Assessments

Self-assessment and peer assessment encourage students to evaluate their own or each other's work critically. This not only helps students develop a deeper understanding of the content and skills but also fosters critical thinking and reflection.

Implementation: After group projects or presentations, have students complete a reflection on their own performance and that of their peers. Provide criteria and scales for assessing specific 21st-century skills such as collaboration, communication, and creativity.

d. Observations and Rubrics

Observations are particularly useful for assessing soft skills like teamwork, leadership, and interpersonal communication. Rubrics provide a detailed scoring guide to evaluate student performances or projects based on predefined criteria.

Implementation: Use observation checklists and detailed rubrics during student presentations, group activities, or while students are working on projects. These tools help ensure that assessments are consistent, transparent, and aligned with the skills being evaluated.

e. Simulations and Game-Based Learning

Simulations and educational games can replicate real-world challenges that require students to apply various skills in a controlled environment. These tools are highly engaging and can be used to measure decision-making, strategic thinking, and problem-solving abilities.

Implementation: Integrate simulation software or online games designed for educational purposes into the curriculum. Assess student responses and strategies as they navigate these simulations to determine their proficiency in relevant skills.

f. Digital Badges

Digital badges are online representations of a skill or achievement, which can be acquired after mastering a particular competency. They motivate students and provide a way to document and communicate their non-traditional educational experiences.

Implementation: Issue digital badges for various competencies such as digital literacy, ethical online behaviour, or teamwork. These badges can be linked to specific assessments or performance milestones.

g. 360-Degree Feedback

This comprehensive feedback method involves gathering feedback from a full circle of people surrounding the student, including teachers, peers, and sometimes parents. It offers a well-rounded view of student skills and behaviours.

Implementation: Use 360-degree feedback for assessing skills such as leadership, empathy, and teamwork. Collect and analyse feedback using structured forms or surveys.

By employing these diverse assessment methods, educators can more accurately measure the complex and interrelated 21st-century skills that are essential for students' success in modern environments. These strategies also promote a learning culture that values continuous improvement and real-world application of knowledge.

The Role of Formative and Summative Assessments in Evaluating Skill Progression

Formative and summative assessments are essential tools in educational evaluation, each serving distinct roles that contribute significantly to the understanding and enhancement of student learning and skill progression.

a. Role of Formative Assessments

Formative assessments are integrated into the learning process and are designed to monitor student progress, provide ongoing feedback, and facilitate instructional adjustments. These assessments are primarily diagnostic, aiming to identify areas where students struggle so that teachers can apply targeted interventions. Unlike summative assessments, formative assessments are generally informal and continuous, often taking the form of quizzes, classroom discussions, or peer reviews. The key advantage of formative assessment lies in its ability to provide immediate feedback, which helps students understand their strengths and areas for improvement. This ongoing evaluation supports personalized learning by enabling tailored instructional strategies to meet the diverse needs of students.

b. Role of Summative Assessments

In contrast, summative assessments evaluate student learning at the end of an instructional period, measuring it against a standard or benchmark. These assessments are often high stakes, contributing to final grades, and include formal testing methods such as final exams, capstone projects, or standardized tests. Summative assessments are comprehensive, covering a broad range of content and skills to provide a holistic view of student achievement. They serve critical roles in measuring the effectiveness of instruction, certifying student competence, and benchmarking performance across different student groups or standards.

Integrating Formative and Summative Assessments

Effective educational assessment involves a strategic integration of both formative and summative assessments. Utilizing formative assessments throughout the teaching and learning process not only prepares students for summative evaluations but also guides educators in refining their instructional methods. Insights from formative assessments help in crafting summative assessments that are well-aligned with students' learning progression. Additionally, the outcomes of summative assessments can provide valuable feedback for planning future instructional strategies and formative evaluations.

By combining the immediate, diagnostic feedback of formative assessments with the evaluative power of summative assessments, educators can create a robust framework for academic instruction and improvement. This balanced approach not only enhances student learning and development but also supports educators in making informed decisions about pedagogical strategies, ultimately leading to improved educational outcomes.

6.9. Lifelong Learning and Adaptability

STEAM (Science, Technology, Engineering, Arts, and Mathematics) education and Community Science Projects (CSPs) play pivotal roles in fostering a mindset of lifelong learning and adaptability among learners. These educational approaches emphasize experiential learning, problem-solving, and creativity, which are key to developing skills that sustain continuous personal and professional growth. Here's how these educational frameworks contribute to cultivating these essential attributes:

Lifelong Learning through STEAM

a. **Interdisciplinary Nature**:

STEAM integrates multiple disciplines that are not traditionally taught together, encouraging students to make connections between different fields of knowledge. This

interdisciplinary approach promotes a broader understanding of how skills can be applied in various contexts, which is fundamental to lifelong learning.

b. **Problem-Solving and Inquiry-Based Learning**:

STEAM education often involves tackling complex, open-ended problems that don't have clear-cut answers. This kind of problem-solving encourages curiosity and a drive to inquire and explore, which are hallmarks of lifelong learners.

c. **Emphasis on Creativity and Innovation**:

By incorporating the Arts into STEM, STEAM education places a strong emphasis on creative thinking and innovation. Creative endeavours in art and design are combined with the logical problem-solving of science and mathematics, fostering a mindset that values creative approaches to problem-solving and the generation of new ideas.

Adaptability through STEAM

a. **Technology Integration**:

STEAM education emphasizes the use of current technologies and prepares students to adapt to and utilize rapidly evolving tools and technologies. This readiness not only applies to personal adaptability in a changing technological landscape but also enhances career adaptability across different industries.

b. **Hands-on Learning**:

The project-based nature of STEAM encourages learning by doing. This hands-on approach builds practical skills alongside theoretical knowledge, which helps students adapt to real-world challenges and solutions more effectively.

Lifelong Learning and Adaptability through CSPs

a. **Community Engagement**:

CSPs involve students directly in real-world community issues, requiring them to apply their learning in practical and often unpredictable situations. This direct engagement

enhances their understanding of the complexities of real-world problems and the need for ongoing learning to address these issues effectively.

b. **Collaborative Skills**:

Working within a community context, often with a diverse group of stakeholders, students develop strong collaboration skills. These skills are essential for lifelong learning as they enable individuals to learn from others, share knowledge, and adapt to group dynamics in various environments.

c. **Empowerment and Responsibility**:

CSPs empower students by making them agents of change in their communities. This responsibility motivates a continuous pursuit of knowledge and skills needed to make impactful decisions and fosters a proactive attitude toward learning.

Integrating Lifelong Learning and Adaptability

a. **Continuous Feedback and Reflection**:

Both STEAM and CSPs emphasize the importance of feedback and reflection in the learning process. Continuous reflection on experiences and outcomes helps students internalize what they learn and understand how to apply knowledge in various contexts, enhancing both adaptability and a commitment to lifelong learning.

b. **Skill Transferability**:

The skills developed through STEAM and CSPs, such as critical thinking, creativity, and collaboration, are highly transferable and valuable in any career. Learning how to apply these skills in diverse scenarios fosters adaptability and prepares students for lifelong personal and professional development.

In summary, the educational strategies employed in STEAM and CSPs are instrumental in developing the flexible, inquisitive mindset that characterizes lifelong learners and adaptable individuals. These attributes are increasingly important in our rapidly

changing world, where the ability to continuously acquire new knowledge and adapt to emerging challenges and technologies is key to personal and professional success.

7. Conclusion

Community science project and outdoor activities are crucial in ensuring that children are able to embrace environmental conservation and sustainable practices. Engagement in such adventure activities like community clean-ups, native plant gardening, and waste reduction activities fosters not only environmental responsibility but also the ability to relate with the environment. Through engagement in these programmes, kids can appreciate the importance of environmental conservation as well as being in a position to take action towards the environmental issues.

Including STEAM education in teaching and outdoor activities enhances the learning process for students. Incorporation of conventional subjects with the practical aspects of life enables the students to develop skills such as critical thinking, problem solving and creativity. This way not only makes learning more engaging and meaningful, but also prepares students for future challenges when problems that require an interdisciplinary approach will have to be solved. The integration of STEAM allows the students to analyse complex issues and come up with new ideas through practical exercises.

STEAM activism is relevant in ensuring that children are fully involved in projects relating to climate change and sustainability. Through the integration of STEAM in environmental issues, children can innovate, communicate and solve problems to make a difference in the world. Environmental management programs allow students to embrace their sense of stewardship and become advocates for sustainable environmental causes.

The involvement of children in STEAM and community science activities helps them develop lifelong learning skills. Through interactive assignments that require critical thinking, teamwork, and imagination, students acquire knowledge about adaptation and resilience. These projects help students to use their knowledge in practice,

enhance their understanding of complex subjects, and develop skills that will be useful when encountering challenges in the future as the world evolves rapidly.

In conclusion, the integration of outdoor activities, STEAM education, and community involvement offers children a full learning process. Combining theory and practice, as well as theoretical knowledge and practical outcomes, students develop skills such as critical thinking, creativity, and environmental and social sensitivity. Not only do these experiences enhance the students' academic achievement but also equip them with the knowledge and attitude to be active learners and contributors to a sustainable future.

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OPEN: WIDE MINDS WILL FIND ECO VIRTUAL STEAM SOLUTIONS TOWARDS CLIMATE

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