ECOTEACH

Teaching science and Maths through EBL for disadvantaged students and schools

WP3- A4

Conceptual and Pedagogical Framework

ECOTEACH Virtual Classroom

By all partners

Table of Content

Pedagogical approach and learning structure

The ECOTEACH Conceptual and Pedagogical Framework provides the educational and methodological basis for the ECOTEACH Virtual Classroom. Its purpose is to support teachers and educators in implementing innovative STEM learning approaches through Environment-Based Learning (EBL), particularly in disadvantaged schools and educational contexts.

The framework has been designed as a practical pedagogical reference that combines theoretical foundations, inclusive educational principles, environmental awareness and active learning methodologies. Rather than presenting purely academic content, the framework aims to provide accessible and transferable guidance that teachers can adapt to different educational realities and student needs.

The ECOTEACH pedagogical approach is based on the integration of Science, Technology, Engineering and Mathematics (STEM) with real environmental contexts. Through this approach, environmental challenges and local sustainability issues become meaningful learning opportunities that help students connect scientific and mathematical concepts with everyday life.

The framework particularly focuses on supporting schools and learners facing social, educational or economic disadvantages. In many educational environments, students experience barriers related to low motivation, limited participation, language difficulties, reduced access to resources or social exclusion. For this reason, ECOTEACH promotes inclusive, flexible and student-centred teaching methodologies that facilitate participation and engagement for all learners.

The pedagogical orientation of the framework combines several complementary educational approaches, including:

- Environment-Based Learning (EBL)
- Inquiry-based learning
- Experiential and outdoor learning
- Project-based learning
- Collaborative and participatory learning
- Inclusive education and Universal Design for Learning (UDL)
- Digital-supported learning and technology-enhanced education

These approaches encourage students to observe, investigate, experiment, collaborate and reflect on real environmental situations while developing scientific thinking, mathematical competences and transversal skills such as communication, problem-solving and critical thinking.

The framework is organised through six interconnected Learning Units, each addressing a specific pedagogical and thematic dimension of Environment-Based STEM Education.

The Learning Units cover the following areas:

- Foundations of Environment-Based Learning in STEM Education
- Designing inclusive STEM learning activities
- Integration of mathematics and interdisciplinary STEM approaches
- Digital tools and technology for EBL learning
- Community engagement and project-based learning
- Assessment and evaluation methods for disadvantaged educational contexts

Together, these Learning Units provide teachers with a coherent progression from theoretical understanding to practical classroom implementation. The framework therefore supports educators not only in understanding the pedagogical principles of Environment-Based Learning, but also in applying them through practical activities, digital resources and inclusive teaching strategies.

The ECOTEACH Conceptual and Pedagogical Framework also serves as the pedagogical foundation for the other components of the ECOTEACH Virtual Classroom, including the Electronic Database, Hands-on Exercises, Evaluation Tools and Online Training Course. In this way, the framework ensures coherence between the learning objectives, pedagogical methodologies and educational resources developed throughout the project.

Ultimately, ECOTEACH promotes a vision of STEM education that is more participatory, contextualised, inclusive and connected to sustainability challenges. By using the local environment as a learning resource, teachers can create more engaging and meaningful educational experiences that support both academic development and active environmental awareness among students.

Learning unit 1: Environment-Based Learning (EBL) in STEM Education

Introduction

Learning Unit 1 introduces the fundamental principles of Environment-Based Learning (EBL) and its implementation in STEM education. By focusing on its core principles, key concepts, and relevance for teaching science and mathematics, particularly in disadvantaged school contexts, it aims to equip teachers with both theoretical and practical skills to implement EBL in STEM education. In this context, the unit serves as the conceptual starting point for establishing a pedagogical basis grounded in subsequent learning units and practical applications.

In many disadvantaged school settings, students often experience difficulties engaging with abstract scientific and mathematical concepts that appear disconnected from their daily lives. Traditional teaching approaches may therefore limit students' participation, motivation and long-term understanding. This learning unit addresses these challenges by encouraging teachers to connect STEM learning with students' immediate environments and lived experiences.

The unit explores key concepts such as environmental awareness, sustainability, place-based learning and experiential education. Through these perspectives, teachers are encouraged to view the local environment as a meaningful pedagogical resource that can support active participation, critical thinking and interdisciplinary learning.

As the introductory unit of the ECOTEACH framework, it provides the conceptual and pedagogical foundation for the following learning units and practical classroom applications. It particularly aims to strengthen teachers' confidence and readiness to implement Environment-Based Learning approaches in diverse and resource-limited educational settings.

Theoretical foundations

This learning unit focuses on the key pedagogical theories and approaches to effectively integrate Environment-Based Learning into STEM activities, specifically targeting implementation in disadvantaged contexts. The grounding approach in this unit situates learning within local environmental contexts rather than an isolated and theoretical traditional teaching approach. By this contextualization, students will be better able to develop a deeper understanding of scientific and mathematical concepts, particularly in disadvantaged settings.

Environment-Based Learning (EBL) constitutes the core theoretical framework of the unit, which situates the environment as an enriching and dynamic learning context. To connect learning experiences to the students' immediate environment, students explore real-world issues and understand the interconnections between ecological, social and scientific systems.

Inquiry-Based Learning encourages students to investigate a phenomenon or solve an authentic problem they have experienced/observed in their immediate surroundings, thereby reinforcing both scientific thinking and problem-solving skills. In this approach, students are engaged in observation, data collection and analysis processes.

Experiential Learning further reinforces these processes by encouraging active engagement at every stage of the learning process. Students interact directly with their surroundings, which makes learning more meaningful and permanent. This approach is particularly effective for students from disadvantaged backgrounds, as it supports understanding beyond traditional.

Inclusive Education Approaches ensure that learning opportunities are accessible and meaningful for each student who comes from different backgrounds. By incorporating flexible teaching strategies and adapting to diverse learning needs, teachers can foster participation and reduce learning inequalities by creating supportive environments. Approaches such as Universal Design for Learning (UDL) provide multiple ways for students to engage with content and demonstrate their understanding.

Social Constructivist Perspectives, influenced by Vygotsky, also play an important role in the unit. Collaborative learning environments encourage students to exchange ideas, learn from peers and develop understanding through social interaction. This is especially beneficial in diverse classrooms where students may demonstrate different learning needs and abilities.

Finally, STEM education integrates science and mathematics through interdisciplinary learning. These disciplines are naturally connected by environmental topics, enabling students to apply mathematical tools such as measurement, data analysis and interpretation within scientific systems. This integrated approach fosters the development of transferable skills, such as problem solving, critical thinking and collaboration.

Together, these theoretical foundations support the development of engaging, inclusive and context-based STEM learning experiences, particularly in schools with limited resources and diverse student populations.

Pedagogical approach

This learning unit is implemented through student-centred teaching methodologies that promote active learning, student engagement, and inclusive participation. These approaches enable teachers to effectively integrate EBL into STEM education, especially in disadvantaged school contexts. As a foundational unit, it aims to upskill teachers' capacity to implement key pedagogical approaches before moving into more practice-oriented applications in subsequent units.

At this level, inquiry-based learning is presented as a mindset rather than a fully structured methodology. Teachers are encouraged to facilitate learning by providing simple, open-ended environmental prompts (e.g. 'What do you observe around our school?' or 'Where do you see mathematics in our daily environment?'). This mindset helps to shift the focus from theory to exploration, which enhances active engagement, particularly among students who may feel disconnected from abstract STEM concepts.

The unit also presents the logic of project-based thinking by equipping teachers with an understanding of real-world environmental problems to be used as entry points for STEM education, to support students' motivation and engagement.

The key strategy for creating supportive and participatory science and maths lessons is collaborative learning. Practical application examples in this unit highlight peer interaction and inclusive classroom environments. The overall aim is to provide teachers with the mindset and practical tools to implement this approach further.

Digital-supported learning increases accessibility among students and diversifies the lesson materials. Digital tools can be used as observation tools such as taking photos of observations, creating basic digital charts, or presenting findings visually. In this context, teachers are encouraged to utilize the ECOTEACH Virtual Classroom as a supportive tool, which provides structured materials, interactive content, and examples of practice.

Importantly, the unit emphasises that effective STEM learning does not require advanced equipment or expensive materials. Everyday surroundings, local environmental issues and low-cost resources can become meaningful learning opportunities when combined with active and inclusive teaching approaches.

Practical application in schools

Starting from simple and flexible real-world situations that are familiar to students, it is highly encouraged to take initial steps in integrating Environment-Based Learning (EBL) into their classroom practices.

- For example, a teacher may begin the lesson by asking a simple question such as: "What kind of waste do we throw away the most in our classroom?", or "Where do we observe the most pollution in our neighborhood?, Why do you think?". Teacher may encourage students to observe their school/classroom/neighborhood and collect simple data over a few days. Students can be encouraged to define their own categories (e.g., plastic, paper, food waste, or, based on colors/texture), encouraging active thinking in the learning process. As the students record their findings, the teacher introduces basic mathematical concepts such as counting, comparing quantities and representing results visually through simple charts. This approach ensures that mathematics is not taught as an abstract subject, but as a tool for understanding real-life situations.

Similarly, teachers can design learning experiences that evolve over time.

- For example, during a plant observation activity, students could be asked to predict how a plant would grow in different conditions, such as sunlight, water and location. They can then measure and record changes regularly. This process helps students to move from observation to reasoning, thereby bridging the gap between experience and conceptual understanding.

To make learning more inclusive, teachers could organize activities so that each student has the chance to take on different roles. For example, some students could measure, some could record data, and some could present the results.

Teachers are further encouraged to connect these activities to students' daily lives by asking reflective questions:

- "Why is this important for our school?" or "What could be changed on this matter?".

Teachers are encouraged to make students explore their surroundings by asking questions:

- "Which areas are always in the sun? Which areas are mostly in shadow? Why do you think?" or "Where do you see sunlight in the morning?"

Students can then record where shadows appear and which areas receive more sunlight. They can compile these recordings and create a chart based on them.

Students can also use simple apps to measure environmental data, take photos of observations, and use basic graphing tools. Interactive tools such as quizzes, visual simulations, or collaborative platforms can also support engagement and allow students to participate in different ways. This could not only provide visual support but also enable students to better understand and reflect on their findings, particularly benefiting those with diverse learning needs or language barriers.

An example to implement in the classroom:

- **"Where does water come from? Where does water go?"**

This activity aims to introduce students to basic system thinking by encouraging them to think and explore how water moves through their immediate environment. This activity involves observation, questioning, and simple reasoning, while also bridging science concepts with their surroundings.

Phase 1: This activity starts with an observation. Students explore the school and the surrounding area to observe where water can be found and how it is used (e.g. in sinks, drinking fountains, in the garden, in puddles after rain or flowing along the street). The teacher can guide the students by asking simple questions such as "Where can we see water?" and "What happens to water after it has been used?".

Phase 2: Students reflect on their observations and attempt to trace the journey of water, answering questions such as:

- Where does the water come from?
- Where does it go after we use it?

They represent their ideas by drawing simple flow diagrams (e.g. tap → use → drain), which allows them to visualize processes even if they cannot fully explain them verbally.

Phase 3: Students present their diagrams to the class. Teacher can support the discussion by comparing different ideas and highlighting similarities and differences. This stage helps students articulate their thinking and learn from their peers.

Phase 4: Teacher encourages deeper thinking through questions such as:

- Where might water be wasted?
- What could we do to use water more carefully?

Students may suggest simple, realistic actions (e.g., turning off taps, using less water, being more careful in daily use). After simple actions, students may be encouraged to develop more advanced and creative solutions, such as water reuse strategies, rainwater collection, or awareness-raising initiatives within the school environment. Following this discussion and based on your student group and available resources, these ideas can be developed further into small-scale classroom or school projects following this discussion.

These gradual and flexible practices enable teachers to help students experience science and mathematics as part of their everyday lives. This is to break down barriers to participation, promote inclusive learning and establish a solid basis for more structured, inquiry-based activities in STEM education.

Conclusions and recommendations

Implementing Environment-Based Learning (EBL) in STEM education has the potential to make science and mathematics more accessible, engaging and meaningful for all students, especially those in disadvantaged schools. By connecting learning to real-life environmental situations, teachers can reduce participation barriers and promote the development of key competencies more inclusively.

To effectively apply this approach, teachers are encouraged to start with simple activities that build on students' immediate surroundings. Using the classroom, schoolyard or local neighbourhood as a learning resource enables teachers to create meaningful learning experiences without the need for advanced materials or infrastructure. This is particularly important in disadvantaged contexts.

Teachers are encouraged to prioritize student-centred, flexible teaching strategies that allow learners to explore, observe and express their understanding in different ways. Providing multiple forms of participation, such as drawing, speaking, measuring or using digital tools, helps ensure that all students, including those with language barriers or lower academic confidence, can actively engage in the learning process.

A gradual progression from simple observation activities towards more structured inquiry and project-based learning is also recommended. This approach supports both teacher confidence and student readiness, especially in classrooms where active learning methodologies may be less familiar.

Collaboration, clear instructions and visual support strategies should be integrated throughout the learning process to reduce barriers and encourage meaningful participation. Simple digital tools may also enhance accessibility, engagement and creativity.

Ultimately, teachers are encouraged to view the local environment as a "living laboratory" that can support interdisciplinary STEM learning, sustainability awareness and inclusive educational practices over the long term.

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Learning unit 2: Designing Inclusive STEM Learning Activities through Environmental-Based Learning

Introduction

This learning unit focuses on supporting educators in designing inclusive STEM learning activities through the integration of Environment-Based Learning (EBL), with particular emphasis on disadvantaged school contexts. Within the ECOTEACH project, this unit plays a key role in bridging theoretical approaches to inclusive education with practical teaching strategies that can be applied in real classroom environments.

In many disadvantaged schools, students face multiple barriers to learning, including limited prior knowledge, language difficulties, low motivation, and reduced access to supportive learning resources. As a result, traditional teaching approaches in Science and Mathematics may not effectively engage all learners or ensure equal participation. This learning unit addresses these challenges by providing teachers with adaptable frameworks and methodologies that promote inclusion, accessibility, and active engagement.

By integrating environmental contexts into STEM education, the unit supports teachers in creating meaningful and relevant learning experiences that connect scientific and mathematical concepts to real-world situations. Through approaches such as Universal Design for Learning (UDL), differentiated instruction, inquiry-based learning, and socio-emotional learning, educators are guided in redesigning their teaching practices to better respond to diverse student needs.

Overall, this unit contributes to the ECOTEACH project by equipping teachers with the knowledge and practical tools needed to implement inclusive, flexible, and engaging STEM learning experiences, particularly in educational settings where supporting disadvantaged learners is a priority.

Theoretical foundations

This learning unit is grounded in a set of complementary pedagogical approaches that support inclusive and effective STEM education through Environment-Based Learning (EBL), particularly in disadvantaged school contexts.

At its core, Environment-Based Learning (EBL) connects learning to real-world environmental contexts, allowing students to explore scientific and mathematical concepts through meaningful and familiar situations. This approach is particularly valuable in disadvantaged settings, where students may struggle with abstract content and benefit from concrete, context-based learning experiences that enhance relevance and motivation.

Inquiry-Based Learning plays a central role in this unit by encouraging students to actively engage in questioning, investigation, and problem-solving. Through inquiry processes, learners develop critical thinking and scientific reasoning skills, while also becoming more actively involved in the learning process. When applied to environmental challenges, inquiry-based learning enables students to explore authentic issues and develop practical solutions.

In addition, experiential learning supports learning through direct experience, observation, and reflection. This approach allows students to engage with their local environment, making learning more accessible and meaningful, especially for those with limited prior knowledge or academic confidence.

The unit also draws on key principles of inclusive education, particularly through the application of Universal Design for Learning (UDL) and differentiated instruction. These approaches ensure that learning activities are accessible to all students by providing multiple ways of engagement, representation, and expression. In disadvantaged classrooms, where learners may have diverse needs, language barriers, or varying levels of readiness, these strategies are essential for ensuring participation and equity.

Finally, STEM pedagogy is integrated in an interdisciplinary manner, promoting connections between science, mathematics, and environmental topics. By situating STEM learning within real-world environmental contexts, students are supported in developing not only subject-specific competences but also transversal skills such as problem-solving, collaboration, and critical thinking.

Overall, these theoretical foundations support the development of inclusive, engaging, and context-based STEM learning experiences, enabling teachers to design learning environments that respond effectively to the needs of disadvantaged learners while strengthening their understanding of science and mathematics.

Pedagogical approach

The pedagogical approach of this learning unit is based on student-centred, flexible, and inclusive teaching methodologies that support active participation and engagement, particularly in disadvantaged school contexts.

A key approach is inquiry-based learning, where students are encouraged to explore environmental issues through questioning, investigation, and reflection. This approach supports the development of scientific thinking and allows students to engage actively in the learning process. In disadvantaged classrooms, inquiry-based activities can increase motivation by giving students a more active and meaningful role.

Project-based learning further enhances engagement by allowing students to work on real-world environmental challenges over a longer period of time. Through projects, students can apply scientific and mathematical concepts in authentic contexts, while developing problem-solving and collaboration skills. This approach is particularly effective for students who may struggle with traditional instruction, as it provides purpose and relevance to learning.

Collaborative learning is essential for promoting inclusion. By working in mixed-ability groups, students can support each other and contribute based on their individual strengths. This approach helps reduce barriers for students with lower academic performance, language difficulties, or limited confidence, ensuring that all learners can participate meaningfully.

Where possible, outdoor learning can be integrated to connect students directly with their local environment. Activities such as observing, measuring, and recording environmental data provide hands-on experiences that support understanding, especially for students who benefit from experiential learning. In cases where outdoor learning is not feasible, classroom-based simulations and local case studies can provide similar opportunities.

In addition, digital-supported learning can enhance accessibility and engagement. Digital tools can be used for data collection, visualisation, and collaboration, offering alternative ways for students to access and present information. This is particularly useful for students with diverse learning needs, as it allows for multiple forms of expression.

To ensure inclusive participation, teachers should integrate:

- differentiated tasks with varying levels of complexity,
- clear and simplified instructions supported by visuals,
- multiple ways for students to demonstrate understanding,
- scaffolding strategies to support learners with additional needs.

Overall, these methodologies enable teachers to create flexible learning environments that support diverse learners, promote active engagement, and facilitate the development of STEM competences through meaningful environmental contexts.

Furthermore, the unit promotes 'Frugal Innovation' in STEM. Instead of expensive laboratory kits, teachers are trained to use everyday recyclable materials and the natural school environment. This ensures that socio-economic constraints of the school district do not limit the quality of scientific inquiry, making STEM accessible to all students regardless of their background.

Practical application in schools

Teachers can apply the concepts of this unit through structured, flexible, and context-based activities that promote inclusion and active participation in STEM learning, particularly in disadvantaged school environments. A practical way to implement these approaches is to organise learning activities in three interconnected phases: observation, analysis, and action, allowing all students to engage progressively and according to their abilities.

Phase 1: Environmental observation
Teachers can begin with simple observation tasks based on the immediate school environment. For example, students may observe and record data related to waste production, water usage, or temperature changes within the classroom or school. At this stage, it is important that teachers provide clear, simple instructions supported by visual prompts, ensuring that all students, including those with language difficulties or limited prior knowledge, can participate.

Phase 2: Data collection and analysis
Students then collect, organise, and represent data using tables, charts, or visual formats. To support inclusive participation, tasks should be differentiated:

- Some students focus on basic recording, classification, or visual representation of data.
- others engage in more advanced analysis, comparison, or interpretation.

This approach allows mixed-ability groups to work on the same activity while participating at different levels, ensuring that all learners are actively involved.

Phase 3: Interpretation and action
Students discuss their findings and propose solutions to real environmental challenges, such as reducing waste or saving energy within the school. Teachers guide this process through structured questions and support students in expressing their ideas through multiple formats (oral, visual, or digital), depending on their strengths.

Teachers can extend these activities to local environmental projects, such as developing a classroom recycling plan, creating awareness materials, or presenting the results to the school community. These projects foster collaboration, responsibility, and problem-solving skills, while also increasing motivation through their real-world relevance.

To effectively support students from disadvantaged backgrounds, teachers should:

- assign clear and differentiated roles within group work (e.g. observer, recorder, organiser, presenter),
- provide visual aids and simplified instructions for students with language or learning difficulties,
- use hands-on materials to support understanding,

- allow multiple ways of presenting results (oral, visual, digital).

Additionally, interdisciplinary STEM activities can be developed by combining science, mathematics, and environmental topics. For instance, students may calculate average water usage (mathematics), analyse environmental impact (science), and propose solutions (problem-solving and critical thinking).

Where available, digital tools can further support inclusion by enabling students to collect, visualise, and present data in accessible ways. Simple tools such as spreadsheets or basic data visualisation applications can enhance engagement, particularly for students who benefit from interactive and visual learning.

Example of classroom application: The "30-Minute Neighborhood Bio-Blitz"

A teacher in a disadvantaged school context can implement a "Bio-Blitz" activity with zero financial cost. In Phase 1, students spend 20 minutes in the schoolyard or the immediate neighborhood street, using a simple checklist to record "Signs of Nature" (e.g., insects, birds, weeds) versus "Signs of Human Impact" (e.g., litter, pavement, noise).

In Phase 2, students return to the classroom to organize their findings. To ensure inclusion, the teacher differentiates the roles:

- Students with language barriers or lower confidence focus on counting and sorting the physical tallies.
- Other students create visual bar charts or pictograms to represent the ratio of nature vs. human impact.
- Advanced learners calculate percentages or compare data between different spots (e.g., "shaded area" vs. "sunny area").

In Phase 3, the class discusses how STEM can help improve their local environment (e.g., "Where could we plant a small tree to increase biodiversity?"). This activity requires no prior knowledge, uses the neighborhood as a "living lab," and transforms students from passive learners into active "Citizen Scientists."

Conclusions and recommendations

The implementation of inclusive STEM learning through Environment-Based Learning (EBL) requires intentional planning, flexibility, and a strong focus on the diverse needs of learners, particularly in disadvantaged school contexts. This learning unit highlights the importance of combining inclusive pedagogical frameworks with practical, real-world learning approaches. By integrating principles such as Universal Design for Learning (UDL), differentiated instruction, inquiry-based learning, and socio-emotional learning, teachers can create learning environments that support participation, engagement, and achievement for all students.

To effectively apply this approach, teachers are encouraged to focus on the following practical strategies and "Quick Wins":

- Prioritize "Resource-Light" Activities: Focus on "frugal innovation" by using recycled materials and the local schoolyard to ensure that financial constraints do not limit inclusivity.
- Design Flexible Entry Points: Create activities that allow multiple ways of participation, ensuring that students with different academic levels can achieve immediate success.
- Promote Empowerment through Role-Playing: Assign clear roles within groups, such as *"Lead Scientist"* or *"Data Journalist"*, to build self-efficacy in students with low academic confidence.
- Language & Visual Scaffolding: Use visual aids and hands-on demonstrations to support students with language barriers or limited prior knowledge.
- Use Local Relevance: Connect STEM topics to the immediate challenges of the students' community to make learning more relevant and meaningful.

Particular attention should be given to students from disadvantaged backgrounds. In these cases, teachers should prioritise supportive and motivating learning environments that value student participation and gradual progress.

Finally, it is recommended that teachers continuously reflect on and adapt their teaching practices, ensuring that learning activities remain accessible and responsive to students' needs. Through this approach, EBL serves as a powerful tool for promoting equity and high-quality STEM education for all.

Learning unit 3: Integrating Mathematics and STEM Content into EBL

Introduction

Learning Unit 3 focuses on the strategic integration of Mathematics and core STEM subjects within the Environment-Based Learning (EBL) framework. Its primary objective is to demonstrate how mathematical concepts—often perceived as abstract, intimidating, or irrelevant by students in disadvantaged contexts. can become tangible and functional when applied to real-world environmental data.

Within the ECOTEACH project, this unit provides educators with the pedagogical tools and professional confidence to move beyond siloed subjects. It transforms Mathematics into a practical language for solving authentic challenges, such as analyzing energy consumption or biodiversity loss. By contextualizing STEM through the students' immediate environment, the unit ensures that learning remains accessible and meaningful, effectively helping to bridge the achievement gap for learners who may face socio-economic barriers, language difficulties, or low academic confidence.

Theoretical foundations

The theoretical framework of this learning unit is built upon the intersection of Interdisciplinary STEM Pedagogy and Realistic Mathematics Education (RME). The core philosophy is that mathematical and scientific concepts should not be taught in isolation but should emerge from "real-world" environmental situations that are familiar to the students. This is particularly vital for disadvantaged learners, as it transforms abstract symbols into functional tools for understanding their own community and surroundings.

Key theoretical pillars supporting this unit include:

- Environment-Based Learning (EBL) & Experiential Learning: Drawing from Kolb's experiential cycle, this unit posits that learning is most effective when it begins with concrete experience. By using the schoolyard or the local neighborhood as a "living laboratory," educators can lower the barriers to entry for students who lack academic confidence, providing a common physical starting point before moving to abstract mathematical modeling.
- Inquiry-Based Learning (IBL) & STEM Pedagogy**:** IBL shifts the focus from rote memorization to active investigation. In this unit, students act as "Citizen Scientists." This approach supports the development of science and mathematics competences by requiring students to identify problems (e.g., local air quality), collect raw data, and apply algebraic or statistical methods to find solutions.
- Inclusive Education & Data Literacy: This unit treats Data Literacy as a tool for equity. For students in disadvantaged contexts, the ability to interpret, analyze, and communicate data (e.g., energy use indices or biodiversity counts) is a form of empowerment. By applying Universal Design for Learning (UDL) principles, the framework ensures that mathematical tasks are scaffolded—providing multiple entry points so that every student, regardless of their prior knowledge or language proficiency, can engage with STEM content meaningfully.

Through these integrated approaches, the environment serves as the catalyst for developing core competences. Mathematics is no longer a "gatekeeper" subject that excludes students, but an inclusive bridge that connects scientific inquiry with real-world sustainability and problem-solving.

Pedagogical approach

The pedagogical strategy for this unit is centered on Authentic Problem Solving and Inclusive Data Visualization, designed to reduce the "math anxiety" often found in disadvantaged school environments. By moving the classroom outdoors and using the environment as a primary resource, teachers can implement the following methodologies:

- Inquiry-Based & Project-Based Learning (IBL/PBL): Instead of starting with mathematical formulas, teachers present a "Big Environmental Question" (e.g., *"How much water does our school garden actually need?"*). This approach encourages students to act as investigators, using mathematics (statistics, ratios) as a necessary tool to find answers. This shift from rote learning to inquiry significantly increases motivation for students who feel disconnected from traditional curricula.

- Outdoor & Experiential Learning: Learning is removed from the confines of the desk. By collecting data directly from the schoolyard or the local street, students engage in tactile learning. For disadvantaged learners, this provides a concrete, shared experience that serves as a bridge to abstract concepts, ensuring that limited prior academic knowledge is not a barrier to participation.

- Collaborative Learning & Differentiated Roles: To support inclusive participation, the unit promotes structured group work where students are assigned specific, professional roles (e.g., *"Lead Researcher"*, *"Data Recorder"*, *"Visual Designer"*). This allows for differentiation by task, ensuring that every student contributes according to their strengths—whether they excel at physical measurement, oral presentation, or digital recording—thus building self-efficacy.

- Digital-Supported Learning: The use of simple, accessible digital tools (e.g., free smartphone apps for measuring light, sound, or spreadsheets for graphing) enhances engagement. These tools provide immediate visual feedback, which is crucial for students with language barriers or learning difficulties, as it allows them to see the results of their inquiry in real-time.

- Frugal Innovation in STEM: A core component of this approach is the use of low-cost or recycled materials for mathematical modeling. By creating physical graphs or geometric models from everyday items, teachers ensure that a lack of expensive school equipment does not limit the quality of the STEM experience.

By integrating these methodologies, the teacher creates a multi-modal learning environment. This ensures that Science and Mathematics are taught not as abstract requirements, but as inclusive, empowering skills that every student can master through the lens of their own environment.

Practical application in schools

Teachers can apply the concepts of this unit by transforming the school environment into a "living lab" through a structured, three-phase pedagogical cycle: Observation, Analysis, and Action**.** This methodology is specifically designed to be "resource-light," requiring zero budget while ensuring the active participation of disadvantaged students through tactile and experiential learning.

The Three-Phase Implementation Cycle:

- Phase 1: Environmental Observation & Data Collection: Students work in collaborative teams to collect raw data from their immediate surroundings. For students with limited prior academic knowledge or language barriers, this provides a concrete entry point, grounding STEM in their daily physical reality rather than abstract theory.
- Phase 2: Data Analysis & Inclusive Modeling: In the classroom, students transform observations into mathematical insights. To support inclusive participation, teachers are encouraged to use "Physical Graphs" (e.g., students standing in lines of different lengths or using recycled bottle caps to represent data). This "embodied mathematics" ensures that core concepts like averages, ratios, or percentages are understood visually and physically before moving to formal symbolic representation.
- Phase 3: Interdisciplinary STEM Action: Students apply their findings to propose "Eco-Engineering" solutions. This empowers disadvantaged learners to see themselves as "Change Agents" and "Citizen Scientists" who can solve problems directly impacting their community.

Practical Examples for Classroom Application:

1. The "Energy & Water Detective": Students analyze school utility bills or measure water flow from taps. They apply Algebra to identify patterns of waste and Physics (e.g., heat transfer) to design simple insulation strategies using recycled materials.
2. The "Geometric Garden": Students design a sustainable planting area, calculating perimeter, area, and volume using measuring tapes or even their own steps. This makes geometry "visible" as they determine the ratio of seeds to surface area and the amount of soil required.
3. "Neighborhood Noise & Light Audit": Using free smartphone sensors, students monitor pollution levels in the schoolyard. They apply **Statistics** to calculate mean and range, using the "Human Bar Chart" method to visualize the data collectively before digitizing their results.

By implementing these interdisciplinary activities, educators can bridge the achievement gap, proving that high-level STEM inquiry is not a set of difficult formulas, but a powerful, accessible toolkit for changing the world.

Conclusions and recommendations

To effectively support disadvantaged learners in integrated STEM education, teachers should move beyond traditional instruction toward a more supportive and flexible framework. The following practical recommendations are key for successful implementation:

- Prioritize Meaning over Mechanics: Always introduce a compelling environmental "big question" before the mathematical formulas. When students understand *why* they need a ratio or a percentage to solve a local problem, their cognitive engagement increases significantly.
- Adopt "Resource-Light" Sustainability: Emphasize "frugal innovation" by using the immediate school environment and recycled materials. This ensures that a lack of funding is never a barrier to high-quality STEM experiences, promoting long-term inclusivity.
- Empower through Professional Roles: Assigning specific roles (e.g., *"Lead Data Analyst"*, *"Environmental Auditor"*) helps build self-efficacy. This is crucial for students with low academic confidence, as it gives them a clear, manageable responsibility within the team.
- Use Visual and Tactile Scaffolding: Always pair numerical data with physical models or infographics. For students with language barriers or learning difficulties, "embodied mathematics" (like physical graphs) is essential for grasping abstract concepts.
- Foster a "Citizen Scientist" Identity: Encourage students to present their findings to the school or local community. This transforms their perception of STEM from a difficult school subject into a powerful tool for social participation and environmental change.

Finally, teachers are encouraged to remain reflective and adaptive, tailoring activities to the unique cultural and social context of their students. Through this inclusive approach, Environment-Based Learning becomes a bridge to equity, ensuring that high-quality STEM education is accessible to every learner.

Learning unit 4: Digital Tools and Resources for Enhancing EBL in STEM

Introduction

Learning Unit 4 focuses on the role of digital tools and technological resources in enhancing Environment-Based Learning (EBL) within Science and Mathematics education. In the context of the ECOTEACH project, this unit aims to support teachers in integrating accessible and practical digital solutions into their teaching practices, particularly in disadvantaged school environments.

In many educational settings, especially those with limited resources, digital tools can act as powerful enablers of engagement, inclusion, and real-time learning. When combined with environmental observation and STEM education, technology allows students to collect, analyse, and visualise data in ways that make learning more interactive and meaningful.

This unit provides teachers with guidance on how to use digital tools not as an end in themselves, but as a means to facilitate inquiry, collaboration, and problem-solving. By connecting digital technologies with real environmental contexts, educators can create learning experiences that are more engaging, inclusive, and aligned with the digital competences required in today's society.

Theoretical foundations

The theoretical foundation of this unit is based on the integration of digital pedagogy, Environment-Based Learning (EBL), and STEM education, with a strong focus on accessibility and inclusion.

Environment-Based Learning provides the contextual framework, where students explore scientific and mathematical concepts through real environmental situations. Digital tools enhance this process by enabling more accurate observation, data collection, and analysis, transforming the environment into a dynamic and interactive learning space.

Inquiry-Based Learning plays a central role, as digital technologies allow students to investigate environmental questions through data-driven processes. Tools such as sensors, mobile applications, or simple data collection platforms support students in acting as active learners, rather than passive recipients of information.

Experiential learning is also reinforced through the use of digital resources. For example, students can document environmental observations using mobile devices, create visual representations of data, or simulate environmental processes using digital platforms. These experiences make abstract concepts more tangible, especially for learners with limited prior academic knowledge.

From an inclusion perspective, digital pedagogy offers multiple entry points for learning. Through visualisation tools, interactive applications, and multimedia resources, students with diverse learning needs, including those with language barriers or low academic confidence, can access content in more flexible and engaging ways.

Finally, the use of open educational resources (OER) supports accessibility and sustainability, ensuring that teachers can implement digital-supported EBL without requiring expensive equipment or specialised infrastructure.

Pedagogical approach

The pedagogical approach of this unit is based on the meaningful integration of digital tools into student-centred and inquiry-based learning environments.

A key strategy is the combination of inquiry-based learning and digital-supported learning, where students use digital tools to explore environmental questions. For example, they may collect environmental data (temperature, noise, light levels) using simple mobile applications and analyse the results using basic digital tools such as spreadsheets or visualisation platforms.

Project-based learning is also central to this unit. Students can work on environmental challenges, such as analysing pollution levels or monitoring biodiversity, using digital tools to support each phase of the project: data collection, analysis, and presentation.

Collaborative learning is enhanced through digital technologies, allowing students to share data, co-create content, and present findings using digital formats. This is particularly beneficial in disadvantaged classrooms, where collaboration can support peer learning and reduce individual barriers.

Digital storytelling and visualisation are especially important in this unit. Students can transform data into visual formats (charts, infographics, simple videos), making learning more accessible and engaging. This approach supports students who may struggle with traditional text-based learning by offering alternative ways of understanding and expressing knowledge.

Importantly, the unit promotes a ‘low-threshold digital approach’, encouraging the use of simple, free, and widely available tools. This ensures that the integration of technology does not create new inequalities but instead supports inclusive participation.

Practical application in schools

Teachers can apply the concepts of this unit by integrating digital tools into environment-based STEM activities through a simple and flexible three-step approach: observe, analyse, and communicate.

In the first phase, students use digital tools to observe and collect environmental data. For example, they may use smartphones to measure noise levels, light intensity, or temperature in different areas of the school. These activities require minimal resources and can be easily adapted to different contexts.

In the second phase, students analyse the collected data using accessible digital tools such as spreadsheets or simple data visualisation platforms. Teachers can support inclusive participation by assigning different roles within groups, ensuring that all students contribute according to their abilities.

In the third phase, students communicate their findings using digital formats. This may include creating charts, presentations, or short videos explaining their results and proposing solutions to environmental challenges.

Practical examples include:

- Conducting a 'Digital Environmental Audit' of the school using mobile apps
- Creating visual dashboards to represent environmental data
- Developing simple digital stories about local environmental issues
- Using open-access platforms to explore environmental datasets

These activities help students connect scientific and mathematical concepts with real-world applications while developing digital competences and collaborative skills.

Conclusions and recommendations

To effectively implement digital tools in Environment-Based Learning, teachers should prioritise simplicity, accessibility, and pedagogical purpose over technological complexity.

Digital tools should be used to enhance learning processes, not to replace them. Teachers are encouraged to start with simple tools that are already available, such as smartphones or basic software, and gradually expand their use as confidence increases.

It is important to ensure that all students can participate, regardless of their digital skills or access to technology. Providing clear instructions, using visual supports, and encouraging collaborative work can help reduce barriers and promote inclusion.

Teachers should also focus on connecting digital activities with real environmental contexts, ensuring that technology supports meaningful and relevant learning experiences.

Finally, by integrating digital tools into EBL, educators can help students develop not only STEM competences but also digital literacy, critical thinking, and problem-solving skills, preparing them to actively engage with environmental and societal challenges.

Learning unit 5: Community Engagement and Project-Based Learning in Environment-Based Learning EBL

Introduction

Learning Unit 5 focuses on the role of community engagement and project-based learning (PBL) in strengthening Environment-Based Learning (EBL) within Science and Mathematics education. In the context of the ECOTEACH project, this unit aims to support teachers in connecting classroom learning with real environmental challenges through active collaboration with local communities.

For many students, especially those in disadvantaged school contexts, traditional classroom-based learning can feel disconnected from their daily lives. This unit addresses that gap by promoting learning experiences that extend beyond the classroom, encouraging students to engage with their local environment, community actors, and real sustainability challenges.

Through project-based learning and community involvement, students are not only exposed to STEM concepts but also encouraged to apply them in meaningful and socially relevant ways. This approach helps increase motivation, develop a sense of responsibility, and foster a stronger connection between learning and real-world impact.

Ultimately, this unit provides teachers with practical guidance to design learning experiences where students become active participants in their communities, using science and mathematics as tools to understand and improve their environment.

Theoretical foundations

The theoretical basis of this unit is grounded in the integration of Environment-Based Learning (EBL), Project-Based Learning (PBL), and community-based education, with a strong emphasis on inclusion and real-world relevance.

Environment-Based Learning provides the framework for connecting STEM education with local environmental contexts. By using the surrounding environment as a learning space, students can explore scientific and mathematical concepts through direct observation and real-life situations.

Project-Based Learning plays a central role by structuring learning around real-world problems that require investigation, collaboration, and solution development. In this unit, environmental challenges, such as waste management, energy use, or local biodiversity, serve as the starting point for student projects.

Experiential learning supports this approach by emphasising learning through action, reflection, and participation. Students engage with their environment and community, making learning more meaningful, especially for those who may struggle with abstract or theoretical content.

Community-based learning further strengthens the educational process by involving local stakeholders such as environmental organisations, municipalities, or community groups. This connection allows students to see the real impact of their work and reinforces the relevance of STEM learning.

From an inclusion perspective, these approaches are particularly valuable in disadvantaged contexts. By focusing on real-world issues and collaborative activities, they provide multiple entry points for participation, allowing students with different abilities, backgrounds, and levels of confidence to engage meaningfully in the learning process.

Pedagogical approach

The pedagogical approach of this unit is based on active, student-centred learning, where students take a leading role in exploring environmental challenges and developing solutions through collaborative projects.

Project-based learning is the core methodology. Teachers guide students in identifying a local environmental issue and developing a project that includes investigation, data collection, analysis, and proposal of solutions. This approach supports the development of both STEM competences and transversal skills such as teamwork, communication, and problem-solving.

Collaborative learning is essential to ensure inclusive participation. Students work in groups with clearly defined roles, allowing each learner to contribute according to their strengths. This is particularly important in disadvantaged classrooms, where differentiated participation can help reduce barriers and increase engagement.

Community engagement is integrated into the learning process by connecting students with local actors. This may include interviews with community members, collaboration with environmental organisations, or participation in local initiatives. These interactions provide authentic learning experiences and help students understand the real-world implications of their work.

Inquiry-based learning also plays an important role, as students investigate environmental issues, formulate questions, and explore possible solutions. Teachers act as facilitators, supporting students throughout the process and encouraging reflection and critical thinking.

Finally, the approach promotes flexibility and adaptability, allowing teachers to design projects that fit their specific context, resources, and student needs.

Practical application in schools

Teachers can implement this unit by organising learning activities around real environmental projects connected to the local community, following a structured but flexible process.

A practical approach can be organised in three phases: explore, develop, and act.

In the first phase, students explore their local environment and identify relevant issues. This may include observing waste management practices, analysing green spaces, or identifying environmental challenges within the school or neighbourhood.

In the second phase, students develop their projects. They collect data, analyse information, and work collaboratively to propose solutions. Teachers can support inclusive participation by assigning roles such as researcher, organiser, communicator, or designer.

In the final phase, students take action by presenting their findings or implementing small-scale solutions. This may include awareness campaigns, presentations to the school community, or collaboration with local organisations.

Practical examples include:

- Designing a school recycling or waste reduction project
- Collaborating with a local environmental organisation on a community initiative
- Creating awareness campaigns on sustainability issues
- Developing small-scale environmental improvement proposals for the school or neighbourhood

These activities help students connect STEM learning with real-life applications while developing a sense of responsibility and active citizenship.

Conclusions and recommendations

To successfully implement community-based and project-based learning, teachers should focus on relevance, participation, and flexibility.

Projects should be based on real and meaningful environmental issues that students can relate to in their daily lives. This increases motivation and helps students understand the value of their learning.

Teachers are encouraged to design activities that allow for different levels of participation, ensuring that all students can contribute regardless of their academic level or background. Assigning clear roles within group work can support inclusion and build confidence.

It is also important to keep projects manageable and adaptable to available resources. Even small-scale initiatives can have a strong educational impact if they are well designed and connected to real contexts.

Finally, fostering collaboration with the local community can significantly enhance the learning experience. By interacting with real stakeholders, students gain a deeper understanding of environmental challenges and develop the skills needed to participate actively in society. Through this approach, Environment-Based Learning becomes not only a pedagogical method, but also a tool for empowering students and strengthening the connection between education, community, and sustainability.

Learning unit 6: Assessment and Impact Evaluation of EBL in Disadvantaged Contexts

Introduction

Unit 6 serves as the concluding learning unit of the ECOTEACH programme. This is designed to help learners to evaluate and explore the overall effectiveness of the implementation of the previous units as part of a focused exploration of assessment and evaluation processes. The unit addresses both formative and summative assessment methods, the evaluation of STEM competences, and the measurement of student engagement and motivation. It also emphasises reflective teaching practices and the monitoring of learning outcomes within disadvantaged school contexts, equipping teachers with the tools and frameworks needed to appraise and evidence the impact of their practice.

Within the ECOTEACH project, this unit occupies a critical position. Effective Environment-Based Learning is not simply a matter of designing and delivering innovative learning experiences. It also requires teachers to be able to assess whether those experiences are fostering STEM competences, and to evaluate the broader impact of EBL programmes on their learners. For students in disadvantaged contexts, this is particularly important, as environmental and socio-economic factors can significantly influence motivation, participation, and learning outcomes. This unit therefore aims to ensure that teachers are equipped to recognise and respond to these influences in their assessment and evaluation approaches.

Unit 6 aims to ultimately empower the target audience to take an autonomous and reflective stance towards their professional practice. By developing the capacity to evaluate the effectiveness of EBL approaches and to communicate findings and recommendations to educational stakeholders, teachers become active agents in the continuous improvement of STEM education for disadvantaged students. In doing so, the unit makes a vital contribution to the core ambition of the ECOTEACH project - supporting teachers, but also schools and stakeholders, in teaching STEM through EBL, particularly in disadvantaged school contexts.

Theoretical foundations

Assessment and impact evaluation are fundamental to the success of any school and/ or school initiative. These activities serve to provide feedback and an evidence base in order to help make informed decisions about teaching, learning, and associated resource allocation. For schools working with disadvantaged communities and/ or students, this is particularly critical. Disadvantaged students often face a complex interplay of barriers to learning, including socio-economic pressures, lower levels of prior attainment, and reduced access to educational resources. This means that the stakes associated with ineffective teaching are often considerably higher and require effective allocation of resources to overcome these issues. The theoretical foundations of Unit 6 include a range of established frameworks in educational assessment, programme evaluation, and contextually responsive pedagogy.

A central concept in this unit is the distinction between formative and summative assessment. A broad range of research has demonstrated that well-designed formative assessment - assessment that is low-stakes, ongoing, dialogic, and feedback-focused - can be used to inform rather than measure teaching and learning. This has been shown to have a strong positive impact on the achievement of lower-attaining students. This approach is often distinguished as "Assessment FOR Learning (AFL)" rather than "Assessment OF Learning". This is highly significant for the Ecoteach project - with a view to working with disadvantaged students and the effectiveness of formative assessment with this demographic. Formative assessment further supports the overall objective of this learning unit in that through formative assessment (through EBL activities such as observation, questioning, peer discussion, reflective journalling, active experimentation, etc.) also allows teachers to gather meaningful data on students' developing STEM abilities and to adjust their teaching accordingly - aligning to the central concept of impact evaluation.

Additionally, the theory of competence-based assessment provides an important foundation for helping to assess and evaluate STEM learning within EBL contexts. Rather than measuring the recall of discrete facts, competence-based assessment focuses on the application of knowledge and skills in authentic, meaningful situations. This aligns closely with the inquiry-driven, experiential nature of EBL, where students are expected to observe, analyse, reflect upon, investigate, and make conclusions based on the natural environment. The process of competence-based assessment also serves to distinguish between the approaches adopted with "lower-order thinking skills" within Blooms taxonomy (i.e. "Remember", "Understand", etc.) to move towards the "higher-order thinking skills" relating to "Analysis", "Evaluation", etc.

The unit is also grounded in Kirkpatrick's Four-Level Model of evaluation, which provides a structured approach to assessing the effectiveness of educational programmes at the levels of reaction, learning, behaviour, and results.

This model is particularly valuable for the ECOTEACH project as it identifies not only the impact of learning among the target audience, but also the satisfaction or engagement with same and potential adaptations in behaviour. This is particularly relevant for disadvantaged students who may not perform strongly in conventional assessment settings.

In addition to the above, the unit includes elements drawing up Vygotsky's concept of the Zone of Proximal Development and Schön's concepts of reflection in educational settings.

Pedagogical approach

Among the range of methodologies which can be used by schools, the following assessment elements are felt to offer strong potential for immediate and impactful effectiveness:

Formative Assessment/ Assessment FOR Learning (AFL)
A core methodology underpinning EBL is the use of practical and "hands-on" learning. For this, the approaches to assessment associated with Assessment FOR Learning (AFL) are particularly relevant. Through structured assessment approaches such as designing observation checklists, developing questioning (rather than only feedback) frameworks, and creating assessment suited to student observation, reflection and experimentation, teachers can develop familiarity with AFL strategies that can be immediately applied in their own classrooms. This "low-stakes", active and learning-focused (rather than score-focused) experiential approach mirrors the inquiry-based pedagogy that characterises EBL itself. In this way AFL approaches and an open, supportive, learner-focused ethos can reinforce the principle that meaningful learning arises from doing rather than simply receiving information. This is felt to be of particular relevance for disadvantaged students and schools.

Zone of Proximal Development
Vygotsky's concept of the Zone of Proximal Development is also identified as a useful approach for supporting the use of EBL for STEM learning in schools. This approach highlights the importance of learner achievement through timely, effective and structured support, as opposed to independent performance or overly-prescriptive, repetitive delivery of content. This approach can involve teachers designing assessment approaches that are scaffolded, collaborative, and sensitive to the social and cultural contexts in which learning takes place. This awareness of cultural contexts is particularly relevant for the EBL approach which draws upon students' own environments, and also for awareness of students whose engagement with formal education may be shaped by socio-economic disadvantage.

Reflective practice
Reflective practice, in particular Schön's concept of reflection-in-action and reflection-on-action, is also of importance and relevance to the EBL for STEM approach. Within an EBL approach, students are frequently encouraged to reflect actively during investigative tasks. This reflection-in-action supports the development of genuine scientific and mathematical reasoning, as students learn to interrogate their own understanding in the moment rather than simply recording outcomes. Reflection-in-action assessment activities - learning journals, peer discussions and feedback, guided discussion prompts, etc. - can therefore provide students with the opportunity to revisit and make deeper sense of their EBL experiences, further enhancing learning.

Beyond assessment approaches, Kirkpatrick's Four-Level Model is recommended as an evaluation framework which would be appropriate for evaluation purposes. Through this approach, teachers analyse evidence of impact at multiple levels — from immediate learner reactions to the learning achieved through to longer-term changes in student behaviour and attainment. This approach helps teachers to understand evaluation not as a judgement of failure or success, but as a constructive process of understanding and improvement. This also has potential relevance for EBL approaches as a means of aligning with sustainability and wider environmental elements.

Practical application in schools

The effective implementation of the assessment and evaluation elements outlined have been designed to align with EBL approaches. It is important to note that rather than presenting assessment and evaluation as abstract or administrative processes, the methodologies employed in this unit are designed to make these practices tangible, purposeful, and directly connected to teachers' everyday experiences of delivering EBL for STEM purposes. In this sense, a key overall consideration is including and embedding formative assessment and evaluation as key elements in the EBL teaching process, rather than an "afterthought" or a "separate" process to the learning experience.

A core methodology underpinning the unit is the use of formative assessment or Assessment FOR Learning (AfL), which is particularly well suited to the hands-on, inquiry-based nature of EBL.
An important consideration for AFL is ensuring that the process is low-stakes, learning-focused and supports effective feedback rather than marks or scores. This is a critical consideration for effectively implementing AFL processes among students and ensuring their engagement and comfort with the assessment processes. This should involve (among students) prioritising understanding over marks and creating an open and supportive ethos in which students feel safe to take risks, make mistakes, and learn from their experiences.

This is of particular significance for disadvantaged students, for whom high-stakes assessment environments can present an additional barrier to engagement and participation in science and mathematics learning. Useful approaches for AFL within EBL can include providing observation checklists, questioning frameworks, and assessment tools designed around student observation, reflection, and experimentation.

Vygotsky's concept of the Zone of Proximal Development can be utilised through the provision of scaffolded and collaborative assessment approaches. Rather than measuring what students can achieve independently within a classroom setting, this approach involves the design of assessment activities that provide timely, structured support (either by a teacher or from peers), enabling students to demonstrate and extend their competences within a collaborative learning environment. This approach is especially relevant within EBL contexts, where learning is grounded in students' own environments and lived experiences. By designing assessment that is sensitive to the social, cultural, and socio-economic contexts of their learners, it is possible to ensure that all students (including those whose engagement with formal education has been shaped by disadvantage) are able to participate meaningfully.

In implementing Schön's reflective practice approach in EBL settings, it is recommended that students be actively encouraged to reflect during investigative tasks. This process serves to help them to interrogate their own observations and reasoning as their understanding develops in real time. Within EBL contexts, this process can help foster authentic scientific and mathematical thinking through a deeper engagement with the processes of enquiry. This can be further complemented by follow-on actives such as learning journals, peer discussion, and guided prompts. These provide opportunities for students to revisit and consolidate their learning after the event, further deepening their understanding. Due to it's flexibility, reflection can be included within most activities as an additional, easily-accomplished and accessible task.

Utilising Kirkpatrick's Four-Level Model as a practical framework for programme evaluation essentially involves a process of data-gathering across multiple levels. While ideally all 4 levels should be addressed, it is not necessary that all be covered. These levels involve measuring:

- Level 1: Reaction. At this level, the intention is to gauge how learners felt, in an immediate general sense, about the programme of learning
- Level 2: Learning. At this level, the intention is to gauge to what degree the desired learning has been achieved.
- Level 3: Behaviour. At this level, the intention is to determine to what degree learners were able to apply what they learned during the learning programme in their day-to-day lives or activities.
- Level 4: Results. At this level, the intention is to determine how successful the learning programme and/ or the organisation has been in achieving its goals

The data for each can be gathered in any way which is felt to be most appropriate for the target audience. In this process, a focus group with students involved in EBL is identified as a likely effective approach.

Conclusions and recommendations

In general, one of the most important overarching recommendations for teachers implementing assessment and evaluation within EBL, as outlined in this unit, is to treat these processes as integral to the learning experience rather than as separate or additional tasks.

When assessment is embedded naturally within EBL activities (as outlined elsewhere in this unit, most often in the form of observation, questioning, peer discussion, experimentation etc.), it becomes a seamless part of the learning journey rather than an interruption to it. This is particularly important for disadvantaged students and for the overall EBL learning process. By keeping assessment low-stakes, learning-focused, dialogic and with an emphasis on feedback rather than marks, teachers can create an environment in which students feel safe to engage openly, take risks, and demonstrate their understanding.

When designing assessment activities, teachers are encouraged to draw on scaffolded and collaborative approaches (as informed by Vgotsky's Zone of Proximal Development). Providing structured support enables all students to participate meaningfully and to demonstrate competences that might not be visible in more traditional, individually-focused assessment settings. Observation checklists, questioning frameworks, and guided reflection prompts are all practical tools that can be adapted to suit a wide range of learner needs and EBL contexts.

Embedding reflective practice into EBL activities is another accessible and highly effective recommendation. Encouraging students to pause and reflect during investigative tasks, and to revisit their thinking through learning journals or group discussions afterwards, supports deeper STEM processes related to reasoning, practical application, etc. while also helping to avoid specific requirements in literacy or formal writing skills (which may be relevant fpr - but not unique to - disadvantaged students) . This flexibility makes reflection particularly well suited to inclusive practice also.

Finally, teachers are encouraged to approach programme evaluation using Kirkpatrick's Four-Level Model, gathering evidence of impact at whichever levels are most feasible for their context. Even a simple focus group or dialogic student feedback activity can yield valuable insights into the effectiveness of EBL approaches, helping teachers to continuously refine their practice and to build a meaningful evidence base that demonstrates impact for students, schools, and wider stakeholders.