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# STEAME ACADEMY
# TEACHING FACILITATION LEARNING & CREATIVITY PLAN (L&C PLAN) - LEVEL 1
# STUDENT TEACHERS
# TITLE: THERMALLY INSULATING ECO-BRICK FROM REUSED POLYSTYRENE

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## 1. Overview

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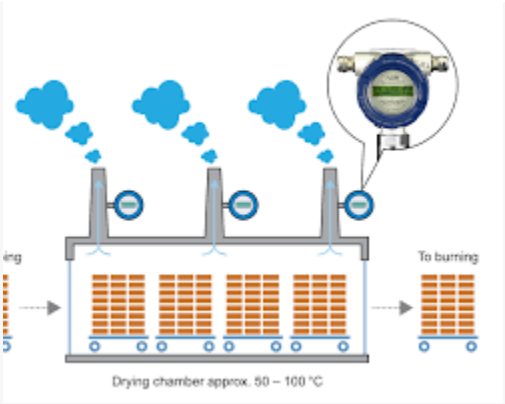
| Title | **Thermally Insulating Eco-Brick From Reused Polystyrene** | | |
| Driving Question or Topic | -Can we Reuse Waste Polystyrene that is found in building sites, empty washing machine boxes and fish markets?<br><br>-Can we improve the thermal insulation as well as the sound proofing of a house/room? | | |
| Ages, Grades, … | 12-15 year old students | Middle School | (Gymnasium) |
| Duration, Timeline, Activities | 60 hours | 2-3 months (A Semester) | Various Combined Activities between Disciplines |
| Curriculum Alignment | **In Mathematics:**<br><br>Several mathematical concepts come into play during brick manufacturing. Here are a few:<br><br>• **Measurement:** Bricks need to be consistent in size in order to create strong and stable structures. Manufacturers use precise measurements to ensure that each brick is identical. This involves concepts like length, width, height, and volume. | | |



Measurement in brick manufacturing

- **Geometry:** The rectangular shape of the brick itself is a geometric concept. Understanding the properties of rectangles, like area and perimeter, helps ensure efficient packing and designing of structures.
- **Ratio and Proportion:** The ratio of the ingredients used in the brick mixture (clay, water, etc.) is crucial for the brick's strength and durability. Brick manufacturers rely on precise ratios to create a consistent product.

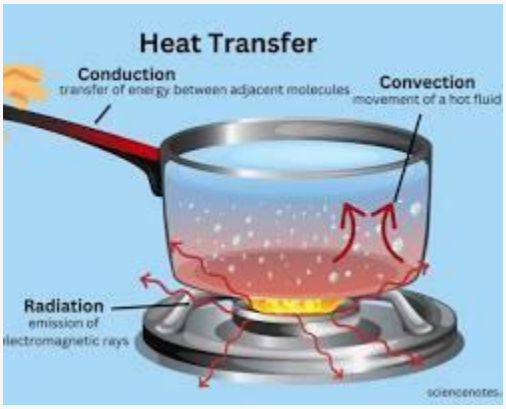
While there's no single chapter on brick making, these foundational mathematical concepts are all essential parts of the process: units of measure, 2D and 3D Geometry (Metric Units and Shapes), Introduction to statistics, Probabilities and Combinatorics.

**In Physics:**

The concept of thermal insulation is introduced and explored throughout various chapters related to heat transfer. Here are the relevant areas where you'll encounter thermal insulation in physics:

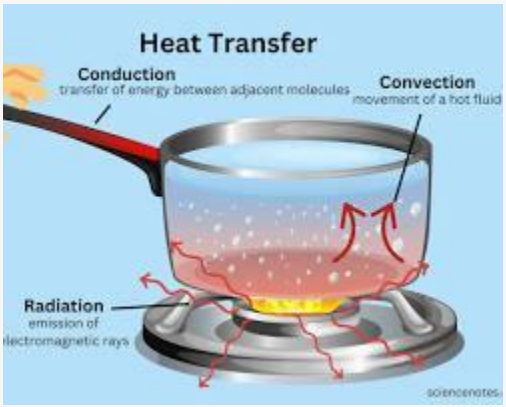
- **Heat Transfer Mechanisms:** This section covers the three basic mechanisms of heat transfer: conduction, convection, and radiation. Understanding these mechanisms is crucial to grasping how thermal insulation works.

    - Conduction is the transfer of heat through direct contact between objects. Insulators typically have low thermal conductivity, which means they resist the transfer of heat by conduction.



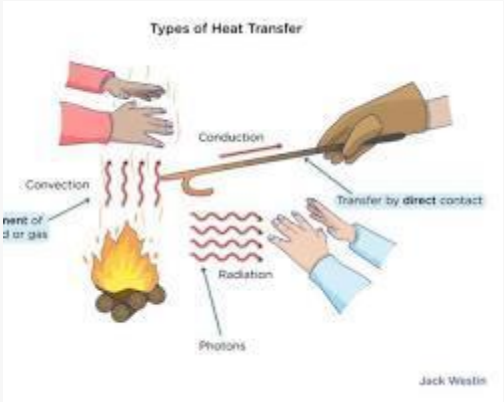
Heat transfer conduction

- Convection is the transfer of heat through the movement of fluids (liquids or gases). Insulators can impede convection by trapping air, preventing large-scale circulation of the fluid.



Heat transfer convection

- Radiation is the transfer of heat through electromagnetic waves. Some insulating materials can reflect radiant heat, reducing heat transfer.



Heat transfer radiation

- **Thermal Conductivity:** This section dives deeper into the concept of thermal conductivity (k), which is a material property that indicates its ability to conduct heat. Low thermal conductivity is a desirable property for thermal insulation. Materials like metals have high thermal conductivity, while materials like air, fiberglass, and styrofoam have low thermal conductivity.

- **Steady-State Heat Transfer:** This section deals with situations where the rate of heat transfer in is equal to the rate of heat transfer out, resulting in a constant temperature throughout the object. Thermal insulation principles are often applied in steady-state heat transfer calculations to minimize unwanted heat transfer.

The underlying principles behind **soundproofing** are rooted in concepts covered in various physics chapters, particularly those related to waves and acoustics. Here's where you'll encounter these ideas:

**Waves:** This section covers the fundamental properties of waves, including sound waves. You'll learn about characteristics like frequency, amplitude, wavelength, and how these relate to the perception of sound (pitch and loudness). Understanding these properties is essential for tackling soundproofing challenges.

**Sound Intensity and Decibels:** This section explores the concept of sound intensity, which is the amount of energy carried by sound waves per unit area. Decibels (dB) are the units used to measure sound intensity on a logarithmic scale. Soundproofing aims to reduce the sound intensity reaching our ears.

**Transmission and Reflection of Waves:** This section covers how waves, including sound waves, interact with barriers. Soundproofing materials work by either absorbing sound wave energy (conversion to heat) or reflecting it back towards the source.

**In Chemistry:**

An understanding of material properties is key. Here are some relevant areas of chemistry that apply to thermal insulation:

- **States of Matter:** Understanding the differences between solids, liquids, and gases is important. Solids and liquids are generally better insulators than gases. Insulation materials often use trapped air (gas) to impede heat transfer by convection.

States of Matter

- **Intermolecular Forces:** The forces between molecules in a material affect how well it conducts heat. Strong intermolecular forces make it harder for heat to vibrate molecules and transfer thermal energy. Good insulators typically have weak intermolecular forces, like the air pockets trapped in fiberglass insulation.

- **Material Properties:** Different materials have varying thermal conductivity. Metals are good conductors, while plastics and ceramics are often better insulators. Understanding these properties is crucial for selecting appropriate insulation materials.

- **Chemical Reactions:** Some insulating materials, like aerogels, are created through chemical reactions. These reactions create materials with a very porous structure, which traps air and improves insulation properties.

By understanding these areas of chemistry, you can gain a better understanding of how different materials function as thermal insulators.
Polystyrene is often covered within the following areas of chemistry:

- **Polymers:** This is the most likely chapter where you'll find detailed information on polystyrene. This chapter would discuss the concept of polymers, their structure, and how they are formed. Polystyrene would be used as an example of an addition polymer.

- **Organic Chemistry:** Since polystyrene is a hydrocarbon (made of carbon and hydrogen), it might be mentioned in a chapter discussing organic functional groups or aromatic compounds (due to the presence of a benzene ring in styrene, the monomer of polystyrene).

- **Chemical Reactions:** The polymerization process that converts styrene monomers into polystyrene chains might be covered in a chapter on chemical reactions, specifically addition reactions.

Here's a breakdown of how polystyrene might be addressed in these chapters:

- **Polymers Chapter:**
  - Definition of polymers and monomers
  - Types of polymers (addition vs. condensation)
  - Structure of polystyrene (chemical formula, repeating unit)
  - Properties of polystyrene (strength, rigidity, thermal properties)

- **Organic Chemistry Chapter (Depending on Book's Focus):**
  - Structure of styrene (the monomer)
  - Aromatic rings (if the book covers them)

- **Chemical Reactions Chapter (Depending on Book's Focus):**
  - Addition reactions (mechanism for styrene polymerization)
  - Free radical polymerization (common method for polystyrene production)

**In Biology:**

Biology focuses on living organisms and the processes within them. Polystyrene is a human-made, non-living material.
However, there might be some sections that touch on polystyrene in the context of:

- **Biodegradation:** Some chapters discussing waste management or environmental pollution might mention polystyrene as an example of a material that's resistant to biodegradation by most organisms. This can lead to plastic pollution problems.

- **Biocompatibility:** If the book covers topics like implants or prosthetics, it might mention that polystyrene is not generally biocompatible, meaning it can cause irritation or rejection when implanted in living tissue.

Overall, while you won't find in-depth discussions of polystyrene in biology textbooks, the material might be mentioned briefly in relation to biodegradation or biocompatibility.

There are sections across different chapters that discuss thermal insulation in the context of living organisms. Here are some potential areas you might find relevant information:

- **Adaptations:** Chapters on adaptations in extreme environments (polar regions, deserts) might discuss how animals use biological structures for thermal insulation. Examples include:
    - **Thick fur or blubber:** These features reduce heat loss in cold environments by trapping air and minimizing contact with the cold exterior.
    - **Feathers:** Birds use feathers for insulation, with down feathers providing superior warmth due to trapped air.
    - **Body size:** Larger animals tend to have a lower surface area to volume ratio, which helps them retain heat more efficiently.

- **Homeostasis:** Chapters on homeostasis (maintaining a constant internal body temperature) might mention how insulation helps organisms achieve this. Examples could include the vasoconstriction response in mammals to restrict blood flow near the skin in cold environments, minimizing heat loss.

- **Integumentary System:** This chapter, focusing on the skin and its functions, might mention how fur, feathers, scales, etc. (depending on the animal group) provide insulation.

**In Computer Science:**

- Excel sheets

- Statistical analysis of data

- Webpage design, building and monitoring.

**In Technology/Engineering:**

Polystyrene's widespread use in various applications makes it relevant across multiple technology chapters
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- **Polymerization Technology:** This chapter would discuss methods for producing synthetic polymers. It might specifically cover **free radical polymerization**, the common process used for polystyrene production. Details on reaction conditions, catalysts, and industrial-scale production methods could be included.

- **Plastics Processing Technology:** This chapter would delve into how plastic materials like polystyrene are shaped into useful products. Techniques like:
    - **Injection Molding:** Used for creating complex polystyrene parts like cups, containers, and toys.
    - **Extrusion:** Used for producing long, continuous shapes like polystyrene sheets, films, and pipes.
    - **Thermoforming:** Used for shaping polystyrene sheets into specific forms for packaging or disposable products.

- **Material Science:** This chapter might discuss the properties of polystyrene, such as its strength, rigidity, thermal insulation properties, and its limitations (brittle at low temperatures, susceptible to some solvents).

- **Building and Construction Technology:** Some sections might mention polystyrene's use in building insulation materials, particularly **extruded polystyrene (XPS)** foams commonly used for foundation insulation or roof panels.

- **Packaging Technology:** Polystyrene's lightweight, shock-absorbing properties make it a common material for disposable food containers, protective packaging for electronics, and packing peanuts.

By exploring these chapters in technology textbooks or online resources, you can gain a deeper understanding of how polystyrene is produced, processed, and utilized in various technological applications.

**In Arts:** Creating eco-bricks that are also well designed to fit the modern houses or studios or create a modern wall. Company logos, design and print.

**In Entrepreneurship:**

- **Introduction to Business and Economics** (this chapter typically lays the groundwork by explaining the nature of businesses, the role of the entrepreneur, and the different forms of business ownership: sole proprietorship, partnership, corporation),

- **Chapters on Microeconomics:** Microeconomics focuses on individual decision-making by consumers, firms, and markets.

- **Supply and Demand** (this fundamental principle dictates how prices are determined based on consumer willingness to pay (demand) and producer willingness to sell (supply). Understanding this is vital for setting prices for your product or service,

- **Market Structures** (Knowing the different market structures (perfect competition, monopoly, monopolistic competition, oligopoly) helps you understand how your company will compete in the marketplace,

- **Production and Cost Analysis** (this explores how firms convert resources into outputs, considering factors like fixed costs, variable costs, and economies of scale. This knowledge helps you optimize production and pricing strategies,

- **Chapters on Entrepreneurship** (some economics textbooks might have dedicated chapters on entrepreneurship, which would directly address), Identifying a Market Opportunity (this involves recognizing a customer need that isn't being adequately met and building a business around fulfilling that need,

- **Business Planning** (this chapter would discuss creating a business plan, a roadmap outlining your company's goals, strategies, target market, financial projections, and how you'll secure funding.

**In Languages and Culture:**

- Essay writing on defensive walls.

- Ancient walls of Nicosia: A complete analysis (Culture)

- Research and Survey writing, contacting and drawing conclusions.

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| Contributors, Partners | Waste/Dirty/Used Polystyrene found on Recycling areas of the city, Factories of Electrical appliances, Fresh fish shops, and construction sites. |
| Abstract - Synopsis | Learning through a Project Based Activity. Students will perform research on non-recyclable polystyrene, different types of cement and fibers used inside a modern brick. They will design and build various types of bricks, in size and material ratio/analogy as well as various shapes (with holes or not). With their final product the students will be able to create their own small scale business (start-up), entering an eco-friendly entrepreneurship world and discovering the basic principles of marketing. A complete STEAME+ Learning Approach that involves Mathematics, Physics, Chemistry, Biology, Technology, Engineering, Computer Science (STEM), Arts (A), Entrepreneurship (E), as well as Language and Culture (+). |
| References, Acknowledgements | The steps for performing our PBL procedure we written following a revised approach from the book "Project Method: Organising and Developing Cross-Thematic and Multi/Inter/ Intra- Disciplinary Projects" by Dr Chrysoulla Hadjichristou, Ministry of Education, Sport and Youth, Pedagogigal Institute – Curriculum Development Unit, Cyprus. |

## 2. STEAME ACADEMY Framework*

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| Teachers' Cooperation | **Teacher 1 (Mathematics)**<br>**Teacher 2 (Physics)**<br>**Teacher 3 (Chemistry)**<br>**Teacher 4 (Biology)**<br>**Teacher 5 (Computer Science)**<br>**Teacher 6 (Technology/Engineering)**<br>**Teacher 7 (Arts)**<br>**Teacher 8 (Economics/Marketing)**<br>**Teacher 9 (Languages/Culture)**<br><br>T3 cooperates with T4 regarding the general research on polystyrene, non-reusable plastics, natural decomposition and chemical decomposition of materials. Various types of cement and fibers used inside an eco-brick.<br><br>T1 cooperates with T2 and T6 regarding the dimensions of the brick and the parameters of its construction (mold size).<br><br>T5 cooperates with T7 and T9 regarding the artistic side of the brick, history of the walls in our city, colors and dimensions of the brick, webpage/ Facebook/ Instagram profile creation for advertising the product as well as taking orders by clients.<br><br>T1 cooperates with T5 regarding the analysis of various data, sound measuring data, as well as various questionnaires' results. Creation and manipulation of Excel sheets.<br><br>T1 cooperates with T7 and T8 for facilitating the creation of a small business for the pupils' product. Name, Slogan, Logo, Structure of the Board (CEO, Marketing Director, Sales Director, Media Manager etc.) |

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| | T6 cooperates with T2 to be able to construct various bricks of different sizes and shapes and examine their sustainability and durability over time. |
| STEAME in Life (SiL) Organization | -Meeting with Recycling Factory owners / Using their polystyrene waste.<br><br>-Factory mechanical tests on durability, pressure and thermal insulating properties.<br><br>-Meeting with Sound studios for testing the Sound-proof bricks using professional equipment as well as the professionals' experience and advice.<br><br>-Entrepreneurship – STEAME in Life (SiL) Days: Creation of a small business for their product. Name, Slogan, Logo, Structure of the Board (CEO, Marketing Director, Sales Director, Media Manager etc.) |
| Action Plan Formulation | <u>Preparation (by teachers)</u><br>1. Relation to the Real World – Reflection<br>Reuse and therefore "Recycle" of Polystyrene<br>Creating a more eco-friendly product for building houses/walls<br>2. Incentive – Motivation<br>Polystyrene cannot be recycled<br>Creating a start-up small business<br>Learning how to promote a product (marketing techniques)<br>3. Formulation of a problem resulting from the above<br><br><u>Development (by students) – Guidance & Evaluation (in 9-11, by teachers)</u><br>4. Research / Gather Information on reusable and non-reusable polystyrene<br>5. Research on Polystyrene, natural and chemical decomposition<br>6. Designing of bricks, research on already available brick designs in the market. Identifying additional materials that can be used (Glues, Fibers) for creating the bricks. Discovering and making contact with factories that reuse polystyrene.<br>7. Construction of various types of bricks - Experiment - Implementation of the bricks.<br>8. Observation of the final products - Experimentation on their durability and thermal insulation as well as soundproofing properties - Initial Conclusions<br>9. Documentation of results – Crash/Cut/Pressure tests, Sound proofing tests - Explanation based on Existing Physics Theories and/or Empirical Results<br>10. Gathering of results / information based on points 7, 8, 9<br>11. First group presentation by students<br><br><u>Configuration & Results (by students) – Guidance & Evaluation (by teachers)</u><br>12. Configure STEAME models to describe / represent / illustrate the results |

13. Studying the results in 9 and drawing conclusions, using 12
14. Applications of the thermal-insulating an sound-proofing brick in everyday life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)

Review (by teachers)

15. Review the problem and review it under more demanding conditions (e.g. building a whole house, defensive walls for military purpose)

Project Completion (by students) – Guidance & Evaluation (by teachers)

16. Repeat steps 5 through 11 with additional or new requirements as formulated in 15
17. Investigation - Case Studies - Expansion - New Theories - Testing New Conclusions
18. Presentation of Conclusions and the final product - Communication Tactics

## 3. Objectives and Methodologies

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| Learning Goals and Objectives | **In General:** The very definition of STEAME+ Education, the pupil to be able to research on a topic that involves all physical sciences, art, entrepreneurship as well as languages and culture and be able to combine knowledge and skills to deliver the final product/project, draw conclusions about the result, discuss feedback, remedies. The essence of metacognition, the process of thinking about one's own thinking and learning.<br><br>**In Mathematics:** To be able to manipulate numbers, measurements as well as calculation of various surface areas and volumes. To be able to perform basic probability and combinatorics knowledge and skills as well as in Statistics. Collect and refine raw data, be able to analyze data, make assumptions, perform various tests and draw conclusions. The pupil should be able to use broad mathematical skills to face any problem that arises during the whole learning and creating procedure.<br><br>**In Physics:** The pupils should understand and apply basic principles of thermal insulation as well as sound waves and be able to perform simple tests on these two areas. Have a full understanding of bricks' durability and be able to perform pressure tests to their product.<br><br>**In Chemistry:** A complete research on plastic materials, origin and composition of petroleum as well as be able to identify different types of polystyrene and their components.<br><br>**In Biology:** The pupils will be able to demonstrate experiments on possible polystyrene decomposition. They will have full understanding on how bacteria and other microorganisms act in nature.<br><br>**In Computer Science:** The pupils will be able to contact a full survey, record the results in Excel sheet and perform basic statistical analysis, |

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| | drawing conclusions and presenting them in graphs. They will also be able to design a webpage for their company or to advertise/sell their product.<br><br>**In Art:** Ability to use appropriate colors and shapes for best promoting their business or logo. Create various artistic styles for the product so that all customers' needs are met and the product is successful.<br><br>**In Greek Language and Culture:** A complete research on the history of the Ancient Walls of their city Nicosia, how they were built and the various types of ancient defensive walls around the world.<br><br>**In Technology/Engineering:** To be able to construct various thermal-insulating as well as sound-proof bricks of different sizes and shapes and examine their sustainability and durability over time.<br><br>**In Entrepreneurship:** The pupil to be able to work as a team and cooperate with other classmates to identify the need for a product, create a basic business plan, create/design a smart logo for his product, think/write a unique company name and a clever/commercial slogan, create/agree on a board of directors and apply the four basic principles of marketing (product, price, place and promotion). |
| Learning Outcomes and expected Results | **In General:** The pupil will get to improve certain STEAME+ skills, such as Problem Solving, Metacognitive Practices, Creativity, Collaboration, Communication, Critical Thinking, Demonstration of STEAM knowledge, Development of an understanding of the variety of STEM careers related to different fields of study, Application of science process/engineering process/product development process, Digital Literacy and other STEM tools - Demonstrating in class and afterschool records for student assessment, Active engagement and focus during learning activities, Active inquiries into STEAM topics, concepts, or practices. In few words, the essence of metacognition, the process of thinking about one's own thinking and learning.<br><br>**In Mathematics:** Easily manipulate numbers and functions, perform measurements as well as calculation of various surface areas and volumes. To be able to perform basic probability and combinatorics knowledge and skills as well as in Statistics. Collect and refine raw data, be able to analyze data, make assumptions, perform various tests and draw conclusions. The pupil should be able to use broad mathematical skills to face any problem that arises during the whole learning and creating procedure.<br><br>**In Physics:** Understand and apply basic principles of thermal-insulation and sound waves and perform simple thermal, pressure and sound-measuring tests. Have a full understanding of bricks' durability and be able to perform pressure tests to the final product.<br><br>**In Chemistry:** Satisfactory research on plastic materials, origin and composition of petroleum as well as be able to identify natural and synthetic fabrics and their components. |

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| | **In Biology:** Perform experiments on possible polystyrene decomposition. Understand on how bacteria and other microorganisms act in nature.<br><br>**In Computer Science:** Contact and run a full survey, record the results in Excel sheet and perform basic statistical analysis, drawing conclusions and presenting them in graphs. They will also be able to design a webpage for their company or to advertise/sell their product.<br><br>**In Art:** Ability to use appropriate colors and shapes for best promoting their business or logo. Create various artistic styles for the product so that all customers' needs are met and the product is successful.<br><br>**In Greek Language and Culture:** Research on the history of the walls of Nicosia, understand how ancient mechanics and builders worked to design/build the walls. Detailed analysis on eco-friendly materials (cement and fibers) as well as reusable and sustainable solutions.<br><br>**In Technology/Engineering:** To be able to construct various thermal-insulating as well as sound-proof bricks of different sizes and shapes and examine their sustainability and durability over time.<br><br>**In Entrepreneurship:** Pupils work as a team and cooperate with other classmates to identify the need for a product, create a basic business plan, create/design a smart logo for his product, think/write a unique company name and a clever/commercial slogan, create/agree on a board of directors and apply the four basic principles of marketing (product, price, place and promotion). |
| Prior Knowledge and Prerequisites | **In General:** Basic STEAME+ Education skills at a lower level, from the elementary school (primary education)<br><br>**In Mathematics:** Number manipulation, basic measurements with a ruler, basic surface areas and volumes. Simple probability and combinatorics skills. Broad mathematical skills to face any problem that arises during the whole learning and creating procedure.<br><br>**In Physics:** Skills from simple thermal, pressure and sound-measuring tests.<br><br>**In Chemistry:** Basic knowledge about the origin and composition of petroleum as well as be able to identify natural and synthetic materials like polystyrene and their components.<br><br>**In Biology:** Waste decomposition. Reusing and recycling materials.<br><br>**In Computer Science:** Basic knowledge on Word and Excel programs.<br><br>**In Art:** Create various artistic expressions using watercolors, pastels, as well as programs on the PC.<br><br>**In Greek Language and Culture:** Essay writing, Creating simple polls on paper or online (Google Forms, Microsoft Forms etc.). |

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| | **In Technology/Engineering:** Basic construction skills, cutting and gluing various materials. Basic wood-working skills.<br><br>**In Entrepreneurship:** Teamwork skills, decision making at a lower (primary education) level. |
| Motivation, Methodology, Strategies, Scaffolds | - Project Based Learning/Activity that involves all Sciences, Mathematics, Art, Entrepreneurship and Languages (Greek) and Culture. Gamification on the same topic may follow as a very interesting extension.<br><br>-Instruction differentiation for students' needs (learning styles, multi-modal representations, roles to students etc.)<br><br>-Active students' engagement, individual-team-classroom work, entrepreneurship skills, carpenter craftsman techniques, style. |

## 4. Preparation and Means

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| Preparation, Space Setting, *Troubleshooting Tips* | Material preparation:<br><br>- Collection of waste/used/dirty polystyrene from factories of our area (Outdoor activity), break them down into smaller pieces.<br>- Fibers and various glues and other bonding material, water, buckets for mixing the glues with water etc.<br>- Wooden molds or other solutions to create the shape of the final product.<br><br>Computer lab for manipulating data in Excel sheets. |
| Resources, Tools, Material, Attachments, Equipment | Internet, Laptops, Projector, Padlet platform for organizing the project and communicating ideas/ brainstorming. |
| *Health and Safety* | Basic safety rules for woodcutting and mixing cement. Special health and safety measures should be used by both teachers and pupils, like rubber gloves. |

## 5. Implementation

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| Instructional Activities, Procedures, Reflections | General research on plastic, reusable and non-reusable polystyrene, natural decomposition and chemical decomposition of materials. Measuring the dimensions of the thermal insulating and sound-proof brick and the parameters of its construction. Exploiting the artistic side of the brick (if possible), history of the walls of our city, colors and dimensions of the brick, webpage/ Facebook/ Instagram profile creation for advertising the product as well as taking orders by clients. Analysis of various data, thermal insulating data sound measuring data, as well as various questionnaires' results. Creation and manipulation of Excel sheets. Testing various glues and how the apply on various fabrics, concluding on the final/optimal selection and preparing the mix of glue and fabric to be applied on the carton base. |

Assessment - Evaluation

Project-based learning (PBL) thrives on a strong foundation of assessment and formative evaluation. An approach/system to effectively measure student abilities in PBL is provided further below. PBL goes beyond rote memorization.

We assess a combination of skills and knowledge acquisition:

- Content Knowledge: Ensure students grasp the core concepts explored in the project.
- 21st Century Skills: Assess critical thinking, problem-solving, collaboration, communication, and creativity throughout the project.
- Project Management Skills: Evaluate how students plan, organize, manage time, and adapt during the project.
- Learning Process: Reflect on how students approach challenges, learn from mistakes, and demonstrate self-directed learning.

Formative Evaluation Strategies for PBL:

- Checklists & Progress Reports: Provide ongoing feedback with checklists outlining key milestones and rubrics for specific tasks. Students complete progress reports reflecting on their contributions and challenges.
- Peer Reviews & Group Discussions: Facilitate peer reviews where students analyze each other's work based on rubrics. Organize group discussions to share ideas, troubleshoot, and refine approaches.
- Exit Tickets & Minute Papers: Use short exit tickets or minute papers at the end of each session to gather student understanding of concepts covered and identify areas needing clarification.

Rubrics are crucial for PBL as they translate project goals into clear expectations. Here's a breakdown for a science project on water quality:

| **Criteria** | Exceeds Expectations | Meets Expectations | Needs Improvement |
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| **Content Knowledge** | Demonstrates a deep understanding of sound waves and fabric recycling/reuse concepts, citing relevant data and scientific principles. | Shows a solid grasp of sound waves and fabric recycling/reuse concepts, applying them correctly in the project. | Understanding of sound waves and fabric recycling/reuse concepts is limited, with some inaccuracies in application. |
| **Collaboration & Communication** | Works effectively within the team, actively participating in discussions, delegating tasks, and resolving conflicts constructively. Communicates ideas clearly and concisely, both verbally and in writing. | Contributes to the team, listens to others, and helps manage tasks. Communicates ideas with some clarity, but may require prompting. | Struggles to collaborate effectively, hindering the team's progress. Communication is unclear or infrequent. |
| **Problem-Solving & Critical Thinking** | Identifies and analyzes problems effectively, proposing creative solutions and adapting strategies when needed. Demonstrates critical thinking by questioning assumptions, evaluating evidence, and drawing sound conclusions. | Identifies and solves problems with some guidance. Uses critical thinking to a moderate extent. | Has difficulty identifying or solving problems. Limited use of critical thinking skills. |
| **Project Management** | Meets all deadlines, manages time effectively, and stays | Completes most tasks on time, demonstrates decent organization. | Frequently misses deadlines due to poor time management and |

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| | organized throughout the project. Adapts to unforeseen challenges and adjusts the plan accordingly. | May need some reminders to stay on track. | organization. Struggles to adapt to challenges. |
| **Learning Process & Reflection** | Demonstrates strong self-directed learning skills, actively seeking and utilizing resources. Reflects deeply on the learning experience, identifying strengths, weaknesses, and areas for personal growth. | Shows initiative in learning, utilizing available resources. Reflects on the experience, acknowledging learning gained. | Limited self-directed learning. Reflection on the experience is shallow or absent. |

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| Presentation - Reporting - Sharing | Essays from pupils on their whole experience, Microsoft PowerPoint Slides showing all their journey (construction and entrepreneurship section), Padlet platform containing all the initial brainstorming and further discussions, ideas and actions, documents, outputs, artifacts, products produced by the students with references, web links etc.), for sharing to media. Photo albums of the procedure and final product.<br><br>https://padlet.com/yiannislazarou/polybrick<br><br>Name of product: Poly-Brick |
| *Extensions - Other Information* | Participate in various national and international competitions on Junior Achievement, Recycling/Sustainability and Mathematical Theatre (The Hendecagon of Savorgniano). |

**STEAME ACADEMY Prototype/Guide for Learning & Creativity Approach**
Action Plan Formulation

*Major steps in the STEAME learning approach:*

## STAGE I: Preparation by one or more teachers

1. Formulating initial thoughts on the thematic sectors/areas to be covered
2. Engaging the world of the wider environment / work / business / parents / society / environment/ ethics
3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
4. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.

## STAGE II: Action Plan Formulation (Steps 1-18)

*Preparation (by teachers)*

19. Relation to the Real World – Reflection
20. Incentive – Motivation
21. Formulation of a problem (possibly in stages or phases) resulting from the above

*Development (by students) – Guidance & Evaluation (in 9-11, by teachers)*

22. Background Creation - Search / Gather Information
23. Simplify the issue - Configure the problem with a limited number of requirements
24. Case Making - Designing - identifying materials for building / development / creation
25. Construction - Workflow - Implementation of projects
26. Observation-Experimentation - Initial Conclusions
27. Documentation - Searching Thematic Areas (AI fields) related to the subject under study – Explanation based on Existing Theories and / or Empirical Results
28. Gathering of results / information based on points 7, 8, 9
29. First group presentation by students

*Configuration & Results (by students) – Guidance & Evaluation (by teachers)*

30. Configure STEAME models to describe / represent / illustrate the results
31. Studying the results in 9 and drawing conclusions, using 12
32. Applications in Everyday Life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)

*Review (by teachers)*

33. Review the problem and review it under more demanding conditions

*Project Completion (by students) – Guidance & Evaluation (by teachers)*

34. Repeat steps 5 through 11 with additional or new requirements as formulated in 15
35. Investigation - Case Studies - Expansion - New Theories - Testing New Conclusions

36. Presentation of Conclusions - Communication Tactics.

## STAGE III: STEAME ACADEMY Actions and Cooperation in Creative Projects for school students

**Title of Project: _____**
Brief Description/Outline of Organizational Arrangements / Responsibilities for Action

| **STAGE** | **Activities/Steps**<br>Teacher 1(T1)<br>Cooperation with T2<br>and student guidance | **Activities /Steps**<br>**By Students**<br>Age Group: ____ | **Activities /Steps**<br>Teacher 2 (T2)<br>Cooperation with T1 and<br>student guidance |
|---|---|---|---|
| | | | |
| A | Preparation of steps 1,2,3 | | Cooperation in step 3 |
| B | Guidance in step 9 | 4,5,6,7,8,9,10 | Support guidance in step 9 |
| C | Creative Evaluation | 11 | Creative Evaluation |
| D | Guidance | 12 | Guidance |
| E | Guidance | 13 (9+12) | Guidance |
| F | Organization (SIL)<br>STEAME in Life | 14<br>Meeting with Business representatives | Organization (SIL)<br>STEAME in Life |
| G | Preparation of step 15 | | Cooperation in step 15 |
| H | Guidance | 16 (repetition 5-11) | Support Guidance |
| I | Guidance | 17 | Support Guidance |
| K | Creative Evaluation | 18 | Creative Evaluation |