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Training Materials

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Summary

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Theoretical framework

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1 PEDAGOGICAL APPROACHES (EDUMOTIVA)

In the fast-changing, complex, and interconnected world of the 21st century, students need to foster skills that go beyond traditional and academic knowledge, like critical thinking, problem-solving, creativity, collaboration, communication, and digital literacy. To support the development of these 21st-century skills, project-based, problem-based, and STEM (Science, Technology, Engineering, and Mathematics) methodologies offer students motivating, innovative, and immersive learning environments. Within project-based and problem-based activities, the students work in teams to investigate, propose, and present their own solution to a given problem or challenge that matters to them or their community, while at the same time deepening their knowledge in specific subjects.

Environmental issues, such as the preservation of biodiversity, offer a rich and engaging context for project-based, problem-based, and STEM activities. Students have the opportunity to address real-world problems and propose innovative solutions by applying knowledge from various fields. They are

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encouraged to create tangible artefacts and actively engage in communication and reflection about their work.

These methodologies foster critical thinking, collaboration, innovation, and interdisciplinary skills, all of which are essential for students to thrive in a rapidly changing society. By integrating these approaches into classroom instruction, educators can empower students to become active, engaged learners who are equipped with the tools they need to tackle real-world problems, navigate technological advancements, and contribute meaningfully to their communities.

In the following pages, teachers will gain practical insights on implementing various pedagogical approaches, comprehending 21st-century skills and competencies, and effectively utilising Problem-Based and Project-Based learning. Additionally, they will explore the significance of STEM education and the European Integrated STE(A)M framework, along with Environmental Education, GreenComp, and Citizen Science education, enabling them to apply these methodologies in their classrooms to empower students as active, engaged learners and problem solvers in the rapidly changing world.

> As Richard Riley (U.S. Secretary of Education under Bill Clinton, 1993–2001) noted, we should be preparing our students for jobs that don't yet exist, to use technologies that haven't been invented in order to solve problems we don't even know are problems yet.

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1.1 Understanding 21st century skills and competencies

By embracing 21st-century skills, teachers equip students with the essential tools to succeed in our rapidly changing world and become active, informed, and responsible global citizens.

1.1.1. Competences

Competences are defined as a combination of knowledge, skills and attitudes, where:

- **knowledge** is composed of the facts and figures, concepts, ideas and theories which are already established and support the understanding of a certain area or subject;
- **skills** are defined as the ability and capacity to carry out processes and use existing knowledge to achieve results;
- **attitudes** describe the disposition and mind-sets to act or react to ideas, people, or situations.

Though there is no clear consensus on what competences should be included in the category of 21st-century skills. The term itself represents a list of skills that students need to acquire for work, life and citizenship.

1.1.1.1 Key Competencies for Lifelong Learning framework

The European "Key Competencies for Lifelong Learning" framework sets out eight key competences:

- **Communication** in the **mother tongue**: Proficiency in the native language, including reading, writing, speaking, and listening skills.

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- **Communication** in **foreign languages**: The ability to communicate effectively in one or more foreign languages, promoting intercultural understanding and facilitating mobility.
- **Mathematical** competence and basic competences in science and technology: Numeracy, mathematical thinking, and understanding of scientific and technological concepts to engage with the modern world.
- **Digital competence**: The confident and critical use of digital technologies, including information management, communication, content creation, safety, and problem-solving.
- **Learning to learn**: The ability to pursue and organize one's learning, acquire new knowledge and skills, and adapt to different learning environments.
- **Social and civic competence**: Awareness of social and civic responsibilities, understanding of democratic principles, active participation, and ability to work collaboratively.
- **Sense of initiative and entrepreneurship**: The capacity to identify opportunities, take initiative, and transform ideas into action, including creativity, innovation, and risk-taking.
- **Cultural awareness and expression**: Appreciation of cultural diversity, intercultural dialogue, expression of ideas through various forms of artistic expression, and respect for cultural heritage.

1.1.1.2 Tony Wagner 7 survival skills

Tony Wagner suggests seven survival skills:

- **Critical thinking and problem-solving**: The ability to analyse complex problems, think critically, and develop innovative solutions.
- **Collaboration** across networks and leading by influence: The capacity to work effectively in diverse teams, build relationships, and lead through influence rather than authority.

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- **Agility and adaptability**: The capability to adapt to changing circumstances, learn new skills, and navigate ambiguity and uncertainty.
- **Initiative and entrepreneurialism**: The willingness to take initiative, be proactive, and pursue new ideas, opportunities, and projects.
- **Effective oral and written communication**: The ability to articulate ideas clearly, persuasively, and effectively through oral and written communication.
- **Accessing and analysing information**: The skill of locating, evaluating, and critically analysing information from multiple sources and using it to inform decision-making.
- **Curiosity and imagination**: The mindset of being curious, having a love for learning, and being open to new ideas and possibilities. This skill involves cultivating creativity, imagination, and lifelong learning habits.

1.1.1.3 Partnership for the 21st-century learning

Another list of 21st-century skills was proposed by the non-profit organisation Partnership for the 21st-century learning (P21). They suggest:

- **Content knowledge** and 21st-century themes.
- **Learning and innovation skills** (better known as the **4C's** as **Critical Thinking, Creativity, Collaboration, Communication**).
- **Information, media and technology skills**.
- **Life and career** skills.

1.1.2 Conclusion

Even though there are some differences in approaches, some skills are on almost every list, such as critical thinking, sense of initiative, digital literacy, collaboration and communication.

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1.1.3 Resources

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- Partnership for 21st Century Learning. (accessed 26/7/2023). P21 Framework. Retrieved from http://www.p21.org/our-work/p21-framework
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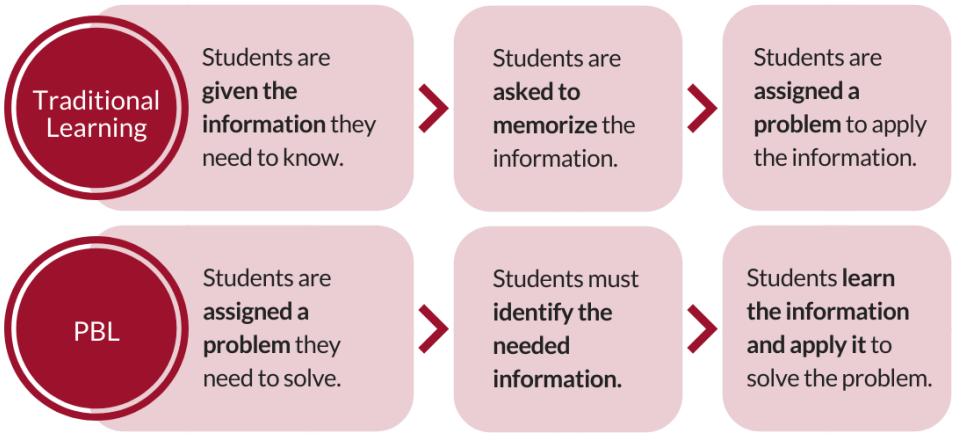
1.2 Problem-Based & Project-Based learning

1.2.1 Introduction

Project-based and **Problem-based** learning involve learning by solving a **real-world problem**. In the context of project-Based and Problem-Based Learning (PBL), the **main character** is the **student**. Those methodologies emphasize **inquiry**, **critical thinking**, and the **application of knowledge**.

1.2.2 Problem-Based learning

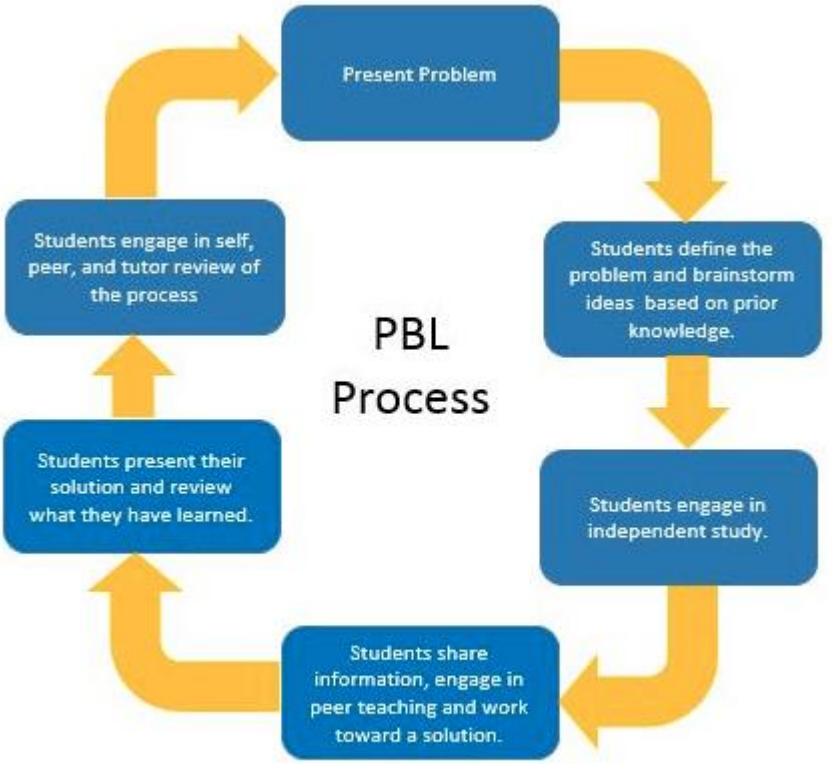
The problems are open-ended, and groups of students are encouraged to **understand a topic** by researching their subject and developing their **solutions**. Students are given a task or question that is relevant to them or their community that they must answer using their **prior knowledge and resources.** They **collaborate** with each other to come up with solutions to the problem. This collaborative effort leads to deeper learning than traditional lectures or classroom instruction.



Students generally must:

- Examine and define the problem.
- Explore what they already know about underlying issues related to it.

- 👀 Determine what they need to learn and where they can acquire the information and tools necessary to solve the problem.
- ⚖️ Evaluate possible ways to solve the problem.
- 💡 Solve the problem.
- 🏛️ Report on their findings.



(Source: http://www.slideshare.net/kategukeisen/problem-based-learning-basics)

Problem Based Learning Process.

The main characteristics of **problem-based learning (PBL)** can be summarized as follows:

- 🌍 **Authenticity**: PBL focuses on real-world problems that are relevant and meaningful to students.
- ❓ **Problem-driven:** PBL starts with a challenging problem that serves as the driving force for inquiry and learning.
- 🔑 **Inquiry-based**: PBL encourages students to ask questions, conduct research, and explore multiple perspectives to deepen their understanding and develop solutions.

- **Collaborative:** PBL promotes teamwork and collaboration, allowing students to work together in groups to analyze problems and develop solutions.
- **Integration of knowledge and skills**: PBL integrates knowledge and skills from multiple disciplines, promoting interdisciplinary thinking.
- **Reflection**: PBL incorporates opportunities for students to reflect on their learning process, assess their progress, and make connections between new knowledge and prior experiences.

Problem-based learning approaches help students develop a larger set of problem-solving skills such as brainstorming, reflection, articulation of problems and solutions, self-assessment, the practice of active listening, and other communication skills.

An example of Problem-Based project:

Presentation and Driving Question	The teacher introduces a specific problem related to endangered species conservation.: **"How can we address the threats to the endangered species and ensure their survival in our local ecosystem?".** The teacher introduces the concept of endangered species and the challenges they face. The students work in teams and each team chooses a specific local endangered species.
Problem Exploration	students are engaged in a discussion about the specific threats faced by their endangered species in their local area or region. They are encouraged to research and gather information about the main challenges, such as habitat loss, pollution, or illegal wildlife trade.
Research and Data Collection	Students are guided in conducting research and collecting data related to the identified threats and their impact on endangered species. This can involve field observations, interviews, or online research.
Problem Analysis and	the teacher facilitates discussions and brainstorming sessions where students analyze the collected data and identify potential solutions to

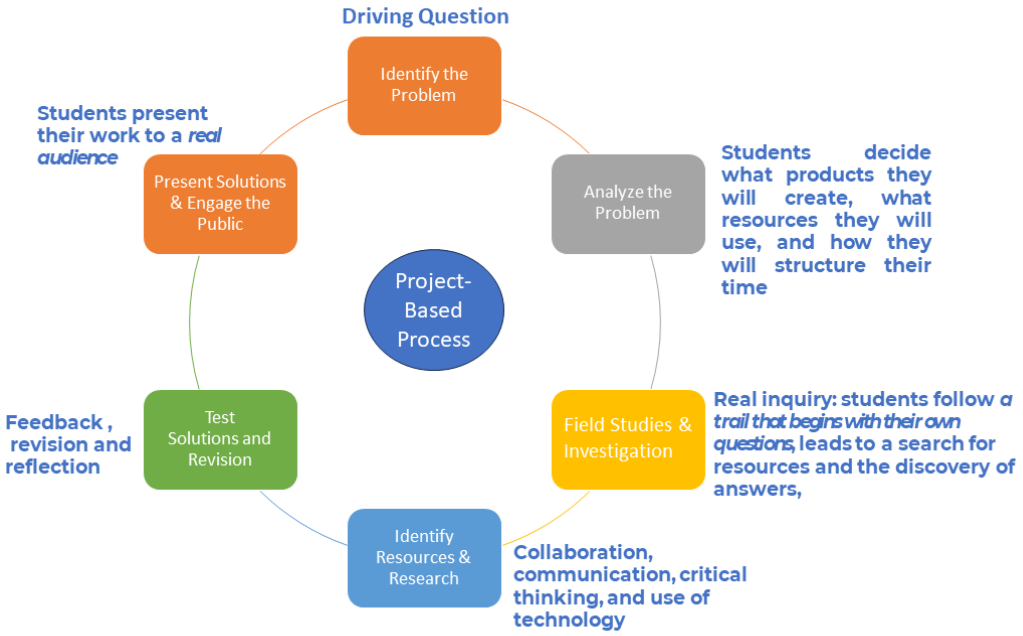
Solution Generation	address the threats (habitat restoration, community awareness campaigns, use of technology to monitor the species, ,...)
Reflection and Presentation:	Students reflect on their problem-solving journey and present their solutions to their classmates

1.2.3 Project-Based learning

Project-based methodology is often confused with problem-based methodology, as they share many similarities. They are both student-centred approaches that promote active students' learning and engagement in real-world projects. While they have similarities, there are notable **differences** in their focus and structure.

Project-based projects integrate **multiple subjects**, encourage **reflection**, and foster **critical thinking**, **problem-solving**, **collaboration**, **communication**, and **creativity**. It provides an active and immersive learning experience, connecting learning to real-world contexts and preparing students for success in the 21st century.

Project-based methodology allows teams of students to actively participate in teams , in authentic, and personally meaningful projects, resulting in a deeper understanding of the subject topic. These projects are usually **interdisciplinary** in nature, allowing students to use a variety of skills and knowledge to complete them. Unlike problem-based methodology, which usually requires a solution to the problem, the **final phase of these project-based Projects frequently requires an outcome and presenting the results to audiences outside of the classroom**.



The main **characteristics** of a project-based methodology include:

- ❓ **A Driving question** connected to real-world issue that is meaningful and engaging for students. This relevance motivates students and helps them see the practical application of their learning.
- 🔎 **Inquiry and Exploration**: Project-based learning involves an extended period of inquiry inquiry where students actively explore and investigate the project's topic or problem. They ask questions, conduct research, and seek solution
- 🔀 **Interdisciplinary Approach**: Projects often integrate multiple disciplines or subject areas, allowing students to make connections and apply knowledge and skills from various domains. This interdisciplinary approach promotes holistic learning and a deeper understanding of complex concepts.
- 🌍 **Authentic Tasks and Products**: Students engage in authentic tasks and create tangible products or presentations that demonstrate their understanding and skills. These products can be shared with real audiences outside of the classroom, fostering a sense of purpose and accountability.
- 🤝 **Collaboration and Communication**: Project-based learning emphasizes collaborative work, encouraging students to collaborate,

communicate, and problem-solve together. They learn to work in teams, negotiate ideas, and effectively communicate their thoughts and findings.

- 💡 **Critical Thinking and Problem-Solving**: Projects involve complex problems or challenges that require critical thinking and problem-solving skills. Students analyse information, evaluate options, and make informed decisions to solve the problems at hand.
- 💭 **Reflection and Evaluation**: Throughout the project, students engage in reflection and self-assessment, evaluating their progress, strengths, and areas for improvement. They reflect on the learning process, problem-solving strategies, and the development of their skills.

An example of Project-Based project:

The driving question, *Introduction and Problem Statement*	The teacher introduces *the concept of endangered species and why they need protection and asks "How can we decide which endangered species to focus on saving first, considering their different needs and challenges?"*
Interdisciplinary Approach:	Topics involved : • human values and biases • Ecology, environment • Law • Economics • sustainability
Inquiry and Exploration	Students investigate why some species are endangered and the importance of biodiversity in our ecosystems. They discuss the different groups involved in endangered species conservation, such as scientists, wildlife organizations, and local communities. They brainstorm on defining their prioritization factors.
Data Collection and Analysis - Communication and Collaboration	Students collect and analyse information about endangered species (habitats, threats,conservation efforts)
Action Plan- Outcome	Students create an action plan to help conserve the prioritized species(raising awareness, fundraising, creating educational materials, creating habitat for specific species) for their school or local community.
Presentation and Reflection	Students reflect on the challenges they faced, the importance of their choices, and how their actions can make a difference. They present their action plans to the community,

1.2.4 Problem-based vs Project-Based methodology

Ultimately, the decision between these approaches should align with the learning goals, available time, curriculum requirements, and the desired level of depth and immersion in the learning experience. Both Project-Based Learning and Problem-Based Learning can be effective, and the choice should be based on the specific context and objectives of the educational setting.

Project-Based Learning	Problem-Based
Project-Based Learning is suitable for a multifaceted project for in-depth exploration and knowledge application across disciplines. Students work on an extended, complex project with interconnected tasks.	Problem-Based Learning is ideal for honing specific problem-solving skills, engaging students in critical thinking, and addressing real-world issues. Students collaboratively address specific problems or challenges that they need to solve.
Students in project-based learning must produce a final product or presentation to demonstrate their mastery of content.	In a problem-based learning class, students present a solution to a clearly defined and authentic problem.
The teacher acts as a facilitator and guide, supporting students throughout the project by providing guidance, feedback, and resources. They encourage critical thinking and help students develop their own solutions.	The teacher's role is similar, but with an emphasis on guiding students through the problem-solving process by asking questions that stimulate critical thinking and analysis.
Project-Based Learning typically involves longer timeframes, allowing for in-depth exploration, research, and the development of a final product.	Problem-Based Learning activities are usually shorter in duration, focusing on specific problems or challenges that require critical thinking and problem-solving within a condensed timeframe.

https://youtu.be/xJlzphbNI70

1.2.5 Resources

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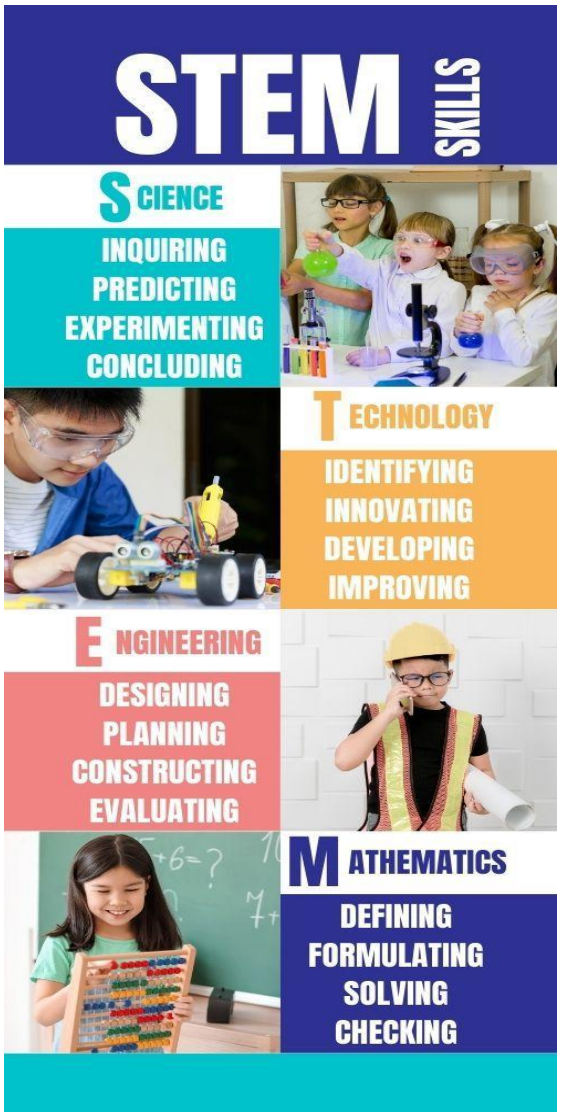
- Problem based learning: a teacher's guide (structural-learning.com). Retrieved July 26, 2023, from https://www.structural-learning.com/post/project-based-learning.
- Problem-Based Learning | Center for Teaching Innovation (cornell.edu). Retrieved July 26, 2023, from https://www.facultyfocus.com/articles/course-design-ideas/problem-based-learning-six-steps-to-design-implement-and-assess/ .
- SpacesEdu. (n.d.). Project-based learning vs problem-based learning. Retrieved July 26, 2023, from https://spacesedu.com/en/project-based-learning-vs-problem-based-learning/ Pressbooks. (n.d.). Problem and project-based learning. Retrieved July 26, 2023, from https://pressbooks.pub/schools/chapter/problem-and-project-based-learning/ .

1.3 STEM education and the European Integrated STE(A)M framework

1.3.1 Introduction



STEM, an acronym for Science, Technology, Engineering, and Mathematics, refers to an educational approach that integrates these disciplines to promote a **holistic** and **hands-on** learning experience.

STEM education goes beyond teaching these subjects individually and emphasizes the **connections** between them. It aims to develop students' **critical thinking**, **problem-solving**, **creativity**, and **collaboration** skills by engaging them in **real-world** applications and challenges.

Combining the disciplines of Science, Technology, Engineering, and Mathematics (STEM) in a cohesive and interdisciplinary manner can greatly benefit students by fostering the development of **essential 21st-century skills**. A STEM project involves various disciplines, each serving a unique purpose:

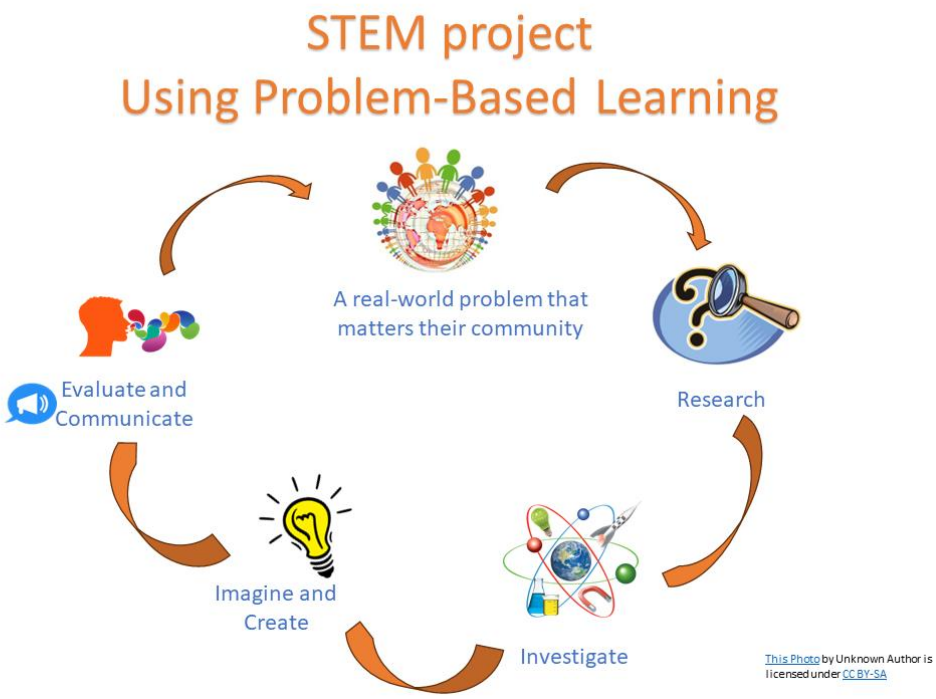
- **Science**: The scientific method is used to investigate and understand natural phenomena.
- **Technology**: Technology is used to design and create solutions to problems.
- **Engineering**: Engineering is used to design and build structures, machines, and systems.
- **Mathematics**: Mathematics is used to model and analyse data.

1.3.2 STEM and problem-based learning

STEM education is closely connected to **problem-based** and **project-based** methodologies, as both learning approaches are **student-centred** and focus on **real-world problem-solving**, emphasizing **active student** engagement, **inquiry-based** learning, **critical thinking**, **collaboration skills**, and **problem-solving skill**s, which align with the goals of STEM education.

The more **common characteristics of a STEM** project are:

- **Engagement**: the teacher presents a specific real-world problem or question that is relevant to students.
- **Investigation**: the students conduct research or gather information related to the problem or question to gain a deeper understanding.
- **Designing**: the students design their solution (plan ,prototype, design…) that addresses the identified problem or question.
- **Implementation**: the students build their solution
- **Testing and Evaluation**: the students assess their solution and propose improvements
- **Reflection**: the students draw conclusions based on the results of the testing and evaluation phases and reflect on the processes they followed during the project.



1.3.3 STEAM and the European Integrated STEM Teaching Framework

The term STEM has been expanded in the past years to **STEAM**, including the **"A" for Arts** , as a way of highlighting the importance of **creativity** in STEM education.

The **European Integrated STEM Teaching Framework (STE(A)M(IT)**, where the (A) stands for "**ALL**", highlighted the importance of combining some or all of the four STEM disciplines of Science, Technology, Engineering, and Mathematics with **at least one non-science subject** (i.e., literature , history , economics , language classes , etc.) in a holistic teaching approach. It also included **STEM careers** teaching as part of its existing subject areas to address the lack of STEM students entering STEM educational programs and career fields. The framework provides knowledge, theory, resources, and guidance to support 21st-century STEM teaching.

Example of a STE(A)M activity

Driving question/ problem ? : How can we effectively protect and conserve local endangered species and their habitats?

European integrated STEM teaching Framework

*T*he executive summary of the European integrated STEM teaching Framework containing the key elements of the full report is available in 9 languages from https://steamit.eun.org/executive-summary/

The full report can be reached from https://steamit.eun.org/about-the-project/the-framework/ .

STEPS		**STEM subjects**	**NON-STEM subjects**
Investigate / Research	Students conduct research to identify and understand the local endangered species in their region.	-**Technology** (computers, internet) -**Science** (biology, ecology)	**Social Sciences**: (socio-economic factors and human impact)
Data Collection	Students collect data on population trends, habitat degradation, and human impacts.	-**Technology** (data analysis, computers, mobiles ..) -**Science** (Conducting field observations, data collection) -**Mathematics** (graphical representation of data)	**Social Sciences** (exploring habitat degradation through surveys or interviews)
Solution/ Habitat design	Students design habitat solutions to address the specific challenges faced by the endangered species	**Engineering**: design and construct habitats Technology: digital tools or software for modeling, simulation, or 3D design of the habitat solutions.	**Art**: Incorporating artistic elements that mimic natural environments.
Evaluate,	Students develop an	**Technology**:use	**Social Sciences:** applying

reflect and Communicate	awareness campaign to educate their local community. They evaluate the effectiveness of their habitat designs and propose improvements or future actions.	software to create posters and leafles. **Science**: Analyzing data collected before and after implementing the habitat solutions to evaluate their impact.	communication strategies **Art**: create visually engaging campaign materials. **Literature**: Crafting persuasive narratives or stories to showcase the significance of endangered species conservation.

1.4 Environmental Education, GreenComp and Citizen Science education

1.4.1 Introduction

Environmental education can promote interdisciplinary learning by integrating concepts from various disciplines such as science, technology, engineering, mathematics, social sciences, arts and the humanities. This holistic approach helps students develop a comprehensive understanding of environmental issues and fosters creativity and innovation.

1.4.2 Environmental and Citizen Science Education

Environmental education and **Citizen Science education** foster environmental awareness, understanding, and action.

Environmental education involves imparting knowledge and skills to students, enabling them to **comprehend** and **respect** the environment, its **interrelationships**, and the **impacts of human activities**.

On the other hand, **Citizen Science education** encourages active student participation in s**cientific research** by **collecting**, **analyzing**, and contributing data to ongoing projects.

The main goals of Environmental education and Citizen Science education are to:

- Enhance students' knowledge of ecological systems, biodiversity, and natural resources in order to prepare them to take relevant decisions and responsible actions for sustainable development and environmental conservation.
- Foster understanding of the interconnectedness of environmental, social, and economic factors.

- Enable informed decision-making and responsible actions for sustainable development and environmental conservation.
- Develop 21st-century skills, such as critical thinking, problem-solving, and scientific inquiry.

Through Environmental and Citizen Science education, students learn to:

- Collect and interpret data.
- Develop hypotheses, design experiments, and engage in collaborative scientific investigations.
- Actively participate in projects with hands-on experience.
- Develop a sense of ownership and empowerment as they contribute to real-world scientific research.

1.4.3 Environmental education and the Sustainable Development Goals Agenda

To define a common education agenda and create a more inclusive world by 2030, the **United Nations** adopted t**he Sustainable Development Goals Agenda in 2015 (SDGs)**. The Sustainable Development Goals (SDGs) or Global Goals are a set of 17 interconnected goals with actions agreed upon by all 193 United Nations member countries in 2015. The SDGs provide a myriad of real-world challenges that can be used in the classroom.

\

SDGs goals related to the environment:

GOAL 13- Climate Action: *Strengthen resilience and adaptive capacity to climate-related disasters, integrate climate change measures into policies and planning, build knowledge and capacity to address climate change, and implement the UN Framework Convention on Climate Change by mobilizing funds for developing countries' needs.*

GOAL 14- Life below water: *Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.*

GOAL 15- Life on Land*: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.*

Video Explaining the SDGs goals

The World's Largest Lesson https://youtu.be/cBxN9E5f7pc

1.4.5 Environmental Education and the European Sustainability Competence Framework

Recognizing the importance of learning for environmental sustainability, the **European Commission** has developed the **European Sustainability Competence Framework**, known as **GreenComp**, as part of the European Green Deal. GreenComp serves as a shared competence framework at the European level, guiding educators and learners in embedding sustainability topics into educational systems and curricula.

The GreenComp consists of 12 competences organised into the four areas.

Visual representation of *GreenComp*.

1. Embodying sustainability values	• valuing sustainability • supporting fairness • promoting nature
2. Embracing complexity in sustainability	• systems thinking • critical thinking • problem framing

3. ❀ Envisioning sustainable futures	• futures literacy • adaptability • exploratory thinking
4. Acting for sustainability	• political agency • collective action • individual initiative

1.4.6 Conclusion

Environmental education and Citizen Science education play a vital role in equipping students with the knowledge, skills, and attitudes necessary for sustainable development and environmental stewardship. By integrating these approaches into the curriculum, schools empower students to become active participants in addressing environmental challenges, fostering a sense of responsibility, and creating a more sustainable future for generations to come.

1.4.7 Resources

- https://www.epa.gov/education/what-environmental-education : definition, goals and benefits of environmental education according to the U.S. Environmental Protection Agency.
- https://earth.org/environmental-education/ : the page explores the concept and importance of environmental education, as well as some examples of how it is implemented around the world. It also provides some tips and resources for educators and learners who want to engage in environmental education.
- https://joint-research-centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en : the GreenComp project, a European framework for sustainability competences for citizens and educators.
- https://eu-citizen.science/about/ : the EU-Citizen.Science platform, a network for citizen science initiatives across Europe. It provides resources, training and support for citizen science practitioners and researchers.

- https://worldslargestlesson.globalgoals.org/ : the World's Largest Lesson, a global education project that aims to teach children and young people about the United Nations' Sustainable Development Goals and inspire them to take action for a better world.

2 KEY LEARNING METHODOLOGIES (WUT)

2.1 Introduction

The document is primarily dedicated to the secondary level education in-service teachers, who are looking for new ideas on how to make their lessons more effective and attractive for students.

For this purpose, the document presents a few main methodological concepts being intensively discussed over the last years and decades as well as a number of publications, projects and links, which in detail describe these methodologies and their practical applications in formal and informal educational settings.

The intention of the authors is rather not to strengthen the readers' theoretical bases on the teaching methodologies, but to help them to modify their teaching style.

It should be mentioned that these concepts are largely not new ones, they are commonly known by teachers and their selected ideas are often used as a complement to the traditional lessons.

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Therefore, the report does not pretend to create any new knowledge nor specific recommendations, but mostly only systematises basic definitions and provides ample references.

As the methodologies in question have slowly evolved over time, the authors usually mentioned the most recent materials.

2.1.1 How to use this document

The reader is encouraged to swiftly go over the method characteristics together with examples of how to implement a given method in the class, and if she/he gets interested in a method, also read the documents linked in the relevant section. The external content is specifically chosen to describe a methodology, its vice versa and its implementation remarks, or directly provide a number of lesson topic suggestions.

2.1.2 Main methodologies presented

The second chapter introduces the notion of a teaching method and serves as an introduction to the next document parts.

The first methodology characterised is a "Project Method" followed by a similar concept "Project based learning".

This concept is especially important as a project is a basic organisational tool to encapsulate many people's activities primarily at work, but to a certain extent in private life as well.

Then the document introduces the related concepts "Problem (solving) method" and a "Scientific method". The necessity to teach these methods at school, possibly early, is caused by a huge flood of misinformation, manipulation, fake news and hate speech currently being observed in mass and

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social media. Logical and critical thinking these methods involve are crucial to strive in current turbulent times.

Flipped classroom is the next method presented, which contains a significant self-learning component. Given the current pace of technical and social changes, self-learning becomes a life-long necessity.

The last methodology characterised here is "Inquiry Based Science Education" which has a lot of common elements with other scientific methods, but is somehow less formalised and puts more pressure on creativity, curiosity and student intuition even at the expense of the strict correctness and validity of conclusions.

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2.2 Teaching methods - definition

According to the PWN (Polish National Publisher) encyclopaedia (**https://encyklopedia.pwn.pl/haslo/metody-nauczania;3940117.html**)teaching methods are "deliberate and systematically applied methods of the teacher's work with students which enable the achievement of learning objectives".

The verbal method is considered to be the oldest teaching method. Lessons usually took the form of lectures. Knowledge was imparted by the Teacher. Speech and writing were used as means of communication. Such lessons did not involve teacher-student interaction.

In order to better motivate pupils to learn, activating methods began to be used. These methods assume not so much the transfer of information and knowledge but encourage students to solve problems and search for answers on their own. The next section characterises the most known methods relevant for science education

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2.2.1 Project Method

Project Method - involves the pupil carrying out a project on a given topic independently. Often the topic can be chosen by the pupil. The project method makes it possible to build on existing knowledge. The teacher's role in this method is to coordinate the work of the students. Projects can be done individually or in groups.

Common characteristics of student projects
Secondary education students are occasionally/or sometimes even frequently engaged in project like activities in many schools in Europe. The student projects cover a variety of topics, last typically from a couple of days to a couple of weeks and involve from 2 till a few students. Also such projects focus on developing different stills like group work, problem solving, creativity, decision making, critical thinking, project management and so on.
Basic project planning and execution aspects:
Regardless of the project subject, its duration, complexity and the number of the people involved in its execution there are a number of topics to be recognized, considered and decided, before, during and after the project execution. Of course, depending of the project, age of the students and particular objective of the activity the aspect listed below may be more or less emphasised:

- General, specific and lateral project objectives

An example: the teacher may suggest a group of students to organise a public long-distance run combined with a festival and a fundraiser for some charity purposes. The project primary objectives are to attract at least a given number of runners and audience, and collect a certain amount of money. The lateral objectives are: to promote the school and to develop organisational skills in students from the project team.

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- Setting up the measurable project target KPIs

In our examples it could be: the number of the runners (e.g. 50), the no. of the event participants (e.g. 100) and the amount of money collected from participants and sponsors (e.g. 2 000 Euros).

- Project decomposition onto the detailed tasks:

It could be: obtaining permission for a public event organisation and checking out requirements such even should meet, finding sponsors, planning marketing campaigns (channels, messages, target groups, social media advertisement), securing medical services, inviting mass media, collecting participant consent, and finally cleaning the place after the event ends.

- Preparation of the project activity schedule

Designing of the project schedule also includes determination of relationship between tasks (or groups of tasks): which tasks have to be completed before other tasks start. Tasks not strongly related may be performed simultaneously. Typically, the project schedule is planned in a way to minimise the project overall duration however given a limited human resources assigned to its execution.

In our example: the timing would relate to the date/time/duration of the event, but also the schedule of information campaign and organisational activities

- Project team nomination and responsibility assignment to the team members

Typically, one main project manager should be nominated, to whom all the team would report and who will monitor all the project progress and take all vital decisions.

- Identification of the milestones, and decision points

Usually, a few critical moments (typically after completion of some tasks) are identified, when the progress of the project is evaluated and some decisions are taken if necessary. E.g. if it turns out that to complete a given task the team needs more time, maybe the project schedule should be updated? due to low

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interest of potential sponsors, the project targets should be decreased? In some cases, even the whole project may be terminated if there is no way to complete some tasks (e.g. to obtain a permission)

- Setting up the communication procedures in the team

It mostly pertains to the schedule of physical meetings or project team telcos, but also to other forms of immediate communication in the team.

- Reflection on the project lessons learned
- After the project ends, a good practice is a discussion and reflection of the project execution within the project team in order to carry out similar project more effectively in the future

Example / Notes

Project method is frequently or occasionally used at European schools (according the to survey carried out in the project). Typically, the students project focus on teamwork enhancement and student creativity development. Secondary education level students have usually to limited practical experience and general knowledge to understand and learn industrial project practices.

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2.2.2 Project Based Learning

2.2.2.1 Definition

Project Based Learning is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge.

(https://www.pblworks.org/what-is-pbl)

The project Based method, although it seems modern, has its origins in the early 20th century. Its creator was an American educator, Professor William Heard Kilpatrick in 1918 published a dissertation entitled *The Project Methods. The Use of the Purposeful Act in the Educative Process*. (https://docs.google.com/document/d/1NNH5JIiNdzK2nOnmWczzrExKElEDWpXD/edit?disco=AAAA196Uexg)

Kilpatrick defines a "project" as a "hearty purposeful act". (https://docs.google.com/document/d/1NNH5JIiNdzK2nOnmWczzrExKElEDWpXD/edit?disco=AAAA196Uexo) He also 4 types of project;

"It may be well to come closer to the customary, subject matter of the school. Let us consider the classification of the different types of projects: Type 1, where the purpose is to embody some idea or plan in external form, as building a boat, writing a letter, presenting a play; type 2, where the purpose is to enjoy some (aesthetic) experience, as listening to a story, hearing a symphony, appreciating a picture; type 3, where the purpose is to straighten out some intellectual difficulty, to solve some problem, as to find out whether or not dew falls, to ascertain how New York outgrew Philadelphia; type 4, where the

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purpose is to obtain some item or degree of skill or knowledge, as learning to write grade 14 on the Thorndike Scale, learning the irregular verbs in French."

2.2.2.2 Learning benefits

- Deeper student involvement
- Encouraging independent thinking
- training problem-solving skills
- Supporting 21st century skills such as collaboration and communication
- Increased independence in learning
- **encourages children to become more independent**

2.2.2.3 The seven-step approach

PBL: step by step Gino Camp Angelique van het Kaar Henk van der Molen Henk Schmidt

stap 1: begripsverheldering (eur.nl)

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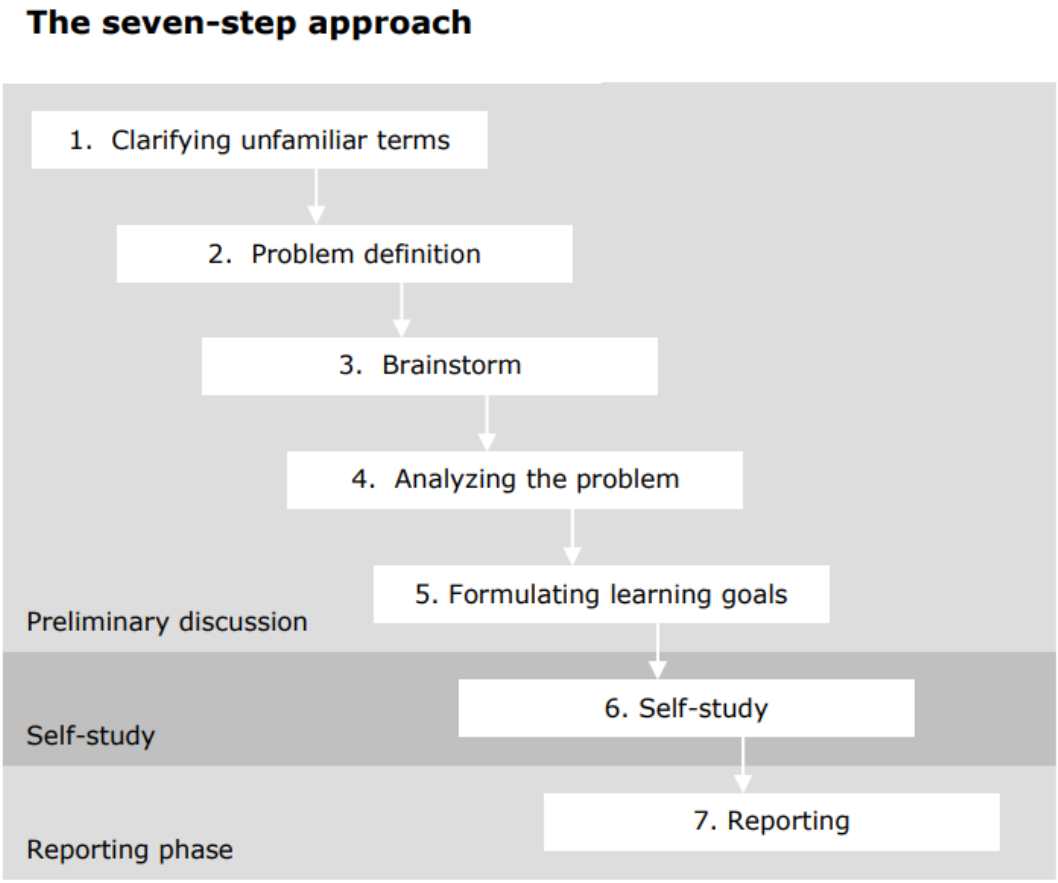

Step 1: clarifying unfamiliar terms Unclear terms and concepts in the problem description are clarified, so that every group member understands the information that is given."

Step 2: problem definition. The problem is defined in the form of one or more questions. The group has to agree upon the phenomena that need to be explained."

Step 3: brainstorm. The pre-existing knowledge of group members is activated and determined. This process entails the generation of as many explanations, ideas, and hypotheses as possible. The ideas of all group members are collected, without critical analysis.

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Step 4: analysing the problem Explanations and hypotheses of the group members are discussed in depth and are systematically analysed. Ideas from the brainstorm are ordered and related to each other.

Step 5: formulating learning goals Based on contradictions, obscurities, and ambiguities from the problem analysis, questions are formulated that form the foundation for the study activities of the group members. In short, it is determined what knowledge the group lacks, and learning goals are formulated on these topics.

Step 6: self-study In the self-study phase, group members search for relevant literature that can answer the questions in the learning goals. After studying this literature, group members prepare themselves for reporting their findings in the next tutorial meeting.

Step 7: reporting After reporting what sources group members have used in their self-study activities, a discussion of the learning goals takes place based on the studied literature. Group members try to synthesise what they have found in different

In essence, the PBL model consists of these seven characteristics (https://docs.google.com/document/d/1NNH5JIiNdzK2nOnmWczzrExKElEDWpXD/edit?disco=AAAA196Uexs) *:

- Focuses on a big and open-ended question, challenge, or problem for the student to research and respond to and/or solve
- Brings what students should academically know, understand, and be able to do into the equation
- Is inquiry-based, stimulates intrinsic curiosity, and generates questions as it helps students seek answers
- Uses 21st-century skills such as critical thinking, communication, collaboration, and creativity, among others.[7]
- Builds student choice into the process

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- Provides opportunities for feedback and revision of the plan and the project, just like in real life
- Requires students to present their problems, research process, methods, and results, just as scientific research or real-world projects must stand before peer review and constructive criticism

Examples Project-Based Learning: Project-based science, disciplined inquiry and WebQuests

https://www.researchgate.net/profile/Michael-Grant-17/publication/228908690_Getting_a_grip_on_project-based_learning_Theory_cases_and_recommendations/links/00b7d52d69f5858a1e000000/Getting-a-grip-on-project-based-learning-Theory-cases-and-recommendations.pdf

Project-based science - Project-Based Science (PBS) is an effort that began in 1991 at the University of Michigan School of Education.

2.2.2.4 Examples

10+ Project Based Learning Examples for Educators:

https://venngage.com/blog/project-based-learning-examples/#2

2.2.2.5 Other useful link on PBL methods

https://educationaltechnology.net/problem-based-learning-pbl/ **(roles of a teacher and a student)**

https://www.edutopia.org/

https://www.pblworks.org/

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https://www.hightechhigh.org/student-work/projects/

Examples https://www.edutopia.org/article/using-pbl-teach-about-homelessness

https://www.smartlablearning.com/project-based-learning-examples/

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2.3 Problem (Solving) Method

Problem (Solving) Method (or Problem Based Learning) - involves the student solving a "problem" on his/her own. The work should involve specific steps such as defining the problem, testing hypotheses, drawing conclusions, and evaluating the results obtained. The work can be done individually or in groups. Pupils acquire knowledge and draw conclusions independently. In addition to knowledge, pupils also learn time management, logical thinking, and how to draw conclusions.

Also, the problem-solving method in teaching involves often **providing students with real-world problems that they must solve through collaboration and critical thinking**. This method encourages students to apply their knowledge and creativity to develop solutions that are effective and practical.

Problem solving methods includes typically 5 steps:

- Step 1: Identify the Problem. As obvious as it may sound, the first step in the problem-solving process is to identify the root of the issue. ...
- Step 2: Generate potential solutions. ...
- Step 3: Choose one solution. ...
- Step 4: Implement the solution you've chosen. ...
- Step 5: Evaluate results.

Problem solving methods is a subject of several articles a.o.:
http://www.vkmaheshwari.com/WP/?p=2375

https://www.samareducation.com/2022/06/problem-solving-method-of-teaching.html

https://www.mizanurrmizan.info/what-is-problem-solving-method-in-teaching-learning-what-are-the-characteristics-of-the-method-and-importance-in-education/

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https://www.pen2print.org/2020/05/the-problem-solving-method-of-teaching.html
https://uwaterloo.ca/centre-for-teaching-excellence/catalogs/tip-sheets/teaching-problem-solving-skills
and many more.

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2.4 Scientific Method

The Scientific Method is somehow similar to the problem-solving method and has been in common use over the last 5 centuries in the process of scientific research conduction, but also it is very efficient in teaching and even in solving everyday problems.

The definition and formalisation of the Scientific Methods is traditionally credited to Galileo, but many aspects of the Method were already formulated by Leonardo Da Vinci one century earlier.

Along with a gigantic deluge of misinformation and fake news, we observe in particular during the last years, teaching scientific methods to students (and people at all ages) is especially important.

Scientific methods usually include 6 steps:

- 1) asking a question about something you observe,
- 2) doing background research to learn what is already known about the topic,
- 3) constructing a hypothesis,
- 4) experimenting to test the hypothesis,
- 5) analysing the data from the experiment and drawing conclusions, and
- 6) communication the finding

2.4.1 Steps

Approaching the problem by the Scientific methods may involve the following steps

- (Asking a question): Why is city air pollution in some areas heavier than in others? What are its key factors ?
- (background research): We could learn about various pollution particles, that the particles could travel thousands of miles, what the main sources

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of pollution are and in general which areas are the most polluted, however we will rather not find information why our city experiences this problem.

- (hypothesis): location of a give city may heavily impact the pollution level: proximity to the sea, industrial areas, valley etc., then we could guess that the season and corresponding weather patterns (wind, direction of wind, rain, air pressure) may correlate the pollution, finally the building heating systems, and the heating season may have impact as well
- (experiment) In this case the experiment would be mostly related to discovery, downloading, and preparation of (mostly historic) data, which we would then use to test our hypothesis. The data primarily includes air pollution level, but also weather observation, geographic data. We may even use the current data instead (or in addition to) the historic ones
- (analysis the data) in the simplest form the analysis is based on data correlation, and event sequence study. Due to the complex nature of the phenomena and many factors the pollution level may depend on, we could not expect discovery of rules which would be 100% valid. Instead many statistically strong correlations would probably be observed.
- Finally, the student team could present their results in the class, deepening the colleagues knowledge and debunking potential misinformation. This particular topic opens room for group discussions and exchanging opinions, which also creates an occasion to develop critical thinking and master communication skills.

2.4.2 Examples

Scientific Method is described and exemplified in many articles, video clips, and educational portals a.o.:

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https://www.sciencebuddies.org/science-fair-projects/science-fair/steps-of-the-scientific-method
https://www.youtube.com/watch?v=qQBZbinoOrI
https://www.youtube.com/watch?v=Xxm_beTs2LU
https://www.techtarget.com/whatis/definition/scientific-method
The attractiveness of the scientific method springs from the fact that it can be introduced even to a young children (in simplified form) and the methods is quite logical and easy to comprehend.

Air Pollution case:
As an example, let us consider the air pollution problem, not a trivial one, but pretty suitable for discussion (a project) with a secondary education students
Air pollution is a common, sadly increasing, problem in many parts of the World, many of us commonly experience, especially living in big cities. Also, air pollution is often monitored and the measurement results are accessible by the public in many open data repositories and some portals.

Approaching the problem through the Scientific methods may involve the following steps:

- (Asking a question): Why in some areas, cities the air pollution is heavier than in others, and which factor may it depend on?
- (background research): We could learn about various pollution particles, that the particles could travel thousands of miles, what the main sources of pollution are and in general which areas are the most polluted, however we will rather not find information why our city experiences this problem.
- (hypothesis): location of a give city may heavily impact the pollution level: proximity to the sea, industrial areas, valley etc., then we could guess that the season and corresponding weather patterns (wind, direction of wind,

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rain, air pressure) may correlate the pollution, finally the building heating systems, and the heating season may have impact as well

- (experiment) In this case the experiment would be mostly related to discovery, downloading, and preparation of (mostly historic) data, which we would then use to test our hypothesis. The data primarily includes air pollution level, but also weather observation, geographic data. We may even use the current data instead (or in addition to) the historic ones
- (analysis the data) in the simplest form the analysis bases on data correlation, and event sequence study. Due to the complex nature of the phenomena and many factors the pollution level may depend on, we could not expect discovery of rules which would be 100% valid. Instead many statistically strong correlations would probably be observed.
- Finally, the student team could present their results in the class, deepening the colleagues knowledge and debunking potential misinformation. This particular topic opens room for group discussions and exchanging opinions, which creates also an occasion to develop critical thinking and master communication skills.

2.5 Flipped classroom

Flipped classroom - in this teaching strategy, students independently learn the theoretical part of the material at home, then at school they do exercises and solve tasks based on the knowledge they have acquired. By reversing the pattern of work in the classroom and at home, pupils are able to independently search for information and acquire knowledge, then during classroom activities, the teacher uses tasks to verify the knowledge acquired by the pupils, helping pupils to summarise the knowledge and draw conclusions.

If accepted by students (in the sense that the students really study the recommended materials at home before the lesson) , flipped classroom is a

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very powerful and effective method, which leads to the really deep understanding of a given subject, especially relevant in STEAM education. Although the identification and selection of the materials for self-study could be a good educational task for students, recommendation of the sources seems to be a rational approach at the secondary education level.

There are many variation of the flip classroom method (https://www.viewsonic.com/library/education/8-flipped-classroom-examples/) which emphasise different aspects of teaching and development of different skills). Regardless of the particular flipped classroom model (or other learning methodology implemented) the main challenge for the teacher are to keep the students engaged during the lesson and get the students motivated to learn.

Flipped classroom is extensively discussed a.o. in
https://ahaslides.com/blog/7-unique-flipped-classroom-examples-and-models/

and (both articles in Polish)
https://www.szkolazklasa.org.pl/wp-content/uploads/2016/11/odwrocona-lekcja-o-pracy-metoda-flipped-lesson.pdf
https://www.learnetic.pl/odwrocona-klasa-dlaczego-i-jak-odwracac-edukacje/

2.5.1 An example

A Physics lesson during which the students explore the principle of interplanetary travels

- Step 1: the teacher finds out appropriate content to be studied at home. The topic covers: the physical laws of the object moving in the gravitational field, energy conservation principle and conversion between the kinetic and the potential energy process, the Keppler laws, object

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trajectory as well as practical cosmic travel aspects. The content is provided in a form of document and videos.

- Step 2. Students learn the content at home and formulate questions and comments.
- Step 3. At the beginning of the lesson students start discussing the subject and try to answer themselves to questions posed by others. The teacher addresses unanswered questions.
- Step 4. The teacher assigns students additional problems and tasks for analysis in order to verify their understanding of the topics. The students come up with new questions, comments and conclusions.
- Step 5. The lesson ends with the final discussion and summary conclusions

2.6 Inquiry Based Science Education

IBSE (Inquiry Based Science Education) - or learning through discovery. As the name suggests, it relates to science subjects. The method is based on self-discovery and involves subject/topic study through hands-on activities, investigation and posing of questions. With this method, the pupil develops his/her research skills, while the teacher's role is to inspire discussion. This model emphasises the acquisition of competences rather than the acquisition of knowledge.

IBSE is often combined with formative assessment, which is not about grades, but about pointing out the strong points of the pupil's work and the points the pupil still needs to work on.

IBSE is often associated with the following activity sequence:

- investigate a problem,
- search for possible solutions,
- make observations,

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- ask questions, test out ideas,
- and think creatively and use their intuition

2.6.1 Examples

An Example

Problem statement

A process of liquid flowing out from a container may be a topic for secondary education student IBSE research. The questions the students may try to answer is which factors determine the speed of a given liquid in a pipe. Working on the problem involves also some hand-out tasks and elaboration of some measurement procedures. The teacher if needed guides the students suggesting that the liquid speed may depend on the pipe length, the liquid pressure, temperature, the pipe diameter and the type of liquid.

1) After task assignment, the students (working in small groups of 2-3 people) start to construct simple experimental sets (using plastic bottles, pipes and container) together with measurement instruments (stopper, weight, utensils of known volume)
2) The students design their experiments: decide on which liquid they will be testing (e.g. water, salt water, oil, alcohol, glycerin), pipe lengths and diameters, how will measure the output liquid volume and calculate the resulting liquid speed.
3) The students formulate initial hypotheses and carry out the experiments to verify them, discuss the result.
4) Based on the materials recommended by the teacher the students learn basic information about liquid behaviour (viscosity) and specific laws of physics behind (Bernoulli law) and then compare their hypothesis and experiment results with theory.

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5) During the last part of the lesson the teachers provide additional information to students, explaining some students' mistakes and improper result interpretations.

Deep discussion of IBSE with a number of examples a.o. presents the following article:
https://helpfulprofessor.com/inquiry-based-learning-examples/ and an article in Polish
http://www.ack.fais.uj.edu.pl/documents/97137412/c08fb2f1-d5c9-4067-acce-f41c810673e3

Many examples of IBSE are described in

https://futurefocusedlearning.net/blog/learner-agency/10-inquiry-based-learning-science-activities-for-young-learners and

https://helpfulprofessor.com/inquiry-based-learning-examples/

An interesting approach to IBSE is featured in:
https://knowledgequest.aasl.org/the-5-es-of-inquiry-based-learning/ as well as in

https://ssec.si.edu/stemvisions-blog/what-inquiry-based-science

A voluminous case study if IBSE in the area of biology teaching (botanic garden) is presented in:

https://www.bgci.org/wp/wp-content/uploads/2019/04/Roots_9.2.pdf

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2.7 Conclusions

We hope the document brought you closer to the methods known for a long time, and which are rather unlikely to completely replace the current school education practices. However, due to the common crisis of young people's motivation to learn as well as the visible shift of the needed qualifications and competences in the 21 century, the lesson plans are expected to be modified. And there is no ready recipe for how to do it. Therefore, the role of the teachers is to experiment with a variety of techniques and recommend the most suitable ones.

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3 STUDENT-CENTRED METHODS (ESHA)

3.1 Introduction

Current education innovation approaches are nearly all based on a student-centred approach to learning as compared to the content(curriculum)- or teacher-centred traditional methods. Although it is possible to implement Creative Writing Laboratories (CWLs) in a content-centred way, in order to achieve the aim of the CREAM project, namely to properly engage students in STE(A)M learning, the benefits of implementing them in a student-centred way are clear.

As one of the main requirements of student-centred methods is to use a variety of approaches, the chapter aims to introduce not only student-centred learning in general, but also provides some teaching and learning methods that can be appropriate in CWLs. The methods included should only be considered as suggestions, the training is also aiming at supporting teachers to choose their own methods.

In this section of the training, participants will learn about

- The definition and characteristics of student-centred methods
- Teachers as leaders of learning

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- Some student-centred approaches that can be relevant and supportive when implementing CWLs

3.2 Definition

In this chapter, student-centred learning is defined, and its benefits, potential disadvantages and characteristics are introduced.

3.2.1 What is student-centred learning?

Student-centred learning, also known as learner-centred education, is an approach to education that puts the student at the centre of the learning process. This means that the focus is on the individual needs, interests, and goals of the student, rather than on a predetermined curriculum or teacher-centred approach.

In a student-centred learning environment, the teacher serves as a facilitator, providing resources and support to help students achieve their learning objectives. The teacher may present information and guide discussions, but the emphasis is on the student to actively engage with the material and construct their own understanding.

While student-centred learning requires a shift in the traditional teacher-centred approach, it has the potential to greatly enhance the learning experience for students. It allows for a more personalized and engaging approach to education and can help students to develop important skills such as critical thinking, problem-solving, and self-direction.

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However, it is important to note that student-centred learning is not a one-size-fits-all approach. It requires careful planning and implementation, and may not be suitable for all subjects or student groups. Teachers should consider the specific needs and goals of their students and adapt their approach accordingly.

Overall, student-centred learning is a valuable and effective approach to education that can help students to achieve their full potential and prepare them for success in the future.

3.2.2 What are the benefits of student-centred learning?

There are numerous benefits to student-centred learning, both for the individual student and for the classroom as a whole. Some of the key benefits include:

Increased Engagement & Motivation – When students are able to take an active role in their own learning, they are more likely to be engaged and motivated. They are able to see the relevance of the material to their own lives and goals, and this can increase their interest in the subject.

Improved Critical Thinking and Problem-solving Skills – Student-centred learning encourages students to think for themselves and to approach problems in a more independent and creative way. This can lead to improved critical thinking and problem-solving skills, as students are able to apply what they have learned to real-world situations.

Greater Independence – Student-centred learning promotes a sense of independence and self-direction in students. They are given the freedom and

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responsibility to manage their own learning, which can help them develop important skills such as time management and self-regulation.

Personalized Learning – One of the key benefits of student-centred learning is that it allows for personalised learning. Each student is able to learn at their own pace and in a way that is tailored to their individual needs and interests. This can be especially beneficial for students who may struggle with traditional teaching methods or who have unique learning needs.

3.2.3 What are the potential disadvantages of student-centred learning?

Problem with Understanding

With less of a focus on lecturing and presenting information to the class in a traditional way, there is a concern that some students may miss important information or misinterpret the information. This issue may cause some students to fall behind or develop the wrong knowledge.

Cooperation and Teamwork

Although student-centred learning is catered to the students' specific needs, collaboration and teamwork are still a vital part of the student-centred learning experience. The skills learned through collaboration and teamwork are extremely important when applying this knowledge to the real world. However, this method may not be suitable for students who prefer to work independently.

Lack of Control in Classroom

In a student-centred learning environment where students are free to interact, the classroom space may feel disorganised and noisy. This can make classroom

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management more of a challenge for the teacher, which could possibly cut into instructional time and hinder the learning process. This can also present a challenge for the students as well if they are not able to focus on learning the material because the classroom is chaotic. Thus, defeating the purpose of a student-centred approach to learning.

Teacher Unpreparedness

If student-centred learning is a new experience for the teacher, the teacher may have to take extra time to adjust their teaching methods. Otherwise, teachers may not fully understand the methods and techniques used in the student-centred learning classroom, which may result in teachers and students not fully understanding the material.

Student Preparedness

While student-centred learning can be engaging to many students, others may feel disengaged for a variety of reasons. Students may not be ready to handle this approach to learning. It may take time for the students to adjust to a new method of learning which may hinder the learning process.

3.2.4 Implementing Student-Centred Learning in the Classroom

There are several key strategies that teachers can use to implement student-centred learning in their classrooms. Some of these include:

Providing choice and autonomy – Giving students some control over their learning can help to increase motivation and engagement. Teachers can do this

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by offering a range of activities or project options for students to choose from, or by allowing students to design their own learning goals and plan for achieving them.

Encouraging Collaboration and Teamwork – Student-centred learning often involves group work and collaboration. This can help students to learn from each other, as well as to develop important social and communication skills. Teachers can encourage collaboration by setting up group projects or assigning roles within a group.

Using A Variety of Teaching Methods – Student-centred learning requires teachers to use a range of teaching methods to meet the diverse needs of their students. This may include lectures, demonstrations, hands-on activities, group work, and individual projects.

Providing Ongoing Support and Feedback – Teachers play a critical role in student-centred learning as facilitators and mentors. They should be available to provide support and guidance to students as needed, and should also provide ongoing feedback to help students track their progress and identify areas for improvement.

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3.3 Teachers as leaders of learning

In this chapter, the potential ways for teachers to lead and facilitate learning are introduced, together with the Ladder of Participation for teachers to be able to check if their methods are truly participatory

3.3.1 Teachers as leaders of learning

In student-centred approaches, teachers have a role that is different from the traditional role of the lecturer, the source of knowledge. Teachers become facilitators of learning that also means they are to be able to support students in their learning journeys that need a varying amount of direct support and guidance.

Harvard professor Richard Elmore defined four main modes of learning – with a need for different types of learning leadership (facilitation) - organised around two axes: individual or collective centred, and hierarchical or free.

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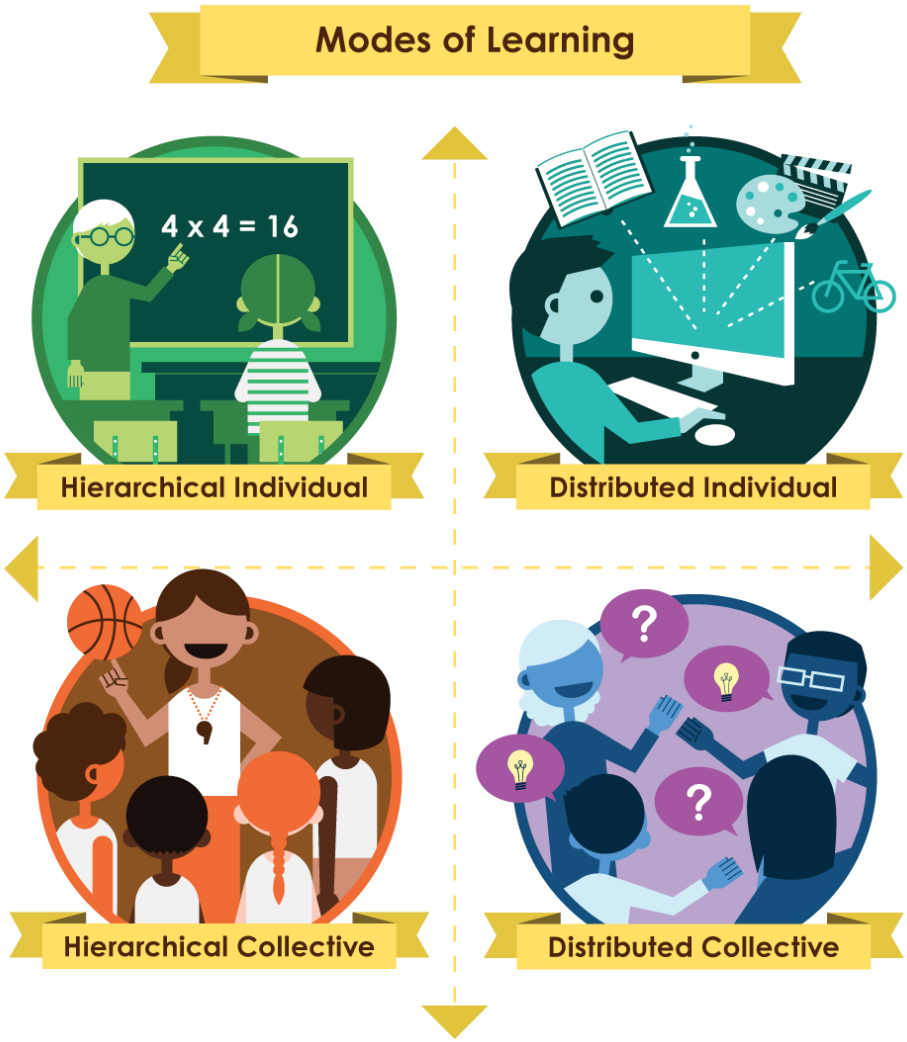

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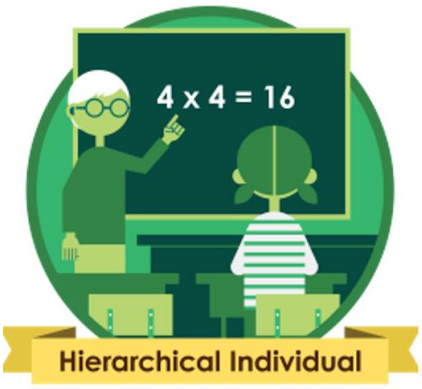
Expectations

- Being a successful leader in a Hierarchical Individual learning environment means bringing the external requirements of a governing institution (frequently state or federal government) into the work and practices of the organization.

Knowledge & Skill Requirements

- A Hierarchical Individual learning environment typically values a leader who:

- Manages successful superiorsubordinate relationships.
- Focuses the organization and its learners on clear performance targets.
- Marshals the human and material resources of the organization in the service of those performance targets.
- Builds and sustains stable relationships with learners and their families based on high expectations.



Expectations

- Being a successful leader in a Hierarchical Collective learning environment means leading according to the requirements of an external authorizing environment, while also encouraging and enforcing the norms, values, principles, and practices specific to the learning community.

Knowledge & Skill Requirements

- A Hierarchical Collective learning environment typically values a leader who:
  - Articulates and models the key values of the organization.
  - Incorporates external requirements into the specific values and practices of the community.
  - Builds and sustains stable relationships with learners and their families ba on norms specific to this learning community.

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Expectations

- Being a successful leader in a Distributed Individual learning environment means articulating an appealing vision of learning that is shaped by the needs, preferences, and dispositions ofindividual learners.

Knowledge & Skill Requirements

- A Distributed Individual learning environment typically values a leader who:
    - Responds to learner needs and interests, and considers how they will change over time.
    - Is unafraid to embark on new, entrepreneurial ventures.
    - Builds and inspires a team of collaborators with diverse knowledge and skillsets.
    - Mobilizes human and material resources to respond to learner needs closely.
    - Monitors learners' engagement, interest, and connections to the learning environment.

Expectations

- Being a successful leader in a Distributed Collective learning environment means identifying and supporting the common values, beliefs, and goals that bind the learning community together. Often it means a openness to sharing ownership of an educational vision with the community.

Knowledge & Skill Requirements

- A Distributed Collective learning environment typically values a leader who:
    - Inspires individuals and organizations with common interests to operate in networked relationships.
    - Recognizes shared community values and articulates them within the community and the larger world.
    - Identifies community members' resources, and motivates members to share them.
    - Brings resources from the external world into the community while maintaining community norms and standards.

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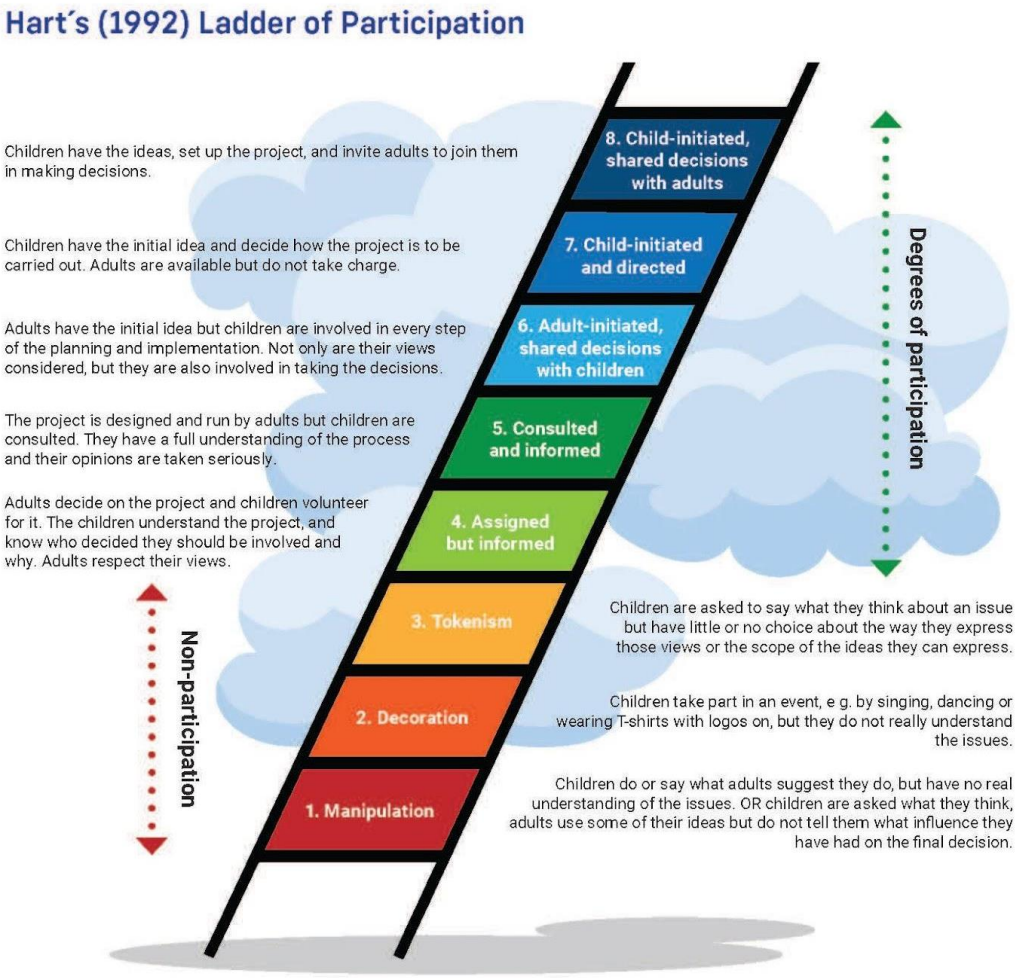
3.3.2 Ladder of Participation

Roger Hart used the Ladder of Citizen Participation developed in 1969 by Sherry Arnstein, and developed the Ladder of Child Participation in 1992, just 3 years after the adoption of the UNCRC. This is a useful tool to check if activities that are considered learner-centred are really participatory or not.



In the above infographic the participatory and non-participatory methods are illustrated by an example each.

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3.4 Methods

In this chapter, some of the recommended learner-centred methods are briefly introduced.

It is not only important to engage children in the planning and evaluation of innovative new programmes at school, but it is necessary if we want to have children as active participants in the classroom. There are various student-centred methods that can be suitable for the CWLs.

The first choice for many would be **project-based learning** – and it is appropriate as in the CWLs there is a final creative writing product -, but it may not be suitable for every student, but also not for every teacher.

A few other methods, chosen for their participatory nature are introduced below (however, it is important to mention that for some students the suitable student-centred method can be different, and might even be individual discovery). From the teacher's perspective, it is important to make conscious decisions. No teacher will be authentic using new methods if they don't believe in the given method or do not feel comfortable learning using that method. The GOGYA Teacher Training Centre in Israel introduced these methods with a training approach that includes the teachers trying them out and then using only the methods they enjoyed with their students. It also includes incentives for schools to make it possible for students to choose which teacher – and subsequently which methods – they think they can learn best with.

For identifying and tackling STEM topics in CWLs both **inquiry-based learning** and **problem-based learning** can be useful.

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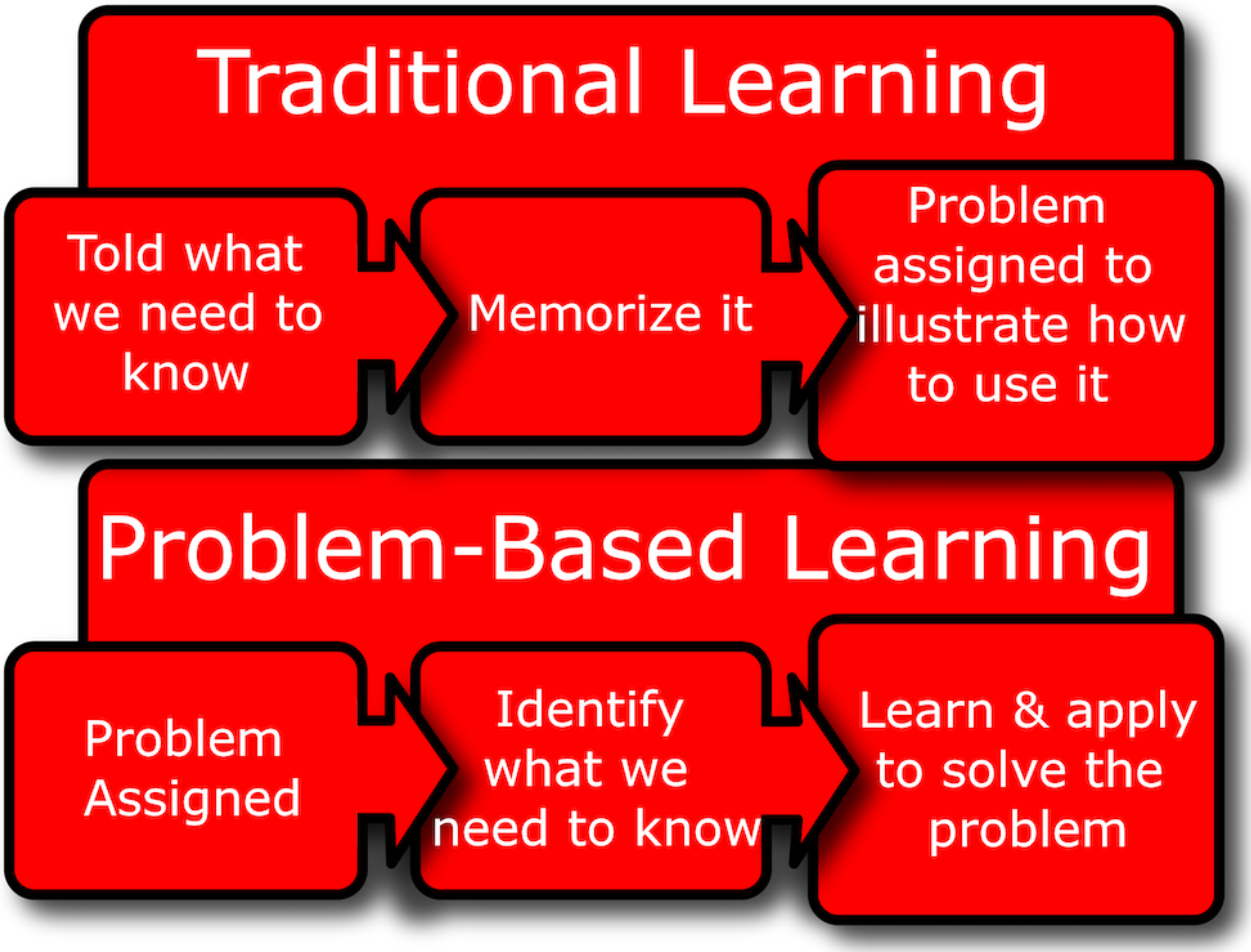
3.4.1 Problem-based learning



Problem-based learning flips the traditional approach to school learning by making the students identify what needs to be known rather than pre-defining it. In problem-based learning, students use "triggers" from the problem case or scenario to define their own learning objectives. Subsequently, they do independent, self-directed study before returning to the group to discuss and refine their acquired knowledge. Thus, this method is not about problem solving per se, but rather it uses appropriate problems to increase knowledge and understanding. The process is clearly defined, and the several variations that exist all follow a similar series of steps.

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The most common approach to it is the Maastricht seven-jump process that clearly defines problem-based learning as a combination of individual and group learning, and is usually used in groups of 10 to 15 students.

The seven steps are:

1. discuss the case and make sure everyone understands the problem,
2. identify the questions that need to be answered to shed light on the case,
3. brainstorm what the group already knows and identify potential solutions,
4. analyse and structure the results of the brainstorming session,
5. formulate learning objectives for the knowledge that is still lacking,
6. do independent study, individually or in smaller groups: read articles or books, follow tutorials, watch videos or use other, trusted sources to gain the required knowledge,
7. discuss the findings.

3.4.2 Inquiry-based learning

Inquiry-based learning takes a further step in student independence by offering students the possibility to identify the problem themselves and design an exploratory route of inquiry to refine their problem and find solutions for that themselves. This methodology is especially suitable for digitally supported activities that allow the inquiry process to be supported by digital learning environments. While the method is often used in science subjects due to its roots in scientific research, it is also suitable for humanities or arts discovery. It is often organised into inquiry phases that together form an inquiry cycle. However, different variations on what is called the inquiry cycle can be found throughout the literature.

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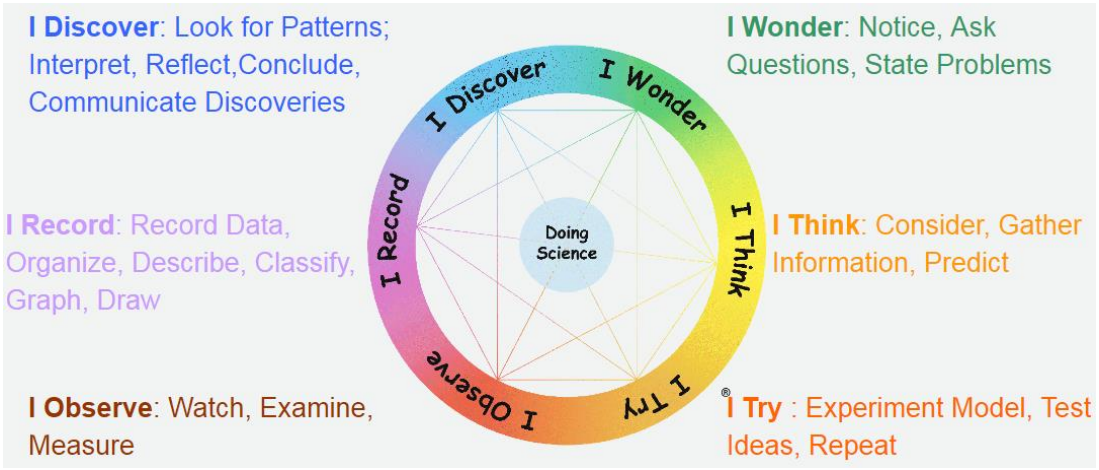

In inquiry-based approaches implemented in the classroom, students generally follow methods and practices similar to those of professional scientists in order to construct knowledge. It can be defined as a process of discovering new causal relations, with the learner formulating hypotheses and testing them by conducting experiments and/or making observations. Often it is viewed as an approach to solving problems and involves the application of several problem-solving skills. Inquiry-based learning emphasises active participation and learner's responsibility for discovering knowledge that is new to the learner. In this process, students often carry out a self-directed, partly inductive and partly deductive learning process by doing experiments to investigate the relations for at least one set of dependent and independent variables.

3.4.3 Project-based learning

Project-based learning is probably the most widely known and used, complex student-centred methodology. Students work on a project over an extended period of time – from a week up to a semester – that engages them in solving a real-world problem or answering a complex question. They demonstrate their knowledge and skills by creating a public product or presentation for a real audience. The creation of a final product is that makes it different from inquiry-based learning.

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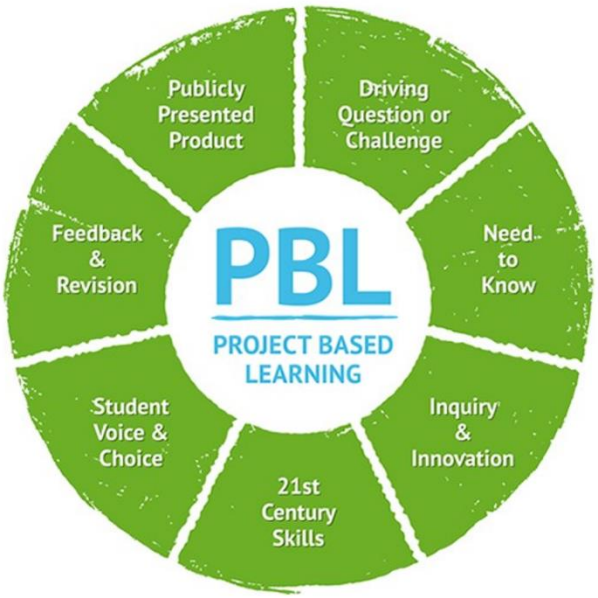

As a result, students develop deep content knowledge as well as critical thinking, collaboration, creativity, and communication skills. If managed well, project-based learning has the potential to boost creative energy among students and teachers.

Experiential learning can be very suitable for programmes that are linked to local challenges as it not only focuses on the topic and the learning outcomes, but also the experiences students have during the learning journey, including their emotions – a very important element especially for environmental topics that can be traumatising for them.

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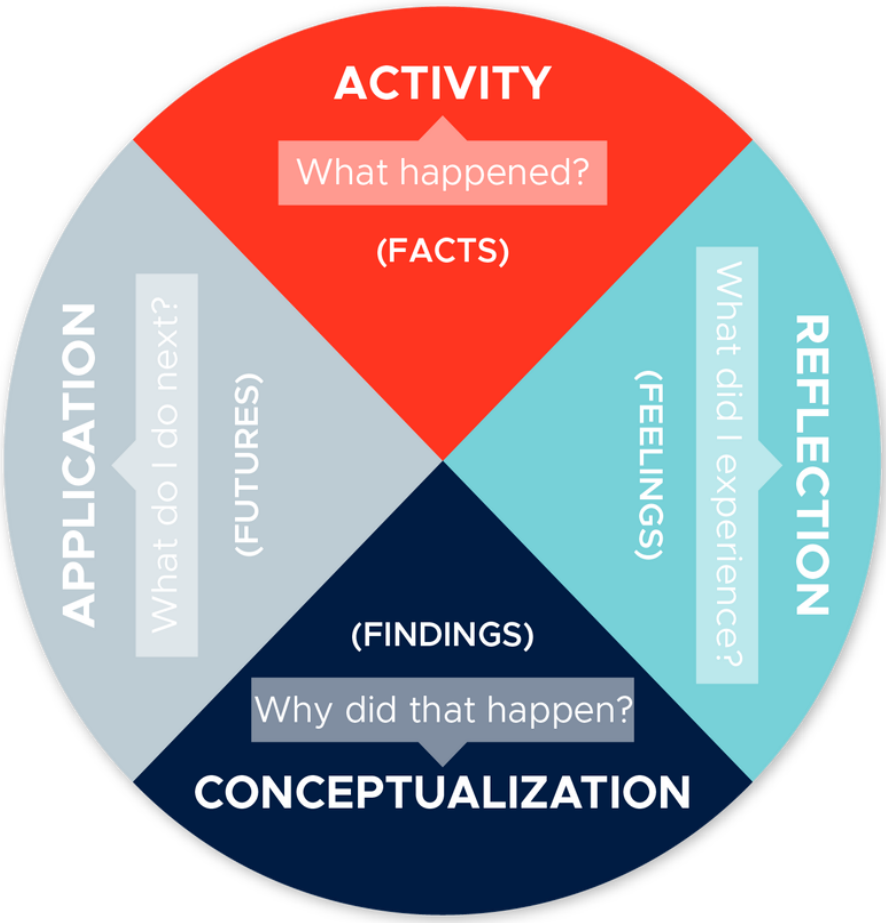

The last methods introduced here are ones that are often confused, even in publications: **playful learning, game-based learning and gamification**.

There are several definitions and frameworks for **playful learning**, the one used in this publication is the one established by scholars at the LEGO Foundation , and is defined as serious play. While most scholars have done research on the benefits of serious play in early childhood, recent studies have also emphasised its benefits for older children and adults, thus making it an approach to consider in all stages of lifelong learning. This is partially rooted in the concept of Csíkszentmihályi's flow and positive psychology . This concept establishes the ideal state for learning as a situation that is challenging, but not over challenging for the individual, and offering meaningful learning moments.

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The framework used in this training also emphasises the socially interactive nature of this methodology. It has several characteristics that make it similar or related to previously introduced methods. The theoretically interesting element of it is that it highlights the importance of iteration, thus celebrating trial and error, a feature often missing from the school context. Another element that builds further on the previously introduced methodologies, especially experiential learning, is that it does not only emphasise the importance of the feelings of learners during the learning process, but explicitly requires the experience to be joyful. This joy, as Csíkszentmihályi establishes, comes from the satisfaction of achievement, so it is not necessarily "fun" or "humour", but

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joy in a broad sense: as pleasure, enjoyment, motivation, thrill, and a positive emotion – whether over a short period of time or over the entire play session. In other words, joy is seen as both enjoying a task for its own sake and the momentary thrill of surprise, insight, or success after overcoming challenges.

The concept is built on the fact that children naturally learn through play, and offers a framework to keep this in later stages and more formal environments of education. It offers a broad framework that can be implemented in any subject-context, and puts an emphasis on developing life skills as a first step and as a basis for curricular learning.

3.4.4 Gamification

Gamification is not game-based learning, although gamified solutions often use games as a vehicle of learning. It builds on successful principles of (primarily computer) games to make learning more interesting, but not necessarily involves an actual game or digital technology. It is aimed at students being more motivated, having a deeper engagement with curricular learning, being genuinely interested and applying learning in real life environments.

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Building on principles previously quoted about playful learning, the approach is based on the gratification players feel in computer games. It is based on experiences of millions of gamers who spend long periods of time in their games online. What is important for this pedagogical approach is the so-called epic win (perhaps it could be translated as cathartic success): difficult problems during games the gamer has to solve, they need to think hard, dedicate all available resources to it – and if they do, in the end success crowns their efforts. Cathartic success is something that really took a lot of effort to reach in the game, at first it seemed even impossible to achieve, but still succeeded. As a teacher this is exactly what you want to achieve – not just students solving tasks based on teacher instruction, bored and disinterested, but also heat them from within with the desire to solve the tasks. Who has played any game knows the

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feeling, e.g. like when, after 80 minutes of play, you manage to equalise in a football match: the fatigue disappears and the goal scorer is able to run out to the spectators impossibly quickly. This is the feeling that you can take it forward, and it also encourages the student to make an extra effort.

Gamified assessment methods, based on awards and no punishments are an especially useful method for motivation, helping students to focus on their weaker points, and achieving learning goals. This is an element – offline or online – that can be introduced easily and independently from introducing other elements of gamification.

3.4.5 Game-based learning

Game-based learning, in contrast, involves designing learning activities so that game characteristics and game principles inhere within the learning activities themselves. Educational games are games explicitly designed with educational purposes, but game-based learning can also mean the use of games that have incidental or secondary educational value. All types of games may be used in an educational environment, however educational games are games that are designed to help people learn about certain subjects, expand concepts, reinforce development, understand a historical event or culture, or assist them in learning a skill as they play. Game types include board, card, and video games. For example, in an Economics course, students might compete in a virtual stock-trading competition; in a Political Science course, students might role-play as they engage in mock negotiations involving a labour dispute.

In short, gamification applies game elements or a game framework to existing learning activities; game-based learning designs learning activities that are intrinsically game-like.

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3.5 Conclusions

In this section of the training, the aim was to redefine the role of teachers and to call their attention to the methods they can implement when organising CWLs. The section was created hoping that it will also have an impact on the general approach of teachers to learning and learners

Full STEAM forward!

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4 STEAM METHODOLOGY (DRPD Novo Mesto)

4.1 Introduction

Globally, educators hope to improve student learning outcomes, such as participation, interest, engagement, persistence and aspiration in STEM (science, technology, engineering and mathematics) and STEM-related fields. STEAM (science, technology, engineering, arts and mathematics) fosters students' creativity and design thinking (Herro et al., 2018; Kang, 2019; Peppler and Bender, 2013). Educators and researchers recognize the importance of these practices (e.g. designing prototypes, modelling or finding solutions to problems) to mathematicians, scientists and engineers (Hogan and Down, 2016). Taylor (2016) explained that STEAM education is a key factor in preparing young people to "deal positively and productively with 21st century global challenges that are impacting the economy. In this module you can find different methodological approaches , from theoretical to practical.

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4.2 STEAM methodology

The STEAM methodology is an educational approach that integrates Science, Technology, Engineering, Arts, and Mathematics to create a comprehensive and interdisciplinary learning experience. It aims to foster creativity, critical thinking, innovation, and problem-solving skills among students by combining traditionally distinct fields into a cohesive framework. Here's an overview of the key components of the STEAM methodology:

Science: The scientific component of STEAM emphasises inquiry, exploration, and experimentation. Students engage in hands-on activities and investigations to understand natural phenomena, conduct experiments, and develop a scientific mindset.

Technology: The technology aspect focuses on digital literacy, coding, and understanding the role of technology in various fields. Students learn how to use technology tools to solve problems, create digital content, and harness the power of technology for innovation.

Engineering: Engineering encourages students to design, build, and test solutions to real-world problems. They learn about the engineering design process, analyse constraints, and develop prototypes, fostering a systematic approach to problem-solving.

Arts: The arts component adds a creative and aesthetic dimension to STEAM. Students explore various forms of artistic expression, such as visual arts, music, drama, and design. The arts encourage innovative thinking and provide a means to communicate complex ideas.

Mathematics: Mathematics is the foundation of many STEAM concepts. Students apply mathematical concepts and techniques to solve problems, analyse data, and make informed decisions. Maths skills are essential for understanding patterns, relationships, and quantitative aspects of STEAM subjects.

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The STEAM methodology involves several key principles and practices:

Interdisciplinary Learning: STEAM integrates different disciplines to show how they are interconnected in real-world contexts. This approach encourages students to view problems from multiple angles and apply knowledge from various fields to find solutions.

Project-Based Learning: STEAM often employs project-based learning, where students work on open-ended, hands-on projects that require critical thinking and collaboration. These projects mirror real-world challenges and encourage students to take ownership of their learning.

Creativity and Innovation: The arts component fosters creativity and encourages students to think outside the box. By incorporating artistic elements, students can approach problems with fresh perspectives and develop innovative solutions.

Critical Thinking: STEAM emphasises critical thinking skills by presenting complex problems that require analysis, evaluation, and synthesis of information. Students learn to question assumptions, consider evidence, and make informed decisions.

Collaboration: Collaboration is essential in STEAM education, as it mirrors the interdisciplinary nature of modern workplaces. Students learn to communicate effectively, share ideas, and work together in diverse teams.

Real-World Relevance: STEAM education often connects learning to real-world applications. Students see how their knowledge and skills can be applied to address practical challenges and contribute to their communities.

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Inquiry-Based Approach: STEAM encourages students to ask questions, explore curiosities, and seek answers through hands-on exploration and research. This approach cultivates a sense of curiosity and a lifelong love of learning.

The STEAM methodology can be implemented in various educational settings, from K-12 classrooms to higher education institutions. It provides a dynamic and engaging way to prepare students for the challenges and opportunities of the 21st century, where innovation and cross-disciplinary collaboration are increasingly important.

The STEAM PROCESS methodology is based on three phases:

- INSIGHT & instinct > the AWARENESS phase, which is focused on personal skills: reflection, awareness of meaning, openness, critical thinking
- PROCESS & test drives > the CURIOSITY phase, which is focused on creativity: social intelligence, seeing the forest from the trees, teamworking, disruption
- OUTPUT & strategic tools > the COMMUNICATION phase, which is focused on social impact: producing scenarios, raising awareness, storytelling, inspiring

4.2.1 How to Evaluate STEAM Learning

Evaluating STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning is important to assess the effectiveness of educational programs and ensure that students are gaining the intended skills and knowledge. Here's a step-by-step guide to help you evaluate STEAM learning:

Set Clear Learning Objectives: Define specific, measurable learning objectives for your STEAM program. These objectives should outline what students are expected to learn, achieve, and demonstrate by the end of the program.

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Select Appropriate Assessment Methods:

Formative Assessment: Use ongoing formative assessments to gauge student progress throughout the learning process. These can include quizzes, polls, discussions, and group activities.

Summative Assessment: Implement summative assessments at the end of the program to evaluate overall student achievement. These could be projects, presentations, exams, or portfolios.

Use Multiple Data Sources: Gather data from a variety of sources to get a comprehensive view of student learning. This could include quantitative data (test scores, grades) and qualitative data (observations, student reflections).

Align Assessments with Objectives: Ensure that your assessments align closely with the defined learning objectives. Each assessment should measure the skills and knowledge outlined in the objectives.

Assess Critical Thinking and Problem-Solving: STEAM learning emphasises critical thinking and problem-solving. Include assessments that require students to apply their knowledge to solve real-world problems or complete open-ended projects.

Evaluate Collaboration and Communication Skills: Many STEAM projects involve teamwork and communication. Assess how well students collaborate, share ideas, and communicate their findings or solutions.

Include Hands-On Activities: Practical, hands-on activities are a cornerstone of STEAM learning. Evaluate how well students engage with these activities and apply theoretical concepts to real-world situations.

Consider Creativity and Innovation: Incorporate assessments that allow students to showcase their creativity and innovative thinking. This could involve designing novel solutions, creating art, or finding unique approaches to challenges.

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Use Rubrics: Develop clear rubrics that outline the criteria for success on different assessments. Rubrics help provide consistent and fair evaluations while offering students a clear understanding of expectations.

Collect Student Feedback: Gather feedback from students about their learning experiences. This can provide insights into how well the program engages them and meets their needs.

Analyse Data: Once you've collected assessment data, analyse it to identify trends and patterns. Look for areas where students excel and areas where improvement is needed.

Reflect and Improve: Use the assessment data to reflect on the effectiveness of your STEAM program. Identify areas for improvement and make necessary adjustments to the curriculum, teaching methods, and assessment strategies.

Long-Term Impact: Consider tracking students' long-term outcomes beyond the program, such as their continued interest in STEAM fields, academic performance in related subjects, and potential career paths.

Comparative Analysis: If possible, compare the results of your STEAM program to other similar programs or national/international standards to understand how well your program is performing on a larger scale.

Stakeholder Involvement: Involve students, teachers, parents, and other stakeholders in the evaluation process. Their perspectives can provide valuable insights into the strengths and weaknesses of the STEAM learning experience.

Remember that evaluating STEAM learning is an ongoing process. Continuously monitor and adjust your evaluation methods to ensure that they effectively capture the impact of your program on student learning and development.

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4.2.2 The Importance of Collaboration in STEAM

Collaboration is a fundamental and crucial aspect of STEAM education. Here's why collaboration holds such importance in STEAM learning:

Real-world Simulation: In the professional world, many projects are interdisciplinary and require collaboration among individuals with diverse expertise. STEAM education replicates this reality by encouraging students to work together on projects that combine science, technology, engineering, arts, and mathematics.

Holistic Problem Solving: Complex problems often require multiple perspectives to be solved effectively. Collaboration in STEAM allows students to bring their unique viewpoints and skills to the table, leading to more comprehensive and innovative solutions.

Skill Diversification: Different students have different strengths. Collaboration enables students to leverage each other's strengths and compensate for individual weaknesses. For example, an artist might bring creative design skills to complement the analytical skills of an engineer.

Communication Skills: Effective collaboration demands clear communication. STEAM students learn to articulate their ideas, share information, and discuss concepts with peers who might have varying levels of familiarity with different aspects of the project.

Critical Thinking Enhancement: Collaborating on STEAM projects requires students to engage in critical thinking and decision-making. They need to evaluate various ideas, methodologies, and solutions, refining their critical thinking skills in the process.

Innovation Promotion: Innovation often arises from the intersection of disciplines. When students from different fields collaborate, they can combine their knowledge and experiences to create novel and innovative solutions.

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Project Realism: Collaborative projects in STEAM closely mirror real-world scenarios, where professionals from diverse backgrounds work together to develop products, systems, or solutions.

Conflict Resolution: Collaborative efforts can encounter disagreements, differing opinions, and conflicts. Learning to navigate and resolve these conflicts is an essential skill in any collaborative environment.

Preparation for Workforce: Many careers in STEAM fields require teamwork. By collaborating in a learning environment, students develop skills that are directly transferable to their future careers.

Global Challenges: Many of the world's most pressing issues, such as climate change and healthcare, require multifaceted solutions. Collaboration in STEAM education prepares students to address these challenges collectively.

Interpersonal Skills: Working collaboratively enhances interpersonal skills, teaching students how to build relationships, respect others' ideas, and contribute effectively to a team.

Exposure to Diversity: Collaboration exposes students to different perspectives and backgrounds. This exposure fosters an appreciation for diversity and encourages open-mindedness.

Engagement and Motivation: Collaborative projects often excite and motivate students due to their interactive and hands-on nature. This can enhance overall engagement and enthusiasm for learning.

Peer Learning: Collaboration allows students to learn from each other. They can share knowledge, exchange insights, and offer support, leading to a deeper understanding of the subject matter.

Incorporating collaboration into STEAM education can be done through group projects, interdisciplinary challenges, workshops, and other interactive activities. By emphasising collaboration, educators help students develop a

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well-rounded set of skills that are essential not only for STEAM fields but also for success in a rapidly changing world.

Example / Notes

https://www.youtube.com/watch?v=0tkAvWWhKf4 - *STEAM Education Program Overview*

A video about the program, educators and students learning with STEAM Education.

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4.3 STEM RESOURCES FOR THE CLASSROOM

These tools provide creative ways to integrate coding and digital literacy skills into classrooms across a variety of subjects and grade levels.

STEAM is not just about learning Science, Technology, Engineering, and Maths content, but rather is a way to connect and support learning in all content areas. STEAM-focused activities help promote digital literacy skills and provide students with learning experiences that will spark curiosity and prepare them for the fields that are in demand.

1. Birdbrain Technologies:

Birdbrain also offers the Finch Robot, which can also be used in any content area. With the Finch, students can explore AI and robotics using Google's Teachable Machine. Students can write programs that enable the robot to recognize images, audio, or poses and respond. It enables students to take a more personalised dive into AI model creation. There are activities, lesson ideas, and materials available for use with students in grades K through college.

2. CODE.org: The popular website offers many resources to help students to learn about coding. Code.org says that 67 percent of new jobs are in computing, and as of today, only 54 percent of schools offer computer science courses to students.

They offer app, game, and web labs for students to learn how to code and study important topics related to sustainability. Courses are available for each grade band, and some are offered in multiple languages. Students can participate in the hour of code and design an app for their class or one based on a project topic, for example.

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3. CSFirst from Google: Here you'll find many resources that can help educators get started with teaching computer science and are aligned to the CSTA and ISTE Standards. Some of the options include animation, art, pitching an idea and being an entrepreneur, and storytelling, in addition to other free materials for computer science and ELA courses.

Teachers can participate in distance training and download the lessons and other ready-to-use materials. The variety of options available make it easy for teachers to find a topic that meets student interests and boosts engagement in learning to code.

4. Elementari: This is a platform that can be used for storytelling and coding together. Students can create a book and learn about coding by creating interactive stories. There are example stories that can be remixed. Elementari is great for use in classes to help students narrate an experience, help them collaborate on a project, or boost creativity.

It also helps students to build coding skills in addition to essential STEAM skills, such as critical thinking and problem-solving, as well as social and emotional learning skills. Whether students are in elementary school or high school, Elementari can be used in all content areas.

5. GoldieBlox: GoldieBlox offers materials for girls to become more involved in STEAM and also has activities and DIY materials for use at home. They recently started the "Code Along" initiative with other STEAM organisations, such as Black Girls CODE, with the goal of bridging the opportunity gap for underrepresented communities in STEAM fields such as computer science.

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6. Ozobot: Ozobot is a one-inch robot that can be used in any classroom and has lessons and ideas available for subjects including English language arts and maths. There are two different ways to code using Ozobots. The screen-free coding is done by using markers and colour codes to draw mazes. There is also computer-based coding for students to program their Ozobot.

One unique idea is to have students illustrate a book summary by using the Ozobot. Students program the Ozobot to move around and stop at each point in the timeline to retell the story.

7. Marty the Robot: Marty is a humanoid that offers multiple ways to learn about coding. With infrared sensors on his feet, he responds to colour cards, providing screen-free coding. The app has block- and text-based coding, and students can quickly create a program to have Marty walk, dance, and talk.

There are many activities available for classes such as algebra, creative writing, Earth and space science, maths, physical science, robotics, and more. Each lesson has objectives, materials needed, descriptions, and extension activities for students. Teachers can request a free trial of Marty for their classroom.

8. Scratch: Scratch and Scratch Jr. are free resources for students ages 8 through 17. They can explore activities for art, games, music, stories, and more. In any content area, Scratch can be used to have students tell a story, create a game, and learn about animation, and to have them connect their program to the specific content. More than 70 languages are available, which helps promote accessibility, and because Scratch is free, it also promotes equity in learning.

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With STEAM, we provide opportunities for students to drive their own learning. The knowledge gained and skills developed through STEAM experiences will enable students to adapt to a changing world of education and work.

4.3.1 STEAM for 21st century citizens

"STEAM ahead for 21st century citizens" encapsulates the idea of preparing individuals to thrive in the modern world by embracing Science, Technology, Engineering, Arts, and Mathematics (STEAM) education. The phrase emphasises the importance of equipping citizens with the skills, knowledge, and mindset needed to succeed in an increasingly interconnected and technologically advanced society. Here's what it means:

Embracing Interdisciplinarity: The integration of STEAM disciplines reflects the interconnectedness of the real world. By fostering a holistic approach to learning, individuals become equipped to address complex challenges by drawing insights from various fields.

Adapting to Rapid Technological Changes: The 21st century is characterised by rapid technological advancements. STEAM education equips individuals with the technological literacy and skills needed to navigate a world driven by innovation and digitalization.

Fostering Creativity and Innovation: The arts in STEAM highlight the importance of creativity and innovation. Encouraging artistic expression alongside scientific inquiry and problem-solving leads to well-rounded individuals who can think outside the box.

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Promoting Critical Thinking: STEAM education cultivates critical thinking skills, teaching individuals how to analyse, evaluate, and solve complex problems by considering multiple perspectives and evidence-based approaches.

Nurturing Lifelong Learners: In a world where knowledge evolves rapidly, the concept of lifelong learning is essential. STEAM education instils a growth mindset, motivating individuals to continuously learn, adapt, and stay relevant in their careers.

Preparing for Multidimensional Careers: Modern careers are often multidisciplinary and require a diverse skill set. STEAM education prepares individuals for these careers by providing a broad foundation of skills applicable across industries.

Addressing Global Challenges: Many of today's challenges, such as climate change, require interdisciplinary solutions. STEAM education empowers individuals to tackle these issues by considering scientific, technological, artistic, and ethical dimensions.

Cultivating Ethical Awareness: The arts and humanities aspects of STEAM education encourage individuals to consider the ethical implications of their actions. This creates responsible citizens who contribute positively to society.

Encouraging Inclusivity: STEAM education promotes diversity and inclusivity by valuing different perspectives and backgrounds. This prepares individuals to work collaboratively in diverse teams and contribute to a globalised world.

Empowering Entrepreneurship: STEAM education nurtures entrepreneurial thinking, encouraging individuals to identify opportunities, innovate, and bring their ideas to fruition.

Enhancing Communication Skills: Effective communication is vital in a connected world. Through presentations, collaborations, and interdisciplinary

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projects, STEAM education hones individuals' ability to communicate complex ideas to diverse audiences.

Inspiring Curiosity: STEAM education sparks curiosity and a thirst for exploration. This curiosity-driven approach motivates individuals to ask questions, seek answers, and contribute to the advancement of knowledge.

In essence, "STEAM ahead for 21st century citizens" signifies the proactive effort to equip individuals with the skills and mindset needed to excel in an era of rapid change and innovation. It's a call to embrace interdisciplinary learning, leverage technology, and cultivate creativity to foster well-rounded, adaptable, and engaged citizens prepared to contribute meaningfully to society.

Examples of activities

When students engage in activities that combine different elements of STEAM, they experience guided inquiry in which they must ask thoughtful questions, discover answers, apply what they learn, and problem-solve creatively. Students learning how to make a wire sculpture that lights up must ask questions about how it works, try out different wiring techniques to get the sculpture to light up, think about the meaning behind their artistic creation, and experience the creative process, going from a design on paper to a tangible, functional object.

Bath bombs

This STEM experiment is great for showcasing chemistry at its finest. Work with chemical reactions, learn about citric acid ($C_6H_8O_7$), baking soda ($NaHCO_3$), and how they react when they combine (3NaHCO3 + C6H8O7 → C6H5Na3O7 + 3CO2 + 3H2O).

Learn about catalysts and why they are important. You could even take this adventure further and dive into teenaged entrepreneurship!

It’s all very complicated and extremely fascinating.

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Plus, when you're done, you'll have some fun bath bombs to enjoy.

How to Make Homemade Bath Bombs

Making homemade bath bombs is not as difficult as it may sound. It's merely a matter of collecting your ingredients and mixing everything together. The hardest part is actually getting the bomb out of your mould but that challenge too can be overcome with the right amount of patience, diligence, and preparation.

Instructions

Measure 1 ½ cups of baking soda and put in a mixing bowl.

Add 1 cup of citric acid to the mixing bowl.

Mix thoroughly.

If using mica powder for colouring add 1 teaspoon and stir into your mixture.

Melt and measure ½ cup coconut oil.

If using an essential oil, add 20 drops to the coconut oil and stir the oils together.

Slowly add the oil into the powder mixture, stirring well.

You may want to get your hands into the mixture to finish stirring.

Press the mixture into your moulds, pack it down.

Leave it in the moulds for 24 hours.

Drop it in water and enjoy the fizzy reaction!

Aquaponics Project

If your high school student is interested in biology and the environment, consider helping them build a miniature ecosystem at home.

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Aquaponics combines a hydroponic indoor garden with a fish aquarium. This is a wonderful STEM activity for high school students, combining tech, engineering, and earth science which of course makes it one of the best real-world science activities on this list. To begin, you and your student will plan together what fish and plants will thrive in the space available. Next, you assemble the main components: a tank, pump and filter system, grow-bed, and light. Once everything's built, you can add plants and gilled friends.

An aquaponics project will provide both a construction activity and ongoing care and maintenance opportunities for your STEM-focused youngster.

4.3.1.2 Benefits of Fun STEAM Lessons and Activities For Students

STEAM and STEM activities are also so effective because they combine multiple learning styles so you can more easily target and include more students. They allow any student to learn how to solve a creative problem by thinking critically!

Whether you have a kinaesthetic learner, a visual learner, an audible learner, or a reading/writing learner, all of these styles can be engaged with STEM and STEAM activities. The world is an increasingly complex place, and it's important for elementary kids and teens alike to be prepared to meet the challenges of the 21st century head-on. That's where STEAM comes in.

Activities that incorporate several or even all five of the main STEAM disciplines can help students to develop critical thinking and problem-solving skills. In addition, each STEAM activity can foster creativity and imagination, two qualities that are essential for success in any field.

And because they're fun, STEM and STEAM activities can help to spark a lifelong love of learning in kids of all ages.

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4.4 Conclusions

In conclusion, the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) into education is a multifaceted and dynamic process. Many schools at various levels have taken the initiative to integrate STEAM into their curricula, fostering interdisciplinary learning and critical thinking.

The recognition of STEAM's significance has led to various good practices in both formal and non-formal education. These practices emphasise co-creation, collaboration, and the practical application of STEAM concepts. They not only provide students with engaging learning experiences but also encourage innovation and creativity.

Teacher training in STEAM is available through workshops, programs, and initiatives offered by schools, faculties, and educational organisations. These training opportunities empower educators to effectively integrate STEAM concepts into their teaching methods.

Overall, the integration of STEAM in the education system is a promising development that aligns with global efforts to prepare students for the challenges and opportunities of the 21st century.

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4.5 Extra Resources

In this section you can find activities, worksheets and videos that implement the theoretical part into practical.

4.5.1 Internet resources

- https://www.warrawongws.com.au/courses/pluginfile.php/40/mod_resource/content/1/STEAM_Aquaponics_for_Sustainable_Living_Years_3_and_4-Intro.pdf
- https://www.edutopia.org/article/stem-english-language-arts
- https://www.youtube.com/watch?v=IuuCZ23ojRM

4.5.2 Printable worksheets for students

- https://raft.net/wp-content/uploads/2020/08/LAS-Abiotic-Dissections.pdf
- https://raft.net/wp-content/uploads/2020/08/LAS-Bread-Bag-Parachute.pdf
- https://raft.net/wp-content/uploads/2020/08/LAS-Casting-Seeds-to-the-Wind.pdf

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Operational content

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5 WELCOMING IDEAS (SINERGIE)

5.1 Getting started

This is the first section of the three-part **W³** module. In this section, you will find lots of practical advice and hands-on techniques to guide your students towards mastering the art of *Welcoming Ideas*.

Welcoming Ideas is designed to approach problems with simple, effective methods. Think of this section as an archive of resources from which you can hand-pick what best suits your project.

This section is organised in three macro-areas:

- simplifying complexity
- brainstorming
- problem-solving

Each area contains a number of techniques with a concise description and either an illustration or a practical example of their application.

You will also find a quick online Test to evaluate your knowledge and an Assignment to help you translate what you have learnt into practice.

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You should be able to complete *Welcoming Ideas* in about one hour. However, feel free to dedicate as much time as you like. After all, you are the agent of your own learning.

Now, you're set. Full STEAM forward!

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5.2 Simplifying complexity

Complexity isn't necessarily a bad thing. "Complex" doesn't automatically mean "difficult", just like "simple" doesn't always correspond to "easy".

Here's a definition: *"Simplifying complexity" refers to the process of breaking down complex systems or problems into smaller, more manageable parts in order to better understand and solve them"*[1]. It involves identifying the root causes of complicatedness and finding ways to address them in a smart and effective manner.

When we try to work our way through or around a problem, the first thing we need to do is understand what the problem is. For this you will need to collect data, sort it, and organise it into information.

Building information is just like building a structure. Its elements are interconnected, often in unexpected ways. They sometimes require adjustments to eliminate the superfluous or ensure that the structure holds properly.

You can summarise the process as follows:

1. Facing a problem – you encounter the *difficulty* of a situation
2. Collecting data – you collect the *complexity* of data
3. Extracting information – you *simplify* that complexity to build information
4. Solving the problem – you use information to design a solution, which is typically *easier* than the initial problem.

The following paragraphs discuss three examples of effective simplification techniques that you can master quite rapidly.

[1] Mastering Complexity Through Simplification: Four Steps to Creating Competitive Advantage (bcg.com)

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5.2.1 Mind maps

Mind maps are useful when you are trying to develop and organise ideas and information visually. They simplify information on a page, distilling data into keywords organised hierarchically from the centre to the rim. The resulting visual summary is easier and faster to process.

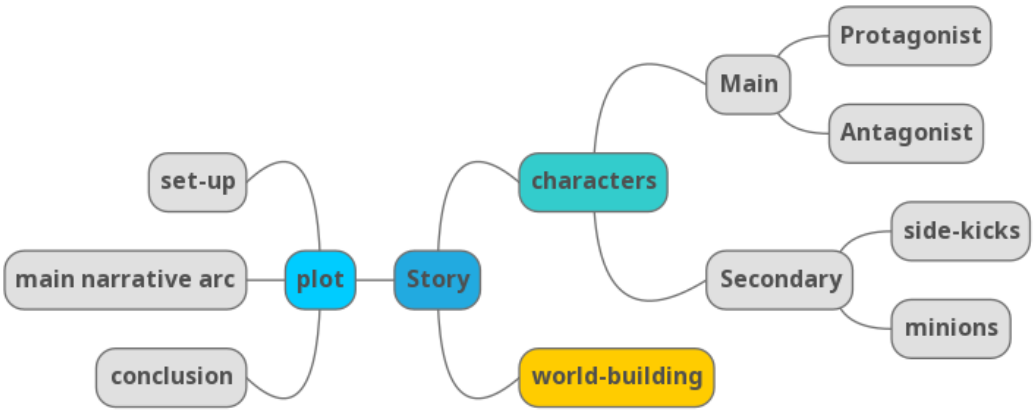
The elements of a mind map include:

- a central image that represents the main idea, subject or focus.
- branches radiating outwards from this central image, representing main themes. These branches are made up of key images or keywords that are drawn or printed on their associated lines. They form a connected nodal structure.
- twigs of the relevant branch, representing topics of lesser importance.

The image below shows a rough categorisation of the basic elements of a story, visualised in the form of a mind map.

Mental maps tend to suffer from three types of problems:

- crafting a good mental map requires a fair amount of time
- they can be messy, especially when drafted with pen and paper
- because they are so concise, it's difficult to elaborate on complex ideas just by looking at them.



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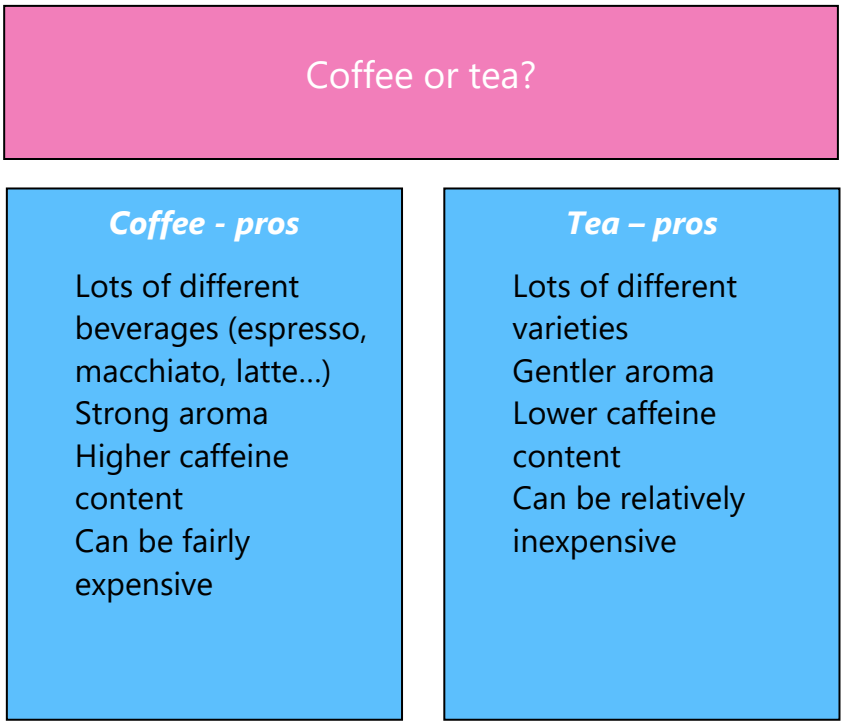
5.2.2 T-charts

T-charts are a very simple way to distinguish a subject into two different parameters. It forms a T-like shape with a heading at the top and two sections on each side.

T-charts are handy because they allow you to identify two variations present inside a given system.

To use a T-chart, all you need to do is write the topic you want to discuss in the heading section, and the two possible alternatives in the side sections.



T-charts' weak points are a direct consequence of their simplicity. Since they often compare only two sets of variables, they are not ideal to depict complex relationships.

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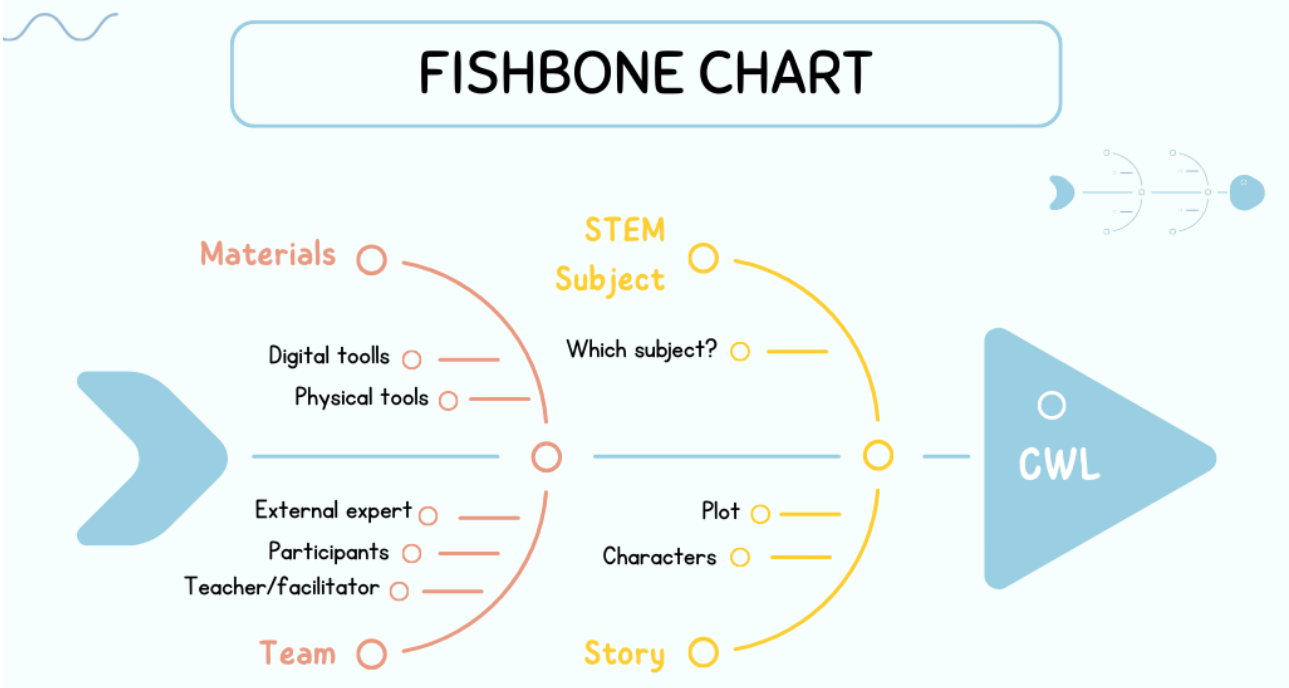
5.2.3 Fishbone charts

Fishbone charts are also called Ishikawa charts after their inventor, Japanese organisational theorist Ishikawa Kaoru. They can be used to display links and relationships among multiple factors of a problem, logically visualising their correlation.

The essential elements of a Fishbone chart are the Head, the Backbone, and the Bones. To use a fishbone chart, you write the problem or outcome you're analysing inside the head of the fish. The backbone's straight line connects all the other bones to the head.

To individual bones represent causes of the main problem, or elements required for a given outcome.

When you use a Fishbone chart, you need to make sure that you are prioritising the right variables and that you are making the right assumptions about the root cause of a problem, otherwise you may reach inconsistent or incorrect conclusions.



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5.3 Brainstorming

Brainstorming is a group creativity technique that delivers exactly what its name suggests: lots of ideas in a short time span.

It is typically used to find a solution to a given problem through a **quantity-over-quality** approach: the more the ideas, the greater the chances to find a suitable solution. The key to its success is collecting ideas spontaneously contributed by the members of a team.

Brainstorming has a number of advantages that make it an excellent teaching strategy. Here are some of them:

- it increases the students' critical thinking abilities by requiring them develop ideas coherent with the problem at hand
- it can be used to cultivate the students' ability to analyse options, innovate solutions, and modify problems into opportunities
- it can help promoting the inclusion of special need students as there is no one right answer

In spite of its versatility and effectiveness, brainstorming has some potential issues:

- some participants may find speaking spontaneously in a group intimidating, while others may be exceedingly talkative
- it may take time to get the whole team to start providing ideas, as some students may need longer to understand the theme
- overlapping of ideas is possible
- some ideas may be very low-quality

Brainstorming sessions can be run in a variety of ways. The following paragraphs details five brainstorming variations, but the list is by no-means exhaustive.

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5.3.1 Role storming / figure storming

Role storming is brainstorming with a role-playing twist.

Participants are asked to assume the identity of a famous personality or a historical figure, and brainstorm ideas accordingly. The rationale behind role storming is that impersonating someone else can reduce the emotional load and make it easier to speak freely and spontaneously. In addition, the role-playing element can be conducive of more original proposals.

Here are some key factors to keep in mind:

1. plan your sessions in advance
2. have simple instructions ready, particularly if it's the participants' first time with brainstorming
3. set precise rules
4. establish clear goals, so that participants don't have to waste time and energy trying to understand what you want from them

For role-storming to be effective, it's essential that participants dedicate appropriate time and effort to really understand their character. Here is a quick list of must-do before bringing ideas to the table:

1. know or decide what role they are going to play
2. describe the character's qualities and motivations
3. make a list of the character's strengths and weaknesses
4. speak in character

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5.3.2 Gap-filling

Gap-filling is also called gap analysis. It's a brainstorming technique often used in business settings when teams struggle with the execution of an idea.

The structure of gap-filling brainstorming is simple: it's literally about finding out how to go from A to E, going through B, C, and D.

The first thing you need to do is identify where you are (A) and define where you want to be at the end of the process (E). After that, all you need to do is fill out the gaps between A and E with the necessary steps.

Example

Teachers of a given middle school gather for a brainstorming session to address the following problem: students are reading less than 4 books a year.

Here's an example of how they could use gap-filling brainstorming to address this problem:

A) Identify the current situation: Children in our school don't read enough books.

*F) State the desired objective: Our children read one book per month.

instorm possible solutions:

B) Start a reading program that rewards children for reading books.

C) Organize a monthly book club where children can discuss books they've read.

D) Invite authors to speak at the school to inspire children to read more.

E) Provide children with a list of recommended books to read.

By brainstorming possible solutions, you can identify ways to bridge the gap between the current situation and the desired objective.

* the final letter would change depending on the number of steps the participants decide to implement

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5.3.3 Rapid ideation

In this brainstorming technique, participants write down as many ideas as possible in a given amount of time, without worrying about quality or feasibility. Speed is essential. Once the time is up, ideas are evaluated collectively, selected, and fleshed out.

By concentrating on speed and aiming and quantity rather than quality, participants can overcome their insecurities and prevent becoming stuck. This technique is particularly effective for teams with a tendency of getting sidetracked, or with a difficulty in maintaining focus.

There are three things you need to do if you want your rapid ideation session to be a success:

1. set a time limit for the ideation session and make sure that the countdown is visible to all participants. The sense of urgency will help participants sustain the pace of the activity and keep their concentration
2. encourage all participants to be bold, imaginative, unconventional. Thinking fast is not enough: they need to think big
3. establish a system to summarise and evaluate ideas once the session is over. For example, team voting.

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5.3.4 Reverse brainstorming

With reverse brainstorming, we are going wild.

We usually employ brainstorming to find good solutions to certain problems. Reverse brainstorming asks participants to find *bad* solutions first, and then devise ways to turn them into good solutions.

There are five steps in reverse brainstorming:

1. identify the Problem – Identify a design challenge and write it down.
2. reverse the Problem: for example; instead of asking 'how can I help? Ask 'How can I make it worse?
3. collect Possible Solution: brainstorm to figure out all possible reverse solutions. Everything is possible: reject nothing!
4. reverse Solutions: flip the reverse solutions to create real design solutions for the actual issue
5. Evaluate the Ideas: evaluate and decide if a real solution can be formed.

Example

A group of students has set up a stepladder brainstorming session to come up with ideas to make their school more "green".

Students n.1 and n.2 suggest starting a school compost to reduce waste and improve the school garden.

Student n.3 is added to the group and proposes using recycled paper and other eco-friendly classroom items like recycled pencils, notepads, and clipboards. The trio discusses both ideas.

Student n.4 joins the group and recommends cutting down on single-use plastics by encouraging staff and students to use reusable water bottles and lunchboxes, and installing water fountains instead of vending machines with single-use plastic bottles.

Student n.5 suggests starting an eco-club to get students involved in green initiatives.

The whole group discusses all ideas for the last time and reaches a consensus.

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5.3.5 Stepladder brainstorming

The Stepladder Technique is a method of decision-making suitable for small groups of five to six people. It can result in a greater number or range of ideas being presented, since conformity processes are minimised.

The Stepladder brainstorming has five steps:

1. present the assignment or issue to the group and give everyone time think about it
2. select a pair and ask them to talk about the topic
3. After a while, add one participant. The new member should voice his/her ideas before the original two members, then the three of them discuss their suggestions together
4. include a fourth member, and then a fifth, allowing time for discussion after each new participant has spoken first
5. the team should make a decision only after everyone invited has had a chance to speak

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5.4 Problem-solving strategies

Problem-solving has become a fashionable expression, but the concept is far from modern. In fact, solving problems has been a major human occupation for most of our history. In its contemporary form, it's an important soft skill that allows people to address and overcome challenges.

Problem solving helps

- think logically
- identify what's wrong
- figure out next steps
- make decisions about the course of action
- enact decisions
- evaluate actions
- learn from mistakes
- change behaviour on the grounds of new information.

Students can derive many benefits from developing problem-solving skills. They have been shown to improve academic performance, increase confidence, and prepare students for their future careers. In addition, critical thinking, decision-making, and collaboration skills can receive a significant boost from engaging in problem-solving activities.

Problem-solving techniques are many and diverse. They typically include clearly defining the problem and trying different approaches.

The following paragraphs illustrate some of the most common problem-solving techniques. The list is not exhaustive, so feel free to add, modify and experiment. Great solutions often emerge as unintended consequences to apparent mistakes.

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5.4.1 Seven steps

"Seven Steps" is a structured problem-solving strategy that works by breaking down problems into more manageable blocks. It can be applied to any complex challenge in business, public policy, or life.

1 Define the problem: this step involves understanding and documenting the problem. A problem statement should commence with a question or hypothesis. It should also be specific, actionable, and focused on what the participants need to move forward.

2 Disaggregate: you break down the problem into its component parts so that it can be divided, and time and resources allocated to them.

3 Prioritise: this step involves prioritising key issues and eliminating non-essential issues.

4 Workplan: a well-made work plan contains information about: the issue proper, hypotheses, analysis (frameworks, process, etc.), sources, who is responsible, timing, desired outcome.

5 Analyse: in this step, you gather data and analyse it critically. It is important to keep the analysis properly oriented, simple, and sufficiently flexible to adapt in the face of new data. Of course, it must also be creative.

6 Synthesise: in this step you distil the information available into a compelling story.

7 Communicate: This step involves building commitment by engaging clients, stakeholders & experts.

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Example

Here is an example of how the "Seven Steps" strategy could be applied to solve the problem of insufficient vegetable intake in children:

1 Define the problem: the problem could be defined as "How can we increase vegetable intake in children?"

2 Disaggregate: The problem could be broken down into its component parts, such as identifying the reasons why children are not eating enough vegetables, determining the target age group, and identifying potential solutions.

3 Prioritise: key issues could be prioritized, such as focusing on the most common reasons why children are not eating enough vegetables and identifying the most effective solutions.

4 Workplan: a workplan could be developed that outlines the steps that will be taken to address the problem, including conducting research, developing and implementing interventions, and evaluating their effectiveness.

5 Analyse: data could be gathered and analysed to better understand the reasons why children are not eating enough vegetables and to identify effective interventions.

6 Synthesise: the findings from the analysis could be synthesized into a compelling story that outlines the reasons why children are not eating enough vegetables and presents effective solutions.

7 Communicate: the findings and recommendations could be communicated to stakeholders, such as parents, schools, and policymakers, to build commitment and support for implementing the proposed solutions.

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5.4.2 Backward chaining

Backward chaining is a problem-solving strategy that involves starting with the goal or conclusion and working backwards to find the steps needed to reach that goal.

Here are the steps to apply backward chaining:

1. identify the goal or the conclusion that needs to be reached
2. identify the rules or facts that are needed to reach the goal
3. work backward from the goal to identify the rules or facts that are needed to reach it
4. continue working backward until you reach a set of facts or rules that are known or can be easily determined

Example

A group of students is trying to identify what they need to prepare a 2-minute video explaining the results of a school project.

1 Goal: a well-edited, 2-minute video. How do we get here?

2 We need footage to edit and editing tool. How do we get the footage?

3 We need to shoot the footage based on a storyboard. What do we need for the storyboard?

3. Storyboards require an outline and a script. Where do we get our outline?

4. We need to collect information about the project (goals, duration, steps,…), and we need to sit down, draft and polish the script. We also need to think about music or voiceovers.

5 […]

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5.4.3 Heuristics

Heuristics, from the Greek *heuriskein* εὑρίσκω, "to find", are helpful to solve problems quickly and efficiently, especially when perfect solutions are improbable or unfeasible.

Heuristics work by shortening the decision-making process. Instead of constantly stopping to think about the next course of action, you use mental shortcuts to make decisions based on prior experiences.

Given their potentially effective but fundamentally non-scientific nature, heuristics share the same upsides and downsides of proper shortcuts: they can get you to your destination faster, but there's also a chance you'll end up somewhere else.

Here are three examples of useful heuristics.

5.4.3.1 Rule of thumb

A rule of thumb is a general principle that uses practical experience rather than theory to provide instructions for accomplishing a certain task or reaching a certain goal.

5.4.3.2 Trial and error

Trial and error is perhaps the quintessential problem-solving solution. Simply put, it's trying out solutions until you reach one of the following outcomes:

- you succeed and solve the problem
- you give up

Failure is the foundation of "trial and error". Without it, it's impossible to find a solution. Participants should be encouraged to seize the opportunity and make as many mistakes as they want in pursuit of a good solution.

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Example

Perhaps the best example of trial-and-error is the learning process itself, particularly when you're trying to learn something completely new. Another good example is when you want to fix something broken, and you try out various solutions until you find one that works…or you give up.

5.4.3.3 Stereotyping

Stereotyping is both a low-resolution problem-solving tool and a potential risk factor. Stereotyping works on the assumption that things displaying the same characteristics will behave in the same way. However, stereotyping can easily mislead those who employ it, and lead to fundamentally incorrect conclusions.

The risks of stereotyping can be offset in several ways. Ensuring a healthy dose of different opinions is probably one of the best, most effective methods to cultivate an open, flexible attitude to problem-solving.

Example

CORRECT

"You should stay away from animals with a sting, because they might sting you".

INCORRECT

"all animals with a sting could sting you, so they are dangerous".

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5.5 Conclusions

In this first module we have covered multiple strategies and approaches to elaborate ideas. Specifically, we have covered Simplifying Complexity, Brainstorming and Problem-solving, each with a set of suitable tactics.

You can now put your knowledge to the test by taking out a questionnaire. If you are interested in doing something more, you can check the next section and select an assignment to work on. It's not compulsory, but it will help you get a feel of the practical applications of what you've learnt so far.

Thank you for your effort, you're doing really well. Just two more sections to go.

Full STEAM forward!

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5.6 Test and Assignment

5.6.1 Test

Every good training session has a small test that goes with it. If you feel ready, you can access the test here.

5.6.2 Assignment

Here is an assignment for you. It will help you get a feel of what applying these techniques in real life might look like. Assignments won't be graded, so no worries. However, they connect across modules and will provide useful content to discuss with your peers during the Closing Seminar. So, don't skip them!

Assignment 1 – Setting up a brainstorming session

You are organising a brainstorming session with your students. You goal is generating ideas to solve a particular problem. Think about:

the problem: is it limited to one subject? Is it multidisciplinary? In what way is it relevant to your students?

the set-up*:* how would you communicate the activity to your students? What could help making the activity more interesting and engaging for them?

logistics: how would you schedule the activity? Would you use large groups or small groups?

management: how would you run the activity? What kind of tactics and techniques would you employ to manage groups and individuals? What could you do to help students who are not engaged or who are having trouble participating?

assessment: how would you evaluate the activity? What parameters would you set? What kind of expectations would you have towards your students?

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6 WORKING TOGETHER (SINERGIE)

6.1 Getting started

In the second part of the **W³** module, *Working together*, we will discuss ideas that can help make group activities as smooth, effective, and fun as possible.

This section is organised in three macro-areas:

- team management
- peer work
- steering strategies

Just like in *Welcoming ideas*, you will find a number of paragraphs with essential descriptions, examples and tips on how to apply a certain technique.

You will also find a quick online Test to evaluate your knowledge.

You should be able to complete *Working together* in about one hour but, again, you can take as much time as you need.

Now, you're set. Full STEAM forward!

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6.2 Team management

Team management is the ability to coordinate a group of individuals so that they can successfully perform a task together. Easier said than done, especially in schools.

Managing your team properly involves:

1. working with people
2. communicating effectively
3. setting realistic objectives
4. evaluating performances
5. identifying problems and resolving conflicts

A team is like an ecosystem. It naturally, and inevitably, tends towards entropy. However, it also contains in itself the elements to reach and maintain a functioning degree of harmony.

There are multiple reasons for applying team management techniques to your classroom activities:

- students have better learning outcomes as a consequence of being involved in activities that foster collaboration, creativity, and critical thinking skills
- students develop a sense of belonging, trust and respect among themselves and between themselves and the teachers, which improves the climate of the classroom
- teachers can delegate tasks, reducing their workload
- combined with peer work, it offers students a chance to learn from their peers

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Two things are going to help you establish a good team working environment:

1. students need to have actual agency and be actually responsible for something. They won't be motivated to act responsibly so long as someone else can do the job for them.
2. Students need to know that there is a system in place, that things aren't just improvised. They need to know what the endgame is, what the expectations are, how the evaluation works. It's difficult for them to be on board if the rules of the game are kept from them.

The following paragraphs discuss a few suggestions to lay solid foundations for your team. They don't work magic, but they will help start the activity with the right foot.

6.2.1 Creating a team identity

Humans are, for the most part, "social" animals, especially in the early stages of their lives, when the group provides protection and validation.

There are many variations of groups and many different ways to construct one, but the basic principle is this: a group must be immediately recognizable and distinguishable from every other group. In other words, a group, or a team, needs an identity. Something that is unique to that team, and that its members can rally around.

You can have your team, or teams, construct their own identity by asking them to choose:

1. a name
2. a symbol
3. a battle cry or a motto

By definition, they will have to agree on something, and this will help them transform from a random group of disparate individuals into a team of people

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working together. It also provides room for participants to showcase their artistic abilities and their creative thinking prowess.

Example

For an activity about Physics, students are divided in groups and given 20 minutes to

choose a name for the team
decide a visual symbol
select or create a motto

Team 1

Name: The Quantum Leapers

Symbol: an atom with an arrow jumping out of its orbit

Motto: "exploring the unknown, one leap at a time".

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6.2.2 Setting rules

Rules aren't just an essential element to maintain effectiveness. They also provide an excellent team-building opportunity.

If you think of your classroom activities as a game with rules, to borrow Piaget's definition, rules become that by which games acquire meaning. If anyone can do anything at any time, there's no point in playing that particular game.

Rules are there for everyone to follow. The crucial question is: why? What is the *motivation* for following rules?

Broadly speaking, there are two types of motivation:

- external (extrinsic) motivation

you are motivated by your fear of consequences, usually in the form of punishment.

- internal (intrinsic) motivation

you are motivated by your desire to fit in and be part of something

Consequences are typically the territory of teachers, who have the authority to enforce them. However, when students discuss and agree on their own rules, that's a different thing. If it's *their* rules, because they contributed to constructing them, they are significantly more likely to abide by them, and make an effort to ensure that other members of the team follow them as well.

Rules help define:

1. tasks and responsibilities: who does what
2. timing / schedule: how much time is available for a certain task, what the deadline is
3. decision-making mechanisms: how the team is going to make a decision on something, without being told by the teacher
4. problem-solving mechanisms: how the team is going to try and solve a problem

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Discussing and agreeing on a common set of rules becomes an exercise in citizenship. Essentially, it's a brainstorming session that you can organise using one of the techniques covered in *Welcoming ideas*.

The activity of setting rules provides you with a fantastic opportunity to build trust and motivation: follow them yourself. Granted, as the person directly responsible for the classroom you have ultimate authority and you are given a greater degree of freedom than any other participant. However, imagine how gratified your students would be seeing that you abide by their same rules, the very rules that they have put time and effort into crafting. This will show them that you take the activity seriously, and anything you genuinely care about they are likely to care about too.

Extra tip

Rules tend to be forgotten over time. Consider having them displayed on a poster on the wall, or written a section of the blackboard, so that students can reference them easily.

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6.2.3 Planning actions

All complex systems naturally tend towards entropy. Meaning: if you let things go on their own, they are more likely to move towards chaos than towards order and harmony.

Teams of students fit the definition of "complex system" very nicely. So, after establishing the team identity and working out a shared set of rules, what can you do to maximise the chances of things going according to plan?

For one thing, there needs to be a plan.

Planning is a very complex action that requires both analytical skills and imagination. You need to be able to imagine a sequence of events leading to the desired outcome, then break down the sequence into smaller parts and repeat the process. And that's only half of it.

Because you *know* that *at least* something is not going to go well. Something will require a correction, or a different solution. That's why you don't just plan for success. You also plan for contingency.

Here's another really good exercise to challenge your teams with. Given a certain goal, what would they do to prevent problems? How would they manage the unexpected? If they start thinking about it in advance, they will at least get used to the idea that plans need reworking, patches, fixes, and temporary solutions. If they act on the assumption that everything is going to be ok, with no effort, they will find themselves in trouble.

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6.2.4 Tracking progress

Let's close the chapter with the capping stone of team management: tracking progress.

You've built your team, established your rules, planned a sequence of actions to reach a goal. Since you made the planning, you know that going from the beginning to the end won't happen in one day. It's going to be days, or weeks, or even months, before you reach your goal. And since you *know* that not everything is going to go smoothly, you need to stop every once in a while to check how you are doing, and make the necessary corrections when you still have time.

In other words, you need to track your progress.

There are lots of tools you can use to track progress effectively. The single most important thing you need is a clear deadline. Deadlines are a reference point in the future that allow you and your team to organise time and structure activities accordingly. Discussing and agreeing on a deadline is not a trivial thing. It's a complicated process that trains the ability to estimate the duration of an activity and the effort required to perform it. It also requires some negotiating skills, because the whole team needs to be on board.

Another useful tool is the Gantt chart. In its simplest form, it's a grid that lists tasks vertically and months horizontally. It gives you a visual representation of how much time is allocated to a certain task, and where you should be at a certain time in the future. Combined with deadlines, it allows you to track progress relatively effectively.

However, remember that tools are useful only if they are actually used. You team will need two or three "interim" checkpoints where they can take evaluate progress and make corrections if necessary.

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6.3 Peer work

Peer work is a collaborative learning method: students work together in pairs or small groups to achieve a common goal. In doing so, they can learn from each other and benefit from the diversity of perspectives, experiences, and skills that they bring to the table.

Some of the benefits of peer work are:

- greater engagement, motivation, and self-confidence
- improved critical thinking, problem-solving, and communication skills
- promotion of social interaction, cooperation, and mutual respect

Perhaps the greatest asset of peer work is that it eliminates the pressure of being taught or corrected by the teacher. However, this is potentially its worst drawback too, as some students may be recalcitrant to accept feedback from peers.

Additional peer work drawbacks are:

- higher amount of time, planning, and coordination required in comparison to individual work
- risk of inaccurate or inconsistent feedback or assessment
- may cause anxiety, frustration, or resentment among some students

Peer work needs to be carefully designed and monitored by the teacher. Students should receive clear instructions, expectations, and guidance.

The following paragraphs describe three iterations of peer-work, but other variants are equally possible.

Extra tip

Students like autonomy. If the activity is set up properly, they will welcome the opportunity to do something by themselves instead of just sitting and listening. That's a great demonstration of trust. Make sure your students understand this, and that they understand that you expect them to do their best. They'll try hard to live up to your expectations.

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6.3.1 Peer tutoring

Peer tutoring is a teaching method in which students help each other learn. Its basic assumption is that peers can explain concepts, provide feedback, and motivate each other effectively, while reducing the emotional load of being taught by a teacher.

Peer tutoring comes in different forms. Here are three examples:

- *fixed-role, cross-ability tutoring*: one student takes the role of a tutor and helps one or more students with their learning. The tutoring student is typically older or more advanced than the others.
- *reciprocal-role tutoring*: students take turns being the tutor and the tutee, and learn from each other's perspectives and questions.
- *peer-assisted learning*: students work in small groups or pairs, and use structured activities or materials to guide their learning.

Several benefits derive from using peer tutoring. The method has been credited with improving academic achievement, enhancing social and emotional skills, increasing autonomy and responsibility, fostering positive relationships, communication, cooperation, and empathy. It can also boost self-confidence, motivation, and interest in learning, and reduce negative behaviours, such as bullying or disengagement.

Last, but not least, it can also relieve teachers of some of their workload, and allow them to focus on other aspects of teaching.

However, there is one big caveat: it needs to be set up properly.

Extra tip

Been given the responsibility to explain something that you don't know is a fantastic learning strategy. Since you need to overcome your own knowledge gap first, you are in an excellent position to identify difficulties and complexities and find ways to simplify them. Just remember that not everybody likes to be taught or mentored by a peer, so make sure you frame the activity in a way that is suitable to all students

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Here is what you need to make your peer tutoring a success:

1. *Clear goals and objectives*
Decide what you want your students to achieve through peer tutoring and communicate it clearly to them.

2. *Appropriate matching and grouping*
No-one knows your students better than you. Take their personality and characteristics into consideration when pairing or grouping them for peer tutoring.

3. *Adequate training and preparation*
Provide tutors and tutees with the necessary skills and knowledge to work effectively. This includes how to explain concepts, ask questions, give feedback, manage time, etc.

4. *Structured guidance and feedback*
Design your activities so that they have clear instructions, roles, tasks, and outcomes. Devise ways to monitor the progress and performance of your students, and provide them with feedback and support as needed. Encourage students to reflect on their experience and share their feedback with each other.

5. *Regular evaluation and improvement*
Assess the impact of peer tutoring on your students' learning outcomes and on their social and emotional development. Collect feedback from your students on their satisfaction and challenges with peer tutoring. Use this information to make adjustments and improvements where needed.

Extra tip

When you want to learn something, nothing is better than direct experience. The next best thing is someone demonstrating something for you. Your mirror neurons will fire up. You'll find replicating the model much easier than you would by just listening to a verbal explanation or being shown a picture. You can minimise explanations and maximise student action by demonstrating exactly what you want your students to do, and how.

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6.3.2 Peer feedback

In this alternative form of assessment, students provide feedback to each other on their performance, learning, or work.

Some benefits associated with peer feedback are:

- improving communication, collaboration, and critical thinking skills
- enhancing self-regulation, metacognition, and motivation
- increasing engagement, ownership, and responsibility for one's own learning
- receiving diverse, personalised feedback
- developing a deeper understanding of the criteria, standards, and expectations for quality work

Peer feedback is not without its drawbacks, mostly because not everyone is willing to accept constructive criticism from someone who they not recognise as a source of authority.

To make peer feedback work, consider these elements:

1. *Purpose and goals*

Why are students giving and receiving feedback? What are they expected to learn from it?

2. *Type and mode*

What kind of feedback are students giving and receiving? Is it formative or summative? Is it qualitative or quantitative? Is it written or oral?

3. *Criteria and rubrics*

What are the criteria and standards for quality work? How are they communicated and explained to students? How are they used to guide and evaluate peer feedback?

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4. *Process and structure*

How are students grouped and paired for peer feedback? How many peers do they exchange feedback with? How often do they give and receive feedback? How much time do they have for peer feedback?

5. *Support and scaffolding*

How are students prepared and trained for peer feedback? What tools and strategies do they use to give and receive feedback? How are they monitored and coached during peer feedback?

6. *Follow-up and reflection*

How are students expected to use the feedback they receive? How do they document and track their progress based on peer feedback? How do they reflect on their learning from peer feedback?

Extra tip

Feedback is typically associated with mistakes, and mistakes are something no-one likes. Students as well as adults are usually sensitive about being told they are wrong by someone who they don't recognise as more experienced or more authoritative. When setting up your peer-feedback activity, make sure that your students understand this is a learning exercise designed to work on their soft skills. The point is not passing judgement on someone else. It's finding the simplest, most effective way to put your knowledge at the service of others, in a manner that they can find helpful.

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6.3.3 Peer editing

Peer editing is a collaborative learning strategy in which students review and provide feedback on each other's writing.

Through peer editing, you can help your students improve their writing skills, learn from their peers, and refine their ability to use their own "voice" to address a given audience properly. It's an effective tool, but it requires careful planning, instructions, and practice from both teachers and students.

The same precaution for peer tutoring and peer feedback applies to peer editing: it needs to be performed in such a way that makes students comfortable with receiving guidance from someone who is not the official figure of authority.

To make peer editing work, you need clear guidelines, scaffolding, and modelling of meaningful and respectful editing. Here are the basics:

1. *Compliments*

First, students identify and praise the strengths of their peer's writing. This helps establish trust and confidence between peer "editors" and authors. It also helps reinforce the positive elements of one's performance.

2. *Suggestions*

"Editors" offer constructive criticism on how to improve a text, using specific examples and questions. Vague or harsh comments should be avoided. Editors should make a point of explaining why their suggestions would improve the writing, and how they can be implemented.

3. *Corrections*

Editors mark errors or mistakes, such as spelling, punctuation, capitalization, etc. They should also provide the correct forms or alternatives.

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To make peer editing more effective and manageable, you can scaffold the process by breaking it down into several sessions, each focusing on a different aspect or type of error. For example, one session could be dedicated to revising content and organisation, another session could focus on editing the grammar, and so on.

It's very important that you model how to give and receive constructive criticism by using sample texts and demonstrating each step of the process.

You can also simplify the process by providing a checklist for "editors" to use.

Extra tip

Here's an excellent opportunity to lead by example: why not having students practice by editing a sample of *your* writing first? Aside from the once-in-a-lifetime opportunity to correct their own teacher, it will demonstrate your willingness to accept constructive criticism even when it comes from people who are potentially less competent and authoritative than you. If you can accept their feedback, they can surely make an effort and accept each other's.

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6.4 Steering strategies

Let's begin with a general principle: less is more. A lower level of teacher-direction is one of the prerequisites of peer work, especially when done properly. It also means you have to commit less energy to achieve the same result. However, you do have goals to achieve and deadlines to meet. Therefore, your teams need to be functioning well. You can't dispense with the teacher's oversight, but you can employ more subtle tactics to make sure that you can reach the maximum result with the minimum effort.

Laozi, the Chinese philosopher, said "when there are no laws, people regulate themselves". Perhaps a bit too optimistic. We could probably rephrase it as "when everyone agrees on the rules, they are more likely to make an effort not to break them".

Having your students discuss and agree on a set of rules is a great first step. When you have to step in and enforce them, there are non-intrusive alternatives to simply giving directives.

The following paragraphs discuss a few of them. These are just examples. There are many others, and you can even invent your own. The basic principle is that your students need to know in advance what to expect and how to react.

Extra tip

Think of your classes as a game. What makes a game fun? The fact that you can't just do whatever you like. Your victory is valid only if you obtain it while following the rules. If you change the rules of the game mid-way, the game becomes meaningless. The same applies to managing your class. For any steering strategy to work, your students need to know what's coming *before* you do it. Make sure they all know what to expect, and your students will be much more willing to follow your lead.

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6.4.1 Mark the spot

Suppose you are running a peer-work session, or an activity that involves role-playing. It took some time to create the right atmosphere, and you don't want to spoil it by stepping in and saying "ok, stop!".

Before the activity starts

- designate a point in the room where you are clearly visible from everyone
- indicate a particular tile on the floor, or use tape to draw a square
- tell your students that whenever you step onto that spot, everybody must stop what they are doing and listen to you

6.4.2 Eye-face-head

Eye contact has the great advantage of not being audible, so everything remains between you and the other person. This is particularly useful to deal in a non-invasive way with people who don't like to be reprimanded publicly. For example, raising a brow or giving a particularly intense look is universally recognised as a warning sign.

6.4.3 Voice

The defining characteristic that sets the human species aside from all other living beings is our ability to speak, which is mediated by our voice. The human voice can perform a vast number of actions and convey a wide range of meanings, including being used for classroom management.

In a normal classroom, people will tend to align with the emotions you are manifesting. If you are trying to inspire excitement and anticipation, your voice

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tone must be reflective of this. In the same way, if you are aiming for a calmer atmosphere, your voice can't be agitated.

Speaking is perhaps the human activity in which "less is more" finds its best application. What you are saying, important as it is, takes time away from the activity. More precisely, it takes time away from the part of the lesson where students can exercise agency. You want your lessons to be as student-centred as possible, and a very simple way to achieve this is reducing Teacher Talking Time (TTT) while boosting Student Talking Time (STT).

Reducing Teacher Talking Time is simple, but it's not easy. It's an exercise in essentiality. Being able to communicate effectively in as few words as possible requires practice and expertise. It can't be improvised.

Here are two ways in which you can use your voice to get attention.

6.4.3.1 Countdown

Raise your arm and start the countdown in a loud, firm voice, following up with your fingers. A countdown is typically associated with something that is about to happen. Your students will get the clue, especially if you have told them in advance.

6.4.3.2 Whispering

It may seem counterintuitive, but if your class is being too loud, instead of trying to best them in a shouting match, try whispering. Make sure it is clearly visible you're not speaking loudly and you're not going to. If your class wants to hear what you have to say, they're going to have to listen to you.

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6.4.4 Gestures

From the point of view of the energy they require, gestures are more economical than raising your voice. However, to be effective they need to be agreed upon in advance.

For example, if you have something like a poster listing all the rules the class has agreed upon, and one of the students is breaking one, you can simply point at the rule while making eye contact, or saying the name of the student.

You can agree with your students on a sort of "master" gesture, and whenever you use it, everybody must stop what they are doing and listen to you. It could be something very simple, like lifting your arm with your index raised.

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6.5 Conclusions

In this second section of the W^3 Module, we have explored methods and techniques for working together.

Specifically, we have looked at Team Management, Peer Work, and Steering Strategies. We have discussed the values of rules as that through which a game becomes meaningful, the effectiveness of providing students with a practical model of what they are expected to do, and the importance of leading by example. We have also stressed the necessity to privilege Student Talking Time over Teacher Talking Time as a way to make lessons and activities more student-centred.

This is an area of teaching that provides endless opportunities for research and experimentation. There simply is no absolutely right or wrong answer. There are individuals, you and your students, with a chance to engage in interactions that are meaningful, constructive, and instructive. It works both ways, of course. An endless spirit of care and genuine curiosity is one of the best assets at your disposal to be the teacher your students need you to be.

Full STEAM forward!

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6.6 Test and Assignment

6.6.1 Test

Every good training session has a small test that goes with it. If you feel ready, you can access the test here.

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7 WEAVING STORIES (SINERGIE)

7.1 Getting started

In the third and final part of the **W³** module, *Weaving stories,* we are following the footsteps of the Greek aoidoi, the Celtic bards, the Viking skálds, and so on: we're exploring the world of storytelling.

This section is organised in seven areas:

macro-areas:

- themes
- characters
- setting
- plot
- conflict
- point of view
- style

It will give you a rough idea of the basic elements that make up a story. However, do keep in mind that there is no substitute for inspiration. The most essential thing in storytelling is having fun.

As always, this section is accompanied by a quick online Test to evaluate your knowledge.

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You should be able to complete *Weaving stories* in about one hour but, again, you can take as much time as you need.

Now, you're set. Full STEAM forward!

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7.2 Building blocks

Stories are human universals. They are found in every single culture that ever existed on Earth, regardless of how advanced or sophisticated. Tribes in the Amazon river as well as people living in megalopolis, we all tell each other stories. That testifies to their enduring importance. Modern bock-busters take hundreds of millions of dollars to produce, and they are essentially a story-telling machine. That's how important stories are to us.

One of the strongest points of stories is that they can be read at multiple levels who co-exist simultaneously. Children who watch the *Star Wars*' original trilogy would probably be attracted by fast-paced battles in space and the flashy lightsabers, while adults would be aware of the "theme" of redemption and the "conflict" between Good and Evil.

Theme and conflict are two of the basic elements that constitute a story. You think of a story as a narrative architecture: these elements are the building blocks you are going to use to create your structure.

Many scholars have studied stories and proposed analyses of their working mechanisms. You can find a list of Propp's 31 Functions in the next page, for your reference.

Speaking of building blocks, let's take a moment to talk about titles. Coming up with a good title is not easy. You want your title to be enticing and representative of your story, without giving away too much of it. Think about the impact of a title like *Heart of Darkness*. Conversely, would you read a book entitled *A Generic Story in which Many Things Happen, but in the End Good Triumphs*? Probably not.

Two things happen quite often in storytelling: a title comes to you and you have to find a story for the title, or you think up a story and you have to find a title for it. Take the time you need, and give your story the title it deserves.

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Propp's Functions

1. *Absentation*: a member of a family leaves the security of the home environment.
2. *Interdiction*: an interdiction is addressed to the hero.
3. *Violation* of interdiction: the interdiction is violated.
4. *Reconnaissance*: the villain makes an attempt at reconnaissance.
5. *Delivery*: the villain gains information about the victim.
6. *Trickery*: the villain attempts to deceive the victim to take possession of the victim or the victim's belongings.
7. *Complicity*: the victim unwittingly helps the enemy.
8. *Villainy or lack*: the villain causes harm or injury to a member of a family or something is lacking in the hero's life.
9. *Mediation*: misfortune or lack is made known; the hero is approached with a request or command; he is allowed to go or he is dispatched.
10. *Beginning counteraction*: the seeker agrees to, or decides upon counteraction.
11. *Departure*: the hero leaves home.
12. *First function of the donor*: the hero is tested, interrogated, attacked, etc., which prepares the way for his receiving either a magical agent or helper.
13. *Hero's reaction*: the hero reacts to the actions of the future donor.
14. *Receipt of a magical agent*: the hero acquires the use of a magical agent.
15. *Guidance*: the hero is transferred, delivered, or led to the whereabouts of an object of search.
16. *Struggle*: the hero and villain join in direct combat.
17. *Branding*: the hero is branded.
18. *Victory*: the villain is defeated.
19. *Liquidation*: the initial misfortune or lack is resolved.
20. *Return*: the hero returns.
21. *Pursuit*: the hero is pursued.
22. *Rescue*: the pursuit ends with rescue from pursuit.
23. *Unrecognized arrival*: the hero, unrecognized, arrives home or in another country.
24. *Unfounded claims*: a false hero presents unfounded claims.
25. *Difficult task*: a difficult task is proposed to the hero.
26. *Solution*: the task is resolved.
27. *Recognition*: the hero is recognized.
28. *Exposure*: the false hero or villain is exposed.
29. *Transfiguration*: the hero is given a new appearance.
30. *Punishment*: the villain is punished.
31. *Wedding*: the hero marries and ascends the throne.

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7.2.1 Themes

A theme is the "message" that you want your audience to understand. It can be an idea, a feeling, or a moral lesson. Another way to think about it is this: themes are what your story actually talks about when you remove all elements of fiction.

Broadly speaking, themes tend to be universal. Love, friendship, loss, sorrow are easily recognisable themes in many of the greatest stories ever told, from Dante's *Comedy* to *Harry Potter*. However, there are significant distinctions in the way different cultures understand these concepts, and the importance they assign to them in their hierarchy of values. For example, "freedom" and "harmony" would have approximately the same meaning in the U.S. and in Japan, but completely different values.

Because of their universal nature, themes tend to become a matter of subjective interpretation. With a bit of imagination, you can take a story that was designed to convey a certain meaning and "read" a different theme, or themes, into it. The same thing can happen to your story when someone else reads it, so here's a piece of advice: make sure your intended theme is as clear as possible.

Example

You have probably watched the film Titanic, or at least heard about it. What are the themes of the film? Love is one, certainly. Sacrifice is another one (spoiler alert). There's also a fair bit of social critique, so Equality would be another. Let's get creative, shall we? The main character travels third class, but fits in with first class guests as soon as he wears a dinner jacket, so the Power of Appearances is a theme. The passengers of the Titanic ultimately meet their fate because the ship lacks enough lifeboats, so Safety Regulations is another one. If you have time and imagination, you can carry on for as long as you want. However, not all themes have an equal value or are equally important. If someone asked you "what's Titanic main theme", what would you say: Love, or Safety Regulations?

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7.2.2 Characters

Characters are the life force of your story. They drive the plot forward through their actions and interactions with one another. Well-crafted characters make your story more relatable and help readers connect with it.

Proper characters have strengths and weaknesses, and they tend to act in a way that is consistent with their character type. To give you an extreme example: the hero of the story doesn't suddenly turn into a villain. Can you imagine Harry Potter becoming a deatheater? He wouldn't be Harry Potter anymore.

Just like themes, there is no single categorization of characters, but many. Here is a possible list[2]:

The Lover

A romantic person who is guided by the heart, passionate but naïve. For example, Romeo and Juliet.

The Hero / heroine

The person who, willingly or unwillingly, confronts and overcomes evil. The hero is typically brave and determined, but also overconfident. For example, Achilles or Jane Eyre.

The Magician

The magician has mastered magic, or power, and uses it to achieve his or her goals, which aren't necessarily good. For example, Gandalf or The Queen of the Night.

[2] All descriptions apply to female characters too. No discrimination intended or implied.

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The Outlaw

The outlaw is someone who refuses to live according to the expectations of society. He is independent, but also potentially close to being a criminal. For example, Batman.

The Explorer

The explorer is naturally inclined to explore and look for adventure. He is driven by his own curiosity and desire to improve, but he's also restless and often dissatisfied. For example, Odysseus.

The Sage

The sage possesses knowledge and experience that others seek, but often hesitates or is unable to take action. For example, the Oracle (Matrix).

The Innocent

The innocent is defined by his moral purity. His intentions are good and benign, but he's usually unskilled, naïve, and vulnerable.

The Creator

The creator strives to achieve what has never been done before. He is characterised by creativity and willpower, but he is also single-minded and self-absorbed. For example, dr. Emmett Brown or dr. Victor Frankenstein.

The Ruler

The ruler has legal or emotional power over others, but he is also out of touch and disliked by other characters. For example, King Lear or Agamemnon.

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The Caregiver

The caregiver supports others and makes sacrifices for them. Honourable, selfless and loyal, he also tends to lack personal ambition. For example, Mary Poppins.

The Everyman/woman

The everyman, or everywoman, is a character that anybody can relate too precisely because it has no super-human traits. He's just like us. As such, the everyman is usually unprepared for the adventure he is about to take part in.

For example: Bilbo Baggins.

The Jester

The Jester is a contradictory character. By acting strange or funny, he provides comic relief. At the same time, he also provides unexpected insights and speaks the truth.

For example, R2D2 and C-3PO from Star Wars.

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7.2.3 Setting

The setting is the place and time of your story. If you will, it's that which allows your story to exist. Think about how almost every single traditional tale or fable starts with the words "once upon a time…". As soon as you hear the words, your mind gets ready for a story that is set in *a* past. It can be real or fictional. The same thing goes for place: it can be a real location, or a land of fantasy.

Thinking about time and place will strengthen your story and make your characters more believable, so don't overlook it.

Example

Establishing a setting for your story doesn't necessarily require many words. Think about the brilliance of the screenwriters that came up with the opening sequence of Star Wars: "a long time ago, in a galaxy far, far away…". In a single sentence they have established time and place.

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7.2.4 Plot

In the simplest possible words, it's the sequence of events that make up your story. It's what happens to your characters and what they do in response to it.

The basic pattern of a plot has five elements:

Exposition : the part of the story where you introduce your characters and the setting.

Rising action : this is where your characters become involved in a conflict or a problem.

Climax : the turning point of the story, where the climax reaches its peak

Falling action: the consequences of the climax are revealed and the conflict begins to resolve

Resolution: the conclusion of the story

Example

Let's take a look at The *Three Little Pigs*.

Exposition: The story begins with the three little pigs leaving their mother's home to build their own houses. The first pig builds a house of straw, the second pig builds a house of sticks, and the third pig builds a house of bricks.

Rising Action: The rising action occurs when the big bad wolf comes to each pig's house and tries to blow it down. He successfully blows down the houses of straw and sticks, but he is unable to blow down the house of bricks.

Climax: The climax of the story occurs when the wolf tries to enter the brick house through the chimney. The three little pigs have placed a cauldron full of hot water under the chimney, and when the wolf lands on it, he gets burned.

Falling Action: In the falling action phase of the story, all loose ends are tied up. In one version of the story, for example, the three little pigs roll the wolf into the river.

Resolution: The resolution of the story occurs when the conflict is resolved. In this case, it is when the wolf is defeated and the three little pigs are safe in their brick

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There are more elaborate versions or the plot structure, like Joseph Campbell's Monomyth (check the next page for the full list), but the basic mechanism is the same: the protagonist must go through difficulties for which he or she is not ready, and become better than himself or herself.

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Example

The Monomyth

The Call to Adventure: The hero is called to leave their ordinary world and embark on a journey.

Refusal of the Call: The hero may initially refuse the call to adventure due to fear or uncertainty.

Supernatural Aid: The hero receives help from a supernatural or mystical guide or mentor.

The Crossing of the First Threshold: The hero crosses the threshold into the unknown or unfamiliar realm.

The Belly of the Whale: The hero faces their first major challenge and must overcome their fear to continue on their journey.

The Road of Trials: The hero faces a series of challenges and obstacles that test their strength and resolve.

The Meeting with the Goddess: The hero experiences a love that has the power to transform them.

Woman as Temptress: The hero is tempted to abandon their quest by a woman or other temptation.

Atonement with the Father: The hero must confront and reconcile with their father or father figure.

Apotheosis: The hero achieves a state of divine knowledge or enlightenment.

The Ultimate Boon: The hero achieves their goal and receives a reward for their efforts.

Refusal of the Return: The hero may initially refuse to return to their ordinary world with their newfound knowledge or power.

The Magic Flight: The hero must escape from those who would take their reward from them.

Rescue from Without: The hero may need help from others to return to their ordinary world.

The Crossing of the Return Threshold: The hero must cross the threshold back into their ordinary world and integrate their new knowledge or power into their life.

Master of Two Worlds: The hero achieves mastery over both their inner and outer worlds.

Freedom to Live: The hero is free to live in the present moment without fear of death.

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7.2.5 Conflict

Generally speaking, conflict in a story is any moment where the protagonist wants something, but someone or something is standing in their way. It can be another character who wants the same thing, or the very opposite thing. The typical conflict is Good vs Evil, but there can be many nuances and different scales too.

Conflict is a crucial element in storytelling because it contributes to making stories interesting. There are two families of conflicts, "external" and "internal", and six types:

Human vs. human

An external conflict in which two people are pitted against each other. Reasons typically include love, power, or revenge. For example, think about King Arthur and Mordred, Robin Hood and the Sheriff of Nottingham, or Sherlock Holmes and Moriarty.

Human vs. Nature

In this type of external conflict, humans confront a manifestation of Nature's power. A great example is Ernest Hemingway's *The Old Man and the Sea*, in which the protagonist contends against a marlin.

Human vs. Self

Human vs. Self is an example of internal conflict: the protagonist faces his own weakness or wickedness, so he undergoes an inner struggle, not an external one. For example, in the 2016 film *La La Land*, Mia struggles with self-doubt and the fear of failure as she goes to countless auditions and faces rejection, while Sebastian, is torn between his passion for traditional jazz and the need to make a living.

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Human vs. Society

This is an external conflict in which the protagonist is at odds with the norms, values and expectations of society. For example, think about Katniss from the *Hunger Games* series and her struggle to take down the authoritarian government that oppresses the nation of Panem.

Human vs. Supernatural

Human vs. Supernatural is a type of conflict in which the protagonist works against supernatural forces, who typically posses abilities or powers far greater than the protagonist's. It's very common in genres like horror and science fiction. For example, in Bram Stoker's *Dracula*, the antagonist is an immortal vampire with the ability to shapeshift, alter the weather, and control certain animals.

Human vs. Technology

In human vs. technology, the protagonist is faced with a problem involving a man-made invention. This type of conflict is mostly found in science-fiction. For example, in the 1984 film *The Terminator*, humans fight against a cyborg assassin to prevent it from killing an important character for humanity's future.

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7.2.6 Point of View

Point of view (POV) is the narrative perspective from which a story is told and the readers experience the plot, observe the characters' behaviour, learn about their world.

Here are the three main types of point of view in fiction. You can think of them as videos shot from an increasingly greater distance.

First person

Possibly the simplest of the three, it's how we tell stories in everyday life. First person can create intimacy between the readers and the characters by giving them direct access to their emotions, psyches and inner thoughts. An example is *Smilla's Sense for Snow* by Peter Høeg.

Third person limited

This is when the narrator only knows the thoughts and feelings of one character, typically the protagonist, and closely follows him or her throughout the story. An example of third person limited in narrative is the *Harry Potter* series by J.K. Rowling.

Third person omniscient

In this point of view, the narrator knows all the thoughts, actions, and feelings of all characters. The author may move from character to character to show how each one contributes to the plot. Third Person Omniscient: *War and Peace* by Leo Tolstoy.

Extra tip

Choose the point of view of your story based on the effect you want to achieve. First person works well if you want to engage your audience as if they were the protagonist themselves. Third person limited is less focussed, but offers a greater amount of detail. Third person omniscient is even less focussed, but gives the audience access to everything that happens outside and inside the characters.

If you want to sound super-preposterous and self-important, try following Julius Caesar's example and speak of yourself in the third person!

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7.2.7 Style

Style refers to the way in which the story is written, including the tone, voice, and language used by the author. You can think of it as the tuning of an orchestra: style is what ensures that all the elements of your story "sound" well together.

As with most things related to art and creativity, there are general guidelines about style, but absolute rules. However, a good rule-of-thumb (which you remember from Section 1…right?) is weighing your choices against your audience.

Think about the way Quentin Tarantino uses violence, profanity and black humour, or Guy Ritchie's habit of super-rapid editing. Would those style be suitable for content aimed at children, or elderly people? Definitely not.

In the end, what fits or doesn't fit into your narrative often comes down to your personal taste, the message you want to communicate, and the audience you are addressing. Within the limit of artistic creativity, make sure you don't undercut your effort by constructing your message in a way that your audience would not accept.

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7.3 Creative writing exercises

Practice makes perfection. The more you practise, the more your writing skills will improve. Here are a few ideas for you to try out:

- *Deafening sound*: think of the most deafening sound you can imagine. Describe the sound in detail, including how it makes you feel and what it reminds you of.
- *Cooking on a third date*: have a man cooking for a woman on a third date, and have her describe the aromas in such loving and extended detail that she realises that she's in love with him.
- *Pick a line from a song*: pick a line from one of your favourite songs, and identify the main emotion. Write a short story or poem based on that emotion.
- *Start with a colour*: pick any colour you like. Now start your sentence with this colour. For example, "Orange, the colour of my favourite t-shirt".
- *Random word*: open a book or dictionary on a random page. Pick a random word by closing your eyes and slowly moving your finger across the page. Now, write a paragraph with this random word in it.
- *Alphabet picture book*: create your own alphabet picture book or list. It can be A to Z of animals, food, monsters or anything else you like
- *Describe using smell*: using only the sense of smell, describe where you are right now.

Extra tips

Writing is a holistic activity. When writing, you connect your feelings and emotions and organise them through your logical mind by way of physical movement, particularly if you are writing by hand instead of typing on a keyboard. As a consequence, you calligraphy says a lot about you. Encourage your students to use handwriting for the more creative stages of their writing process. They'll see the difference.

Here's another tip: writing has the strange property mirroring your efforts. You get as good as you give. If you really make an effort, your writing will be good.

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7.4 Writer's block

This is something every person who has ever tried to write has experienced at least once. You're sitting there, pen in hand, with a sheet of white paper staring right at you, and you're thinking: "now, *what?*".

There are many potential reasons for the writer's block, but no real scientific explanation. So, what can you do if it happens to you, or your students?

With a little research you will find many ideas about ways to overcome the writer's block. They can be summed up in two broad categories: charge it head on, or leave it be.

Charge it head on is exactly what it sounds like: you keep writing. Even if you're not convinced, even if it feels like you have nothing to say. You just keep writing until you are done. Alternatively, you keep writing, but you change the topic, or the chair you are sitting on, or the pen you are using. A small variation can kick-start your inspiration.

Leave it be is the very opposite. You stop whatever it is you are doing, and you do something else, particularly if it involves physical movement. Disengaging and taking the time to recharge your mind and your feelings is likely to help you recuperate the focus you need to finish what you've started.

Extra tips

Your students probably won't be able to just stand up and go for a walk if they have run out of inspiration. When you are designing your activity, make sure that you plan for contingency and include options for what to do if your students get stuck with their writing. You can find some suggestions in Section 2 – *Working together*.

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7.5 Conclusions

This is the end of the W^3 module. In this last part, we have discussed the mail building blocks of storytelling and a few ways to address the writer's block. Just like any other form of art, writing isn't easy but it's well-worth your time, especially if you do it regularly. There is simply no better way to become a more articulate and more effective communicator than training yourself to write well.

Natural talent is a factor, but talent isn't as important to writing as practice is. It's crucial that your student understand this: honing your writing skills is like polishing a gem. The beauty is right there from the very beginning, but you must be willing to pay the price in patience and effort.

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7.6 Test and Assignment

7.6.1 Test

Every good training session has a small test that goes with it. If you feel ready, you can access the test here.

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8 CWL STRUCTURE (SINERGIE)

7.1 Getting started

CREAM's CWLs are about combining the study of STEM subjects with creative writing.

You need 6 things to build you CWL:

1) an original idea
2) a problem to solve via a STEM subject
3) an activity organised around solving the problem
4) a story, to embed your activity into a narrative
5) a narration, to make the activity, the story and the solution visible
6) a conclusion, to show everybody what your students have achieved.

The idea is what you would like your students to do with the CWL.

The STEM subject you choose to include should match your idea, and be the basis for the practical activity, or activities. You plan your activities thinking about:

- the task your students need to perform
- the space they need
- the time allotted
- the materials they can use

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- the external actors you'll need to involve
- the way you are going to evaluate the activity
- the schedule, which is:
    - when and how you launch the activity
    - how the main activity is going to unfold logistically
    - how you are going to close the activity (party, event…)
    - when and how are you collecting feedback from students, teachers and parents.

The task links directly to the problem the students need to solve. By finding a solution, they will also solve the conflict within the story.

The story should match the idea and the STEM subject. When you think about your story, you need to devise:

- a plot, in which your students take part
- characters your students can relate to
- a setting, to make the story believable
- a conflict in the story. The conflict is particularly important because it links directly to the Task of the practical activity: it's the problem your students need to solve.
- a resolution: this can be decided beforehand or you can give your students the option to invent one on their own, based on the activity they perform.

The Problem is where the Task and the Conflict meet. The solution your students will find is simultaneously the result of their task and the key to solving the conflict in the story. You can set up the problem in many ways, including:

- students need to choose between two or more options
- students have to invent, or discover, an original solution
- students have to overcome one or more challenges

Once they completed their task and have taken the story to a successful closure, your students need to make what they have done visible.

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They need to do so by going through the same steps you went through in planning the CWL: decide on a medium, write a script, produce the content.

The final step is releasing the students' output. It’s the coronation of all their efforts, so make sure to make a big deal about it.

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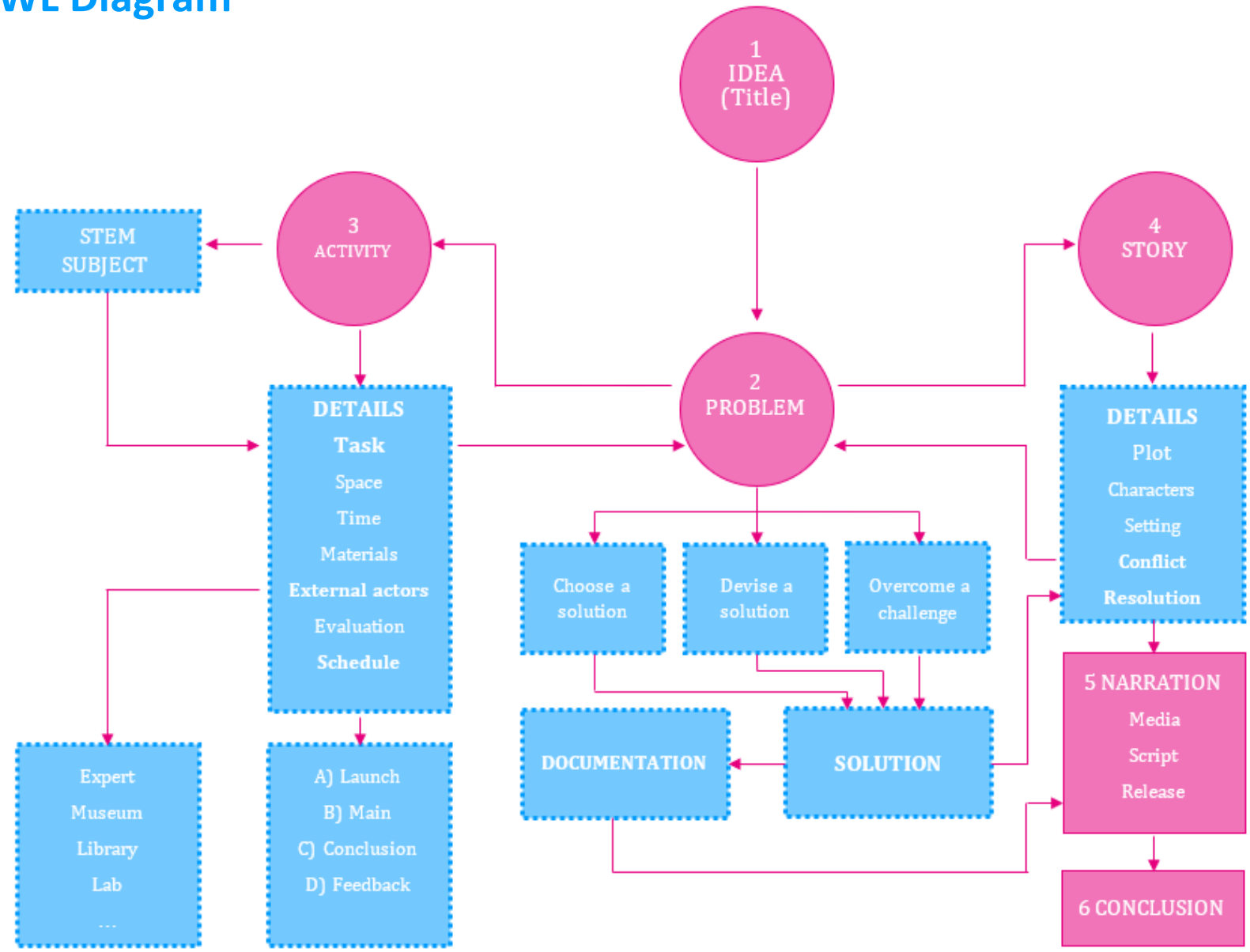
8.2 CWL Diagram



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8.3 CWL Checklist

8.3.1 Template

You can use this checklist to plan your CWL. Take a look at the guiding questions in the template, and work your idea until you are satisfied.

Make sure you check all the boxes and do take the time to plan everything very carefully. The more accurate your planning, the easier it will be to adapt and react to the unexpected.

Element	Detail	Descriptor	Done
1 Idea			
Title		the title of your CWL	
2 Problem			
Subject 1		What kind of problem is it	
Subject 2		What STEM subject(s) do your students need to solve it?	
Subject 3		How does it fit into the narrative of your story?	
3 Activity			
Task		what your students have to do or perform to find a solution to the Problem (connects to Conflict in "Story")	
Place		where the activity takes place	
Time		what time and for how long the activity lasts	

Materials		what your students can or must use to perform the task	
External Actors		whose help they need to perform the task	
Evaluation		how you are going to grade your students' performance	
Schedule	Launch	how you are launching the CWL (communication to families, school event, other...)	
	Main activity	start and end date	
	Closing	how you are going to close the activity (connects to Narration)	
	Feedback	how you are collecting feedback from all the involved parties	
4 Story			
Plot		what happens in the story	
Characters		the protagonists and antagonists of the story	
Setting		where and when the story takes place	
Conflict		the problem your students help the protagonists solve (connects to Task in "Activity")	
Resolution		what happens if the problem is solved	
5 Narration			
Media		students select a medium to tell their story	
Script		students work on the script / storyboard	
Output production		students produce the output	
Release		how you are showing the students' output (party, school event, online event...)	
6 Conclusion			
Closing		how you are going to close the activity (connects to Narration)	

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8.3.2 Blank

It's your turn now. Let's get to work!

Element	Detail	Descriptor	Done
1 Idea			
Title			
2 Problem			
Subject 1			
Subject 2			
Subject 3			
3 Activity			
Task			
Place			
Time			
Materials			
External Actors			
Evaluation			

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Schedule			
4 Story			
Plot			
Characters			
Setting			
Conflict			
Resolution			
5 Narration			
Media			
Script			
Output production			
Release			
6 Conclusion			
Closing			

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8.4 The end

Congratulations! You've made it to the end of this training module, and now you have everything you need to start planning a fantastic CWL.

We thank you for your effort, and we're looking forward to hearing about your feedback and about your success stories.

Full STEAM forward!

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Digital tools and resources

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9 INTERNET TOOLS (WUT)

9.1 Introduction

Nowadays, the Internet offers teachers a lot of education materials, aids, guidelines and suggestions on how to teach creatively and keep the student's attention. You can find literally tons of websites and apps dedicated exclusively to education. The educational content available in the Internet, often provided under open licences, is usually an outcome of various national and international public funded projects, a free part of services offered by for profit organisations, and finally contributions of individual educators who share their work or completely free of charge or making money in the YouTube, Google and other content provider advertisement models.

Being primarily an education program, Erasmus+ has produced and tested a lot of original teaching ideas and ready to used learning content which could be found on the Erasmus+ project results platform (https://erasmus-plus.ec.europa.eu/projects) and on individual project webpages and social media project profiles. In addition to the content, the projects usually provide methodological guidelines, seminars and training sessions for teachers.

Some initiatives, starting even from a modest initial public or private investment, managed to develop a rich teacher support service environment, build a large teacher and educator community and implement a sustainable business model, which keeps the initiative alive for many years. Scientix project (https://www.scientix.eu/) is an example of such successful initiatives.

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In this document, we present just a few tools, portals, projects or concepts which earned significant interest from the educational community and became and stay widely popular over the last few years. We believe using external educational content certainly makes lessons more attractive and gives teachers new opportunities. The solutions we present are freeware or are available on free licences.

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9.2 Classic Computer Science Unplugged

https://classic.csunplugged.org/activities/community-activities/

Ready-made scenarios and exercises in programming and coding. Useful if you don't know how to conduct a Computer Science and coding lesson.

Each Unplugged activity is available to download in PDF format, with full instructions and worksheets. Background sections explain the significance of each activity to computer science, and answers are provided for all problems. All you need for most of these activities are curiosity and enthusiasm. There are photos and videos showing some of the activities in action, and we've collected links to other useful resources.

The activities are primarily aimed at the five to twelve-year-old age group, but they are by no means restricted to this age range: we've used them to teach older children and adults too, with little modification.

The materials are divided into sections:

Data: Representing Information (Binary Numbers, Image Representation, Text Compression, Error Detection, Information Theory, Modems Unplugged, Databases)

Algorithms: Putting Computers to Work (Searching Algorithms, Sorting Algorithms, Sorting Networks, Minimal Spanning Trees, Routing and Deadlock, Network Protocols, Phylogenetics, Divide and Conquer, Line Drawing)

Procedures: Telling Computers What to Do (Finite State Automata, Programming Languages, Programming Languages - Harold the Robot, Class Simulation of a Computer)

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Intractability: Really Hard Problems (Graph Colouring, Dominating Sets, Steiner Trees)

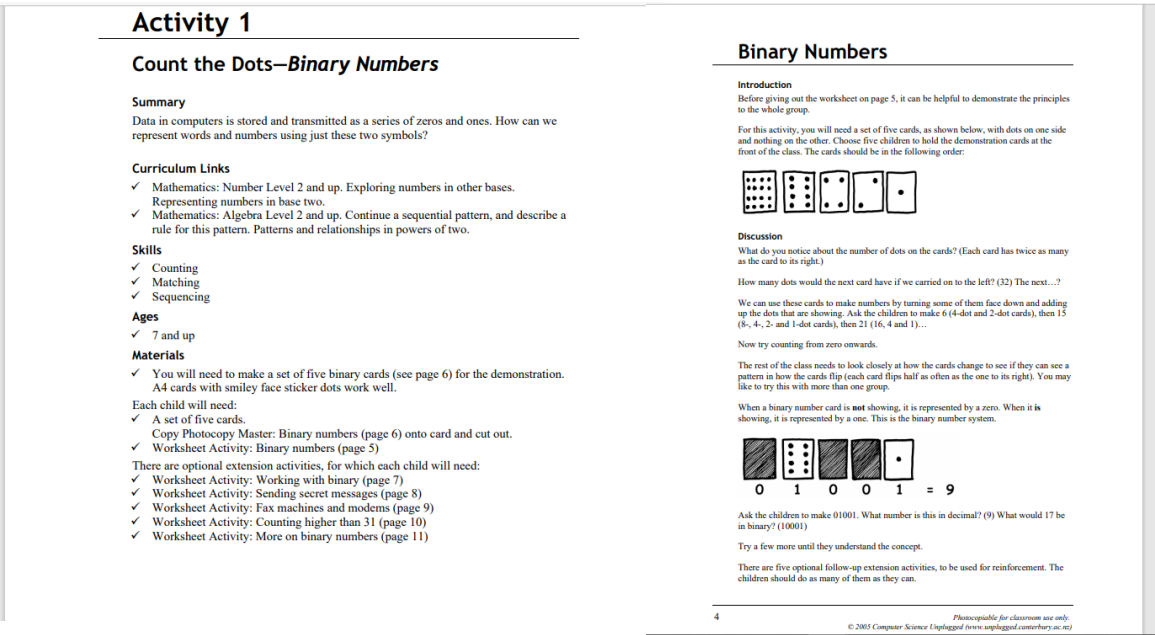
Cryptography: Sharing Secrets (Information Hiding, Cryptographic Protocols, Public Key Encryption)

The Human Face of Computing: Interacting with Computers (Human Interface Design, The Turing Test, Artificial Intelligence)

Community Activities (The Defrag Game, Artificial Intelligence, Class Simulation of a Computer, Databases, Divide and Conquer, Harold the Robot, Line Drawing, Modems Unplugged, Phylogenetics, Scout Patrol (Encryption)

Each topic includes a ready lesson plan in pdf format

Scenarios are available in many language versions, e.g. Polish, Greek, Slovenian



Activity 1

Count the Dots—*Binary Numbers*

Summary

Data in computers is stored and transmitted as a series of zeros and ones. How can we represent words and numbers using just these two symbols?

Curriculum Links

- ✓ Mathematics: Number Level 2 and up. Exploring numbers in other bases. Representing numbers in base two.
- ✓ Mathematics: Algebra Level 2 and up. Continue a sequential pattern, and describe a rule for this pattern. Patterns and relationships in powers of two.

Skills

- ✓ Counting
- ✓ Matching
- ✓ Sequencing

Ages

- ✓ 7 and up

Materials

- ✓ You will need to make a set of five binary cards (see page 6) for the demonstration. A4 cards with smiley face sticker dots work well.

Each child will need:

- ✓ A set of five cards. Copy Photocopy Master: Binary numbers (page 6) onto card and cut out.
- ✓ Worksheet Activity: Binary numbers (page 5)

There are optional extension activities, for which each child will need:

- ✓ Worksheet Activity: Working with binary (page 7)
- ✓ Worksheet Activity: Sending secret messages (page 8)
- ✓ Worksheet Activity: Fax machines and modems (page 9)
- ✓ Worksheet Activity: Counting higher than 31 (page 10)
- ✓ Worksheet Activity: More on binary numbers (page 11)

Binary Numbers

Introduction

Before giving out the worksheet on page 5, it can be helpful to demonstrate the principles to the whole group.

For this activity, you will need a set of five cards, as shown below, with dots on one side and nothing on the other. Choose five children to hold the demonstration cards at the front of the class. The cards should be in the following order:

Discussion

What do you notice about the number of dots on the cards? (Each card has twice as many as the card to its right.)

How many dots would the next card have if we carried on to the left? (32) The next…?

We can use these cards to make numbers by turning some of them face down and adding up the dots that are showing. Ask the children to make 6 (4-dot and 2-dot cards), then 15 (8-, 4-, 2- and 1-dot cards), then 21 (16, 4 and 1)…

Now try counting from zero onwards.

The rest of the class needs to look closely at how the cards change to see if they can see a pattern in how the cards flip (each card flips half as often as the one to its right). You may like to try this with more than one group.

When a binary number card is **not** showing, it is represented by a zero. When it **is** showing, it is represented by a one. This is the binary number system.

0 1 0 0 1 = 9

Ask the children to make 01001. What number is this in decimal? (9) What would 17 be in binary? (10001)

Try a few more until they understand the concept.

There are five optional follow-up extension activities, to be used for reinforcement. The children should do as many of them as they can.

4

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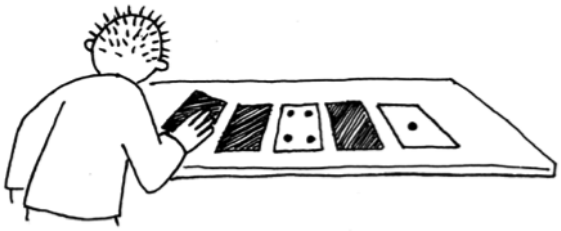
The pdf materials are enriched with videos and additional materials

Classic Computer Science Unplugged

Search

- The Book
- Activities
  - Binary Numbers
  - Image Representation
  - Text Compression
  - Error Detection
  - Information Theory
  - Searching Algorithms
  - Sorting Algorithms
  - Sorting Networks
  - Minimal Spanning Trees
  - Routing and Deadlock
  - Network Protocols
  - Finite State Automata
  - Programming Languages
  - Graph Colouring
  - Dominating Sets
  - Steiner Trees
  - Information Hiding
  - Cryptographic Protocols
  - Public Key Encryption
  - Human Interface Design



Activity description (PDF)

- Instructions for Binary Numbers activity (English)

Translations and other versions:

- Arabic language version
- Bahasa Indonesia Version
- Bosnia and Herzegovina Version
- Chinese Version
- French language version
- German language version
- Greek language version
- Hungarian language version
- Indonesian language version
- Italian language version
- Persian (Farsi) language version
- Polish language version
- Portuguese (Brazil) language version
- Russian language version
- Slovenian Language Translation
- Turkish language version

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9.3 PhET: Free online simulations

PhET: Free online physics, chemistry, biology, earth science and math simulations (colorado.edu)

Interactive simulations for science and maths

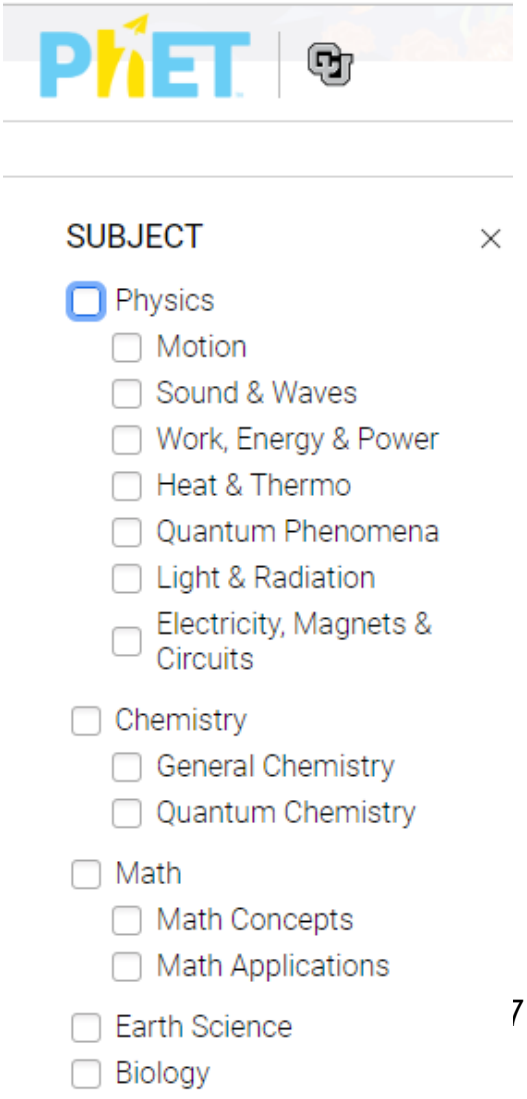
Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.

164 interactive simulations

120 language translations

3328 teacher-submitted lessons

Simulations are divided into sections:



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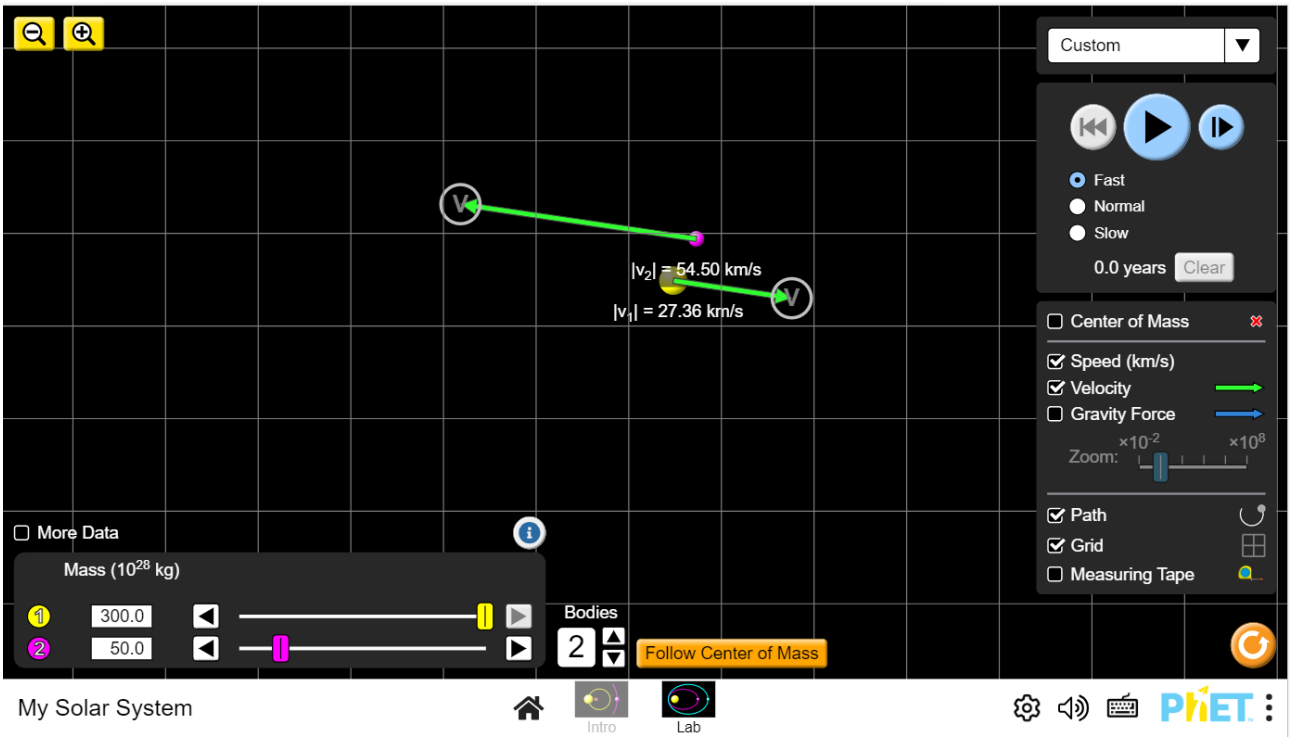
The site allows the teacher or students to perform interactive experiments on their own.

Each topic simulation is associated with Teaching Resources (some theoretical information explaining a given simulation and tips for teachers on how to present the subject) and Activities, a list of documents created and shared by the education community. Although the Phet project ended almost 10 years ago, new activity ideas are still being uploaded, which confirms the long-lasting teachers' and students' interest in this learning resource.

Active simulation, as the form of learning materials promotes students self-learning and experimental skills. Very useful in school during lessons.



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9.4 GeoGebra

https://www.geogebra.org/classic

GeoGebra is an interactive cloud service application. It combines geometry, algebra, spreadsheets, graphs, statistics. GeoGebra is available on multiple platforms, with apps for desktops (Windows, macOS and Linux), tablets (Android, iPad and Windows) and web.

GeoGebra is intended for learning and teaching science, technology, engineering, and mathematics from primary school up to the university level.

Teachers and students can use GeoGebra as an aid in formulating and proving geometric conjectures, but also GeoGebra provides tools to develop quizzes, simulation, design and visualise shapes and their evolution depending on their parameters.

Useful in Maths lessons.

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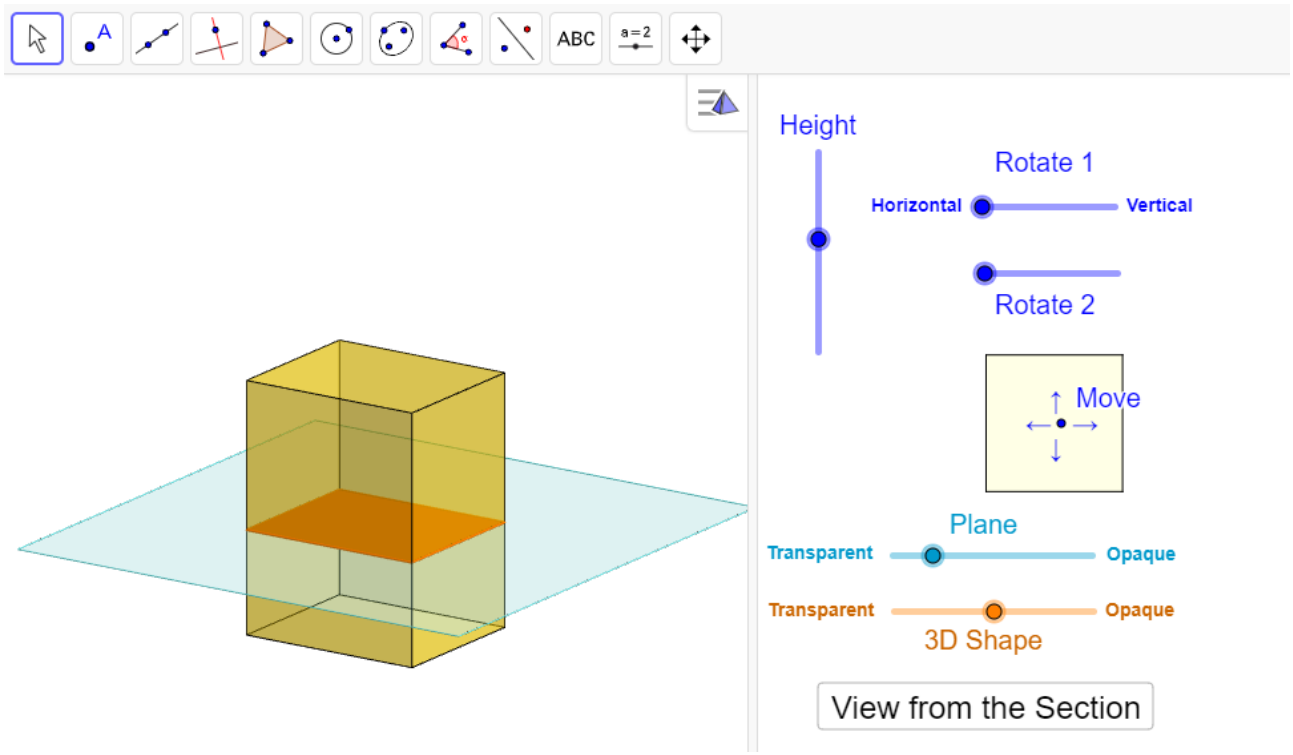
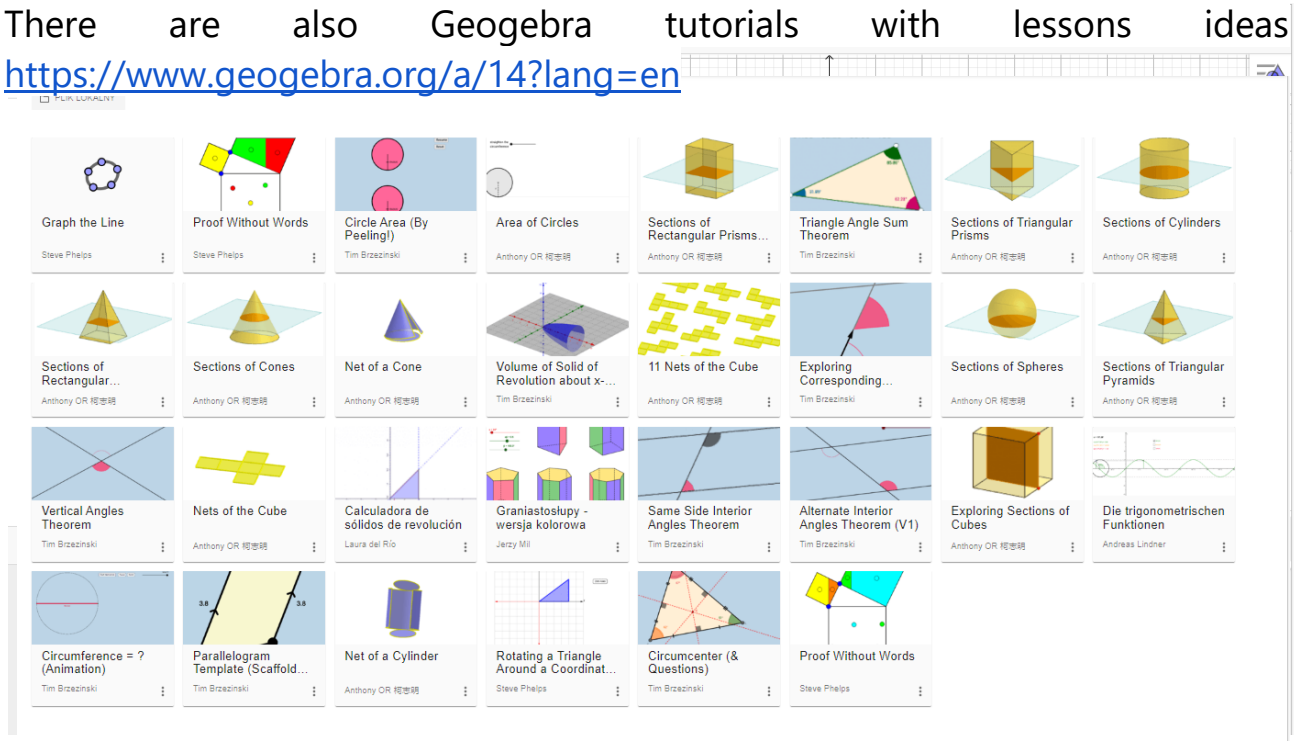


A ready database of examples and community created resources make work easier https://www.geogebra.org/

There are also Geogebra tutorials with lessons ideas https://www.geogebra.org/a/14?lang=en



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9.5 Tiny Theatres

https://www.exploratorium.edu/tinkering/projects/tiny-theaters

Tiny Theatres is a continuation of the tinkering activity Paper Circuits.

Paper Circuits is an idea of creating simple electric circuits from: copper type, gumdrop LEDs and coin cell batteries. The circuits are mounted on a flat surface like a piece of paper. The students, usually under 12 years old, design the circuits and join the elements. The more advanced version of the Paper Circuits concept is to connect sensors and processors and thus enlarge the circuit's capabilities.

Tiny Theatres builds upon the Paper Circuits leading concept, but also allows experimentation with light and shadows, which develops the student's creativity, imagination and hand-on skills.

The idea is to tell stories inside cardboard boxes using craft materials and light. Turn on and off LEDs using a homemade switch and a circuit made with copper tape.

The Tiny Theatres projects are at large more complex and often are carried out in groups, so the students have occasions to discuss their ideas, plan who does what and assess the final effect.

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Materials

Consider the materials you have on hand in your space and how they can be leveraged into constructing a tiny world inside a box. Many great substitutions exist, so don't shy away from trying things wonderful and wacky!

☐ **A cardboard box**: A shoebox is a great fit for this activity, but also consider food packaging boxes, delivery boxes, and more.

☐ **Light source(s)**: Paper circuits are a great way to illuminate a scene, but consider other light sources like a flashlight or the sun.

☐ **Paper and adhesives**: Keep general craft supplies nearby like colorful cardstock, scrap cardboard, markers, masking tape, hot glue guns, and utility knives (with adult supervision).

Getting Started

Brainstorm a Narrative

What story do you want to tell? One strategy is to pick a simple cause and effect, like a traffic light turning green makes the car move. The next step then is to connect that action to lights and movement.

Sketch Your Circuit

Decide where the circuit will live on your box and where you want to place your LED. Consider your battery placement somewhere near the edge of the box so that a binder clip can hold it in place.

Build a Box

With all of your components ready, start assembling your box. Choose whether you'd like to cut an opening in your cardboard box or use an existing opening. If you're looking to add complexity, consider adding another light to your scene.

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9.6 films4edu

(Polski) Movies - Faculty of Science and Technology | University of Silesia in Katowice (us.edu.pl)

It is an Erasmus+ project, an example of many Open Educational Resources which provide high-quality distance learning STEM content primarily in the form of short subtitled YouTube, voice-less videos, so the materials could be easily used by teachers and students. The project focuses on two science disciplines: Physics and Chemistry and presents 10 selected topics for each discipline which could be visualised in a form of experiments.

In addition, the experiments are complemented by the structured instructions for teachers drafted in 5 languages (English, German, Spanish, Polish and Slovak). The experiments are chosen to illustrate phenomena commonly met in real life. Performing these experiments (both in a teacher supervised, or not supervised mode) contributes to developing a bunch of 21-century competencies including: independent thinking, ability to self-learn and formulate conclusions, algorithmic thinking and learning experimental methods commonly used in science, technology, engineering and mathematics.

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About the project

About the project
News
Movies
Youtube
Contact us

The project is aimed at developing and disseminating high-quality distance learning in STEM education, as well as strengthening the basic and transversal skills defined in the European Key Competences Framework in the learning process. The key competences in the basic and transversal dimensions include scientific and technical competences, the ability to learn and algorithmic thinking. As indicated in the European Commission study "Supporting the development of key competences: Learning approaches and environments in school education (November 2019)", learning in a real-life scenario and scientific experiment methods used in science, technology, engineering and mathematics (STEM) can favour the development of a number of competences. For this reason, increasing students' motivation to study science, technology, engineering and mathematics (STEM) and improving achievement in these areas are important challenges facing European education systems. At the same time, schools in Europe face a new and unprecedented challenge: replacing traditional, mostly frontal learning with distance learning. These are completely different organizational models of the school, different pedagogical methods, different applications of digital technologies in teaching.

The project is targeted at 2 groups: primary and secondary school STEM teachers and primary and secondary school students

Chemistry

- ANALYTICAL CHEMISTRY
- BIOCHEMISTRY
- CHEMICAL REACTIONS
- INORGANIC CHEMISTRY
- ORGANIC CHEMISTRY
- OSMOTIC EQUILIBRIUM
- PHYSICAL MAGNITUDES (PRESSURE)
- PROPERTIES OF FLUIDS
- REDOX REACTIONS
- SEPARATION OPERATIONS
- SOLUBILITY EQUILIBRIUM

Physics

- ACOUSTICS
- AIR PRESSURE
- ELECTROMAGNETISM
- ELECTROSTATICS
- FLUIDS
- MECHANICS
- NUCLEAR PHYSICS
- OPTICS
- THERMAL PROPERTES OF MATTER
- WAVE PROPERTIES OF SOUND

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The films are accompanied by scripts in English, German, Polish, Slovak and Spanish. The videos themselves are recorded without any commentary, so they can be used by teachers in any country.

The films can be used for two purposes: to show the pupils during lessons and discuss them afterwards, and as inspiration for teachers who would like to construct their own experiments to show to pupils. Some of the experiments require professional equipment, but others have been carried out using freely available materials.

Determination of the acidity of vinegar

Scenario: English (200.33 kB), German (202.75 kB), Polish (213.37 kB), Slovak (202.47 kB), Spanish (193.69 kB).
University of Malaga (Universidad de Málaga):
Scenario: M. Olga Guerrero Pérez;
Actor: M. Olga Guerrero Pérez;
Camera and film editor: José M. Alonso Calero.

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9.7 Scratch

Scratch - Educators (mit.edu)

Launched in May of 2007 as a downloadable desktop application, Scratch is still an attractive idea on how to start teaching children the basics of computer programming. Developed at MIT in the team led by Professor of Learning Research Mitch Resnick, Scratch in an incredibly simple and intuitive way shows that even young primary school children may easily learn the basics of programming. Instead of somehow abstract line of code, Scratch introduces a few classes of graphical shapes which could form a block only if their shapes match. In this way Scratch deals with a challenge how to introduce the notion of programming language syntax to young people.

However, the ultimate objective of the project is rather not to learn how to code, but to learn how to express yourself, create new ideas and present them in a structured, algorithmic way. As prof. Reswick told Scratch “learn to code and code to learn”.

Programming skills and more generally algorithmic thinking is regarded as one of the most important 21st century competencies, widely promoted by former US president Barack Obama in the second decade of the 21 century (he proposed that all children learn Java Script language).

Scratch offers for teachers, students (aged under 12) and a rich graphical programming environment to code their own interactive stories, animations and games. In the process, children learn to think creatively, reason

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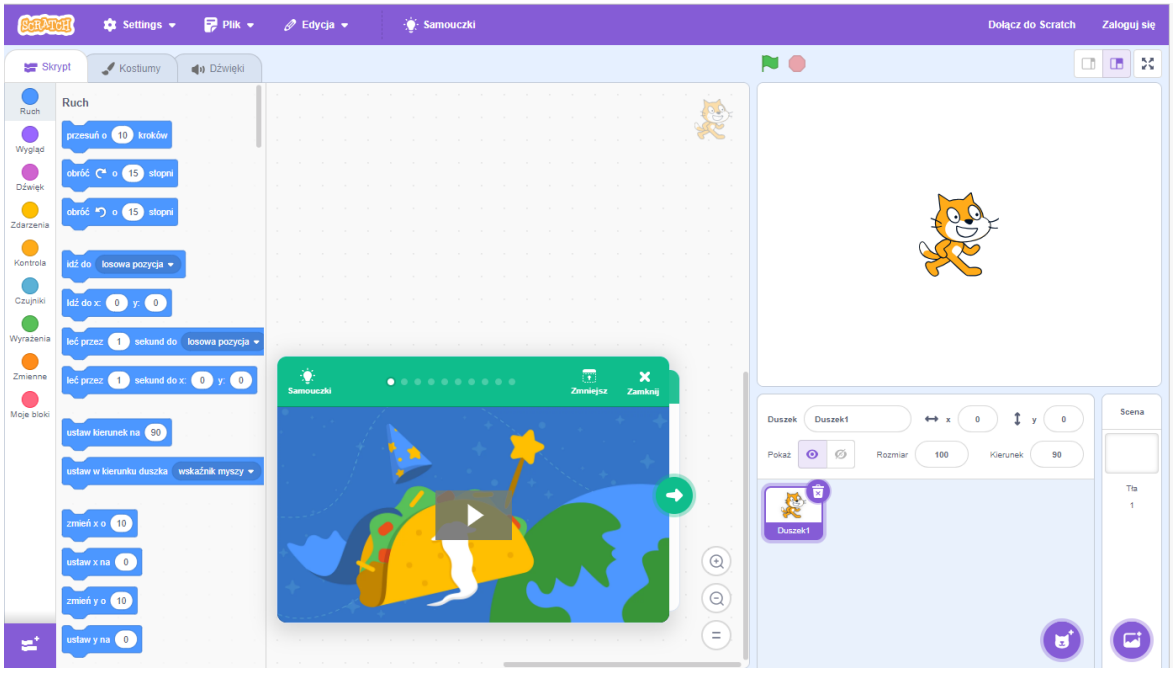
systematically, and collaborate — essential skills for everyone in today's society. Teachers use Scratch in many different subject areas and age groups.

Finally, Scratch users may freely share their project with others.



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9.8 STEAM APPS

https://www.weareteachers.com/steam-apps/ - free and paid educational STEAM Apps for kids and teens.

The webpage is dedicated primarily for teachers and includes many articles, documents, ideas related to the teachers' challenges in school environment, professional development and finally educational content mostly in the form of STEAM applications.

Many of the STEAM applications recommended on the webpage are grouped in: Science, Technology, Engineering, Art and Match categories and are also classified according to the recommended age of the users.

Following the increasing children and teenagers' interest in computer (or mobile phone) games, social media and other digital services, the educators are trying to harness learning apps in school. Two screenshots presenting a portal education application subpage are enclosed below.

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65+ Best STEAM Apps for Students in the Classroom and at Home

Science, technology, engineering, art, and math ... this list has them all.

Jill Staake on March 30, 2020

STEAM subjects (science, technology, engineering, art, and math) are all about understanding the world around us and how things work. There's no better way to do that than hands-on exploration, and these STEAM apps ensure kids and teens always have the tools they need to discover amazing things everywhere they go. Plus, many of them are just plain fun!

- STEAM Apps: Science
- STEAM Apps: Technology
- STEAM Apps: Engineering
- STEAM Apps: Art
- STEAM Apps: Math

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STEAM Apps: Science

The field of science encompasses a lot of subjects. These STEAM apps cover geology, biology, physics, chemistry, ecology, meteorology, and more.

Britannica Kids

Britannica offers a whole variety of STEAM apps for kids age 8 and up. Choose from Volcanoes, Snakes, Rainforests, Solar System, and Dinosaurs. (iOS, $1.99 each)

Tappity

Kids K-5 can get a complete science education from this subscription-based app It covers every topic imaginable, with fun interactive lessons, games, and experiments. (iOS, $14.99/month)

NSF Science Zone

Students of any age can get lost for hours browsing the high-res photos and videos on this app. They cover any science topic you can think of, from space to microbiology and everything in between. (iOS, Free)

Google Science Journal

Turn your phone into a pocket-size science tool. Try free science activities, document experiments and research, and record observations of the world around you. (iOS, Android, Free)

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9.9 Conclusions

Unprecedented technical development during the last decades resulted in creation of many digital tools and educational portals and content. Some of these tools and ideas are really deep and are applicable in a school environment, notably as support for STEM subjects teaching, but not only. Unfortunately, digital tools are still not too often exploited in a school formal education. There are basically two reasons for this situation:

1. A huge supply of digital tools (often of varied quality) in the Internet which makes finding the really valuable and relevant tool a quite challenging process.
2. Real or self-percept insufficient teachers' digital skills and reluctance to change long-standing habits

Both these reasons could be partially overcome:

1 To recognize which content a tool can be useful, one may check to what extent a given concept managed to build the teachers' and users' community and how often is it used.

2 In turn, the fears of teachers (related to their digital abilities) are usually largely exaggerated and unfounded. A common misunderstanding is that many people give too much importance to technical issues, which are usually easy to learn, instead of focusing on the much more important concept of the tool itself and its educational effect.

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10 EDUCATIONAL TOOLS&RESOURCES (EDUMOTIVA)

10.1 Introduction

Project-based, Problem-Based, and STEM-based approaches require students to not only utilise and apply their knowledge from different fields but also become proficient in the use of different tools like communication and collaborative web 2.0 tools, coding platforms, presentation tools, and mobile applications. By integrating these tools into their learning process, students are engaged in more authentic, extended, and complicated learning by sharing ideas and thoughts, communicating, working in teams, and co-creating presentations, posters, and stories to exhibit their work. This enables them to develop essential skills that empower them to navigate the complexities of the 21st-century world. Selecting adequate Web 2.0-technologies can enhance their learning both inside and outside of the classroom. The next chapters present some of the most used educational tools in the classroom to support those approaches.

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10.2 Collaboration , presentation and storytelling tools

10.2.1 Google Drive, Google Docs, and Google Slides

10.2.1.1 Google Drive

Google Drive (https://drive.google.com/) is a free cloud (*) storage platform provided by Google that allows users to store, access, and share files and documents online. It enhances collaborative work in the classroom by providing a centralized and easily accessible platform where students and teachers can collaborate, share files, and work on projects together, promoting seamless collaboration and efficient document management.

(*) Every Google Account comes with 15 GB of storage that's shared across Google Drive, Gmail, and Google Photos.

Supporting Project-Based and Stem projects with Google Docs

How to use Google Docs for project-based and STEM projects:

Project planning and organization: Use Google Docs to create project outlines, timelines, and task lists. Students can collaborate and contribute to these documents, ensuring everyone is on the same page.

Data collection and analysis: Students can use Google Docs to record and analyze data collected during experiments or research projects, making it easy to share and collaborate on data analysis.

Documentation and reflection: students can document their project progress, reflections, and observations in a shared Google Docs document. This promotes critical thinking and enables students to track their learning journey throughout the project.

Peer editing and feedback: Encourage students to share their work with peers and provide constructive feedback using the commenting feature in Google Docs.

Storytelling: enables collaborative writing and editing of narratives, provides feedback, allows revision history, and offers multimedia integration.

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10.2.2.2 Google Docs and Google Slides

Google Docs (https://docs.google.com/document) is a web-based word processing tool that allows users to create, edit, and collaborate on documents, while Google Slides (https://docs.google.com/presentation/) is a web-based presentation tool for creating and sharing slideshows. Both tools are free to use and can be used by anyone with a Google account.

Google Docs and Google Slides are two Web 2.0 tools available in Google Drive that allow **multiple users** to work on a document **simultaneously**, enabling r**eal-time collaboration** and allowing students to collaborate on group projects, share ideas, and make edits together, regardless of their physical location. By providing the **ability to track changes** made by each collaborator, it offers **automatic saving and revision history** and ensures that no work is lost.

The **commenting** feature allows for constructive **feedback** and **discussion** within the document, fostering effective communication and enhancing the collaborative process not only between the members of the team but also between the teacher and the teams. The students can connect with their Google Classroom accounts, their personal accounts in accordance with the GDPR policies, or work on a shared-document from the teacher.

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Example: using Google Slides for Storytelling

How to use Google Slides for project-based and STEM projects:

Project presentations: create and present project outcomes, allowing students to showcase their work and communicate their findings effectively.

Visual data representation: Use Google Slides to present data and findings in a visually appealing and easy-to-understand manner, enhancing the impact of project-based and STEM projects.

Collaborative brainstorming: Students can collaboratively brainstorm ideas, plan project milestones, and outline their project on Google Slides, facilitating effective collaboration and organization.

Demonstrating processes and procedures: Google Slides can be used to illustrate step-by-step processes or procedures involved in project-based or STEM activities, aiding comprehension and knowledge retention.

Storytelling and comics: enhances storytelling through visual elements and multimedia integration in dynamic presentations that can publish allowing the presentation to be available to the whole world.

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Overall, Google Docs and Google Slides provide a user-friendly and versatile platform that promotes seamless collaboration and enhances productivity in the classroom.

10.2.2.3 Tutorials

- Google Drive tutorials

- Google Docs tutorials

- Google Slides tutorials

- Google Docs training and help (https://tinyurl.com/4syzy4vf)
- Google Slides training and help (https://tinyurl.com/4cw79ah3)
- Google Drive training and help (https://tinyurl.com/4zmn92u5)
- Your Guide to Collaborative Document Editing With Google Docs (https://tinyurl.com/3px5pb5y)

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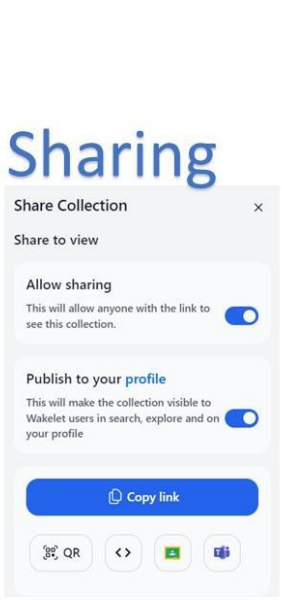
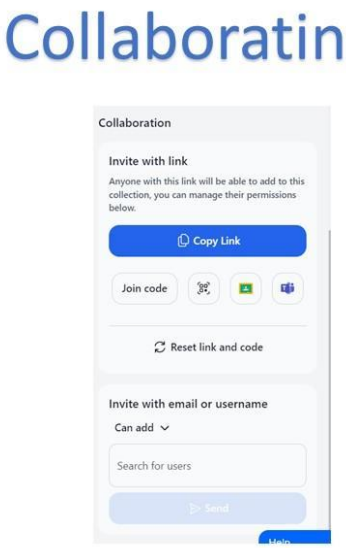
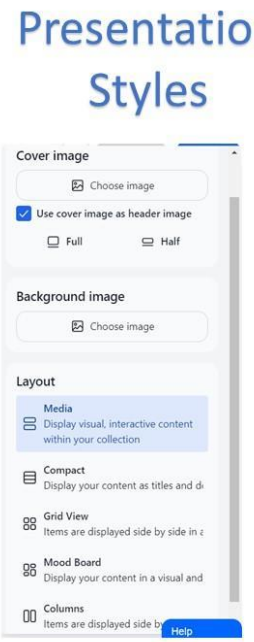
10.2.2 Wakelet

Wakelet (https://wakelet.com/) is a free online content **curation platform** that allows users to **save**, **organise**, and **share** various types of digital content, such as articles, videos, images, and social media posts. It enables individuals and teams to create collections, called "Wakes," which can be used for personal bookmarking, **collaborative projects**, or professional purposes like curating educational resources or showcasing **portfolios**.

Wakelet's main features







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Wakelet for teachers

🔑 **Resource Curation:** Educators can create curated collections of articles, websites, videos, and other online resources related to specific subjects or topics. These collections can be shared with students as supplemental materials or used for lesson planning.

📰 **Current Events and News:** Wakelet can be used to curate timely and relevant news articles, opinion pieces, and videos to keep students updated on current events. Educators can create curated Wakes focused on specific topics or themes and encourage discussions and critical thinking around them.

🤝 **Collaborate and share**: Create collections with fellow teachers and students, and share them in one click.Educators can create a shared wakelet where students can contribute resources, share ideas, and collaborate on research or assignments. **Wakelet Spaces** enable users to create collections of content, organize them into folders, and share them with others. It is an ideal tool for teams, educators, and anyone who wants to organize and share curated content or collaborate together.

🤲 **Inclusion**: Built in Immersive Reader for enhanced inclusivity and language translation

🌐 **Create virtual classrooms**: Create safe, private spaces to collaborate with your learning community! If your students have a Google Classroom or Microsoft account , you can import them, otherwise, collections can be shared with students by links..

Integration with external tools: can work with external educational tools and LMS platforms

🔒 **Security**: Change and update permission levels

🎨 **Presentation**: arrange and present your resources in different visuals ways

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Wakelet for students

Research: work to gather and organize research materials such as articles, scientific papers, and websites related to their project or STEM topic of study.

Collaboration and Group Projects: work together on group projects by sharing resources and conducting research, experiments, or coding.

Differential Learning: the embedded Immersive reader (text-to-speech, font customization, and focus modes) and translation tool help students with reading challenges, dyslexia, or visual impairments comprehend and engage with content more effectively

Presentation/Storytelling: document and showcase project progress using Wakelet. They can capture and share images, videos, and notes to demonstrate different stages of their project's development, create a final presentation or a storytelling

Digital Portfolios: Wakelet can be used as a platform for students to showcase their work and create digital portfolios. Teachers can encourage students to gather their best projects, essays, presentations, and other achievements in a visually appealing and organized manner.

Student Reflection and Journals: Wakelet can serve as a platform for students to document their reflections, thoughts, and learning experiences. They can create personal or team Wakes where they compile their reflections on assignments, experiments, or any other educational activities.

Peer Collaboration and Feedback: Students can use Wakelet to collaborate with their peers and provide feedback on each other's projects. They can comment on shared collections, offer suggestions, and engage in discussions, fostering a collaborative and supportive learning environment.

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Tutorials

The Educators' Guide to Wakelet (https://tinyurl.com/ne7a4fpd)	**The official guide for Wakelet** (https://tinyurl.com/bdfbsndr)
Spaces in Wakelet (https://wakelet.com/wake/vaD9fV74bS52MJpk-rVGQ) **How to use Wakelet for teachers as a collaborative tool** (https://tinyurl.com/425e26k7)	
Wakelet in 5 minutes (2023) **https://youtu.be/S-0Njai8qjQ**	Make engaging student portfolios! https://youtu.be/_BBqsv3lF-w

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10.2.3 Padlet

Padlet (https://el.padlet.com/) is an online real-time collaborative platform that allows users to create virtual bulletin boards or "pads" where they can easily share and organize various types of content. It serves as a digital canvas where individuals or groups can post text, images, videos, links, and documents in a visually appealing and interactive manner.

With Padlet, users can create customizable boards for brainstorming, note-taking, project collaboration, or simply sharing ideas and resources.

It offers a user-friendly interface that supports drag-and-drop functionality, enabling seamless content creation and arrangement.

Padlet has gained popularity in educational settings as a versatile tool for fostering engagement, collaboration, and creativity among students and educators.

Its flexible features and accessibility make it a valuable resource for **organising** and **visualising** information in a dynamic and **collaborative** way.

Padlet has a free version (3 fully customizable padlets) and a paid version. Students do not need to create their own account, they can join a shared padlet.

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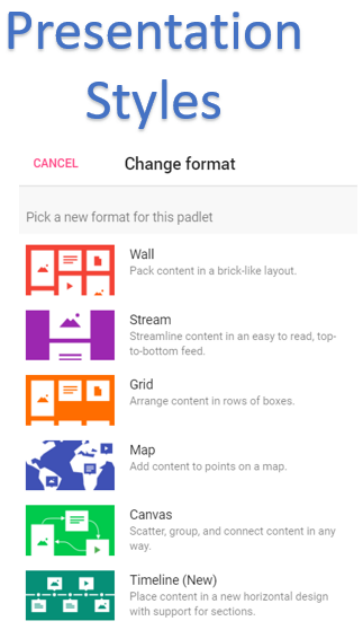
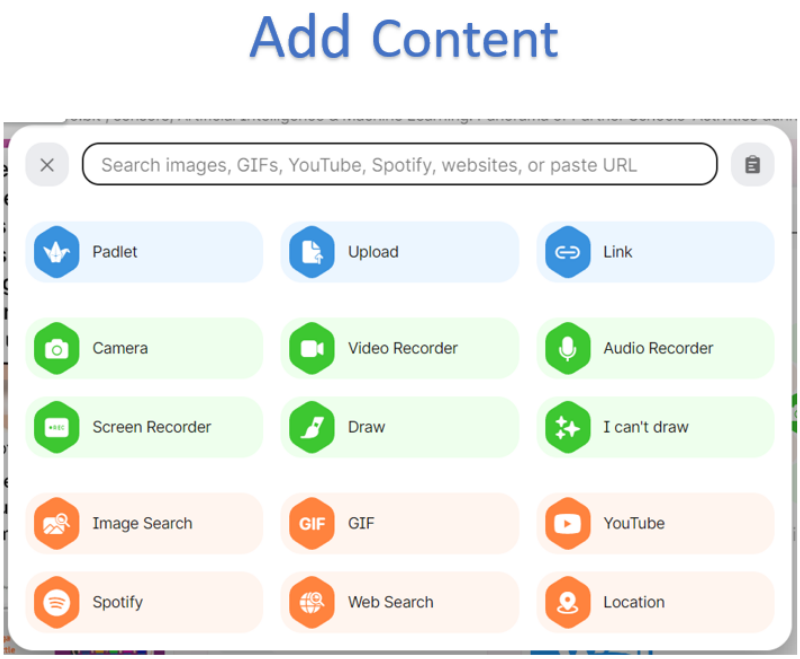
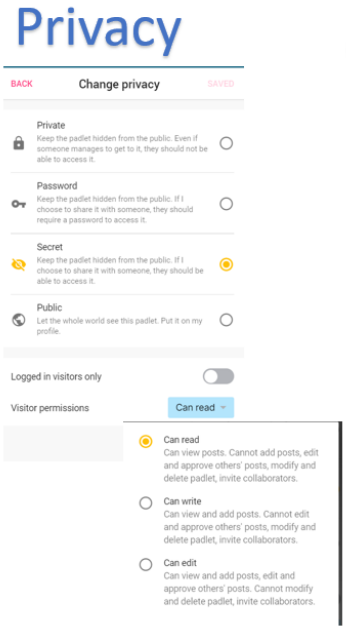
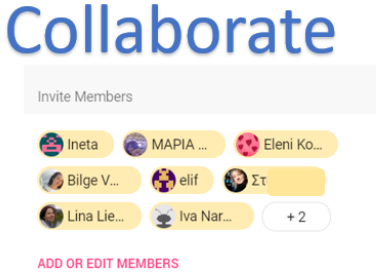
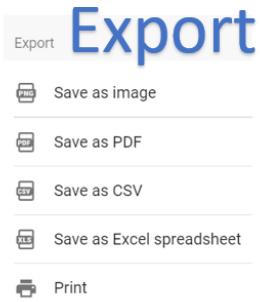
Padlet's main features:

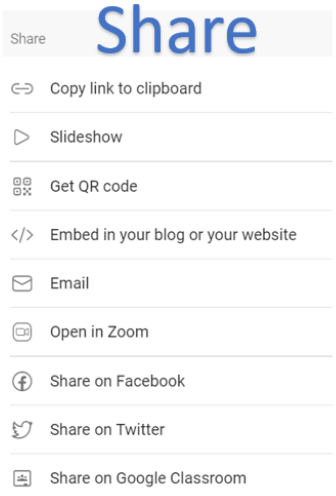












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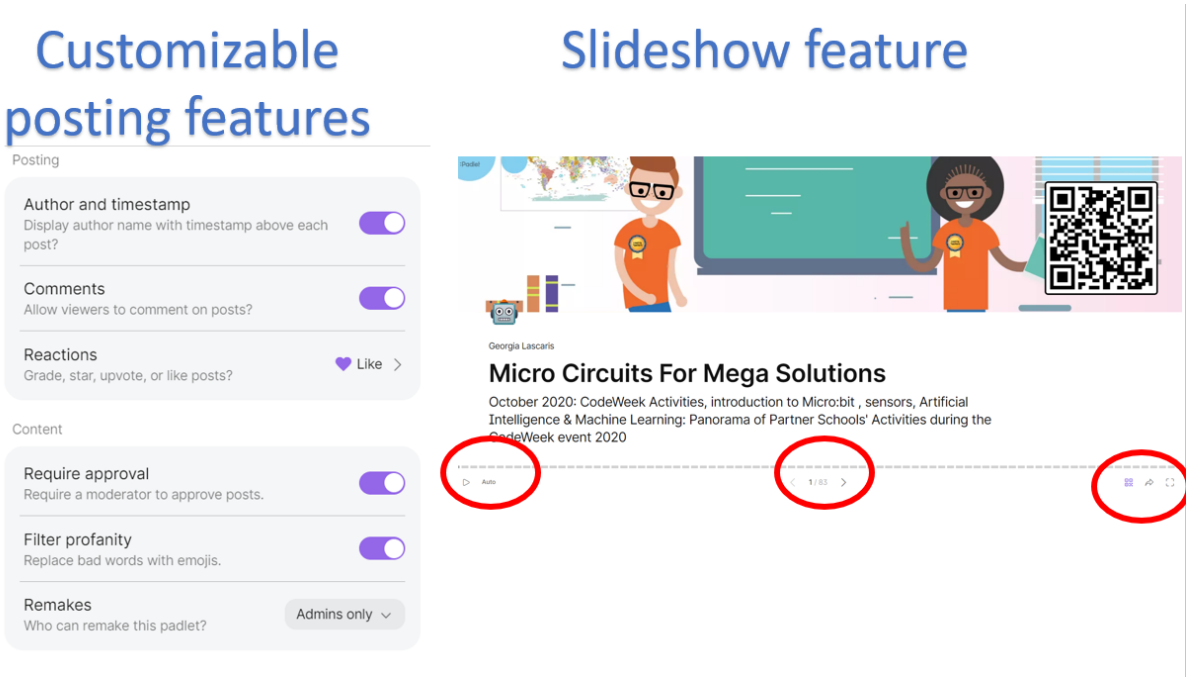

Using Padlet in collaborative projects

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How to use Padlet in collaborative projects

Tutorials

Brainstorming and idea sharing: Padlet provides a digital space where students can brainstorm ideas, share their thoughts, and collaborate on project concepts. They can post text, images, videos, and links related to their project topic, allowing for easy sharing and collaboration.

Research and resource gathering: Students can use Padlet to collect and organize research materials, relev

ant articles, videos, and websites related to their project. This helps in consolidating information and ensuring easy access to resources for all project members.

Collaborative problem-solving: Padlet enables students to pose questions, share problems they encounter, and seek solutions from their peers. Other team members can provide suggestions, resources, or even solutions on the Padlet board, fostering a collaborative problem-solving environment.

Documenting project progress: Padlet can serve as a digital project journal or portfolio, where students can regularly update and document their progress. They can post updates, images, videos, or reflections on their work, providing an overview of the project's development over time.

Peer feedback and evaluation: Padlet allows students to give and receive feedback from their peers. They can post their work or ideas and ask for constructive feedback or suggestions from their teammates. This facilitates a collaborative and supportive environment where students can learn from each other and improve their project outcomes.

Presentation and showcasing: Padlet provides an engaging platform for students to present their project findings, showcase their work, or create interactive displays. They can arrange and design content on the Padlet board to create visually appealing presentations or portfolios.

Virtual collaboration and remote learning: Padlet's online nature makes it an ideal tool for collaborative projects and STEM activities in remote or hybrid learning environments. Students can access and contribute to Padlet boards from anywhere, enabling seamless collaboration regardless of physical location.

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Padlet: Official Page Tutorial

What's Padlet

https://youtu.be/pLdZJAc3bGQ

Padlet: Official videos Collection

https://www.youtube.com/padlet

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10.2.4 Canva

Canva (https://www.canva.com/) is a **graphic design platform** that offers a wide range of creative tools and templates. Beyond its popular usage in the design industry, Canva has found its way into classrooms, proving to be an invaluable resource for **collaborative project-based projects.** With its user-friendly interface and extensive library of design elements, Canva enables students and educators to create **visually appealing and engaging content**. In educational settings, Canva can be used for tasks such as designing **presentations**, **infographics**, **posters**, **videos**, **storytelling**, **comics and interactive visuals**.

It fosters collaboration by allowing students to work together, **share** ideas, and contribute to **shared design projects**. By incorporating Canva into the classroom, students can enhance their digital literacy, creativity, and communication skills, while bringing a visually captivating dimension to their project-based and STEM initiatives.

Canva offers a free version for all, a paid version, and an educational version. **Canva for Education** (https://canva.com/education) , is free for educators and students and includes additional features such as classroom management tools (Microsoft Teams and Google Classrooms integration) , collaborative project capabilities, and enhanced privacy settings, ensuring a secure and productive learning environment. Teachers and students have access to thousands of materials, educational templates, and lesson plans for any subject, grade, or topic.

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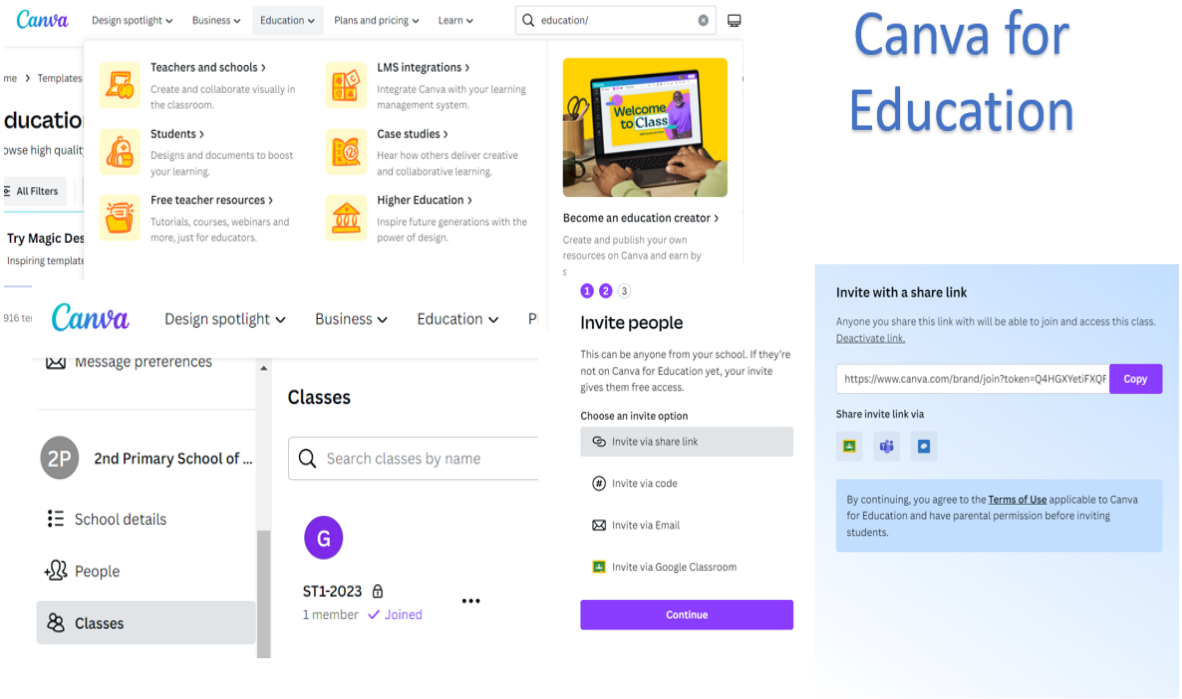
Canva for Education



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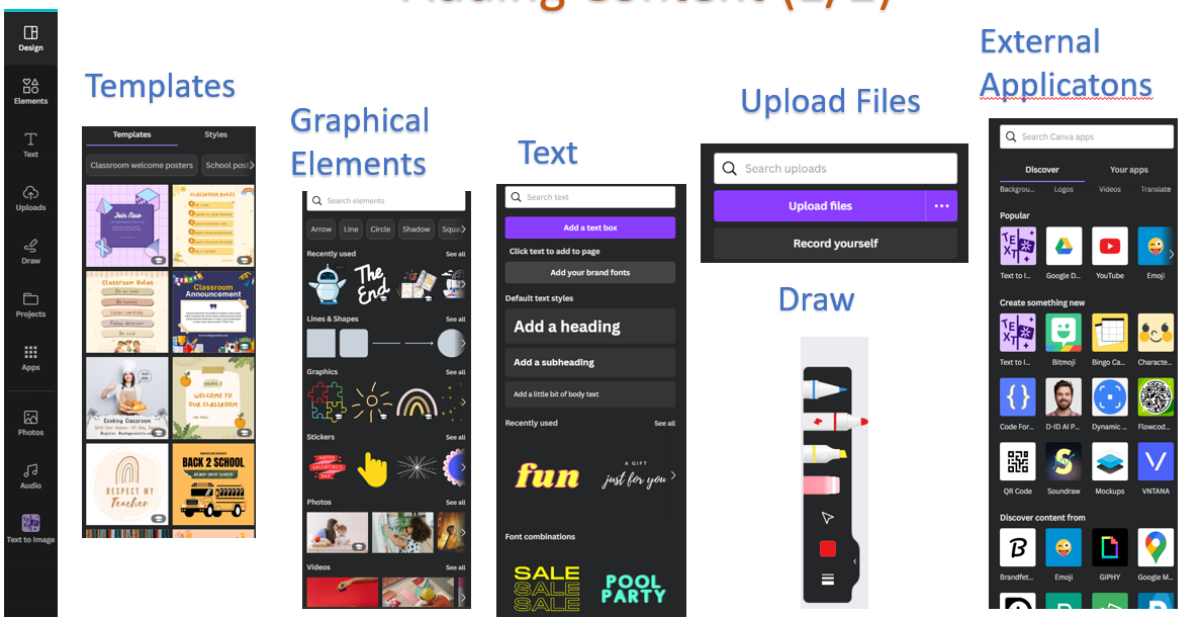
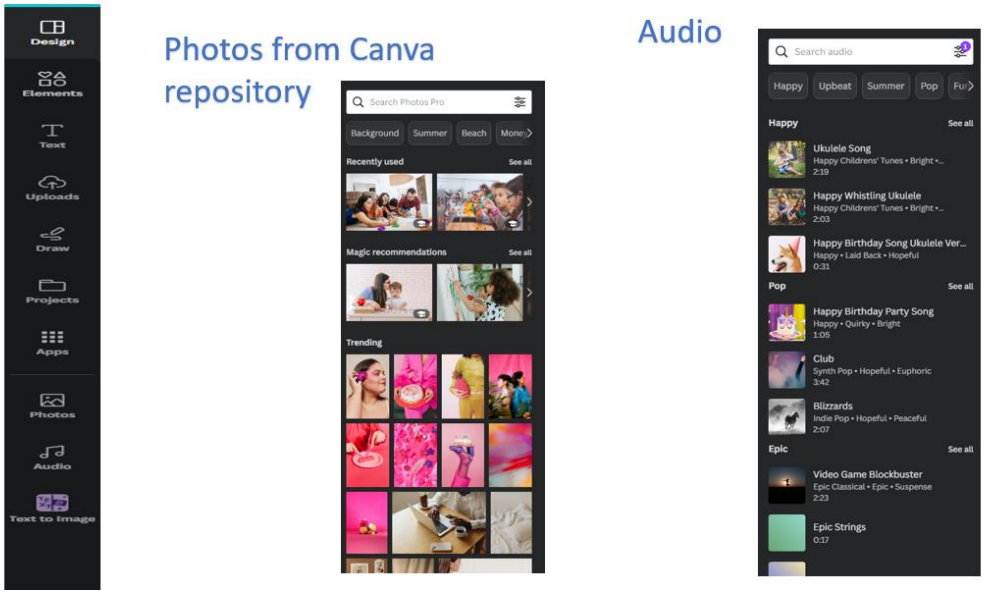
Adding Content (1/2)



Canva's main characteristics

Adding Content (2/2)



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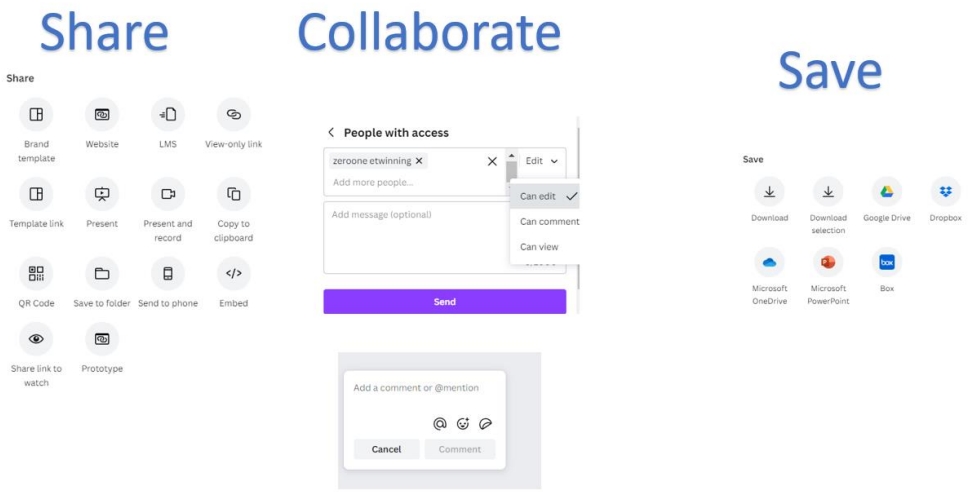

Using Canva in the classroom

Tutorials

Welcome to Canva for Education

https://youtu.be/gIcFqbIFGa8

Canva Official videos tutorials list

https://tinyurl.com/5d9jzx4c

Getting started with Canva (https://www.canva.com/designschool/tutorials/getting-started/)

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Classroom materials: Creation of visually appealing, customizable, appealing and engaging classroom materials such as worksheets, handouts, posters, or presentations by using Canva's templates and design tools

Interactive visuals: creation of interactive visuals like infographics, timelines, or mind maps that help students grasp complex concepts in a visual and engaging way. Incorporate images, icons, charts, and text to present information effectively.

Student projects: assignment of creative projects to students, such as creating digital portfolios, designing book covers, or producing infographics.

Collaboration: Foster collaboration among students by assigning group projects that require them to work together on Canva. They can create shared design boards, presentations, or posters, allowing for real-time collaboration and seamless teamwork.

Presentations: Encourage students to use Canva for their presentations. They can create visually appealing slides, incorporate images, icons, and graphics, and effectively communicate their ideas.

Digital storytelling: Use Canva to support digital storytelling activities. Students can create visual narratives, storyboards, or comic strips using Canva's templates and design elements, enhancing their storytelling skills and creativity.

Promote critical thinking: Assign students tasks that involve designing infographics to analyze data, present research findings, or summarize complex topics. Canva's tools and visuals can help students think critically and present information in a visually compelling manner.

©Digital citizenship: responsible and ethical use of visual content (copyright, attribution, and fair use principles)

Video creation and editing: videos can be created and edited by combining images, text, graphics, and music. Students can be engaged by assigning video projects, presentations, or storytelling activities, allowing them to develop multimedia skills and enhance their communication abilities.

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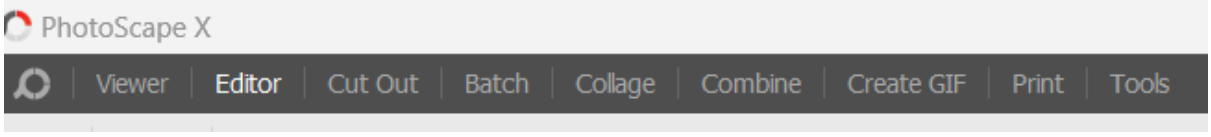
10.3 Video & Image processing tools

10.3.1 PhotoScapeX

PhotoScapeX (http://x.photoscape.org/) is a user-friendly **photo editing software** that offers a range of powerful features. With its intuitive interface, PhotoScapeX allows both beginners and advanced users to enhance, manipulate, and edit their images with ease. This software provides a wide array of tools, including **filters**, **effects**, **cropping**, **resizing**, and c**olour adjustments**, allowing users to unleash their creativity and bring their photos to life. It offers additional functionalities such as batch editing, **collage creation,** and **GIF creation**, making it a valuable tool for various photographic needs. With its combination of simplicity and robust features, PhotoScapeX is a valuable tool for image editing.

There is a desktop free and paid version (PRO) of PhotoScapeX for Windows and Mac-OS.

Main Characteristics



- **Viewer**: Photo | Video | Audio Browser
- **Editor:** 1,000+ Filters & Effects, Frames, Objects, Brushes & Tools, Rotate, Straighten, Flip, Resize, Crop, Circular Crop, Perspective Crop, Mask (Local Adjustments).
- **Cut Out**: Remove the background from an image. (Magic Eraser, Lasso tool, Brush tool)
- **Collage**: Merge multiple photos on the collage frame to create one final photo.
- **Combine**: Attach multiple photos vertically or horizontally to create one final photo.
- **GIF Creator**: Create Animated GIF.
- **Print**: Print photos.
- **Screen Capture**: Capture your screenshot and save it.

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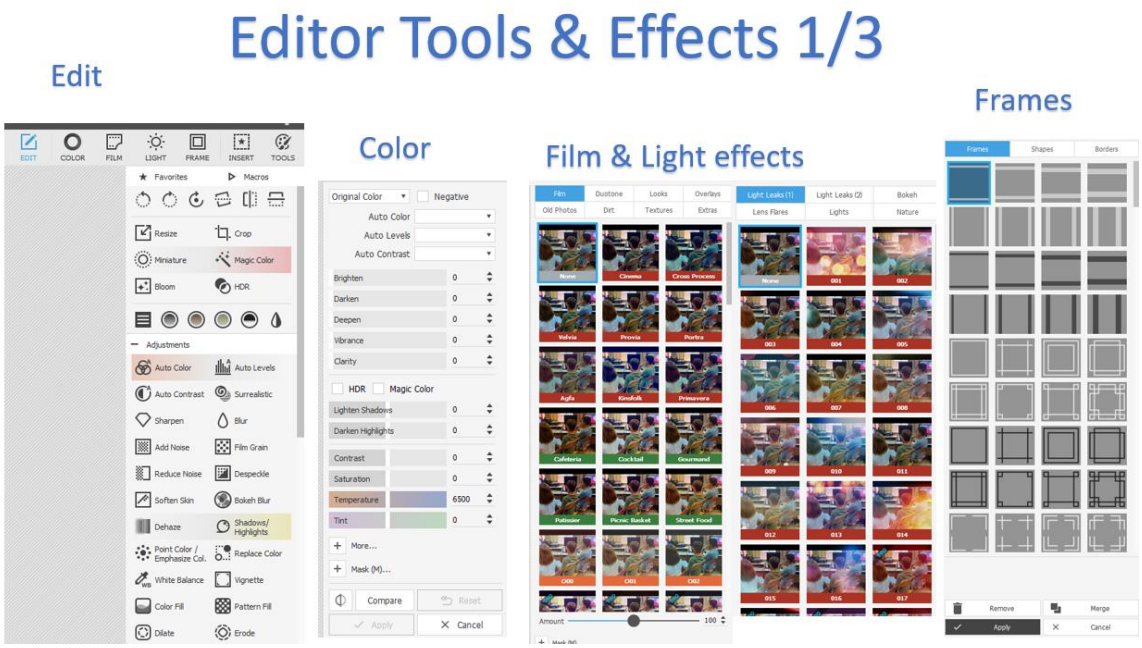
- **Colour Picker**: Zoom in on images, search and pick a colour.
- **Split**: Slice a photo into several pieces.
- **Batch Format Change**: Convert multiple images to another format at once.
- **Batch Resize**: Resize multiple images at the same time.
- **Batch Rename**: Change photo file names in batch mode.
- **Photo Merge**: Focus Stacking, Merge to HDR
- **Filters & Effects**: Magic Colour, Miniature, Bloom and more.
- **Frames**: 290+ Frames, 240+ Shapes, Borders
- **Objects**: Stickers, Figures, Image, Text, Magnifier, Arrow, Line, Circle and more
- **Brushes & Tools**: Draw,Paint Brush & Bucket, Mosaic, Spot Healing and more
- **Languages**: English, Español, Português, Deutsch, Français, Italiano, Nederlands, Polski



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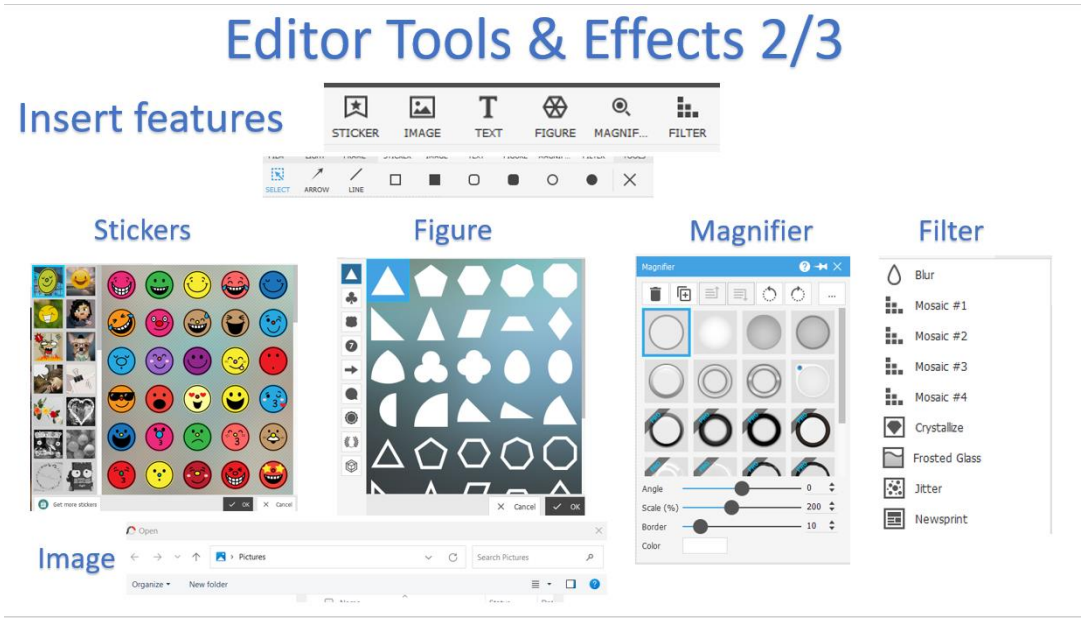

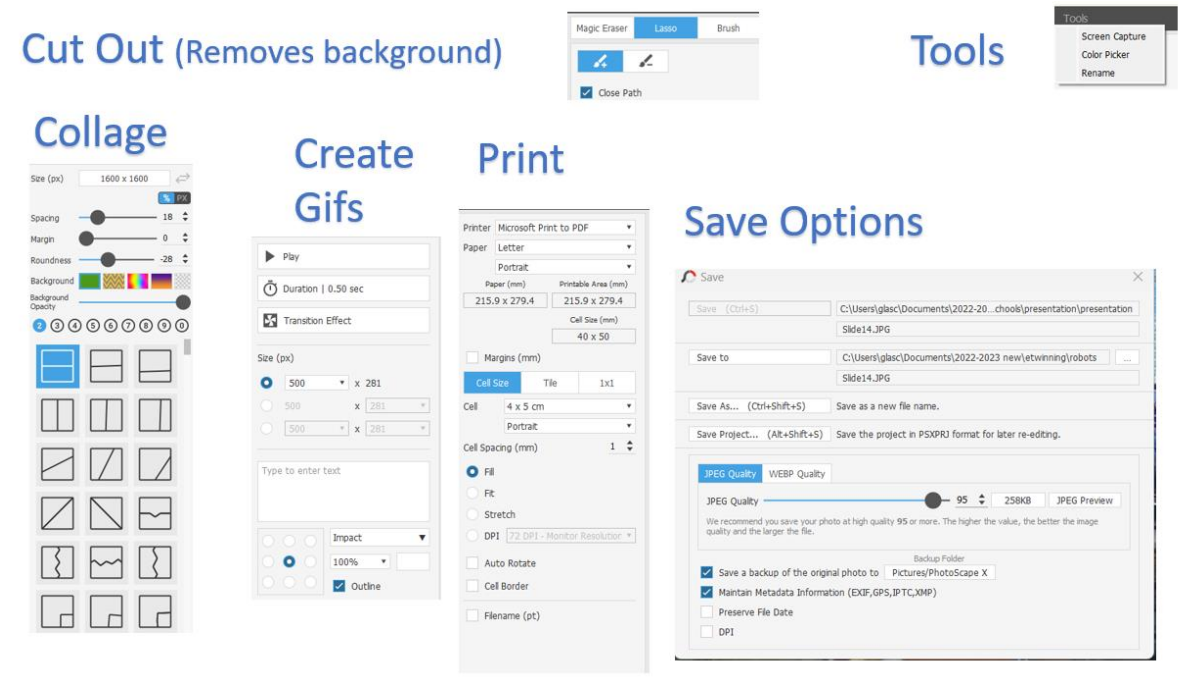

Tutorials

- 🔗 📽 Official Photoscape Video Tutorials

(https://tinyurl.com/4fxbjjuz)

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10.3.2 Microsoft Clipchamp

Microsoft Clipchamp (https://tinyurl.com/54xmd4hz) is a dynamic, and user-friendly **video creation and editing** platform. Clipchamp offers a range of powerful features that allow users to easily create and customise professional-looking videos. Whether it's for personal or professional use, Clipchamp provides a wide array of **editing tools**, including **trimming**, **cropping**, **adding transitions**, and **applying filters**, enabling users to enhance their videos. It offers a diverse collection of templates, stock media, and audio tracks to choose from, making it easy to create engaging and visually appealing content. Its intuitive interface and cloud-based functionality make it accessible from anywhere. Microsoft Clipchamp empowers users to unleash their creativity and produce high-quality videos without the need for extensive technical expertise, making it a valuable tool for content creators. ClipChamp also offers an Artificial Intelligence feature that allows users to create videos effortlessly.

Microsoft Clipchamp is **integrated into Windows 11**, and you can easily install it from the Microsoft Store. It offers both free and paid versions, and you can access it either through the desktop application or via your web browser.

Main Characteristics

Import Data: import media, records, templates, music, videos

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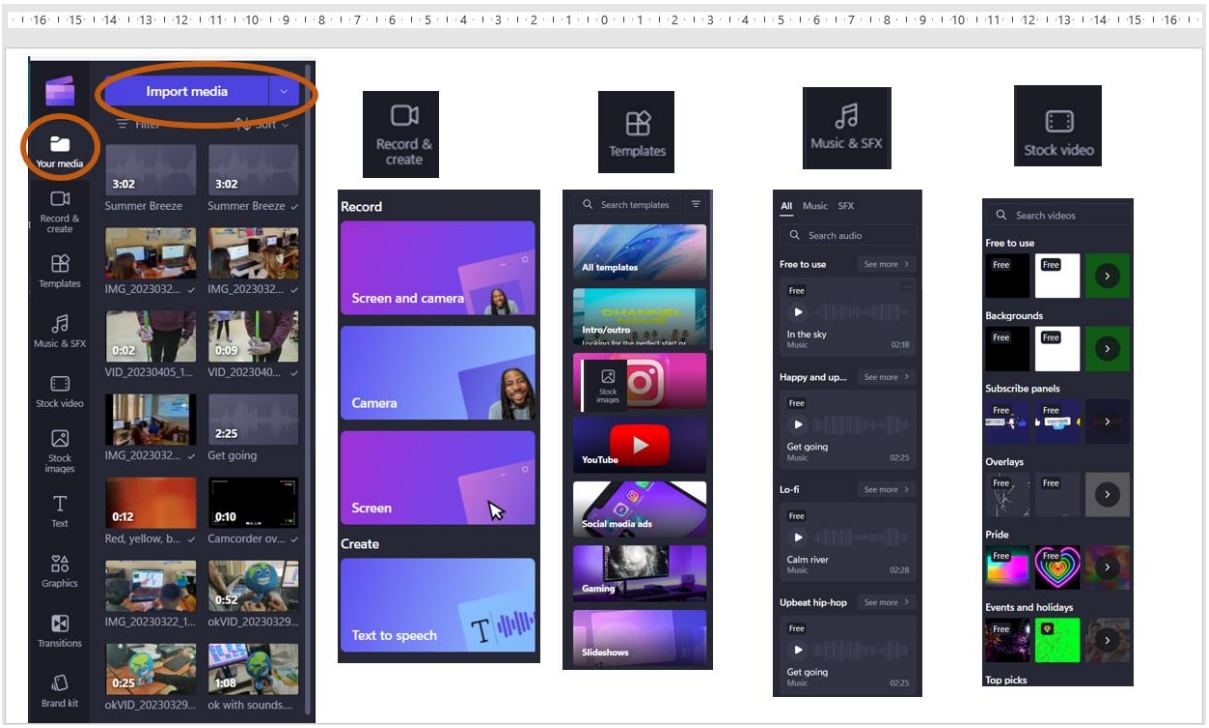
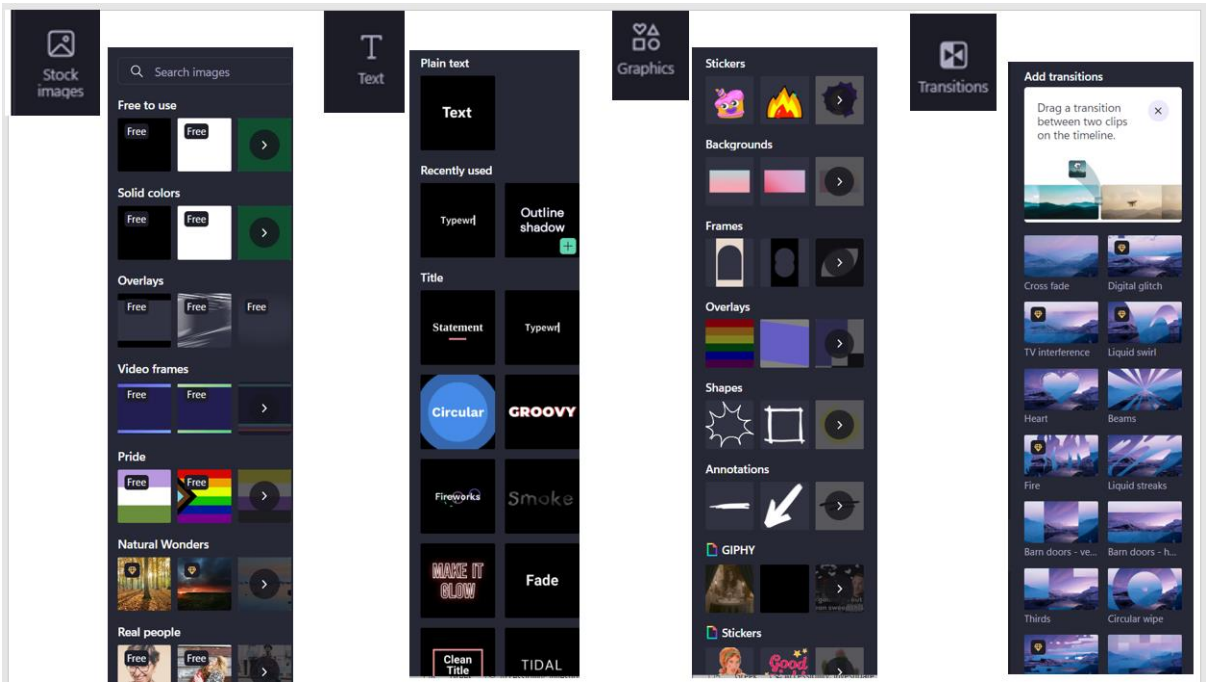


Add Content : stock images, text, graphics, transitions



Add Content: captions, audio, effects, filters

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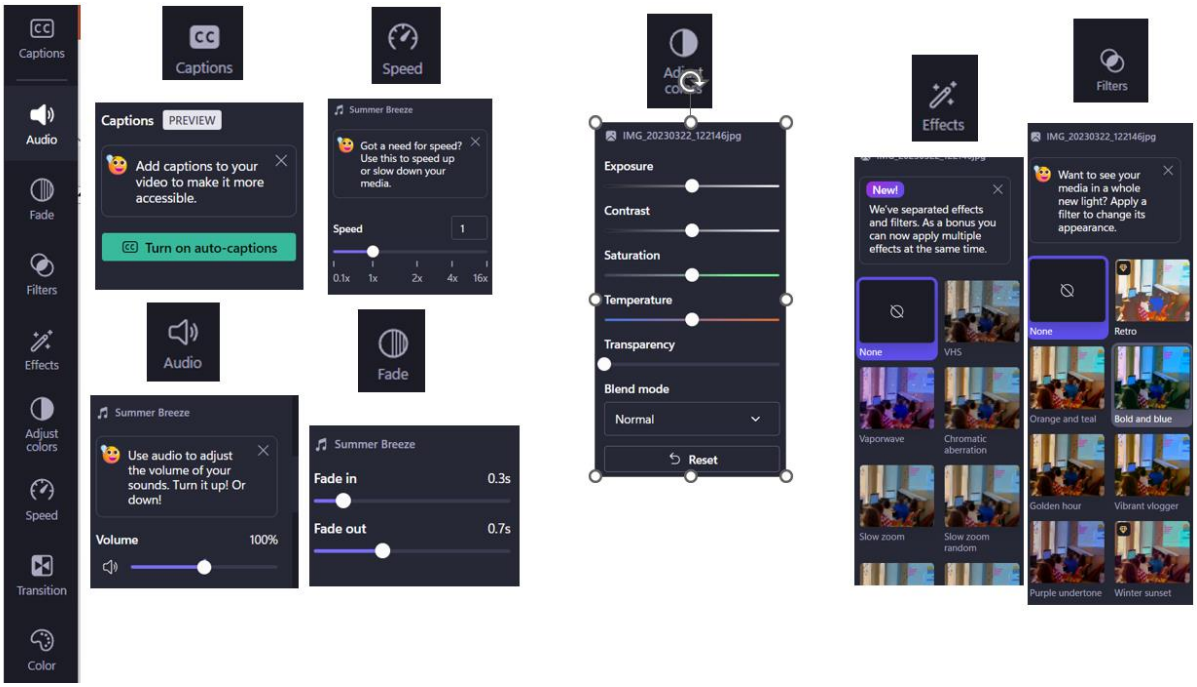
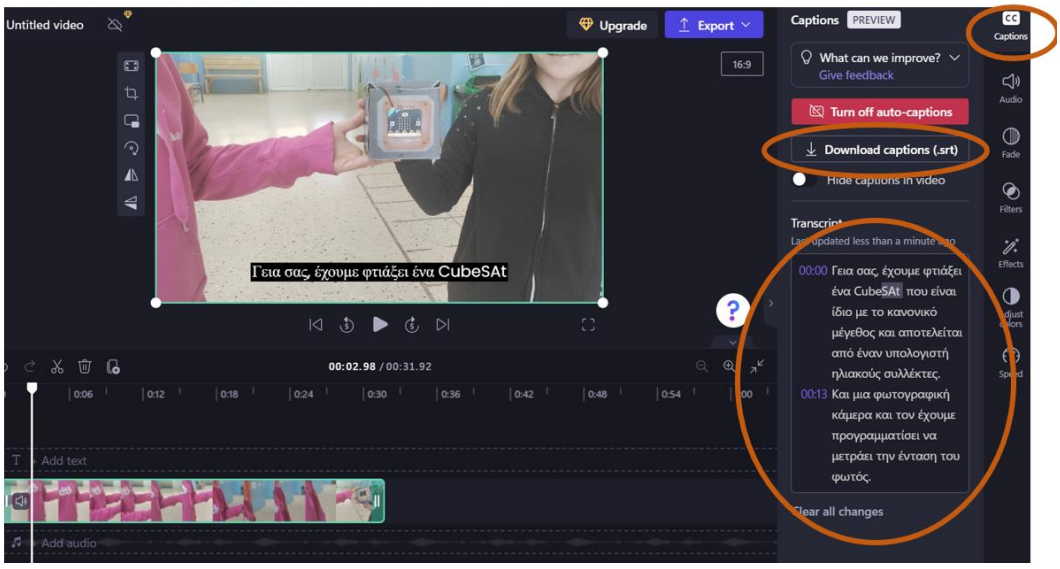


Generates captions from the video



Tutorials

- 🔗 Training Center (https://clipchamp.com/en/training-center/)
- 🔗 📽 Video tutorials (https://tinyurl.com/bddhn8up)

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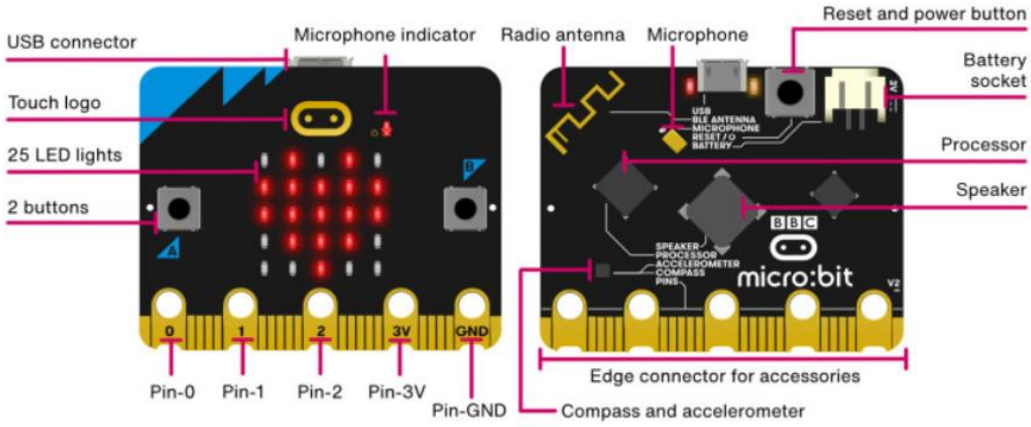
10.4 Technology & Programming tools

10.4.1 BBC Micro:bit and MakeCode

The BBC Micro:Bit (https://microbit.org/) is a user-friendly microcontroller that has become a valuable tool in STEM education. It can be used to engage students in exciting hands-on environmental and STEM projects.

How to use the BBC Micro:bit in STEM projects

- By programming its sensors with the web-based and block-based coding platform Microsoft's MakeCode (https://microbit.org/code/), the students can develop projects that monitor air quality, measure temperature and humidity levels, track energy consumption, collect and analyse data, and many more.



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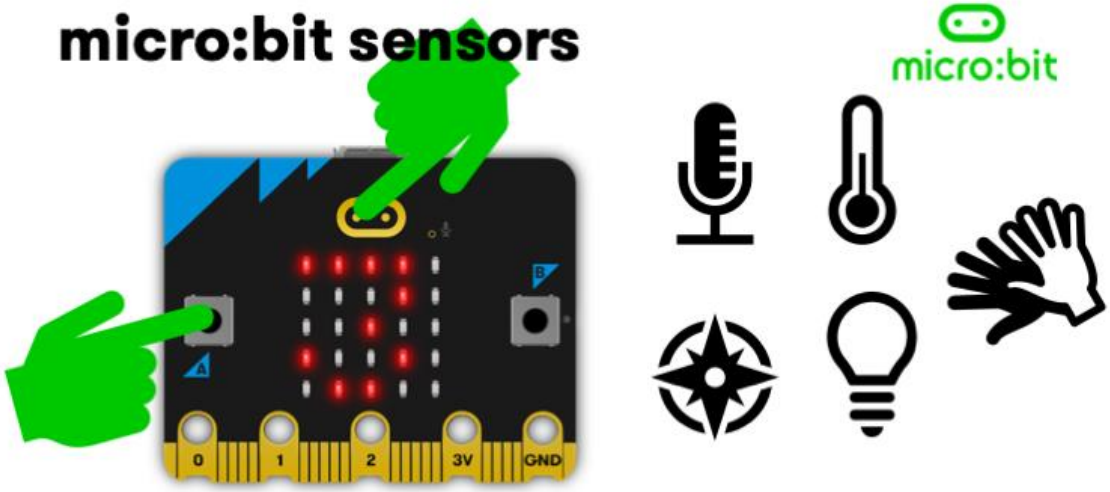
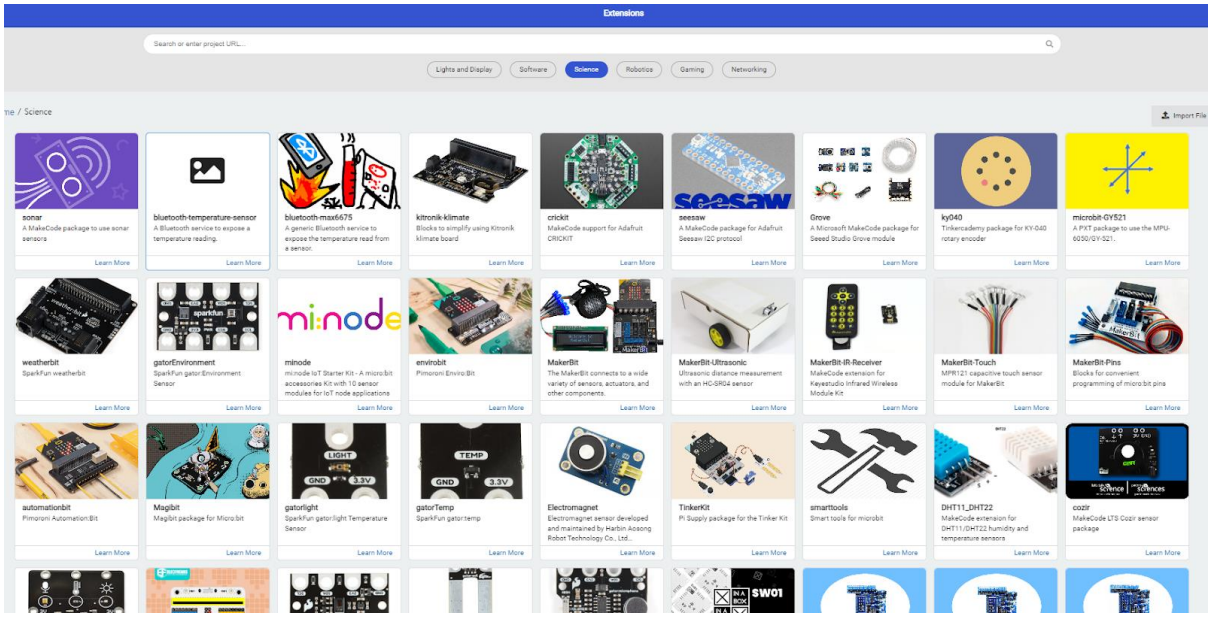


- The Micro:Bit's compatibility with various accessories and peripherals enables students to design and construct interactive prototypes, such as automated irrigation systems, smart recycling bins, or wildlife monitoring devices.



- The Micro:bit simulator allows you to simulate BBC Micro:bit programs within your browser. The simulator can emulate sensor data or user interactions.

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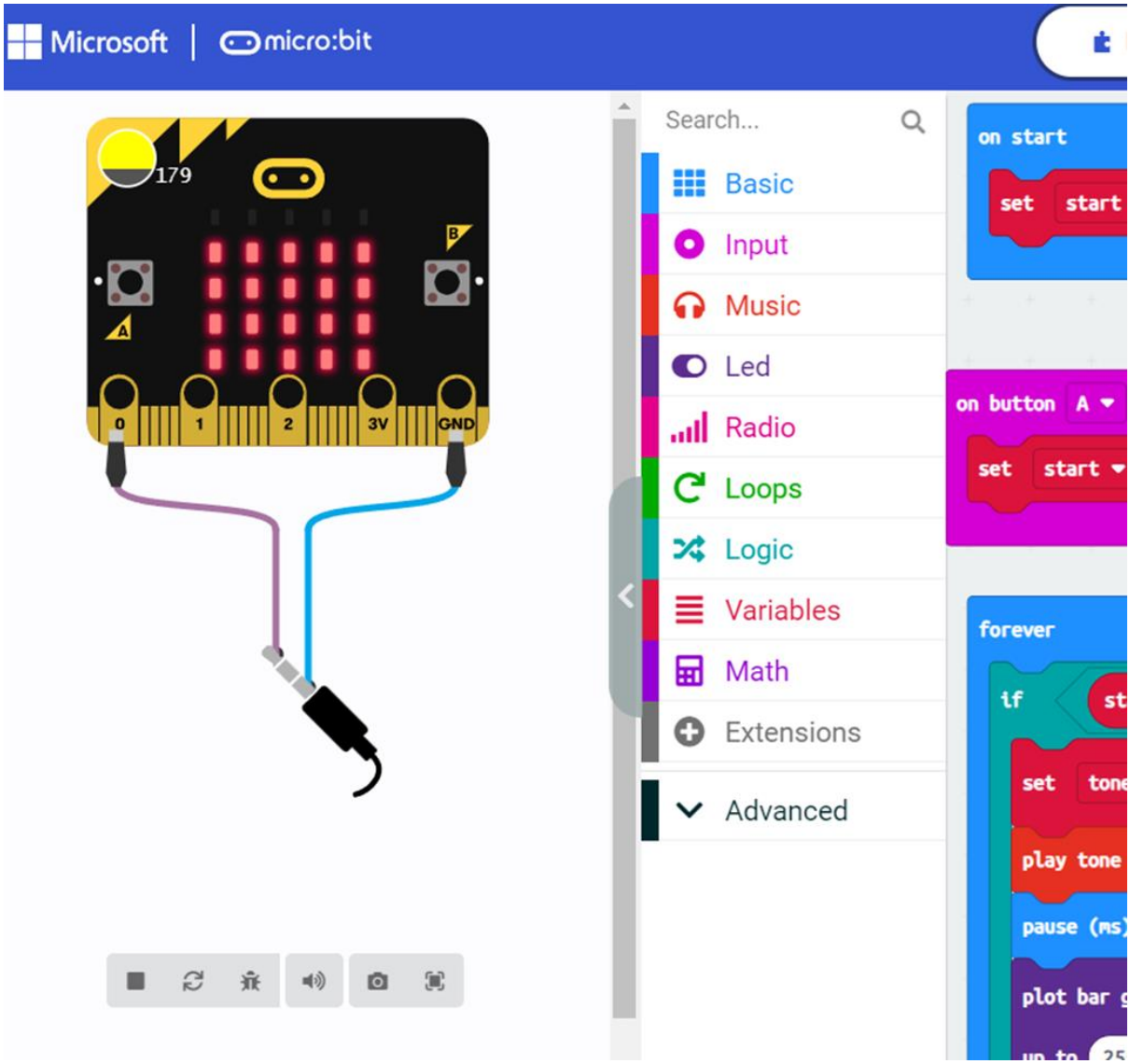

- The Micro:Bit **Classroom feature** allows teachers to manage programming lessons in school, remotely, or even a mixture of both. Within the virtual classroom, the teacher can share with students, monitor their progress, and resume students' work. Registration for both teachers and students is needed, and data is saved on the teachers' computer.

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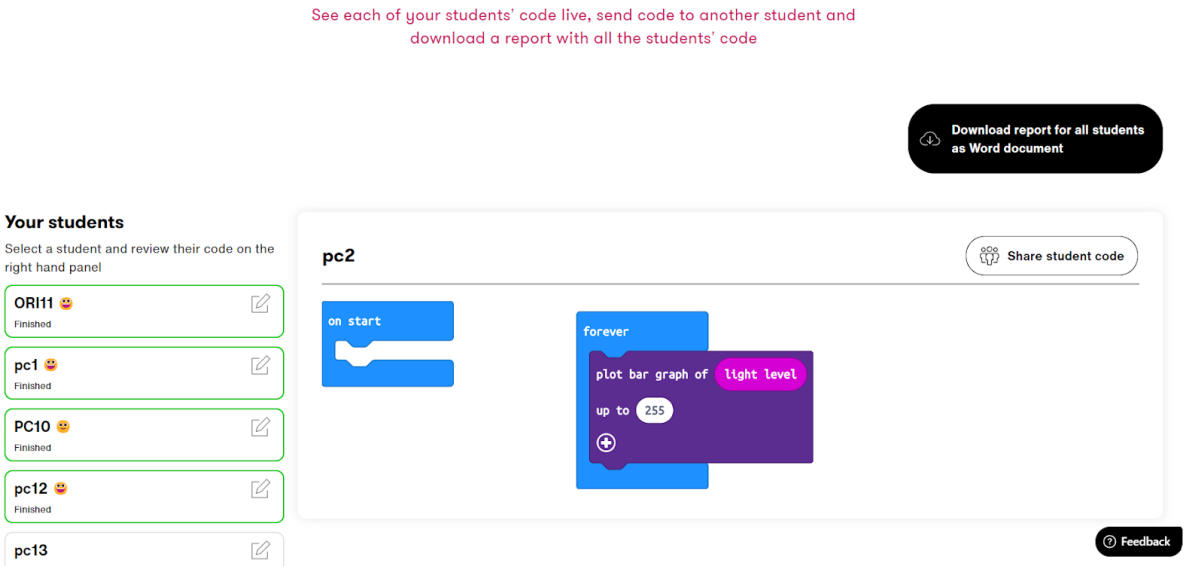

- Using the Micro:Bit in **STEM environmental projects**, students not only learn coding and electronics but also develop a deep understanding of environmental issues and cultivate a sense of responsibility towards our planet.

Tutorials

- Get Started:What is the Micro:bit (https://microbit.org/get-started/what-is-the-microbit/)
- Classroom resources (https://microbit.org/teach/classroom-resources/)
- Teaching tools (https://microbit.org/teach/teaching-tools/)
- Make it: code it (https://microbit.org/projects/make-it-code-it/)
- Video collection

(https://www.youtube.com/@microbit_edu/playlists)

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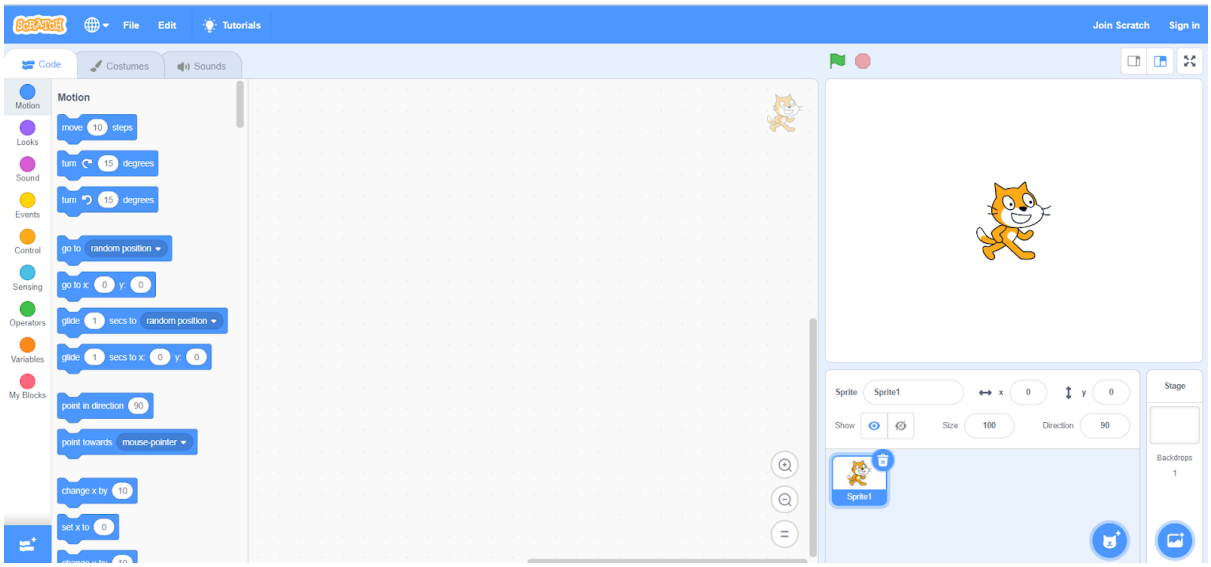
10.4.2 Scratch 3.0

Scratch (https://scratch.mit.edu/) is a free, web-based **visual programming** language and online community developed by **MIT Media Lab** that provides an excellent platform for students to **learn coding** and engage in **creative interdisciplinary projects** combining Music, Mathematics, Languages, Science and Arts. With Scratch, students can code **interactive stories**, **animations**, **games** and more by dragging and dropping code blocks.



Using Scratch in the classroom

- Teachers can create a **teacher account** which provides them with additional features to m**anage student participation on Scratch**, including the ability to create student accounts, organize student projects into **studios**, and **monitor** student **comments**.

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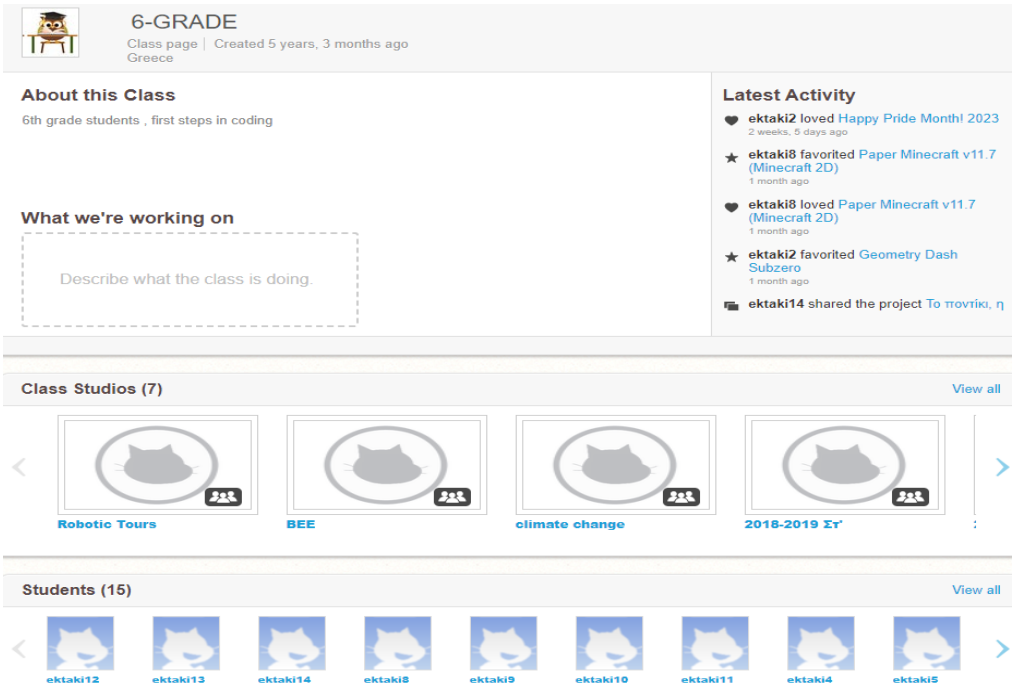
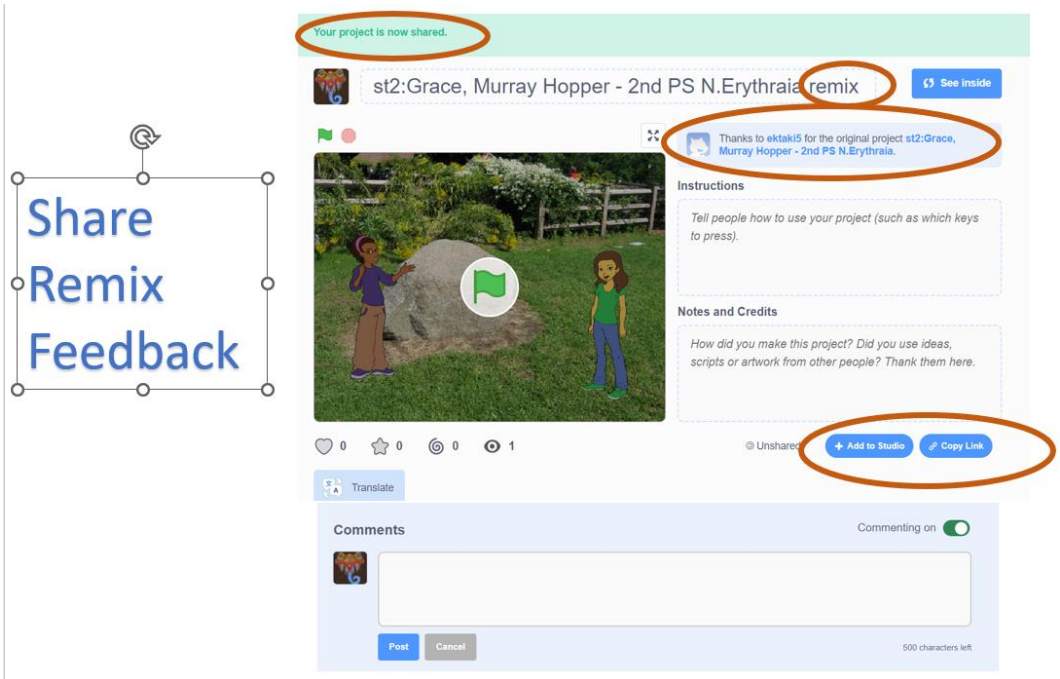


- Scratch encourages collaborative learning by allowing students to share their projects, explore and remix others' creations, and provide feedback. This fosters a sense of community and teamwork within the classroom.



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- Scratch can be a powerful tool to create i**nteractive narratives and storytelling** by combining pictures, drawings, sound effects, background music, and voice recordings with coding ("*How to Make a Story in Scratch*" tutorial) .

Tutorials

- 🔗 Scratch Tutorials (https://scratch.mit.edu/ideas)
- 🔗 Create a Story tutorial (https://scratch.mit.edu/projects/editor/?tutorial=tell-a-story)
- 🔗 Code a cartoon (https://scratch.mit.edu/projects/331474033/editor?tutorial=code-cartoon)
- 🔗 📹 How to Make a Story in Scratch

https://youtu.be/uv8mbL-MC58

- 🔗 📹 Videos playlist

https://www.youtube.com/@ScratchTeam/playlists

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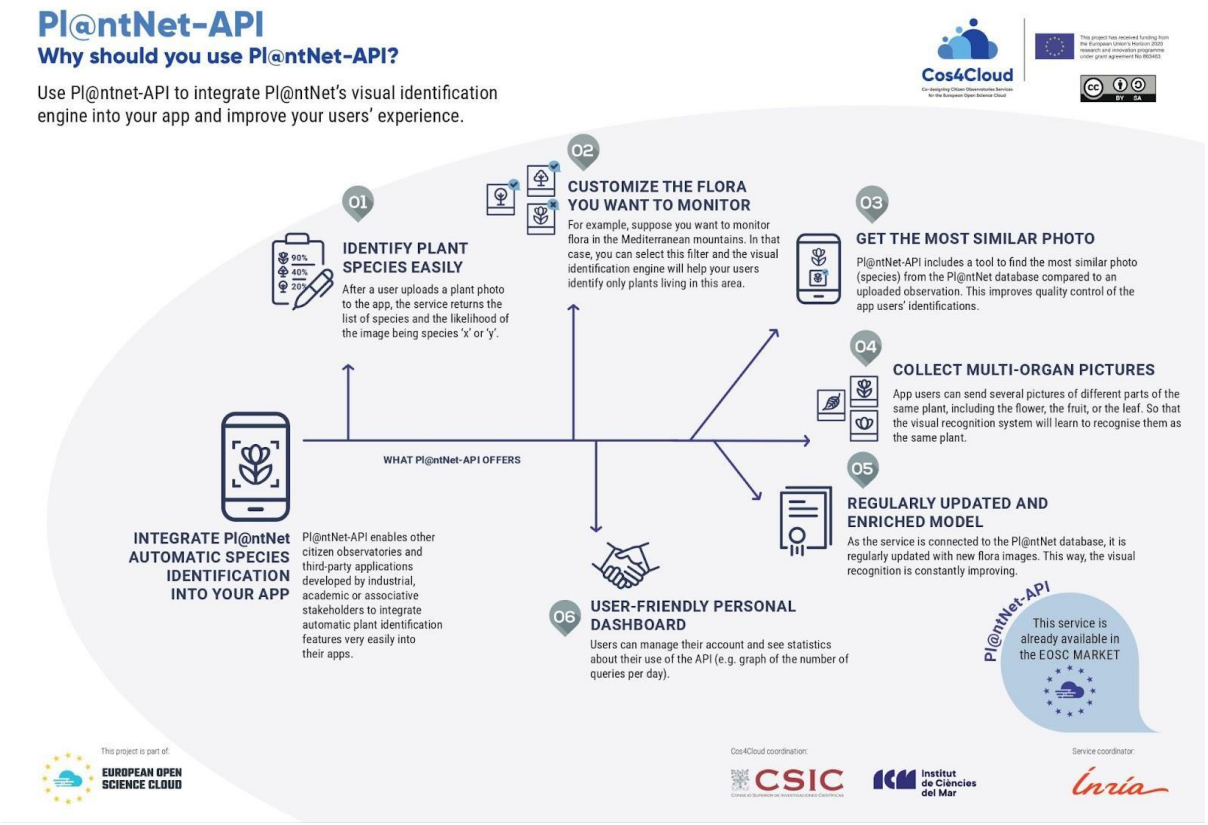
10.5 Citizen Science tools

10.5.1 The Pl@ntnet application

Pl@ntNet (https://plantnet.org/en/) is a free **citizen science platform** that allows users to collect, share, and review **plant observations** using automated identification. Its main goal is to **monitor plant biodiversity** and make plant knowledge accessible to the general public.

The platform's web and mobile interfaces are used by a large community of several million users, who contribute hundreds of thousands of plant observations on a daily basis. This **data** is highly **valuable** for **research** in various fields, including **ecology**, **agronomy**, and **energy**.



Source: https://zenodo.org/record/7657684#.ZACETS8rxN0

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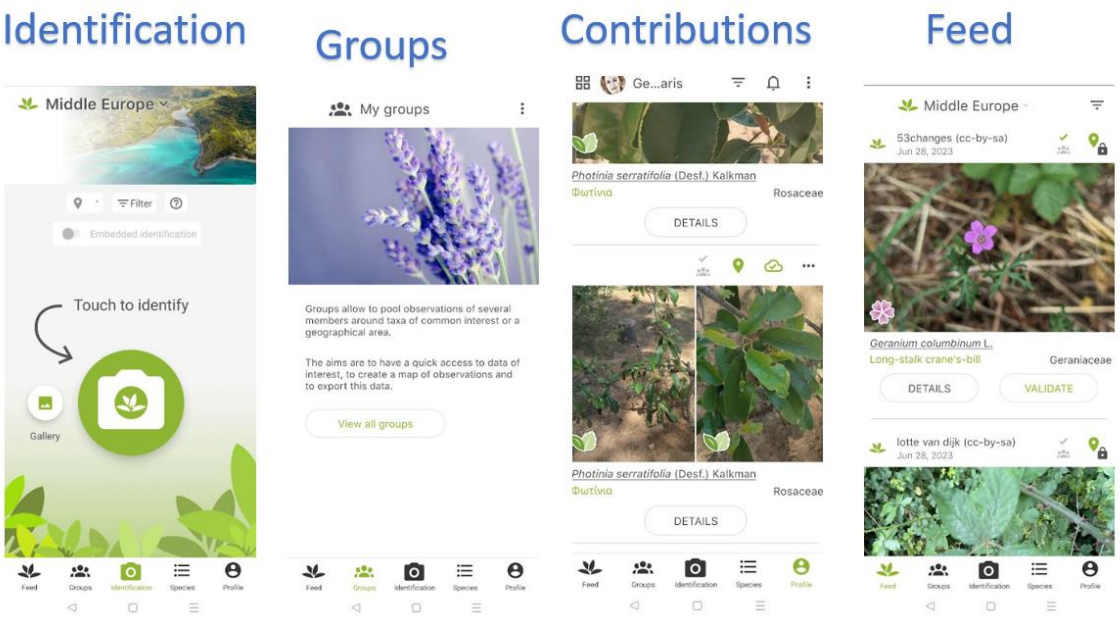
One of the app's key features is its v**isual recognition software**, which enables users to identify plant species by **uploading photos** . Through the power of **artificial intelligence**, the app provides species identification based on the uploaded image. Additionally, each observation helps enhance the app's performance through the inclusion of new species, training data, and improved quality.



Using Pl@ntnet in environmental and STEM projects

Using Pl@ntnet in the classroom promotes active learning, critical thinking, and a deeper connection with the natural world. It empowers students to become confident in plant identification and understanding, making environmental science engaging and relevant to their lives.

Pl@ntnet can be used to:

- Teach plant identification.
- Introduce students to AI-driven applications and the use of technology for good.

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- Enhance outdoor learning experiences during field trips.
- Engage students in citizen science projects, contributing to research.
- Explore invasive species and their impact on ecosystems.
- Foster student projects and presentations on plant-related topics.
- Create a virtual plant collection for future reference.
- Organize plant identification challenges for interactive learning.

Tutorials

- Short video tutorial https://youtu.be/zw4ooSHlNWM

https://youtu.be/zw4ooSHlNWM

- Pl@ntnet an application that can identify plants

https://youtu.be/W_cBqaPfRFE

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10.6 Gamification & Assessment tool

10.6.1 Kahoot, the game-based learning platform

Kahoot (https://kahoot.com/) is an interactive **online learning platform** that offers engaging **quizzes** and **games** for educational purposes. It provides a fun and interactive way for users to test their knowledge on various subjects and topics. Participants can join in **real-time competitions** and challenges, making learning entertaining and enjoyable. With its user-friendly interface and customizable features, Kahoot has gained popularity among students, teachers, and individuals seeking an interactive learning experience.

Kahoot offers both free and paid versions with different features. The free version allows up to 50 players, 5 teams, and a teacher group of up to 5 people. It provides formative assessment reports and supports multiple-choice questions, images as answers, and access to a GIF library.

Using Kahoot in the classroom

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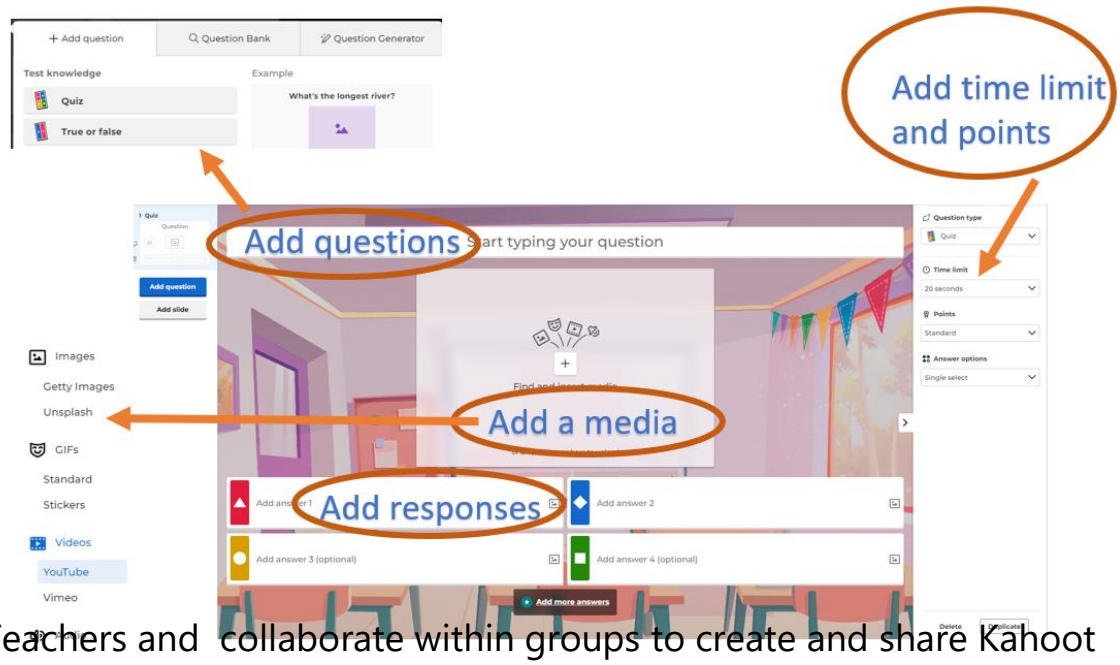
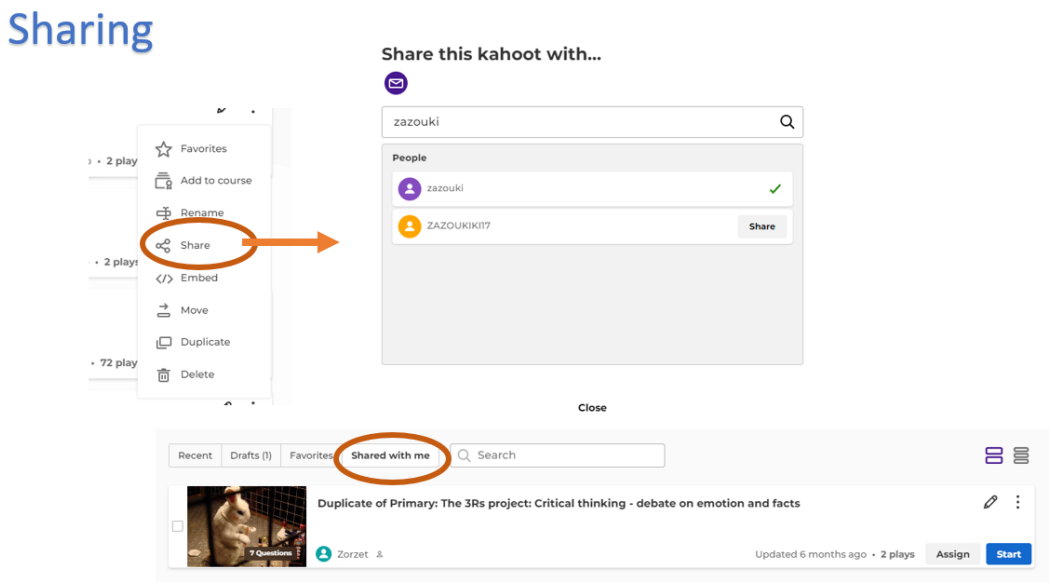
- Create interactive for real-time online quizzes and quiz-based games:
-



- Teachers and collaborate within groups to create and share Kahoot quizzes, surveys, games or discussions.



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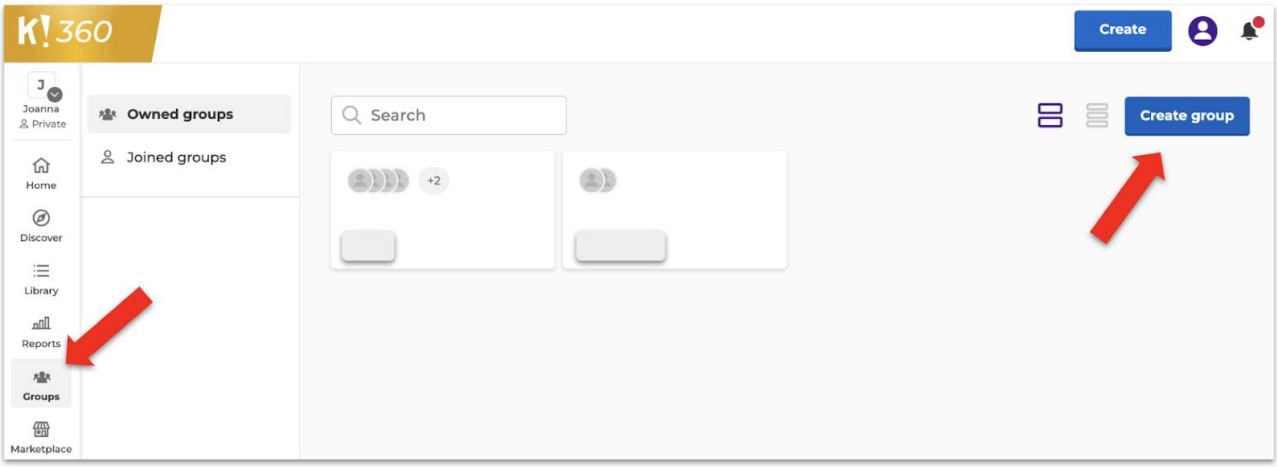
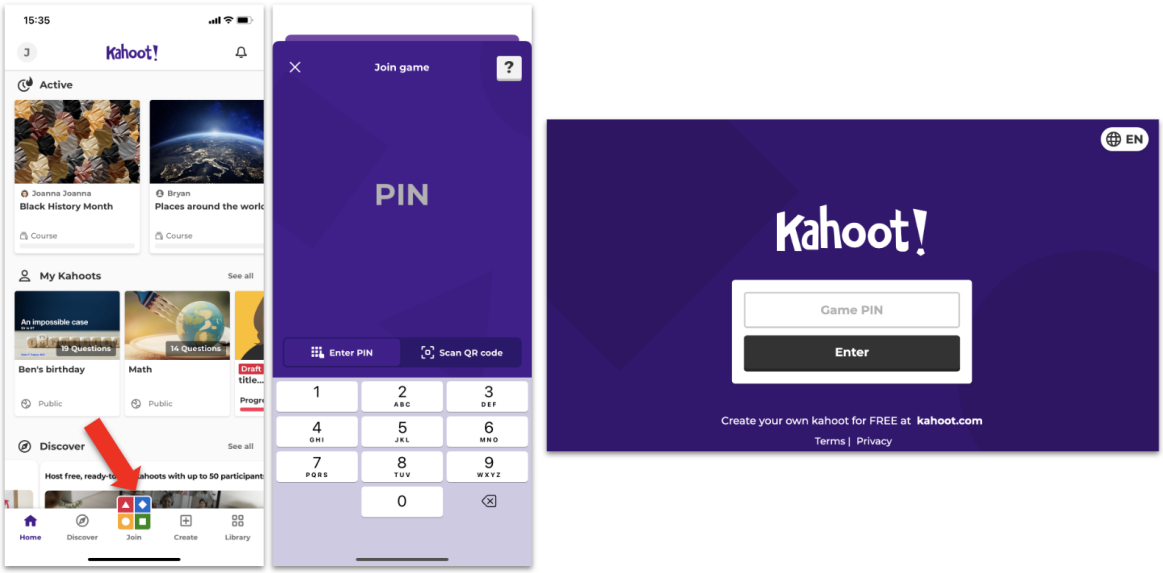


- **Students** can access a **Kahoot quiz** by entering the **unique game PIN** provided by their teacher on the Kahoot website or app. Once they join, they can participate in the interactive quiz or activity by selecting their answers within the given time limit. During a Kahoot session, **all students join and play the game in real time**, answering questions simultaneously. As they submit their answers, a live leaderboard displays their scores, allowing them to compete and compare their performance with their classmates.



Tutorials

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- Help and Support Center (https://support.kahoot.com/hc/en-us)
- Kahoot Guides playlist

(https://www.youtube.com/@getkahoot/playlists)

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10.7 Teacher's resources on sustainability & Learning communities

- **Gynzy -Terra Mission** is an interactive learning program for primary and secondary school students about the Earth and its climate. It is available in six languages: Dutch, German, Greek, Italian, Portuguese and Spanish: https://www.gynzy.com/en/topic/terra-mission .
- **52 steps towards a greener city** is a booklet with 52 suggestions on how to support urban biodiversity throughout the year from the materials of the European Learning Corner, available in all EU languages, designed for students aged 12 and above: https://tinyurl.com/579vcuds
- **Know your pollinators** is a card game learning material from the European Learning Corner, available in all EU languages that teaches about the importance of pollinators for biodiversity and food security (9 to 15 years old): https://learning-corner.learning.europa.eu/learning-materials/know-your-pollinators_en
- **Youth & Climate** is part of the European Climate Action website with materials about climate change, quizzes, board game and publications for young people available in all European languages: https://climate.ec.europa.eu/citizens/youth-climate_en
- The Education for Climate Coalition is the European participatory community to support teaching and learning for the green transition and sustainable development: https://education-for-climate.ec.europa.eu/community/

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