MISSION:STEAM
A guide for ethnic minorities in STEAM

Handbook for teachers

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MISSION STEAM

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MISSION STEAM

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Summary

The MISSION:STEAM project identifies and creates the opportunities for children coming with a minority background to be engaged with STEAM activities and further follow the STEAM pathways through education and trainings from the early ages of life (primary school).

Researches show (e.g. Olsson, M., & Martiny, S. E. (2018), Steinke, J. (2017) women and men form gender roles in childhood, largely based on their exposure to media and popular culture.For example, talking with friends and family about science and consuming science media in childhood is predictive of STEAM identity in further career choice. Another research "Implementing STEAM in the Early Childhood Classroom" - compliments the idea by stating that providing meaningful hands-on STEAM experiences for early childhood and elementary age children positively impacts their perceptions and dispositions towards STEAM.

Planned results

R1 - MISSION:STEAM e-Hanbook and Curriculum (incl. Pedagogical Model, Lesson plans, Worksheets). The handbook will be produced in 7 different languages: Lithuanian, Portuguese, Russian, Polish, Ukrainian, Italian, Spanish - fot those coming with ethnic minority background. And common version in English.

R2 - MISSION:STEAM Science on the Sofa weekends (incl 18 live-stream online lessons in 7 different languages: Lithuanian, Portuguese, Russian, Polish, Ukrainian, Italian, Spanish).

R3 - MISSION:STEAM Community learning platform (incl. 18 edited online lessons in n 7 different languages: Lithuanian, Portuguese, Russian, Polish, Ukrainian, Italian, Spanish; Lesson plans and Worksheets for download, Pedagogical Model)

Target group

The main target group are primary school students with ethnic minority background, 6 to 12 years old. They will be invited to join online educational activities (O2/A5) using their parents help to connect (if needed). They will reached by using media, social networks, national educational networks, NGOs and schools, some of which are associated partners

The future of jobs

With the increasing use of emerging technologies, the need for STEAM- related professions has grown. Additionally, the Covid-19 pandemic has created a highly uncertain outlook for the labor market and accelerated the arrival of careers relying on STEAM competencies as the demand for roles that bridge the gap between humans and machines increases (WEF, 2020).

The Future of Jobs Report 2020 by the World Economic Forum states that the following themes are critical to understanding future labour:

a) The pace of technology adoption is expected to remain unabated and may accelerate in some areas;
b) Automation, in tandem with the COVID-19 recession, is creating a 'double-disruption' scenario for workers;
c) Although the number of jobs destroyed will be surpassed by the number of 'jobs of tomorrow' created, in contrast to previous years, job creation is slowing while job destruction accelerates. (WEF, 2020)

In the face of a rapidly changing global economy and the appearance of new technologies and automatization processes, Science, Technology, Engineering, Arts and Mathematics (STEAM) as a concept has become a central focal point of both a specialist supply-demand relationship, and in turn a challenge for teaching in middle to high school up to university. The challenge of training young people for these types of careers often falls on the shoulders of education policymakers, educators, teachers, and higher education institutions.

The future of jobs

The key aspects within STEM education is adding Arts section in the formula. Having the creativity aspects integrated into the educational paradigm of STEM is directly linked with how creativity is recognized as a key competence of this age, even in hard science fields. There is, however, an overarching challenge within the STEAM field of education and career choice - the overall motivation and engagement of students to study in STEM subjects.

While the idea and benefits of the STEAM curriculum are spreading around the world, it still does not impact each demographic in the same way. It is still the case that those are coming from ethnic minorities are consistently underrepresented in science, technology, engineering, arts and mathematics. For example, in the fields of computer engineering and computer science, there is a substantial disparity between minorities and their counterparts. Of the 5 million employed workers in the computing field, minorities only account for about 30% of employees (A Guide for Minorities in STEM: Increasing Workplace Diversity, March, 2020). At the same time, STEAM practitioners agree that that the manner by which science is taught at the level of primary schools influences students' (including those with ethnic minority background) perceptions and attitudes towards science, and their uptake of STEAM subjects and careers later on (STEM in Primary School, Scientix 2019, EU).

The future of jobs

According to the survey of The attractiveness of STEM subjects (2019) the interest and perception raise while children at the primary school (age 8-12). However, the interest and perception of children from ethnic minorities become a difficult process as they have to face and resolve other issues: adaptation, cultural shock, learning a new language etc. This makes them to stay apart from being engaged in STEAM subject at the age when they are most eager to learn. It is also difficult to learn STEAM subjects in foreign language as it requires additional linguistic skills in order to understand the terminology and the content itself. Young people value learning STEAM subjects and their impact on the world; however, the perception of STEAM studies as being too difficult can hinder their interest later on. Particularly, inability to make first steps in STEAM in the native tongue drops down the chance of young people with ethnic minority background succeed in STEAM careers.

The trends in education

This section briefly describes the educational and learning trends affecting educational changes within the education system worldwide. This summarises aims to investigate and compare global trends in and how they deal with the labour market and educational challenges.

The trends in education

One of the key global trends in education currently is a focus on core competencies or competency-based education. You can observe this trend promoted in countries such as Finland, Canada, Singapore, and Scotland (Dale Frost et.al., 2015). In these jurisdictions and others, there is a significant shift away from content-based curricula towards competency-based learning because organizations have articulated lists of competencies and 'key competencies' which include, for example, 'the ability to use language, symbols, and text interactively' (OECD 2005). This trend will become much more common over time since many systems are looking into how to integrate content and competence (Lavonen, 2020, Levin and Patrick, 2019).

In primary education levels, one can see an increased focus on a play-based approach. This approach is connected to the concept of gamification overall in education methodologies and systems. This part is especially noted in terms of developing creativity in students even in the STEAM environments, adhering to the "Art" part of STEAM (Bozkurt, et. al 2019). Many works emphasize the importance of play to children and cognitive development. As an example, in Pasi Sahlberg's "Let's children play" it is stated that play and physical activity are critical foundations of childhood, academics, and future skills. Even though educational systems tend to shy away from play in childhood education,

The trends in education

they stress the importance of standardization, stress, and forcible physical restraint, which are damaging to learning and corrosive to society (LEGO Foundation, 2017, Sahlberg, 2019).

Phenomena-based learning is a multidisciplinary, constructivist form of learning where students study a topic or concept in a holistic approach instead of in a subject-based approach. Because phenomena are embedded in the real world, it is suggested that students can be more engaged (Symeonidis and Schwarz, 2016). Much like the real world, students must investigate phenomena from multiple perspectives - these break down the siloed traditional subject-based approach to learning. Because of the expected increased relevance of the studies, students can take greater ownership of their work (Symeonidis, Schwarz, 2016).

The concept of hybrid learning is becoming more and more popular (Hrastinski, 2019). Following the immediate response to the pandemic, schools in Lithuania started opening partially so students could return in person for a partial school day or a few days a week (UNESCO, 2020). In some cases, this approach will continue to combine online and in-person learning in the class, find new forms of digital classrooms, beyond the pandemic. It is worth mentioning that it is a significant challenge for both students and educators. However, as European economies move further toward automatization, digitalization, and new technologies, it is suggested that this trend will become more prevalent.

The trends in education

Socio-emotional learning. The role of design and neurobiology in terms of how we design the learning spaces is an additional concept for consideration. There is a large pool of research (Altmann, 2015, Shamaki, 2015, Lisiane Closs, Marian Mahat & Wesley Imms, 2021) pointing to how learning environments influence learning achievements. Different design elements, such as daylight, temperature, acoustics, and color have the most influence on students, and when designed precisely can positively affect the learning process (Bojer, 2021).

Furthermore, the COVID-19 crisis has shown the importance of individuals' human relationships and well-being. The pandemic has dramatically influenced contemporary learning experiences, as most educational institutions in Europe have adopted either a virtual educational experience or a hybrid model with a mix of in-person learning and virtual learning. School closures have had a heavy impact on all students, but especially on the most vulnerable ones who are more likely to face additional barriers: children and youth from low-income and single-parent families; immigrant, refugee, ethnic minority, and those with special education needs. They risk falling further behind and becoming isolated with school doors closed (National Foundation for Education Report, 2020).

STEAM Education at glance

The term "STEAM education" refers to teaching and learning in the fields of science, technology, engineering, art, and mathematics; typically including educational activities across all grade levels, from pre-school to universities, and in both formal and informal classroom settings (Gonzalez, & Kuenzi, 2012). STEAM education is not just a collection of single subjects. It is also a teaching and learning philosophy, an integrated approach to teaching subjects under its umbrella. It requires an intentional connection between standards, lesson design and implementation, final assessment, and reflection.

Thinking outside the box, meshing different subjects and disciplines prepares the students for real-life problems they will face in any career path regardless of whether it is STEAM or humanitarian based.

It is suggested that using an interdisciplinary, or integrated, curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for students (Jacobs, 1989). The philosophy of interdisciplinary teaching consists of three principles related to: (1) the way students best acquire knowledge; (2) the important role of not only reaching students during their developmental stage but influencing the teaching of subjects; and (3) the cooperative involvement of both students and teachers in planning and learning together to modify the instruction of the end product-the students (Jacobs, 1989; Antonellis & James, 1973).

STEAM Education at glance

In a way, we can modify the education system where the relationship between science, engineering, design, and art is holistic and interconnected, where the input for one domain becomes the output for another. Science converts information into knowledge, engineering converts knowledge into utility, design converts utility into cultural behavior and context, and art converts cultural behavior and questions our perception of the world (Oxman, 2020).

STEAM education is not only designed to teach students those subjects but also help them to develop 21st-century skills such as analytical thinking, teamwork, leadership, problem-solving, resilience, confidence, and creativity, which are deemed as key competencies in technology-driven careers. STEAM education can play a crucial role as young people will need to meet and solve global challenges that impact our living. Therefore, students will need deep learning (Fullan, Quinn, McEachen, 2018) – an education system that helps them develop critically necessary skills of the 21st century: problem-solving, creativity, ability to work in a team, social interaction through communication and resilience. To create such learning, we need fundamental changes in what and how students learn. This, of course, does not mean we need to waive traditional subjects like languages and grammar, geography, history. Along with this, students will be required to have skills of analytical thinking and innovation, active learning, leadership, technology use, etc. (OECD, 2018, WEF 2020, HolonIQ 2018).

In general, people will need to learn to absorb a lot of information and adapt to new conditions in the world. Therefore, the primary goal of educators becomes not to prepare kids and young people for the future knowing a specific path, but rather to teach them to be responsible, accept challenges, and feel confident.

Kids as problem solvers

As educators, we can start introducing STEAM knowledge to kids at an early age. Even toddlers engage in hands-on activities that involve STEAM skills without realizing it. Children naturally explore and investigate their environment by building structures, manipulating shapes, pouring liquids into containers of different shapes and sizes, and mixing colors to create new ones. These activities are great examples of STEAM skills in action.

As adults, we can provide children with opportunities and resources to support their investigation and discovery. We can create a learning environment that fosters collaboration, interaction, and examination, which are essential elements of STEAM activities. When children are encouraged to explore and investigate, they feel a sense of satisfaction from discovering and solving problems.

Interdisciplinary learning in STEAM

Interdisciplinary STEAM education is the pedagogical approach by which students learn the interconnectedness of the disciplines of science, technology, engineering, art and mathematics.

Interdisciplinary STEAM education also provides a platform to introduce problem-based learning, cooperative learning, expand problem-solving capabilities, and introduce students to the use of engineering design.

Several research studies suggest that when students are introduced (early) to the STEAM disciplines through integrated and problem-centered learning activities, they are more likely to remain engaged throughout formal education and are more likely to enter one or more of these fields as a career

In this section we will take a short look how the subjects are interconnected and compliment each other while implementing STEAM activities.

Science

In science, students learn about the natural world, how it works, and how to explain and predict phenomena. They use scientific inquiry and methods to gather data, conduct experiments, and develop models that explain and predict natural phenomena. For example, in physics, students learn about the laws of motion, gravity, and thermodynamics, while in biology, they learn about the cell, genetics, and ecology.

In STEM education, science provides a context for students to learn and apply other disciplines such as mathematics, engineering, and technology. Science is often the starting point for engineering design challenges or technology-based projects. For example, in a STEAM class, students may study the science of energy and then apply that knowledge to design a more efficient wind turbine.

Technology

In STEAM education, technology is an important tool for teaching and learning. It enables students to access information, collaborate with others, and create new products and services.

For example, in the context of science, technology is used to gather and analyse data, develop new theories, and test hypotheses. For example, in biology, technology is used to study cells and organisms, such as through microscopy or genetic sequencing. In chemistry, technology is used to analyse compounds and study their properties, such as through spectroscopy or chromatography.

In engineering, technology is used to design and build systems, machines, and structures that solve problems and meet human needs. For example, in civil engineering, technology is used to design and build bridges, roads, and buildings. In mechanical engineering, technology is used to design and build machines, engines, and vehicles.

Engineering

Engineering is an essential component of STEAM because it connects scientific and mathematical theories to real-world applications. Engineers use their knowledge of physics, chemistry, and mathematics to design and build systems and structures that solve problems and meet the needs of society.

In addition, engineering also involves the development of new technologies and materials that enable innovation and progress in various fields such as manufacturing, construction, transportation, energy, and more.

Art

Art and STEM education can be connected in various ways. Both fields require creativity, critical thinking, and problem-solving skills. Integrating art into STEM education help students develop these skills in new and unique ways, and can also provide opportunities for interdisciplinary learning and collaboration.

For example, STEAM projects that incorporate design elements from the arts can help students better understand and communicate their ideas, while art projects that use technology and engineering principles can broaden students' perspectives and deepen their understanding of the technology they use. Additionally, the integration of art and STEM can help prepare students for careers in fields that combine these disciplines, such as design, architecture, and video game development.

Mathematics

In STEM fields, mathematics is used to describe and quantify natural phenomena and relationships between variables. It helps us understand the world around us by providing a language to express ideas and concepts. For example, in physics, math is used to describe the laws of motion and the behavior of objects in space. In biology, math is used to model population growth and the spread of diseases. In civil engineering, math is used to design structures that can withstand natural forces, such as earthquakes or hurricanes. In electrical engineering, math is used to design circuits and control systems.

In technology, mathematics is used to develop algorithms and software that power many devices and applications. It is used to analyze data, make predictions, and optimize systems and processes.

How to speak STEAM language?

Children should play an active role in the learning process. They gain knowledge and skills by interacting with the world and building knowledge structures based on their own experiences. As Piaget explained, “Children have real understanding only of that which they invent themselves, and each time that we try to teach them something too quickly, we keep them from reinventing it themselves.” Learning should be an open-ended, creative process that results in a finished project that can be shared with others.

In this chapter we will be going through a number of hands-on approaches which allows children to keep them motivated in learning and growing.

Challenge-based learning and Problem-based learning

Before we go you may probably have a question in mind “What is the difference between Problem-based learning and challenge-based learning?”

Challenge-based learning and project-based learning are both instructional approaches that promote active learning and student engagement. However, they differ in terms of their focus, structure, and outcomes.

Challenge-based learning is a teaching approach that starts with a complex real-world problem or issue, which students investigate and attempt to solve collaboratively. The focus is on developing childrens' critical thinking and problem-solving skills, as well as their ability to work in teams, communicate effectively, and take action. The process usually involves several stages, including identifying the problem, researching the issue, developing and testing solutions, and reflecting on the learning process. The outcome is often a proposed solution or a plan of action to address the problem.

Project-based learning, on the other hand, is a teaching approach that involves students working on a specific project or task for an extended period of time, often several weeks or months. The focus is on developing students' knowledge and skills in a particular subject area, as well as their ability to work independently, manage their time, and present their work. The process usually involves several stages, including planning, research, implementation, and presentation. The outcome is often a product or artifact, such as a model, a report, or a presentation.

What is CBL?

Challenge Based Learning provides an efficient and effective framework for learning while solving real-world Challenges. The framework is collaborative and hands-on, asking all participants (students, teachers, families, and community members) to identify Big Ideas, ask good questions, discover and solve Challenges, gain in-depth subject area knowledge, develop 21st-century skills, and share their thoughts with the world.

The Challenge Based Learning framework emerged from the “Apple Classrooms of Tomorrow—Today” (ACOT2) project initiated in 2008 to identify the essential design principles of a 21st-century learning environment. Starting with the ACOT2 design principles, Apple, Inc. worked with exemplary educators to develop and test Challenge Based Learning.

Challenge Based Learning builds on the foundation of experiential learning and leans heavily on the wisdom of a long history of progressive ideas. The framework is informed by innovative ideas from education, media, technology, entertainment, recreation, the workplace, and society.

The Challenge Based Learning Framework divides into three interconnected phases: Engage, Investigate, and Act. Each phase includes activities that prepare the Learners to move to the next stage. Supporting the entire process is an ongoing process of documenting, reflecting and sharing.

The process of CBL

Phase 1: Engage
Through a process of Essential Questioning, the Learners move from an abstract Big Idea to a concrete and actionable Challenge.

1. Big Ideas are broad concepts that are explored in multiple ways and are relevant to the Learners, and the larger community (e.g. health).
2. Essential Questioning allows the Learners to contextualise and personalize the Big Idea. The end product is a single Essential Question that is relevant to the individual or group (e.g. What do I need to do to be healthy?).
3. Challenges turn the Essential Questions into a call to action by charging participants to learn about the subject and develop a Solution. Challenges are immediate and actionable

Phase 2: Investigate
All Learners plan and participate in a journey that builds the foundation for Solutions and addresses academic requirements.

1. Guiding Questions point towards the knowledge the Learners will need to develop a Solution to the Challenge. Categorizing and prioritizing the questions create an organized learning experience. Guiding Questions will continue to emerge throughout the experience.
2. Guiding Activities and Resources are used to answer the Guiding Questions developed by the Learners. These activities and resources include any and all methods and tools available to the Learners.
3. Analysis of the lessons learned through the Guiding Activities provides a foundation for the eventual identification of Solutions.

The process of CBL

Phase 3: Act
Evidence-based Solutions are developed, implemented with an authentic audience, and then evaluated based on the results.

1. Solution concepts emerge from the findings made during the investigation phase. Using the design cycle, the Learners will prototype, test and refine their Solution concepts.
2. Implementation of the Solution takes place within a real setting with an authentic audience. The age of the Learners and the amount of time and resources available will guide the depth and breadth of the implementation.
3. Evaluation provides the opportunity to assess the effectiveness of the Solution, make adjustments and deepen subject area knowledge.

Each of the phases and the steps are explored in greater detail in chapter three. Before diving deeper into Challenge Based Learning, some thinking about planning and preparation is necessary.

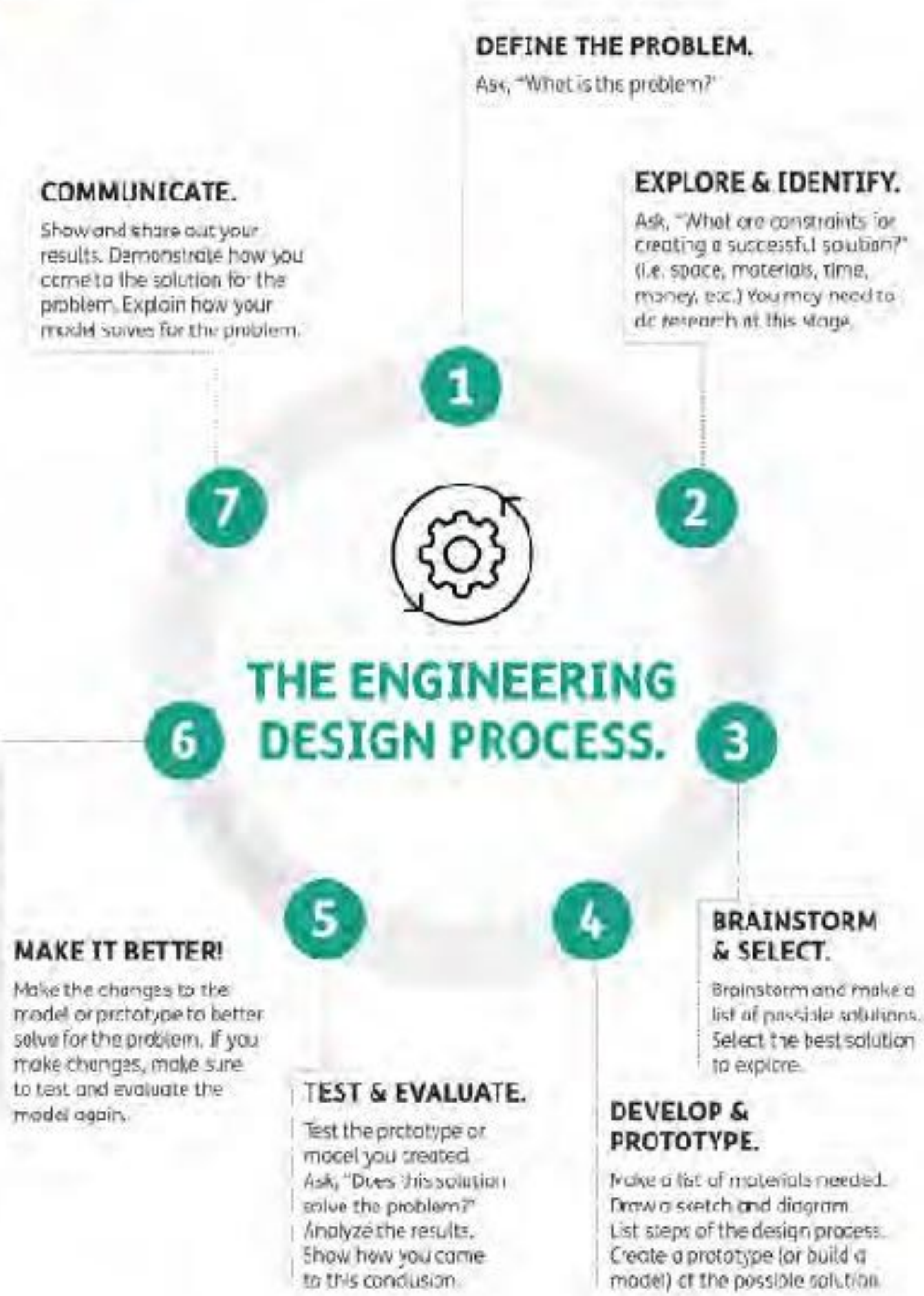
Foundation of a project-based learning

A great way to elicit and sustain intrinsic motivation is getting students to work on real-world problems. Understanding the kids' perspective "When people work on projects they care about, they're willing to work longer and harder", writes Mitchel Resnick, one of the creators of Scratch and professor of learning research at MIT Media Lab. A student of 20th-century education reformer Seymour Papert, Resnick has concluded after decades of research that the four key components of creative learning are projects, passion, play and peers.

With problem-based learning, we can engage even those who are less interested in such topics. For example, if we're teaching Mendel's genetic principles, we should choose a problem related to the students' daily lives, which they won't be able to solve without applying Mendel's laws. This will help the kids understand and remember the material, and apply their knowledge later on

Problem-based learning goes hand-in-hand with hands-on learning. If we ask our students to design sustainable systems that will ensure the survival of people on Mars, they can also model these solutions. This way they learn abstract concepts experientially, through working together, not just in theory

Foundation of a project-based learning



Design Sprint

One of the most innovative approaches towards CBL is the Design Thinking/Sprint (DTS) methodologies. These easy to use and implement methodologies can be employed in order to create CBL/PBL activities in learning environments.

Design Sprint is intended to be used within the framework of CBL where students can develop soft skills. The CBL/PBL approach seeks to have students develop a project providing real solutions to real problems in a technology rich environment incorporating 21st century skills (Conde et al., 2021). This way we can simulate real world problems and create life- like solutions to them while incorporating critical knowledge and skills from STEAM disciplines.

Inquiry-based learning in STEAM education

Inquiry-Based science education is a process whereby children and young people answer their own questions and satisfy their curiosity about the world around them through experiments.

When it comes to science and technology, children have an insatiable thirst for knowledge and boundless curiosity. Trying things out for themselves leads to new experiences, ideas, and conclusions. Educators are putting this to good use. With inquiry-based learning, children and young people learn to pose their own questions before applying different methods to find answers, reflect on the results, and process what it means to them as individuals (The Future of learning, 2015).

Inquiry-based education begins with questions that come from the everyday experiences of children and young people. Children are constantly observing the phenomena of their environment and everyday lives. They describe, compare, and interpret these experiences. This is where classroom lessons need to begin. The only way for a lesson to really stick is when a young learner can recognize the real-life relevance of a subject. More importantly, this connection is a motivator when it comes to exploring that subject further (Interdisciplinary thinking and activity become givens rather than exceptions.

Inquiry-based learning in STEAM education

IBL teaching begins either by asking questions or making observations or describing a particular scenario. The specific processes students should ideally undergo are as follows:

Make a conjecture
Devise their own questions
Obtain evidence to be able to answer their questions
Explain the evidence gathered
Link this explanation to the knowledge obtained during the research.
Create an argument and a justification for the explanation or else make a new conjecture and begin the cycle again.

Game-based learning and gamification.

These two concept might be interchangeable, however they are two separate techniques to enhance the learning-teaching experience. Gamification is turning the learning process into a game, while game based learning is using a game as part of the learning process.

When it comes to game based learning the STEM fields there are two main approaches a teacher can take. This is the traditional approach where games are used in the process of teaching be it in gamification of learning or using separate games such as board games with a STEM topic. The other route is to use various digital games created specifically for learning and teaching STEM. These, for example, are VR chemistry, physics, biology or engineering games.

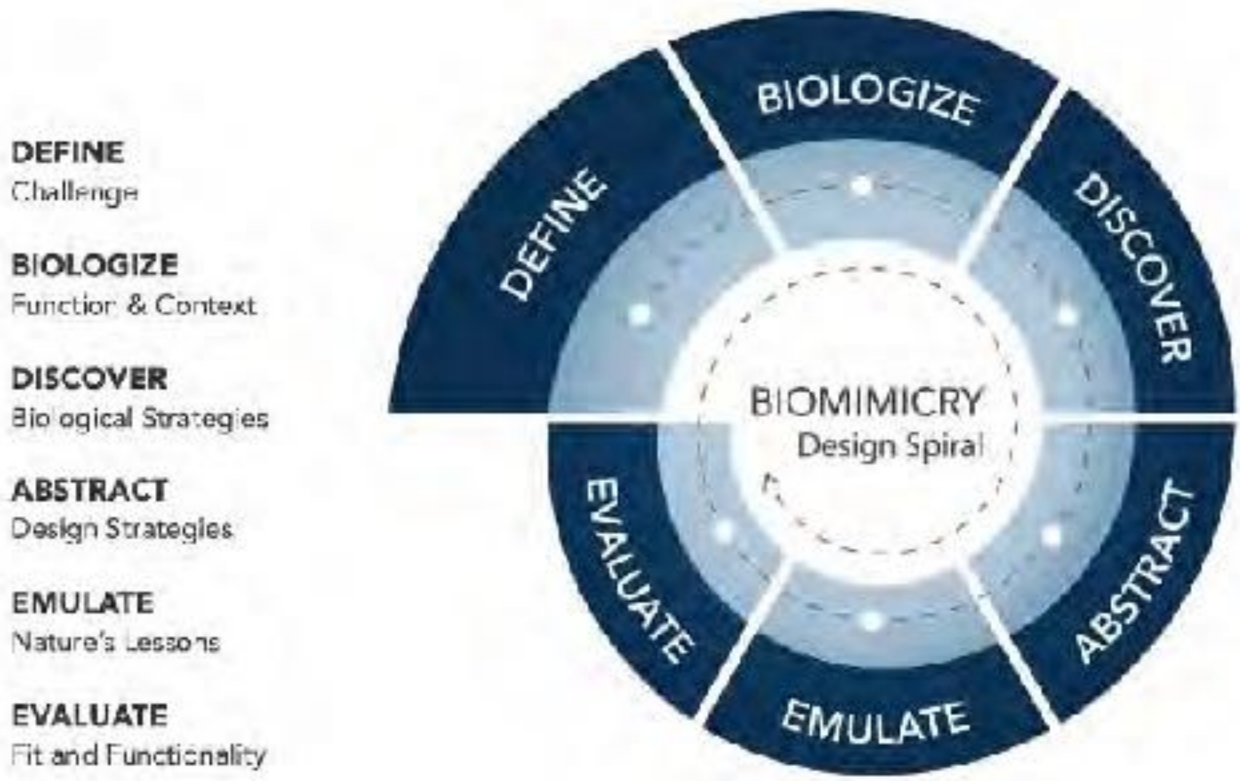
GAMIFICATION	GAME-BASED LEARNING
Gamification is adding game elements to a non-game scenario. You reward certain behaviors with benefits or by "unlocking" new features or services.	Game-based learning (GBL) flips gamification on its head. Rather than implement game-like tropes into lessons, GBL uses actual games to teach.
Adding game-like elements (badges, experience points, etc.) to a lesson	**Using games (such as Minecraft) to teach** specific learning objectives
Motivation: Likely **extrinsically rewarding**. I.E. the reward is tied to grades.	Motivation: Games are designed to be **intrinsically rewarding**. May also be extrinsically rewarding.
Assessment is **not within** the "game."	Assessment is **in-game**.
Game-like aspects are adjusted to fit the lesson content.	**Lesson content is adjusted** to fit the game.

Biomimicry – nature inspired solutions

Teaching through the lens of biomimicry offers opportunities to reconnect students with the wonders of our natural world.

Biomimicry is the practice of applying lessons from nature to the invention of healthier, more sustainable technologies for people. Biomimetic designers ("biomimics") focus on understanding, learning from, and emulating the strategies used by living things, with the intention of creating designs and technologies that are sustainable.

The Biomimicry Design Spiral is a helpful tool for learning the steps that are critical to successful biomimetic design. Use it when you are interested in solving a specific problem (a "challenge") or see a design opportunity and want to look to biological models for inspiration.



Biomimicry – nature inspired solutions

Challenge to Biology Design Process

DEFINE
Clearly articulate the impact you want your design to have in the world and the criteria and constraints that will determine success.

BIOLOGISE
Analyze the essential functions and context your design solution must address. Reframe them in biological terms, so that you can "ask nature" for advice.

DISCOVER
Look for natural models (organisms and ecosystems) that need to address the same functions and context as your design solution. Identify the biological strategies that support their survival and success.

ABSTRACT
Carefully study the essential features or mechanisms that make the biological strategies successful. Use plain language to write down your understanding of how the features work, using sketches to ensure accurate comprehension.

EMULATE
Look for patterns and relationships among the strategies you found and hone in on the key lessons that should inform your solution. Develop design concepts based on these strategies.

EVALUATE
Assess the design concept(s) for how well they meet the criteria and constraints of the design challenge and fit into Earth’s systems. Consider technical and business model feasibility. Refine and revisit previous steps as needed to produce a viable solution.

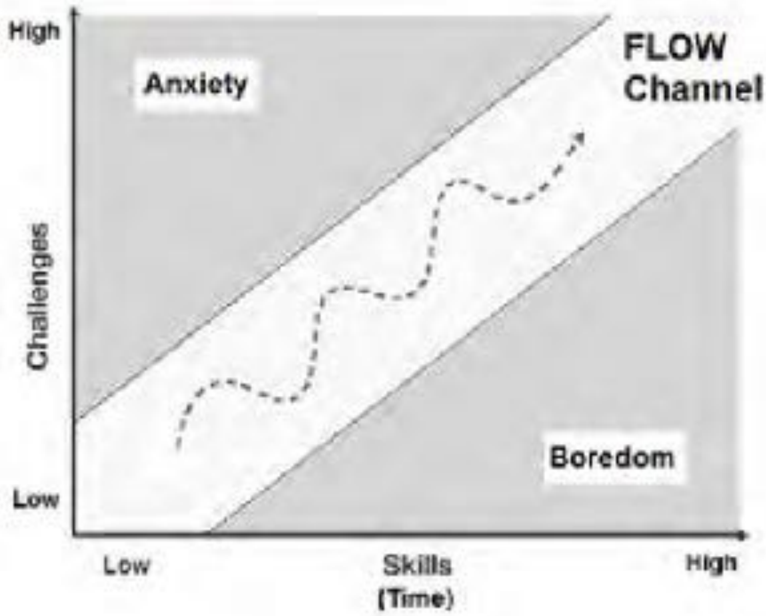
Importance of play in STEAM

When using play to build STEAM skills, you are also helping foster a healthy, natural relationship with learning and education. Your child will begin to associate fun with the process of learning new things. Some studies even show children who get exposed to STEM learning at a young age often become more self-confident and possess a learning-based mindset. There is a growing need for STEM thinkers: As the world evolves and science, technology and computers become more ingrained in our daily lives, the demand for STEM thinkers grows. Indeed, the need for STEM professionals in the workforce is growing two times faster than non-STEM careers. Research suggests the younger children begin learning STEM, the more likely they are to understand and pursue STEM-related careers later on. Preschool may be a bit early to think about a child's career, but it is never too soon to begin building the foundation for a life of learning and study.

A child metaphorically during the play experiences an authentic learning environment, which allows facing real-life situations related to STEAM fields by staying in a comfort zone and experiencing what some call a "roller coaster ride". Children feel varying comfort levels as they move through the process and the challenges.

The "Flow Model" (fig. 1) by Mihalyi Csikszentmihalyi describes this roller coaster experience. The model illustrates how learners reach the state of "flow" – when our competence match the challenge we face are in balance with each other. The model also shows that a lack of challenge leads to boredom and how being faced with too great challenges creates anxiety. The model further shows how our personalities become more complex (competent) due to our experiencing flow (high-point experiences / high quality of life). Effective learning occurs when we are genuinely engaged in something and doing something we desire to do (Csikszenmihalyi, 1991).

Importance of play in STEAM



Conditions for Flow:

1. Clear goals.
2. Balance between perceived challenges and perceived goals.
3. Clear and immediate feedback

The research (2018) shows that today's parents are increasingly aware of the power play has to shape their child's personality, skills and emotional intelligence in the early years. More than 9 in 10 parents believe play is essential to their child's wellbeing, happiness and development. They recognise play helps build the skills that lead to academic success, but also how play helps foster creative, sociable, emotionally-resilient adults.

Some useful questions to be done while “steaming” with children

Children are pure researchers. They try to know and investigate how the world works. They become scientists and this “job” involves: to observe, to make questions and predictions as well as experimenting and discussing while they are exploring the world around them.

Like “little genuine scientists”, children usually learn from others. They watch what children and adults do and learn from trying to copy what they’ve observed or by asking questions and then, they just watch the results.

While teachers are observing what children are doing, they can ask them some questions and then work and practise with them; in this way, teachers can help them to advance their own knowledge and interpretation of the world. Some of the questions, adults (teachers or parents) can make them to help to walk through progressively complex ways of thinking can be as follows:

Let’s investigate:

How are they different?
What do you notice?
What happens when you try?
What is changing?
You seem curious about...
What did you try?
What were your predictions?
What do you see?
What happened?
What do you hear?
What did you notice?
How do they sound and smell?
Why do you think that happened?
How are they the same?

Asking questions benefits children to make them reflect on what they are trying to do, to know if it works or not, and how to plan their next steps. On the other hand, listening to children will help teachers to learn how to

help them to extend their learning which will also support children in participating and continuing when solving problems.

How to establish online STEAM environment

Online classes pose a new challenge for teachers who have spent their careers honing their abilities on in-person teaching. It’s no exaggeration to say that, after Covid, online classes are here to stay since they have offered a convenience if the circumstances of time and space require it. But how can a teacher bring STEAM effectively to the student’s screen?

It may feel like the lack of a classroom space, proper equipment and real-life presence is limiting; but from online resources to easy home activities and games, the task isn’t so difficult as it may initially seem.

How to organise STEAM activities online ?

Organise
For the educator, it is important to plan ahead. Keep the space comfortable and distraction-free, pleasant to look at for the students and able to convey a feeling of security and confidence. Check lighting, background clutter and limit interruptions that may side-track the lesson. Have clear image and sound equipment, so the students can feel closer to a physical classroom experience.

Plan out the lesson with an outline and/or a time schedule. Think where to place the theory, the activities and any breaks to maintain a good balance during the lesson that will keep the students' focus and interest. Manage time carefully -the lack of a bell shouldn't leave the course dragging on. Lastly, implement interactive tools and technologies to make the class easier and more interesting, and continuously add to your digital skills. Learn good use of class platforms like Zoom to benefit from all its features, as well as other platforms such as Google apps for real-time teamwork.

Speak STEAM - Encourage discussion
Educators need to be able to include conversations in their online classes. This engages the students and keeps them focused, through asking questions and making them think with the aim of guiding them to problem solving.

What happened in this activity? What did you observe? Why do you think it happened? What do you think would happen if you changed this? Allowing the students to be heard on the topics of STEAM and present their own thoughts towards the solution is essential for their confidence and participation in the online environment.

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Offline activities from home

The absence of a physical classroom doesn't mean activities need to be limited to a screen. With a little creativity, teachers can provide many different learning activities that the students can recreate at home, in real time or at another point, alone or with the help of their parents.

Paper airplanes to teach about flight, building a bridge or a car with kitchen materials to teach about engineering, making a pillow fort or a castle in a room to teach about architecture and art. These are just a few examples of fun activities children can do at home to apply the theory into action by engaging their senses, based on which the teacher can then hold discussions.

Encouraging outdoor activities to do at home is also very important for students to interact with their environment away from the screen. Making sun clocks, testing boat buoyancy, finding and sorting rocks, are a few fun ways students can connect with the outdoors without straying far from their house.

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Incorporating interactive and hands-on elements in the online STEM activities.

1. Incorporating interactive simulations and games: Using simulations and games can make the learning experience more engaging and interactive, helping kids stay focused and motivated.
2. Encouraging hands-on projects and experiments: Providing opportunities for kids to work on hands-on projects and experiments can help them learn by doing, and can make the learning experience more engaging and memorable.
3. Using virtual reality and augmented reality: Incorporating virtual reality (VR) and augmented reality (AR) can help create a more immersive and interactive learning experience, bringing STEM concepts to life in new and exciting ways.
4. Encouraging collaboration and peer-to-peer learning: Allowing kids to work together and learn from each other can help create a more engaging and dynamic learning environment, and can help foster important social and emotional skills.
5. Providing immediate feedback and support: Offering immediate feedback and support can help kids stay engaged and motivated, and can help them feel more confident in their abilities and understanding of the material.

Online resources

There is a plethora of information and resources out there that the teacher can use to enrich their online courses, both by studying them beforehand and by interacting with them together with their students.

There are a few free European resources available to use. One of those is Science is Wonderful!, which gives primary and secondary school students the chance to interact with leading researchers and innovators, learn more about their work in engaging formats (such as activities) and ask questions about scientific careers.

Europeana is another resource for the educator, which provides “learning scenarios”, as in course structures the teacher can use regarding STEAM and not only, complete with teaching materials for the educator to use.
How to Smile is a group of science museums dedicated to bringing STEAM out of the academic cloister and into the wider world. On this blog is a collection of STEAM activities educators can choose from to apply in their online classrooms.

Scratch is a simple coding tool where kids can program their own interactive stories, games, and animations — and share creations with others in the online community. Scratch helps young people learn to think creatively, reason systematically, and work collaboratively.

Odyssey of the Mind is an international educational program that provides creative problem-solving opportunities for students from kindergarten through college. Team members apply their creativity to become problem solvers.

Online resources

In the National Gallery of Art you will find grade-level-specific lesson plans organized into thematic units, each focusing on a single work of art and able to be executed within one to two class periods. The Art Institute of Chicago also provides similar content targeted to educators.

CIESE (Center for Innovation and Science Education) sponsors and designs interdisciplinary projects that teachers throughout the world can use to enhance their curriculum through compelling use of the Internet.

These are just a few examples of the numerous freely available resources a teacher can use to make the online STEAM experience more enjoyable for the students.

SMART GAMES

National Geographic Kids for biology, history and science games and experiments
Smithsonian STEM games includes a variety of games on life science, engineering, earth science etc.
BrainPop includes programming and science games, among other information useful for the educator
NASA Kids Club is an initiative where kids can explore space through a series of interactive games.
Science Kids for science experiments, games and resources
Turtle Diary for science games, quizzes and resources
Gizmos for interactive math and science labs and virtual simulations for grades 3-12
CodeMonkey for a gaming approach to the introduction to coding

How make team activities online

Distance between students can be only physical. Teachers can implement group work in their activities, either by a score/leaderboard addition or through new creative group activities. These activities and games that support group work promote cooperation and team thinking to guide the team to the solution.

As for platforms, there are many ways to bring a classroom together in real time. Team platforms such as Basecamp can aid in cooperation and interaction on the same topic, where the work of everyone is visible immediately to all members and several communication channels and boards make teamwork much easier.

Another helpful creative platform is Miro, where the educator can create and manage and infinite board on which any content can be added (pictures, video, post-it notes, drawings, text etc). Students can enter through a link and interact with the board in real time, like during the course itself, under the guidance of the teacher.

And of course, the platform used for the course itself, whether it's Zoom or Skype or Microsoft Teams, offers its own tools that the educator can use in the duration of their lesson to aid in the management of the class and its distinct groups during team work.

Make space online

The easiest way to provide engaging content and information before, during and after an online class is online spaces that students can access from their own devices. The educator may use these spaces to include information on the course and useful links, provide a communication channel between the students themselves and allow them to share their own material with the rest of the class.

The most accessible and easiest way to create this online space is through Google apps.
On Google Docs, students can work on one common document and make real-time changes in the same text.
Google Drive can provide a wide range of free productivity tools to create, collaborate and sync files across devices.
Interactive learning can be made easy with Google Hangouts, where communication, learning and fun converge into a single simple platform.
Google Sheets can introduce students to the concept of statistics and commands in terms adjustable to the educator's preference and the students' capabilities.
Google Classroom is a blended learning platform for educational institutions that aims to simplify creating, distributing, and grading assignments.
With Google Slides, students can unravel their creative skills to make presentations unique to their ideas, while the educator can also use this tool to make their lessons more interesting and easy to follow.

Design of an activity

This text is assumed to provide you with a guiding principles how to create an activity for primary school kids (age 6-12).

Process

- Think about the topics you want to discuss with students. Make sure it is related to real-life situations (architecture, climate change, space travel etc.).
- Once you agreed on the topic for activity you should prepare a lesson plan:
  - Theoretical part - the aim of this part is to engage students in activity and to show the purpose why they will be doing the practical work. Length of presentation 17-25 mins. Format - Power point presentation.
  - Every slide should include teacher's note - a text explaining the slide and what should be said to students. Use simple language, don't overwhelm the presentation with complicated terminology or make sure you can explain it in accessible to students way. Don't use too much text. Use more visuals: pictures and videos.
  - At the end of your presentation you should include explanation of the
  - task - Task title, objectives, what tools we will use, time frame.
- When thinking about the tools for practical part, think about simple ones that can be found at home or easily bought at local store (and not expensive).
- Design a simple worksheet template for you activity for students to keep the records (page/two).
- The total length of activity 60-90 mins. It may also be an activity consisting of a few lessons. This could be split eg. 45min+45min.

Design of an activity

Activities that promote executive steam education in schools

1. Establish a STEAM Club: Set up a club for students interested in STEAM topics. Encourage students to explore and share their knowledge on various topics, such as coding, robotics, engineering, and more.

2. Hold Design Thinking Challenges/Design Sprint (DTS): DTS challenges are a great way to get students thinking critically and creatively about how to solve a problem. Break students into small groups and provide them with a problem to solve. Allow them to explore different ideas and come up with creative solutions.

3. Hold a Science Fair: Science fairs are a great way to get students excited about science and engineering. Have students create projects that demonstrate their knowledge and understanding of a STEAM topic.

4. Conduct STEAM Workshops: Organise STEAM workshops to give students hands-on experience with STEAM topics. Have experts come in and teach students about coding, robotics, and other topics.

5. Utilise Technology: Technology is a great way to engage students in STEAM education. Explore websites and apps that teach STEAM topics.

6. Invite Guest Speakers: Invite professionals from STEAM fields to speak to students about their careers. Have them share their experiences and offer advice to students.

STEAM in books

At times, it may be difficult to know any STEAM-related book to review for class planning, and we must know there are many to choose from.

No matter if you train teens or children, there are some fiction and nonfiction books which can help teachers to connect, motivate, and update about STEAM. Here you can find a list for teachers as well as for learners to be used while “Steaming”.

FOR TEACHERS

1. **From STEM to STEAM: Brain-Compatible Strategies and Lessons That Integrate the Arts** by David A. Sousa and Thomas J. Pilecki. Arts activities enhance the skills critical for achieving STEM success, but how do busy STEM educators integrate the arts into the sometimes inflexible STEM curriculum? This new edition of From STEM to STEAM explores emerging research to detail the way.”

2. **Maker Lab: 28 Super Cool Projects** by Jack Challoner. This award-winning science book is bubbling over with entertaining and educational experiments for budding scientists to follow at home or in the classroom.

3. **Awesome Science Experiments for Kids: 100+ Fun STEM / STEAM Projects and Why They Work** by Crystal Chatterton. Hands-on projects to get kids ages 5 to 10 excited about science. When kids grow older, they become more and more curious about the world around them and they often may ask, “How does this work?” Awesome Science Experiments for Kids teaches young brains scientific methods using fun, hands-on experiments designed to show kids how to theorise, experiment, investigate and even record their findings.

STEAM in books

4. **The Big Book of Makerspace Projects: Inspiring Makers to Experiment, Create, and Learn** by Colleen and Aaron Graves. This book offers practical tips for beginners and open-ended challenges for advanced makers. Each project features non-technical, step-by-step instructions with photos and illustrations to ensure success and expand your imagination. You will learn smartphone tweaks, paper circuits, e-textiles, musical instruments, coding and programming, 3-D printing, etc.

5. **A Month-by-Month Schoolwide Model for Building Meaningful Makerspaces** by Lacy Brejcha. This book provides field-tested and research- based knowledge that will serve educators as they create and maintain a meaningful makerspace. Although science, technology, engineering, arts, and maths have made huge gains in the past decade, STEAM jobs are not being filled at the rate they are being created or needed. It promotes innovative thinking in students that fills this need.

FOR CHILDREN

1. **See You in the Cosmos** by Jack Cheng. Eleven-year-old Alex Petroski loves space and rockets, his mom, his brother, and his dog Carl Sagan — named for his hero, the real-life astronomer. All he wants is to launch his golden iPod into space the way Carl Sagan (the man, not the dog) launched his Golden Record on the Voyager spacecraft in 1977.

2. **The Girl Who Thought in Pictures: The Story of Dr. Temple Grandin (Amazing Scientists)** by Julia Finley Mosca. There's a name you should know. Meet Dr. Temple Grandin — one of the world's quirkiest science heroes! When young Temple was diagnosed with autism, no one expected her to talk, let alone become one of the most powerful voices in modern

STEAM in books

science. Yet, the determined visual thinker did just that. Her unique mind allowed her to connect with animals in a special way, helping her invent groundbreaking improvements for farms around the globe!

3. **Maya Lin: Artist-Architect of Light and Lines** by Jeanne Walker Harvey. As a child, Maya Lin loved to study the spaces around her. She explored the forest in her backyard, observing woodland creatures, and used her house as a model to build tiny towns out of paper and scraps. The daughter of a clay artist and a poet, Maya grew up with art and learned to think with her hands as well as her mind. From her first experiments with light and lines to the height of her success nationwide, this is the story of an inspiring American artist: the visionary artist-architect who designed the Vietnam Veterans Memorial.

4. **Code Your Own Games! 20 Games to Create with Scratch** by Max Wainewright. Calling all creative young gamers! With its easy-to-follow, illustrated step-by-step instructions, this book will teach you key concepts — like drawing shapes — so you can code your own games. By the end, any kid will be able to make 20 popular games, from Snake to Brick Bouncer.

5. **The Boy Who Harnessed the Wind: Young Readers Edition** by William Kamkwamba and Bryan Mealer. When a terrible drought struck William Kamkwamba's tiny village in Malawi, his family lost all of the season's crops, leaving them with nothing to eat and nothing to sell. William began to explore science books in his village library, looking for a solution. There, he came up with the idea that would change his family's life forever: he could build a windmill. Made from scrap metal and old bicycle parts, William's windmill brought electricity to his home and helped his family pump the water they needed to farm the land.

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