SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

Global Schools Program

Greening STEAM Education

Activities for Primary and Secondary Classrooms

Produced by the Global Schools Program, UN Sustainable Development Solutions Network (SDSN) in partnership with Siemens Energy.

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About the Global Schools Program

The Global Schools Program is an initiative of the UN Sustainable Development Solutions Network in support of UNESCO's Roadmap for Education for Sustainable Development (ESD). The program's vision is to create a world where every primary and secondary school student has the knowledge, values, and skills necessary to respond effectively to this century's most significant challenges and shape a sustainable and prosperous world for all.

Global Schools Program

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Acknowledgements

The Global Schools Program is grateful to the following educators and individuals for providing their expert input into this guide: Amanda Abrom, Lucía Vázquez García, Katja Anger-Delimi, Ahmet Murat Zeytcioglu, Chinasa Gloria, Cynthia Brawner, Garima Singh, Lizzie Muringi, Marti Hendrichs, Nouf Youssef, Raymond Mitchell Africa, Sandra Ospina, Saumya Tripathi, Katrina Taylor, Elyana Zawaideh, Catarina Dos Santos Vara, Sanam Arzoo, Elena Martelli, Semih Esendemir, Sudha Rakesh, Fotoh Louis Fonkeng, Fred Swai Ferdnand, Catarina Suzzi, and Dorothea Mueller.

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7 AFFORDABLE AND CLEAN ENERGY

TABLE OF CONTENTS

Page

Introduction to the guide 4

Part One: STEAM and Sustainable Development Goals 5

STEAM: A holistic educational approach
STEAM and its relation to the SDGs
A gender-sensitive approach
Pedagogical approaches

Part Two: Integrating the SDGs into STEAM-based activities 11

For teachers
For students

Part Three: Classroom Activities 13

Primary Learners
Lower Secondary
Upper Secondary

Part Four: Additional Resources 20

Resources for Beginners
Resources for Advanced Learners

Introduction to the guide

The Global Schools Activities Guide for Greening STEAM Education supports teachers and facilitators in engaging students with STEAM-based activities connected to the Sustainable Development Goals (SDGs). It aims to support educators in sparking inspiration and inquiry amongst primary and secondary students, helping them understand the essential principles of SDGs.

It also utilizes UNESCO's Education for Sustainable Development framework to emphasize the importance of learning across cognitive, socio-emotional, and behavioral domains.

This guide provides a range of activities that can be utilized not only in classrooms but also throughout the entire school community. Facilitators are encouraged to follow a well-structured series of lessons that lead to meaningful, hands-on student projects centered around green skills, combating climate change, renewable energy, and sustainable consumption.

This guide is organized into four sections:

PART 1

STEAM and the Sustainable Development Goals.

This section explores the definition of STEAM and STEAM's connection to the Sustainable Development Goals.

PART 2

Integrating the SDGs into STEAM-based activities.

This section of the guide includes relevant pedagogical approaches and a roadmap for designing a STEAM-based lesson.

PART 3

Classroom Activities.

A step-by-step collection of activities designed to inspire students and enrich the school community. These activities can be adapted and repurposed for diverse classrooms and contexts.

PART 4

Additional Resources.

This section provides additional resources and career insights to help deepen engagement with STEAM education as a powerful tool for advancing the Sustainable Development Goals (SDGs).

Part One: STEAM and Sustainable Development Goals

STEAM: A holistic educational approach

STEAM Education is an approach to learning that uses Science, Technology, Engineering, the Arts, and Mathematics as access points to guide student inquiry, dialogue, and critical thinking. STEAM requires an intentional connection between standards, assessments, lesson design, and implementation. Inquiry, collaboration, and an emphasis on process-based and experiential learning are at the heart of the STEAM approach.

STEAM and its relation to the SDGs

In 2015, 193 countries unanimously agreed to adopt a global action plan to address humanity's significant challenges, including climate change, inequality, hunger, and other pressing issues. This roadmap is outlined in the 2030 Agenda for Sustainable Development.

The new global agenda establishes 17 Sustainable Development Goals (SDGs), commonly referred to as the SDGs, to which all UN Member States have committed to achieving within a 15-year timeframe. The 2030 Agenda calls for action and collaboration across all sectors of society, including businesses, public institutions, citizens, and educational institutions. However, for this vision to become a reality, everyone must realize these goals and explore how they can contribute to achieving the SDGs.

Learn more: https://sdgs.un.org/

Education for Sustainable Development

Education for Sustainable Development (ESD) emphasizes frameworks that extend beyond traditional subject-based learning, including creativity, problem-solving, and critical thinking. Furthermore, ESD combines cognitive, value-based, and behavioral aspects of learning. These vital skills can be disseminated to students and learners in STEAM classrooms. The core ESD competencies are often already integrated within STEAM curricular objectives.

Want to learn more about ESD? https://www.unesco.org/en/sustainable-development/education

What do we mean by greening STEAM education?

Green STEAM Education represents an interdisciplinary and collaborative approach to teaching STEAM subjects. It engages learners with the natural environment and real-world challenges, including climate change, biodiversity loss, unsustainable resource use, and inequality. This adaptable, hands-on, inquiry-based approach fosters active learning among students. Students can take on various levels of responsibility, from collaborating on a team project to planning and leading a learning expedition. This encourages problem-solving while enhancing environmental knowledge and fosters environmental stewardship. It empowers students to make informed decisions and take action to change society and care for the planet (International Association for Quality Education).

What is STEM vs. STEAM?

STEM education centers on the curricular content of Science, Technology, Engineering, and Math.

STEM Education

The science aspect sparks students' curiosity and encourages students to experiment and explore. Learning about biology, chemistry, and physics builds a strong foundation for future scientific discoveries.

Technology is essential to navigating a world filled with digital innovations. Educational technology enables students to learn continuously, empowering them to create and innovate while refining their problem-solving skills. Coding and robotics are opening exciting doors, making technology a vital focus in preparing students to thrive with the digital skills that they can use in their personal and professional lives.

In engineering courses, students engage with real-world challenges, designing and testing solutions for novel sustainable energy systems or groundbreaking materials. By weaving creativity and design into their studies, students expand their horizons and discover diverse ways to tackle problems. At the same time, these creative pursuits inspire them to turn their imaginative ideas into tangible results.

Mathematics is a crucial element celebrated for its precision and promotion of logical thinking. Highlighting the importance of mathematical competence opens up a world of opportunities, motivating students to recognize math as an essential competency that can lead to numerous exciting pathways in their future journeys.

STEAM education

This guide embraces STEAM, providing a more cohesive approach that aligns with the holistic vision of Education for Sustainable Development. STEAM education centers on science, technology, education, the arts, and mathematics. The critical distinction is the addition of the "A" and what it represents. The "A" in STEAM represents more than the fine arts. It integrates all artistic and human-centered fields, fostering a comprehensive and interdisciplinary educational experience.

Here's how different art forms enhance STEAM and their importance when addressing the SDGs.

STEAM Education

Fine Arts: The fine arts include painting, sculpture, and music. They nurture creativity by providing students with an excellent platform to express their abstract thoughts, enhance their visual literacy, and share complex ideas that connect emotionally. The skills developed through the fine arts—such as keen attention to detail and a spark of originality—are invaluable for creating innovative solutions to the world's challenges.

Applied Arts and Manual Arts: These emphasize design, craftsmanship, and problem-solving in real-world contexts. These disciplines merge artistic creativity with practical applications, enabling students to develop prototypes, models, and functional designs that address real-world challenges. This hands-on approach is crucial for tackling the SDGs, which require concrete solutions, such as developing sustainable technologies or enhancing green infrastructure.

Language arts: These are crucial for effective communication. They teach students how to express their thoughts clearly, write in a way that connects with others, and engage in sharing information. Strong language skills are essential in the STEAM fields, whether writing reports, launching awareness campaigns, or delivering presentations. The ability to distill complex ideas and present them interestingly and understandably ensures that proposed solutions make a meaningful difference in the world.

Liberal Arts: These include philosophy, economics, geography, history, ethics, and social studies, all of which help students grasp the bigger picture of their efforts. In these disciplines, students are encouraged to reflect on how their actions impact the cultural, ethical, economic, and social spheres of influence. When tackling the SDGs, it is essential to consider how solutions might impact different communities and environments. The liberal arts provide a thoughtful and ethical framework, guiding us toward responsible and sustainable innovation.

A gender-sensitive approach

Women are significantly represented in the humanities and liberal arts; however, the percentage of women entering undergraduate programs related to STEM disciplines (Science, Technology, Engineering, and Math) is only 18.5% compared to 56.5% across all academic disciplines (Women in STEM).

Educators have a unique opportunity to foster girls' interest in STEM. Schools can actively engage and inspire girls to pursue STEM fields, providing them with high-quality career guidance.

Pedagogical approaches

Now that we have explained the definitions of STEAM, STEM, and the concept of Greening STEAM Education, let's discuss how to implement these approaches in the classroom. We will provide three educational approaches that can serve as tools for applying the STEAM methodology.

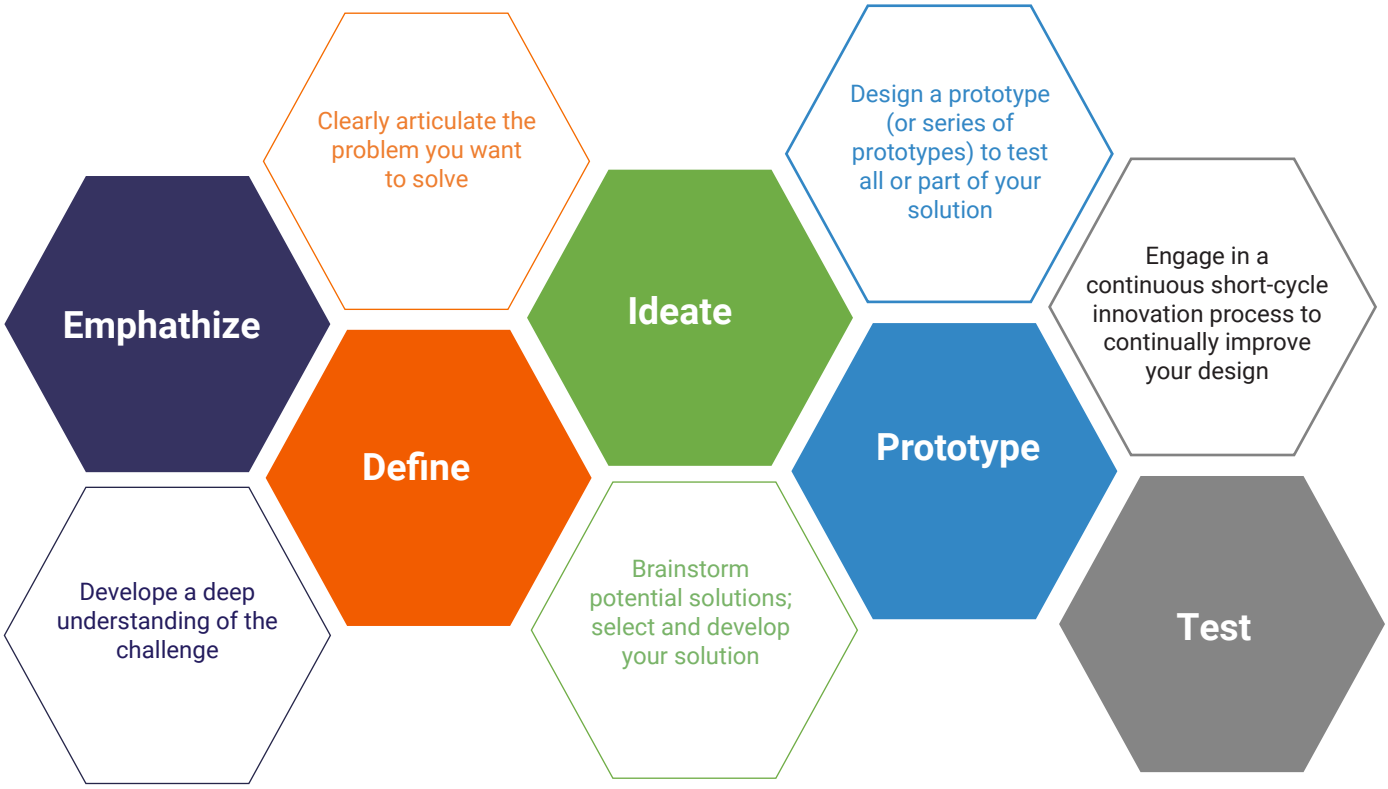
Scientific method

The scientific method is a systematic approach for asking questions, testing hypotheses, and drawing conclusions. Scientists have used this method to make groundbreaking discoveries in physics, biology, and chemistry. The scientific method involves:

Design Thinking

Design thinking is a human-centered approach to problem-solving, placing empathy and the needs of the end-user at the core of innovation. Like project-based learning, a design thinking approach in the classroom involves defining a problem and developing a solution to address it. Students learn to be innovative, be forward-thinking, and propose creative solutions. This approach is powerfully interlinked with Education for Sustainable Development (ESD) because it encourages students to use emotional intelligence skills and empathy.

To learn more: https://tll.gse.harvard.edu/design-thinking



Citation: Design Thinking. Center for Innovation in Teaching & Learning. University of Illinois Urbana-Champaign. citl.illinois.edu/paradigms/design-thinking.

Visual Thinking Strategies

Visual Thinking Strategies (VTS) is a collaborative, student-centered teaching method that improves critical thinking skills and fosters inclusive community-building and dialogue through facilitated discussions of artistic images. VTS encourages students to independently observe a work of art and back up their comments with evidence. The instructor's role is to facilitate the discussion. This is accomplished through open questions and facilitation techniques.

- **Paraphrase comments neutrally**—do not use words like "correct," "wrong," or "good."
- **Summarize student responses** using conditional language ("Sam thinks this could be…"), keeping the conversation open to other interpretations.
- **Physically point** to the area being discussed in the image.
- **Link contrasting and complementary** student comments.

To learn more: https://www.watershed-ed.org/

The three pedagogical approaches discussed—the Scientific Method, Design Thinking, and Visual Thinking Strategies—are essential for STEAM implementation; however, they may not fully encompass all aspects of STEAM learning. Although these approaches provide a strong foundation, incorporating a wider range of strategies could offer teachers greater flexibility in adapting STEAM education to suit various learners and contexts.

Part Two: Integrating the SDGs into STEAM-based activities

When considering how to incorporate the SDGs into a STEAM-based lesson, regardless of the discipline you teach, you can follow these steps to promote engaging, inquiry-based learning while maintaining a central theme or key question related to the SDGs

For Teachers

As a teacher, to create an activity or project with a STEAM focus, you need to:

1. **Identify Core Subjects.** Start by defining the main subjects of the lesson, such as science, technology, engineering, arts, or math.
2. **Analyze Key Problems.** Identify the real-world problem that students will investigate and align it with one or more of the SDGs.

For example:

In a Science class, ask students, "*Why are plants essential for the rest of the living beings that inhabit the planet?*". This question is related to SDG 13: Climate Action and SDG 15: Life on Land.

In Economics class, ask a question related to SDG 8: Decent Work and Economic Growth, such as why people within a country need decent jobs.

In Mathematics class, introduce issues related to the SDG targets and how to measure each country's progress against the targets. This is an easy way to bring an international perspective into the classroom.

3. <u>Create interdisciplinary connections.</u> Collaborate with educators from diverse disciplines to address common challenges and strive towards achieving the SDGs. For instance, think about the ways that the arts, technology, and engineering can work in tandem to generate innovative solutions. By exploring the relationships between different fields and understanding the roots of these challenges, you can build upon knowledge and skills that students are already familiar with or working towards.

For example

SDG 11: Sustainable Cities and Communities is interconnected with the other Global Goals. You can use this SDG to draw connections across almost any subject.

A question to explore could be: What makes a city sustainable? Students could start looking for elements that promote urban sustainability, connecting this to science, technology, engineering, the arts, and math.

In science classes, students can analyze air pollution, water quality, and urban designs, such as green roofs, that utilize biodiversity to promote healthy ecosystems.

In technology and engineering classes, students could learn about sustainable urban design or systems that support efficient transportation, renewable energy, and water management.

In arts classes, students could create aesthetic buildings or public spaces that promote environmental sustainability, quality of life, and positive societal well-being.

In mathematics courses, students could use data and modeling to analyze city finances or optimize disaster response.

You can also ask students to bring in an article each week that discusses topics relevant to a city in your area and have a weekly 15-minute discussion contrasting urban versus rural living.

For Students

Once the topic or project parameters are created, your students should follow these steps:

1. **Inquiry & Exploration**
   - Students explore and discuss real-world challenges related to the topic.
   - Students identify a problem that they want to solve.

2. **Investigation & Research**
   - Students research current solutions and what isn't working based on existing solutions.

As a teacher, you can use this stage to analyze your students' gaps in skills or processes and explicitly teach those skills or processes.

This is an excellent opportunity to explore inspiring examples of the chosen SDGs and how current solutions are being implemented. Ask the students to analyze whether these solutions will be helpful in your local context and how to adapt them.

3. **Implementation & Design**
   - After students have thoroughly explored a problem or question, analyzed existing solutions, and identified what still needs to be addressed, they will develop their solution or composition. This is where they apply the skills, processes, and knowledge they learned in the previous stage.

4. **Testing & Reflection**
   - Students test their models and prototypes. Alternatively, they can explain the design or creative process of their proposed solutions.
   - Students should consider:
     1) What worked well?
     2) What challenges did they face?
     3) How could this prototype be used in real life?

For example

If you are working on SDG 9: Industry, Innovation, and Infrastructure in your technology class, you can encourage students to apply their technology skills to create real-world solutions to challenges related to Goal 9.

This could include designing sustainable infrastructure or raising awareness about the difficulties people face due to a lack of access to medical services powered by advanced technology. Students can also learn about how technology contributes to sustainable development.

5. Presentation & Action

- Students share their solutions in a presentation or demonstration. This also provides an opportunity to facilitate feedback and help students learn how to give and receive input.
- Ask the other students in the class to participate in a discussion after each presentation. Possible discussion questions include:
    1) What aspects did you appreciate about their presentation? This phrasing is designed to provoke positive comments while enabling participants to share their thoughts respectfully.
    2) Do you have any questions you would like to ask the presenter?

Students' presentations should be engaging and visual, regardless of the subject. Art serves as a powerful tool in this regard. Contemporary artists produce stunning and impactful works that raise awareness of current issues. Numerous websites and online resources offer inspiration. Alternatively, students can create a mural or collage to present their work. Be creative!

6. Reflection

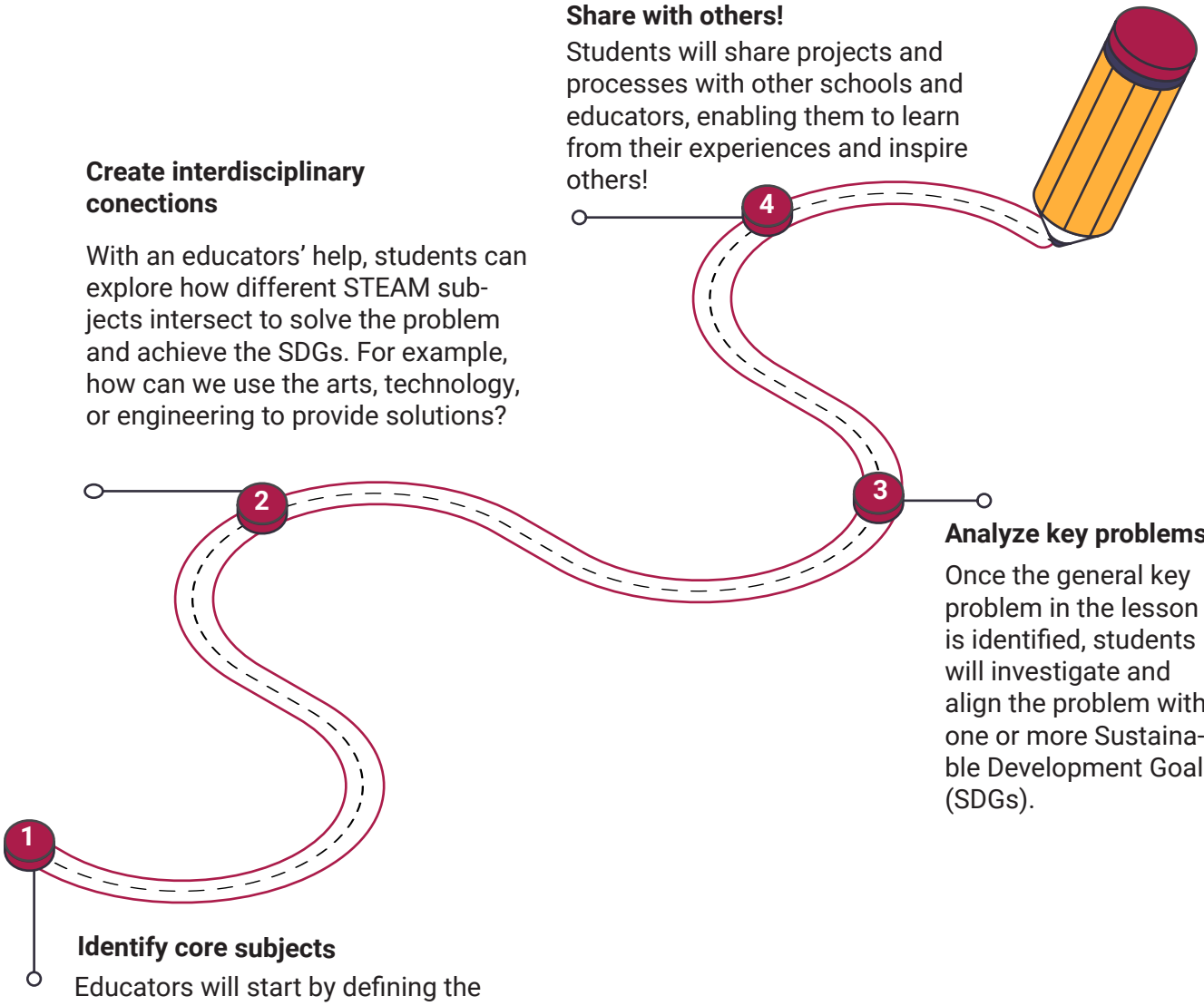
- Students reflect on the feedback shared during their presentations and on their new skills.
- Based on that reflection, students can revise their work and produce an even better solution.

This step involves self-reflection, detailed analysis, and the development of an action plan. These questions can aid and motivate facilitators to foster discussions that lead to productive outcomes:

- What insights did you gain from this project?
- What would you like to focus on going forward? This helps individuals identify their next steps.
- What is the next action you will take?

For teachers

STEAM Lesson Plan integrating SDGs



Identify core subjects

Educators will start by defining the main subjects of the lesson, such as science, technology, engineering, the arts, or math.

Create interdisciplinary conections

With an educators' help, students can explore how different STEAM subjects intersect to solve the problem and achieve the SDGs. For example, how can we use the arts, technology, or engineering to provide solutions?

Analyze key problems

Once the general key problem in the lesson is identified, students will investigate and align the problem with one or more Sustainable Development Goals (SDGs).

Share with others!

Students will share projects and processes with other schools and educators, enabling them to learn from their experiences and inspire others!

For students

Share with others!

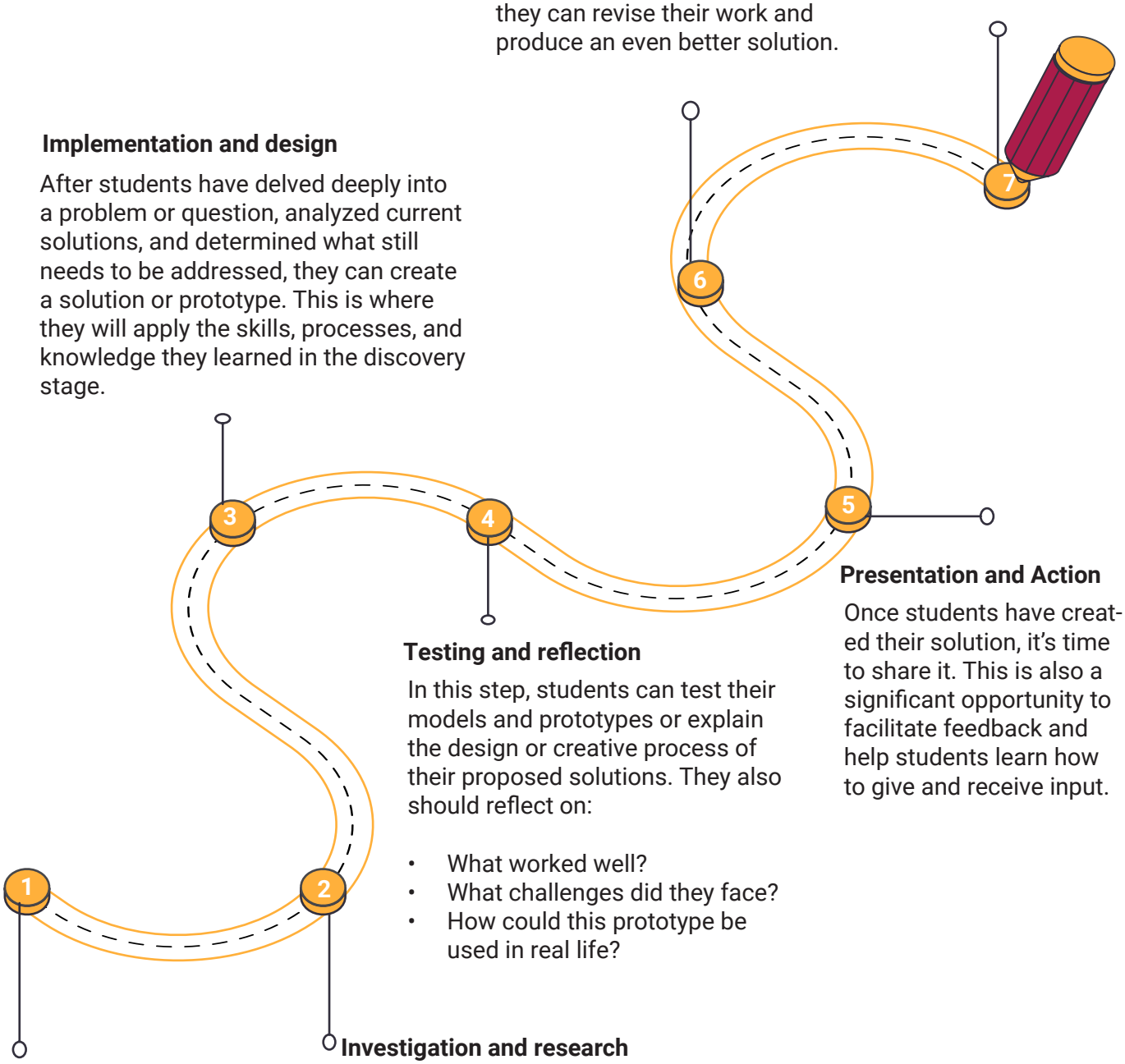
Students will share projects and processes with other schools and educators, enabling them to learn from their experiences and inspire others!

Reflection

Students have a chance to reflect on the feedback shared and on their processes and skills. Based on that reflection, they can revise their work and produce an even better solution.

Implementation and design

After students have delved deeply into a problem or question, analyzed current solutions, and determined what still needs to be addressed, they can create a solution or prototype. This is where they will apply the skills, processes, and knowledge they learned in the discovery stage.



Presentation and Action

Once students have created their solution, it's time to share it. This is also a significant opportunity to facilitate feedback and help students learn how to give and receive input.

Testing and reflection

In this step, students can test their models and prototypes or explain the design or creative process of their proposed solutions. They also should reflect on:

- What worked well?
- What challenges did they face?
- How could this prototype be used in real life?

Investigation and research

Students research current solutions and what isn't working. Educators can use this stage to analyze the gaps their students may have in a skill or process and teach those skills or processes explicitly.

Inquiry and exploration

Students will explore and discuss real-world challenges related to the topic. Then, they will narrow and identify a specific problem that they want to solve.

Part Three: Classroom Activities

In this section, you will find several example classroom activities. These activities were contributed to the guide by Global Schools Advocates, Global Schools Alumni, the Global Schools Program team, and the Global Schools SDG7 Educators Committee via a co-creative and collaborative process. This guide is conceived as a living document that will continuously evolve and include new educator contributions.

The following activities are structured according to the step-by-step approach outlined in the previous section. Additionally, they are **divided into three categories:**

Primary learners
for those aged 6 to 11

Lower Secondary
for those aged 12 to 15

Upper Secondary
for those aged 15 to 17

All of the activities detailed in this guide can be **carried out in the classroom or the broader school community.** They are divided into parts, allowing them to be adapted to various school contexts. **Feel free to adjust them to your students' needs.** You **don't need to complete all the activities**; each teacher can select activities that best suit their educational context.

As part of the learning process, teachers can encourage students to keep a **STEAM Journal**, which serves as a notebook for reflecting on their learning. In these journals, students can document ideas, observations, sketches, experiments, and inquiries. While a STEAM Journal is explicitly mentioned in some activities, it can also be used across all the activities in this guide.

Primary Education		
Activity: Creating fashion from recycled materials	Primary Learners	SDG 12: Responsible Consumption and SDG 17: Partnerships for the Goals
Activity: Renewable Energy & Innovation Challenge	Primary Learners	SDG 7: Affordable and Clean Energy; SDG 9: Industry, Innovation, and Infrastructure; SDG 17: Partnerships for the Goals
Activity: The Giving Ecosystem	Primary Learners	SDG 4: Quality Education; SDG 9: Industry, Innovation and Infrastructure; SDG 12: Responsible Consumption and Production; SDG 15: Life on Land
Lower and Upper Secondary Education		
Activity: Producers and Consumers	Lower Secondary	SDG 12: Responsible Consumption and Production; SDG 17: Partnerships for the Goals
Activity: Investigating the Role of Bacteria in Sustainable Agriculture	Lower Secondary	SDG 2: Zero Hunger; SDG 3: Good Health and Well-being; SDG 15: Life on Land
Activity: Saving the Oceans	Lower and Upper Secondary	SDG 12: Responsible Consumption and Production; SDG 14: Life Below Water; SDG 9: Industry, Innovation, and Infrastructure; SDG 17: Partnerships for the Goals
Activity: Sharing the Planet	Lower and Upper Secondary	SDG 13: Climate Action; SDG 17: Partnerships for the Goals
Activity: The Impact of Plastic Pollution on the Environment	Lower and Upper Secondary	SDG 12: Responsible Consumption and Production; SDG 14: Life Below Water; SDG 15: Life on Land
Activity: Biodiversity for the Planet: Integrating Mathematics with Climate Action	Lower and Upper Secondary	SDG 13: Climate Action; SDG 15: Life on Land

Upper Secondary Education		
Activity: Building Bridges	Upper Secondary	SDG 9: Industry, Innovation, and Infrastructure; SDG 12: Responsible Consumption and Production; SDG 17: Partnerships for the Goals
Activity: A Sustainable Vision	Upper Secondary	SDG 11: Sustainable Cities and Communities; SDG 9: Industry, Innovation, and Infrastructure
Activity: Sustainable Homes	Upper Secondary	SDG 11: Sustainable cities and communities; SDG 9: Industry, Innovation, and Infrastructure; SDG17: Partnerships for the Goals
Activity: Tidal Power: Harnessing the Energy of Sea Currents	Upper Secondary	SDG14: Life Below Water; SDG 7: Affordable and Clean Energy; SDG 13: Climate Action
Activity: Identifying Deforestation Issues Through Artificial Intelligence	Upper Secondary	SDG 15: Life on Land; SDG 13: Climate Action
Activity: SDG 11 and Market Failure	Upper Secondary	SDG 11: Sustainable Cities and Communities; SDG 9: Industry, Innovation, and Infrastructure; SDG 13: Climate Action; SDG 17: Partnerships for the Goals
Activity: History's Lessons on Global Sustainability	Upper Secondary	This activity relates to the three dimensions of Sustainable Development: social, economic, and environmental. It demonstrates how these dimensions are interconnected.
Activity: Foreign Aid	Upper Secondary	SDG 1: No Poverty; SDG 2: Zero Hunger; SDG 3: Good Health and Well-Being; SDG 4: Quality Education; SDG 8: Decent Work and Economic Growth; SDG 16: Peace, Justice, and Strong Institutions; SDG 17: Partnerships for the Goals
Activity: Tech Museum of Time	Upper Secondary	SDG 4: Quality Education; SDG 9: Industry, Innovation and Infrastructure; SDG 12: Responsible Consumption and Production

Part Four: Additional Resources

For Beginners

Resources suitable for those new to the topic. These links offer foundational knowledge about the concepts in this guide.

The Institute for Arts Integration and STEAM supports teachers, schools, and districts in creating future-ready classrooms through the integration of arts and STEAM (Arts Integration).

STEM vs STEAM A Teacher's Guide to Transforming Classrooms (The I Will Projects).

Comparing STEM vs. STEAM: Why the Arts Make a Difference. This article emphasizes the integration of the Arts and Humanities into the STEM approach (University of Central Florida).

STEM & STEAM Lessons. LEGO Education offers different activities with a STEM and STEAM design (LEGO Education).

Facilitating a VTS Session. In this simple graphic, Visual Thinking Strategies outlines the steps for conducting a VTS Session (Visual Thinking Strategies).

Artists and Climate Change is a platform where educators can find artistic images related to sustainability issues (Arts and Climate Change).

For Advanced Learners

Resources for those with a firm grasp of the subject, focusing on in-depth analysis, complex concepts, and specialized skills.

Project Zero, located at Harvard University, is an educational research group within the Graduate School of Education. Its mission is to understand and enhance learning, thinking, and creativity in the arts, humanistic, and scientific disciplines (Project Zero).

Full Steam, MIT is a collection of online teaching and learning resources (Massachusetts Institute of Technology).

Harvard LabXChange and the Smithsonian Science Education Center, have resources on STEM and the SDGs for all ages, that can be easily integrated in K12 education classrooms. Furthermore, teachers with experience in Minecraft Education can integrate the Planet Rescuers Minecraft Education game into their classrooms.

UNESCO's Greening Curriculum Guidance is a publication that offers an overview of opportunities to connect various curricula to the Global Goals and the STEAM educational approach (UNESCO).

The Center for Sustainable Development (CSD) of Columbia University's Climate School works at the intersection of the environment, education, gender, social justice, and economic development. Along with SDSN's SDGs Today team, it hosts the EcoAmbassadors Program, a multi-week initiative where students engage in interactive virtual sessions, digital hands-on activities, and technical training to explore geospatial technologies. For examples of past projects, please visit this site (SDGs Today & CSD).

Global Schools
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