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EDU SIM STEAM

Guidance for STEAM Scenarios

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GUIDANCE FOR STEAM SCENARIOS

1. INTRODUCTION

The study of Science, Technology, Engineering, Art, and Mathematics jointly is commonly referred to as STEAM education, which is a teaching approach that integrates content, skills, and competencies specifically in an interdisciplinary way. It has become an important approach in education because of its role in jobs of the 21st century, and this approach inspires students to practice the left and right sides of their brains concurrently as they should in a 21st century work environment (Azamatovna, 2022). Thus, STEAM education has already gained popularity and come into prominence both in an innovative educational context and in the future work environment.

It is very difficult to imagine a world without science, technology, engineering, arts and mathematics, in short, STEAM disciplines (Burrington, 2015). While there are still societies in the world that have not fully engaged in integrating these five disciplines in school settings, STEAM has allowed human beings to represent cognitive, emotional, and physical actions and thus facilitated their survival (Saralar and Esen, 2021; Sousa and Pilecki, 2013). In traditional education systems, students' learning in STEAM disciplines is tested through closed-ended questions with only one correct answer, and both practices and assessments target convergent thinking. However, divergent thinking, which directs the creative process, activates more parts of the brain compared to convergent thinking and provides new neural connections (Sousa and Pilecki, 2013).

By leading the development of divergent thinking, the integration of science, technology, engineering, and mathematics with the arts supports the creative thinking that underlies the breakthrough innovations and inventions of scientists and engineers (Fox and Schirrmacher, 2018). For this reason, Leonardo da Vinci and Michelangelo Buonarroti, who are well-known as painters and sculptors, have made many innovations in history (e.g. flying machines, catapults, suspension bridges) as inventors, engineers, and scientists at the same time. (Laurenza, 2018; Sousa and Pilecki, 2013). With this in mind, in recent years, researchers in the field of education have focused on the planning and implementation of educational processes in which STEAM is integrated. This has brought the ideas on whether and how to prepare good teaching and learning settings for K-12 students while integrating STEAM education; they all came together with the benefits as well as the concerns.

Concerns about what kinds of skills and competencies students need to acquire for successful future lives have been a major focus of pedagogues over the past two decades (European Commission, 2007, 2019; OECD, 2018). STEAM education asserts these skills and competencies as essential: problem-solving; innovation and creativity; communication; critical thinking; meta-cognitive skills; collaboration; self-regulation and disciplinary competencies (scientific skills, engineering design skills, etc.) in order to make a successful living for every individual (McLoughlin et al., 2020). Teachers are in the front line to bring these skills and competencies to students and enhance them for their future lives. STEAM education provides teachers with the opportunity to create a learning environment that encourages all learners to participate, collaborate, solve real-life problems, use their digital skills, and design engineering products (Azamatovna, 2022; McLoughlin et al., 2020).

In this case, teachers may need some guidance for this kind of new approach because they are inexperienced in this new domain and there are some confusing questions to overcome and apply STEAM practices in the classrooms:

- How to integrate STEAM programs into the curriculum
- How to motivate students (parents) in STEAM education
- What pedagogical approaches are to be adopted
- How to reorganize teaching and learning practice
- How to design classroom materials
- How to assess STEAM skills and competencies

2. STEAM Scenarios

As a roadmap for the teachers to cope with all the concerns they have, we prepared this document which provides STEAM scenario guidelines for teachers who would like to work in a STEAM education context. We aimed at providing a clear vision for innovative interdisciplinary pedagogical practice supported by technology. The scenarios aim to design an authentic learning situation composed of different tasks in order to achieve certain STEAM learning outcomes through different learning and teaching strategies. Scenarios are not lesson plans but describe the broader framework and the general ideas. Teachers can use the scenario ideas to create a lesson plan for learning and teaching activities that fits into the actual objectives of the STEAM program (European SchoolNet, 2018).

Scenarios in the EDUSIMSTEAM project play an essential role in helping the learning and teaching process evolve and respond proactively to trends in society, education, and technology. In the scope of the project, a total of 22 scenarios are created, whose themes are listed below:

- Street Lighting in a Smart City (6 Scenarios)
- Waste Collection in a Smart City (4 Scenarios)
- Mission to Mars (3 Scenarios)
- Various Themes for Elementary Level (3 Scenarios)
- Covid-19 Pandemic (4 Scenarios)
- Mobility in a Smart City (2 Scenarios)

A STEAM scenario from the list above describes theme, grade level, duration, real-life scenario setting as the theoretical framework for each problem addressed; task, technical information, prerequisite skills, STEAM learning outcomes, activity process, assessment, career connections, materials, and related resources necessary to the implementation of each activity.

2.1. Designing a STEAM Scenario: Steps

When we consider creating a scenario-based learning environment, we need to make our students understand the scenario we prepared based on the scenario template in Appendix. For this, we need to let them apply the knowledge and skills through a choice of student-based activities. Then, as a next and concurring step, we need to provide constructivist feedback so the students reflect on what they just did and how to improve. The following are the formal steps that are used to develop sample Edusimsteam scenarios. In each phase, teachers need to consider all the items noted to prepare well-considered learning scenarios.

- **Planning Phase:** In the planning phase, teachers need to decide the title, explanation, theme, grade level and duration of the scenario.
    - Title is the name of the scenario such as life expectations and sustainable environments.
        - ***Sample Title:*** *"Street Lightning"*
    - **Description (Purpose)** is a short statement about the purpose of the learning scenario. It needs to be explained why the scenario should be a necessary part of the learning environment; for example, the purpose of this scenario is to discover the Pi number and how it could be used in real-life.
        - ***Sample Description:*** *"Design a device that will determine the areas that have inefficient lighting."*
    - **The theme** is the explanation of the topic with one to three words; e.g., sustainable environments.
        - ***Sample Theme:*** *"Street Lighting in a Smart City"*
    - **Grade level** is the level of students. It can be written as an age group or grade level.
        - ***Sample Grade Level:*** *"Middle Schools / Junior High Schools (Ages 10 to 14)"*
    - **Duration** is the time spent on the scenario, which can be designed as lesson hours (e.g., 40 minutes; varies from country to country) or hours.
        - ***Sample Duration:*** *"2 class hours"*
- **Preparation Phase:** In the preparation phase, teachers need to decide on the real-life scenario environments, tasks, prerequisite skills, and STEAM learning outcomes.
    - **Real-life scenario settings** refer to connecting with real life and can be defined as a link and bridge where previous or new knowledge is used to create or strengthen interaction between STEM ideas, concepts, or representations. By revealing the real life problem, the problem situation is determined.
        - ***Sample real-life scenario setting:*** *"Considering factors affecting the design and use of a thriving street lighting system in the city, DRDI thinks that the first step of SCMP related to a new lighting project should include the decisions of the areas that have inefficient (too much or too little) lighting in the given street and determine the factors that can affect the amount of lighting on the streets. This process will help determine the problems in street lighting and*

develop sustainable and effective solutions for your city's digital transformation. Suppose you are a team member at the DRDI office and are responsible for turning your city into a smart city with a new lighting project. Your team will have several tasks towards smart street lighting in the city by developing an adaptable lighting plan and implementing your lighting solution in the robotics simulation program."

- **Task** is the activity that the students must complete, which may include reading, creating a dialogue, role-playing, and responding to questions. These are the tasks that students are expected to perform within the scope of the scenario. In educational environments, learning tasks are quite significant. They may be thought of as a bridge between the learners and the information available in the learning environment. They assist successful learning by activating and controlling learning processes.
  - ***Sample Task:*** *"In this activity, the task of each team is to:*

    a. *Observe the lighting on the streets given in the simulation environment.*

    b. *Determine the improper lighting spots by using light sensors.*

    c. *Report light levels by numerical values. You can compare the light levels on your streets with the acceptable light levels (given information in the technical part).*

    d. *Prepare a report and present it to the other teams of DRDI."*

- **Technical information** is the specific information regarding a particular topic in the scenario that is needed to complete the task, such as formulas and functions. In other words, within the scope of the scenario, all the technical concepts, terms and information that students are expected to know are included.
  - ***Sample Technical Information:*** *"Did you ever walk on a poorly lighted street, too dark or too bright? It is important to adjust light levels appropriately to walk safely on the street for people and minimize light pollution for the environment. There are many factors that specialists pay attention to when designing light poles, such as pole height, the shape of the lamp, etc. From a physics aspect, there are several terms that we need to know to understand lighting:*
    - ***Luminous flux:*** *refers to the rate of light emitted from a light source per unit of time. It is measured in lumen (lm) and represented by φ.*
    - ***Luminous intensity:*** *Light sources emit light in different directions with different amounts. Luminous intensity refers to luminous flux but in a specific direction. It is measured in candela (cd) and represented by I.*
    - ***Illuminance:*** *It refers to the amount of light that reaches a surface. This term indicates if a surface is lighted*

appropriately to walk, ride, drive, etc. It is measured in lux (lx) and represented by E.

As you can see, to design or investigate a light pole, if it is appropriate or not in terms of light level, we need to consider illuminance. For medium-density streets, including pedestrians and cyclists, illuminance should be at least 7.5lx. This value can increase according to the density of street usage. For example, 50lx can be appropriate for roads with heavy traffic conditions."

- **Prerequisite skills** *are whatever you must know or comprehend before you can learn or grasp anything new.*
  - ***Sample prerequisite skills:*** *(1) Investigate the proper and appropriate outdoor lighting conditions (2) Understand that light travels through straight paths in all directions*
- **STEAM learning outcomes** are the acquisitions related to the disciplines within the scope of the scenario in the learning program. They are the increased STEM knowledge and skills, not only limited to the STEAM disciplines but also related to 21st century skills.
  - ***Sample STEAM Learning Outcomes***

    Science
    - *Use luminous flux, luminance, and illuminance in explaining lighting.*
    - *Determine light pollution.*

    Technology
    - *Use a light sensor*
    - *Use led or buzzer module*
    - *Use branching module*
    - *Create flowcharts in the simulation environment*
    - *Run an algorithm*

    Engineering
    - *Make designs for street lighting poles and fixtures*

    Arts
    - *Gain awareness on light pollution*
    - *Gain awareness on energy consumption*
    - *Gain environmental awareness*

    Mathematics
    - *Use ratios and proportions*

- **Practice Phase:** In the practice phase, teachers need to decide the activity and evaluation types of the scenario.
  - **Activity** is the realization of the described task. It includes the actual actions the students and the teacher take during the scenario.
    - ***Sample activity process:*** *Teachers are recommended to follow the following steps:*

- *Encourage students to carefully read the task statement and brainstorm about lighting conditions around their neighborhood. Ask students:*
- *Have you ever thought about the lighting conditions on the streets? Do you come across streets that have poor or excessive lighting conditions?*
- *Do these poor or excessive lighting conditions cause problems? What kind of problems can they create for both pedestrians and drivers?*
- *What are the factors that may affect light levels?*
- *Guide students to set up a sensor that can be used to measure light levels in various places on the map.*
- *Ask students to use and determine inefficient lighting areas on the map.*
- *Ask students to determine the factors that affect light level when they move the sensor around a light pole.*

  - **Evaluation** includes formative and summative assessments. It is done to measure efficiency, which, in general terms, is the degree to which an activity, action, or behavior, as far as possible, achieves the purpose for which it was directed. In other words, it is a criterion that shows whether it is sufficient to achieve the goal.
    - ***Sample evaluation:*** *The following question can be considered for formative assessment purposes.*
      - *What are the definitions of luminous flux, luminance, and illuminance?*
      - *What are the units of these terms?*
      - *What are the definitions of these units?*
      - *What is the term used for light level?*

    The following are expected from students:

      - *Develop a sensor that can measure the illuminance of several points on the map in the simulation environment.*
      - *Write and share a report on the lighting issues on the map using technical terminology appropriately.*

- **References Phase:** In the references phase, teachers should note career links, materials, related sources, and reference lists.
  - **Career connections** are the connections of scenarios to STEAM careers. In other words, they are the STEAM occupations that are associated with the learning scenario.
    - ***Sample Career Connections:*** *City and Regional Planning, Electric and Electronic Engineering, Earth and Space Science, Environmental Engineering*
  - **Materials** are the tools required for the scenario.
    - ***Sample materials:*** *The Simulation environment including a street map and light sensors*

- ***Related sources*** *are the sources related to the scenario that are thought to be useful for others but are not actually used in writing learning scenarios.*
  - ***Sample related sources:***
    - *Project for Public Spaces. (2008). Lighting Use & Design. https://www.pps.org/article/streetlights.*
    - *Römhild, T. (2017). (rep.). Dynamic Light Handbook about Interpretation of En 13201. European Union. Retrieved from https://www.interreg-central.eu/Content.Node/Dynamic-Light/04-DL-Handbook-about-interpretation-of-EN-13201.pdf*
- ***Reference list*** *is the resources used in writing learning scenarios.*
  - ***Sample references:***
    - *Barr, D., Harrison, J., & Conery, L. (2011). Computational thinking: a digital age skill for everyone. Learning & Leading with Technology, 38(6), 20–23.*
    - *Bers, M. (2010). The TangibleK robotics program: Applied computational thinking for young children. Early Childhood Research and Practice, 12(2), 1–20.*
    - *DeJarnette, N. (2012). America's Children: Providing Early Exposure to STEM (Science, Technology, Engineering and Math) Initiatives. Education, 1, 77–88.*
    - *Han, I. (2013). Embodiment: a new perspective for evaluating physicality in learning. Journal of Educational Computing Research, 49(1), 41– 59.*
    - *Jung, S., Won, E.S. (2018). Systematic review of research trends in robotics education for young children. Sustainability, 10(4), 905.*

Writing about the steps mentioned above in each phase is actually not enough to take this into action. Teachers need to consider their own students and their needs, and when necessary, adapt their scenarios from one class to another, or for different groups of students within a classroom.

2.2. Scenario Implementation

This section seeks to provide a conceptual model for teachers in the implementation of STEAM scenarios. Apart from the learning scenarios of the EDUSIMSTEAM project, there are many resources for STEAM scenarios. Throughout all these inspiring scenarios, it is necessary to guide teachers on how to implement a learning scenario in their classroom context, which carries many variables like the learning objectives, students' background, teachers' capability, learning environment, etc., in order to overcome and practice STEAM scenarios even if it seems simple to implement the existing ready-made scenario.

Here is a conceptual model for teaching of EDUSIMSTEAM scenarios inspired by Komis, Romero, and Misirli's (2016) study and adapted for the EDUSIMSTEAM project in Figure 1.

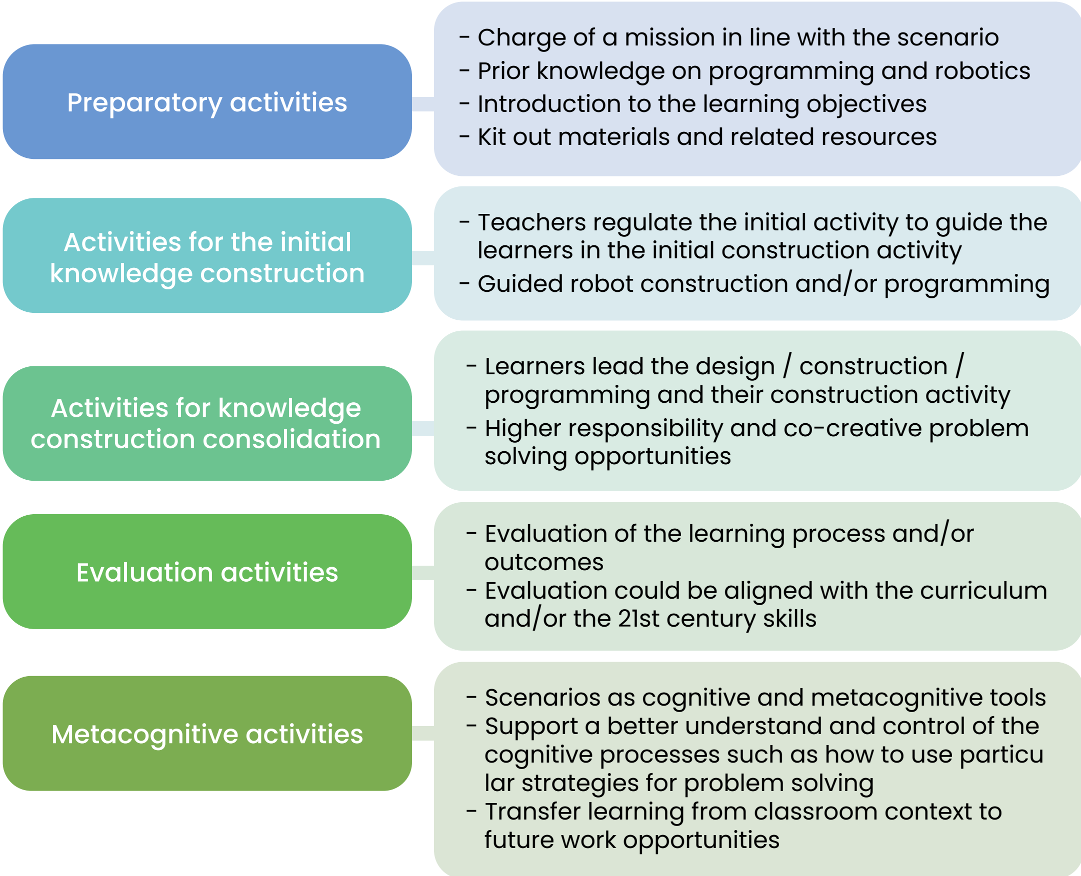

Figure 1. A conceptual model for the teaching of EDUSIMSTEAM scenarios

The conceptual model intends to develop an advanced engagement in knowledge construction, skills, and competencies adopted in the scenario. After teachers agree that the scenario is appropriate for some standards like learning objectives, their students' level, time schedule, etc., they can move on to the steps of the conceptual model. The following part gives further details of each step of the conceptual model for the teaching of EDUSIMSTEAM scenarios clearly.

Step 1-Preparatory activities aim to prepare the students for the following activities in the scenario. They include the introduction of the learning objectives with STEAM learning outcomes, the presentation of real-life scenario setting and tasks, and the identification of materials and related resources. In addition, students are supported with prior knowledge in terms of construction and/or programming, which contains technical information and prerequisite skills for more detailed activities.

Step 2-Activities for the initial knowledge construction: Teachers guide the students in these kinds of activities by fostering their inquiring, exploring, discovering, and cognitive conflict through peer-group (collaborative) interaction and engagement.

Step 3-Activities for knowledge construction consolidation: The students are more autonomous and they take their own responsibility for learning. They design, construct, and/or program the robotic literacy and algorithmic thinking activities in these activities thanks to their higher co-creative problem-solving opportunities. The activities lead the students to a more reflective process for testing and formative assessment.

Step 4-Evaluation activities can be embedded through activities for the knowledge construction consolidation or can be carried out in a separate way. The activities build on learning objectives aligned with the curriculum or 21st century/STEAM skills such as problem solving, collaboration, creativity, critical thinking, and computational thinking.

Step 5-Metacognitive activities are seen as potential cognitive or metacognitive tools which can engage the students to better understand what they already know, identify and implement effective learning strategies, and monitor their cognitive processes, such as how to use particular strategies for problem solving. Learners also evaluate and revise their own work, and they transfer their learning from the classroom context to future work opportunities in these activities.

EDUSIMSTEAM scenarios can be implemented in classroom settings by benefitting from the conceptual model for teaching (see Figure 1). On the other hand, the scenarios can be embedded into the platform where students and teachers can practice their STEAM skills together based on robotic design. One of the EDUSIMSTEAM project's most prominent purposes is to integrate STEAM scenarios into the Innovative Online Platform, which provides simulation software based on the robotic algorithms with the problem-solving models, the solution instructions, and feedback for effective training results. The platform engages the learners in the use of robotics. technologies for the development of learning objectives, skills, or competencies in formal or informal contexts. At the moment, the Innovative Online Platform is in the development process, and it is believed to be an important keystone in the implementation of STEAM skills via simulation software by teachers and learners.

3. DISCUSSION AND CONCLUSION

It is almost impossible to conceive of a world without science, technology, engineering, arts, and mathematics (STEAM) around us (Burrington, 2015). While some countries have yet to completely integrate these five disciplines in classroom settings, STEAM has shown that it enables humans to express cognitive, emotional, and physical behaviors, facilitating their survival (Saralar and Esen, 2021; Sousa and Pilecki, 2013). Students' learning in STEAM fields, in traditional education systems, is mostly measured by using closed-ended questions with just one right answer, and both practices and assessments focus on convergent thinking. Divergent thinking, on the other hand, leads the creative process, engages more areas of the brain than convergent thinking and creates new neural connections (Sousa and Pilecki, 2013).

For divergent thinking, the combination of science, technology, engineering, and mathematics with the arts fosters the creative thinking that underpins scientists' and engineers' breakthroughs and creations (Fox and Schirrmacher, 2018). As a result, well-known artists and sculptors like Leonardo da Vinci and Michelangelo Buonarroti have developed numerous inventions in history (e.g., flying machines, catapults, suspension bridges) as innovators, engineers, and scientists all at the same time. With this in mind, educational experts have recently concentrated on the development and implementation of STEAM-integrated instructional procedures, and learning scenarios have become very popular. This has brought up questions about whether and how to build appropriate teaching and learning environments for K-12 children while including STEAM education; they have all been raised.

To conclude, this document provided a guide for preparing STEAM scenarios for those teachers who have yet to prepare efficient learning scenarios. It included the discussion of general literature about the need for learning scenarios; a description of learning scenarios; steps for developing a learning scenario and how to implement it; and finally, sample learning scenarios.

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5. APPENDICES

Appendix: A Sample Scenario Template in the EDUSIMSTEAM Project

Scenario Name:

Planning	
Explanation	
Theme	
Level	
Duration	
Preparation	
Real-life scenario setting	
Task	
Technical information	
Prerequisite skills	
STEAM Learning outcomes	

Practice	
Activity	
Evaluation	
Reference	
Career connections	
Materials	
Related sources	
Reference list	
Career connections	

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