Module 2. Introduction to Data-Centered STEAM education

Introduction

Module 2 aims to introduce participants to data-centered STEAM pedagogy for civic engagement. The module presents the main pedagogical models and frameworks used in STEAM education. It also discusses the importance of integrating data science into K-12 STEAM education to enhance students' data science literacy and equip them with vital skills for future careers and effective citizenship.

Learning objectives

It is expected that upon completion of this module learners will be able to:

- Describe and articulate the theoretical foundations and pedagogical principles of the STEAM approach.
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- Outline the primary pedagogical models adopted to promote STEAM education.
- Connect the pedagogical models and methods of the STEAM approach to the core principles, psychological frameworks, and epistemological dimensions of contemporary learning theories.
- Explain the critical role of data science literacy in fostering civic engagement and community resilience.
- Advocate for the integration of data science into STEAM curricula to prepare students for a data-centered world.

Expected/estimated time for completion: 5 hours

Outline of course structure and activities

Name of activity	Type of activity	Duration
1. Essential readings 1.1 Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review *Thinking*	Pre-requisite reading and study of learning resources	2 hr

Skills and Creativity, *31*, 31-43. https://doi.org/10.1016/j.tsc.2018.10.002 1.2 Dvir, M. and Ben-Zvi, D. (2023). Students' actual purposes when engaging with a computerized simulation in the context of citizen science. *British Journal of Educational Technology*, *53*(5), 1202-1220. 1.3. Study examples of STEAM education projects		
2. Preparatory activity: Before joining class	Pre-requisite reading in preparation for the online meeting	0,5 hr
3. Introduction to data-centered STEAM education 3.1. Presentation of key concepts 3.2. Group activity 1: Ideas for a school project based on the design thinking methodology 3.3. Group activity 2: examination of STEAM scenarios/lesson plans	Synchronous session (face-to-face or online)	2 hrs
4. Post a short reflection message on online forum	Reflection on online forum	0,5 hr

Description of the activities

1. Essential reading about STEAM education

1.1. Read 'STEAM in practice and research: An Integrative literature review' (Perignat & Katz-Buonincontro, 2019)

This integrative review examines 44 published articles (empirical, descriptive, and pedagogical frameworks) on the topic of STEAM (Science, Technology, Engineering, Arts, Mathematics) education from 2007 to 2018. It examines descriptions of the overall purpose of STEAM education, definitions of the STEAM acronym and the 'A' in STEAM, creativity as a learning outcome, elements of arts education, and arts education learning outcomes. It also differentiates in methods for merging STEAM disciplines, described in one of five ways: transdisciplinary, interdisciplinary, multi-disciplinary, cross-disciplinary,

and arts-integration. Recommendations are provided to advance both research and practice in STEAM education.

1.2. Read 'Students' actual purposes when engaging with a computerized simulation in the context of citizen science.' (Dvir & Ben-Zvi, 2023).

This paper explores using simulations to generate and examine data in a Citizen Science context, presenting a case study of two middle school students. The study reveals that while the simulation was designed for scientific purposes, the students attributed four different purposes to it. As their engagement deepened, they adopted the intended purpose and developed more advanced views of data concepts. Key design elements supporting this shift are discussed.

1.3. Study *examples of STEAM education projects*

Below you will find a list of interesting resources which will help you improve your understanding of STEAM education.

Augmented reality mural at Ziggy's Frozen Yogurt shop

https://www.stemartslab.com/artaos-tisa-augmented-reality-mural-at-ziggys-frozen-yogurt-shop/

The website describes the AR Mural Work/Study Project coordinated by the STEMarts Lab (as well as provides links to other relevant projects)

Forensic Science International Project (website and video)

Project website: https://forensicscience.school/

https://www.youtube.com/watch?v=yo9LxpAS3_I

This in an international project that has involved many schools and thousands of students from around the world. Secondary school students develop STEAM knowledge and skills while participating in the investigation of a simulated crime. Three case studies (crimes to be solved) are included in the project. The project is presented in the video and you can learn more about the 3 case studies on the project website.

Design thinking: a problem-solving framework.

https://www.youtube.com/watch?v=kfBa2AdjRB4

This is a video showing how the *"design thinking" (and more specifically the so called "Stanford model" or "d model" was used in a STEAM education project implemented in an elementary school classroom.*

2. Preparatory activity: before joining class

Read the following STEAM scenarios which will be discussed during the online synchronous session.

Gamification in scientific museum: lateral thinking approach.

This is a scenario that uses Europeana digital resources. Europeana is a European Union initiative that provides digital access to European cultural heritage material from institutions across Europe (e.g., galleries, museums, libraries), including artworks, videos, newspapers, books and more.

Margaret Hamilton Saves the Moon Landing

A STEAM scenario developed within the context of the Erasmus+ FemSTEAM Mysteries project.

The pollution and the Greenhouse effect

A STEAM scenario from the repository of the STE(A)M IT project.

3. Introduction to data-centered STEAM education (Synchronous Meeting)

The following activities will take place during the synchronous (face-to-face or online) meeting of the module.

3.1. Presentation of key concepts regarding STEAM education, data science, and civic engagement

This is a presentation which will address the following topics: a) the evolution of STEAM from STEM, and definitions of the STEAM acronym, b) main pedagogical models and frameworks used in the STEAM approach, and c) the integration of data science education into STEAM to promote civic engagement and strengthen community resilience.

3.2. Group activity 1: Ideas for a school project based on the design thinking methodology

We will break into groups and each group will work together to propose a topic for a STEAM project where teams of students can work together to solve a real-world problem using the design thinking methodology. Then we will return to the whole-class session and the groups will present their proposed topic.

3.3. Group activity 2: Examination of STEAM scenarios/lesson plans

The activity aims to actively engage all participants in learning and deepen their understanding of the characteristics and approaches used in STEAM education. Participants will divide into groups of 4-5 and evaluate the three educational scenarios from Activity 3 using a provided evaluation rubric. Following the group discussions, we will reconvene as a whole class, and each group will present its conclusions.

4. Post a short reflection message on online forum

After completing the activities, post a brief reflection (approximately 100 words) on the module's online forum, sharing your thoughts on data-centered STEAM education as a tool for promoting civic engagement. You might reflect on whether your experience in the training program has altered your initial perceptions of STEAM and/or data science education. Have you learned anything new that you find particularly interesting? Have the activities prompted new questions about integrating data science into STEAM education for civic engagement? What aspects of implementing data-centered STEAM pedagogy in your classes do you find intriguing or challenging?

Additional resources for further study

Catterall, L. (2017). A brief history of STEM and STEAM from an inadvertent insider. *The STEAM Journal*, *3*(1). (Available Online)

This article traces a history of STEM and STEAM from the perspective of someone involved in arts integration research for the last 35 years, and proposes a vision for the next steps.

Condon, M., & Wichowsky, A. (2018). Developing Citizen-Scientists: Effects of an Inquiry-Based Science Curriculum on STEM and Civic Engagement. *The Elementary School Journal*, *119*, 000–000

This article reports on a cluster-randomized trial of an inquiry-based science curriculum conducted with 551 students in grades 6–8 across 13 schools. The intervention combined science and civics instruction in a unit focused on community and family water conservation, supplemented by teacher professional development and technology-based instructional tools. The study examined the effects on student engagement in both science and civics, finding positive outcomes in both areas. The authors suggest that best practices in inquiry-based science instruction contribute to students' civic development and that integrating science and civics in the classroom can enhance student outcomes in both fields.

Hasso Plattner Institute of Design at Standford. (n.d.) An introduction to design thinking. Process guide.

This is a short guide explaining the steps and processes of design thinking, and more specifically of model d (the Stanford model).

Helmane, I., & Briška, I. (2017). What is developing integrated or interdisciplinary or multidisciplinary or transdisciplinary education in school? *Signum Temporis*, *9*(1), 7.

In this article the authors explain the differences between the various approaches to integrated teaching and learning (multidisciplinary, interdisciplinary, and transdisciplinary).

Henriksen, D. (2014). Full STEAM ahead: Creativity in excellent STEM teaching practices. *The STEAM Journal, 1*(2), Article 15. (Available Online)

This article emphasizes the value of creativity and arts-based learning in the sciences (STEAM education), using one example from a recent research study of creative and effective classroom teachers. The author argues that future of innovative thinking in STEM disciplines relies on breaking down the distinction between disciplines traditionally seen as “creative” like the arts or music, and STEM disciplines traditionally seen as more rigid or logical-mathematical. The most exceptional thinkers in fields like science or math are also highly creative individuals who are deeply influenced by an interest in, and knowledge of, music, the arts and similar areas. In light of this, STEAM must become an essential paradigm for creative and artistically infused teaching and learning in the sciences.

Lee, V. R., Wilkerson, M. H., & Lanouette, K. (2021). A Call for a Humanistic Stance Toward K–12 Data Science Education. Educational Researcher, 50(9), 664-672.

This article emphasizes the need to consider the human aspects of data work in discussions about teaching and learning. The authors argue, based on established research, that practices involving data creation and manipulation are influenced by personal experiences, cultural tools, and political factors. Through two examples, they demonstrate that making data relevant for youth involves cultural and sociopolitical dimensions that shape learning opportunities in data-rich environments. The authors propose an interdisciplinary framework from various educational research to enhance responsible and inclusive student learning experiences with data.

Liston M., Morrin A.M., Furlong T., & Griffin L. (2022). Integrating data science and the internet of things into science, technology, engineering, arts, and mathematics

education through the use of new and emerging technologies. *Frontiers in education*, p. 348

This paper examines a collaborative STEAM (Science, Technology, Engineering, Arts, and Mathematics) education initiative in Ireland, integrating a transdisciplinary approach through a data science and IoT-based Environment Monitoring System. It highlights the importance of collaboration among educators, artists, scientists, and students, emphasizing how this partnership enhances learning. Qualitative data from various stakeholders indicated that the program encourages a reconceptualization of traditional subject teaching, fostering creativity and engineering mindsets. The project's success demonstrates how innovative technologies can improve STEAM knowledge and skills, offering valuable insights into the role of technology in enriching educational experiences.

Quigley, C., Herro , D., & Jamil, F. (2017). Developing a Conceptual Model of STEAM Teaching Practices. School Science and Mathematics, 1(117), 1-12.

This paper introduces a conceptual model for STEAM, designed to help educators teach more effectively through transdisciplinary inquiry. The model emphasizes instructional content that includes problem-based learning, the integration of different disciplines, and the development of problem-solving skills.