Co-funded by the
Erasmus+ Programme
of the European Union

# PEDAGOGICAL FRAMEWORK

**DESIGN YOUR OWN MULTIMEDIA LEARNING ENVIRONMENT (D.O.M.E.)**
Project number: **2022-1-PT01-KA220-SCH-000089939**

# Table of Content

# The D.O.M.E. Consortium

| Organisation ID | Legal Name | Acronym | Country |
|---|---|---|---|
| **E10192724** | NUCLIO NUCLEO INTERACTIVO DE ASTRONOMIA ASSOCIACAO | NUCLIO | Portugal |
| **E10212356** | ELLINOGERMANIKI AGOGI SCHOLI PANAGEA SAVVA AE | EA | Greece |
| **E10279600** | Cosmos Education CLG | BCO | Ireland |

# 1. Introduction

The project aims to empower students by involving them in building a low-cost cardboard planetarium system and developing presentations that will engage the local community and allow them to benefit from the planetarium and its associated resources. Students will use this opportunity to increase their competence profiles as well as to promote the science capital of their community and the scientific reasoning and awareness of its members. To achieve this, students will need to develop competencies in many areas, from Computational Thinking, Mathematics and Physics to aesthetic and artistic sensibility, supported by innovative thinking. These competencies are essential for 21st-century students and citizens.

To reach these objectives the teachers are extremely important, and they are supported in several ways by the project team. On the project website, there are resources and materials available with instructions and information about the cardboard planetarium. The teachers will also have the opportunity to develop and enhance their competence profile during specific events and offer their students a practical, inclusive and interactive STEAM learning experience that will help them engage more deeply with the subject matter. This approach is completely in line with the recommendations of the DigiCompEdu (Redecker & Punie, 2018) and the Digital Action Plan 2021-2027[1].

The project is focused on important aspects of STEAM learning as well as integrating the principles of the Universal Design for Learning (García-Campos *et al.*, 2020). It addresses curriculum content while inviting students to make use of digital tools and resources for problem-solving. This will take advantage of the immersive experiences offered by planetariums that translate into unique learning experiences and promote learning retention (Zimmerman *et al.*, 2014).

[1] available in https://education.ec.europa.eu/focus-topics/digital/education-action-plan

# 2. Literature Review

A planetarium is a natural non-formal learning space, where it is always possible to learn in an immersive way by being inside the show. The stimulation and development of non-formal learning opportunities like this can elevate scientific knowledge for all the participants (Gomes *et al.*, 2017). According to Gohn (2014), non-formal education is an invaluable tool for the formation process of the student as a whole, forming a citizen in their fullness. The author highlights the characteristics of this kind of education, like a process more flexible and with a structure less rigid, which is relevant for young people, reaching their attention and imagination.

Eidam *et al.* (2014) report experiences of science popularisation using a mobile planetarium with high school students. Likewise, Oliveira & Silva (2015) discuss the use of small telescopes (Galileoscopes) on night observations of the Moon and Venus. Oliveira (2016) pointed out that a mobile planetarium can reach people who live in small cities far away from the big centres, where museums, planetariums, and science centres are usually located. Planetariums present unique educational capabilities, for instance, allowing the simulation of the night sky at different times and locations. Marques *et al.* (2021) state that planetariums can be used to explain the Earth's movement around the Sun and change the viewpoint to a geocentric perspective. It can also display the sky thousands of years in the past or the future. The authors note how the planetarium presentations sparked the increase of the audience's curiosity, and how they helped clarify misconceptions and superstitions.

For an application more modern and STEM, Malchenko et al. (2021) analysed Stellarium, a well-known planetarium software available for all platforms, including mobile devices, that offers virtually infinite possibilities for classroom and extra-classroom activities. The authors pointed to the diverse uses of technology in the classroom and how they can increase student interest.

Besides, it is possible to point to a strong relationship between Science and Arts, as noted by Chappell et al. (2019), where the authors advocate the progressive transformation from a STEM to a STEAM approach. For that matter, during all of human history, creativity was always present in both vision, science and arts. For example, a rock figure is, in the same way, a representation of nature and a work of art. Only in century XIX these two areas were separated, and sometimes, put as opposite matters (Hoffmann, 2021).

## 2.1 Projects-Based Learning

Project-Based Learning (PBL) is a dynamic approach to teaching in which students explore real-world problems and challenges. With this type of active and engaged learning, students are inspired to obtain a deeper knowledge of the subjects they are studying.

In PBL, students are encouraged to work in teams, which helps them develop collaborative skills. They learn to research, problem-solve, and produce tangible results. For instance, students might design a new smartphone app, create a budget for a fictional startup, or plan a mock election.

The role of the teacher in PBL is more of a facilitator than a traditional lecturer. They guide students through the learning process, providing support and feedback when necessary. The teacher also helps students reflect on what they've learned, how they learned it, and what they need to improve on in the future.

The D.O.M.E. project is a perfect example of a PBL as a powerful pedagogical approach that makes learning relevant and meaningful for students. It's not just about memorising facts and regurgitating information. Instead, it's about active learning, where students are engaged in the learning process and take ownership of their education.

# 3. Needs Analysis

In this section, it will be discussed specific aspects of innovation in education with the use of digital tools and resources in a STEAM methodology. The main focus is not only to build a cardboard planetarium and to have access to digital tools for planetariums but also, and maybe more importantly, the competence profile of educators and learners. These findings will help the design of the Implementation Kit and the professional development suggestions to accompany the implementation of D.O.M.E. in schools. Although many of the schools in all the participating countries are well-equipped computationally speaking, this is frequently not associated with the proper preparation of teachers and students for its use and integration in classroom practices or non-formal uses. In Summary, we are focusing on the competence profile of teachers and students and how to support them to take advantage of technology-enhanced learning opportunities.

The D.O.M.E. project is focused on supporting educators in the relevant introduction of Astronomy and contemporary science into the classroom, to adopt student-centred methodologies, in particular, project-based learning and collaborate with their colleagues, from different STEAM domains and grade levels, while delivering important parts of their mandatory curricula. Another important aim of the project is to engage students in a more profound understanding of Astronomy and our place in the cosmos.

STEAM teachers are the first target audience but teachers from all subject domains and grade levels are encouraged to participate in the D.O.M.E. project. Knowing that, in general, teachers embracing innovative projects are teachers that already innovate in their practice and are willing to step out of their comfort zone, it becomes our goal to also engage other educators, with the support of these champion teachers, and offer our constant support. This will enable the participation of more students in the creation

of the school planetarium and as such provide them with a sense of ownership of the project in their schools.

## 3.1 Ireland

The Digital Learning Framework was introduced to Irish schools in the 2018-2019 school year. It provides a roadmap to help Irish schools manage the transformation of teaching and learning as a result of new digital technologies, with descriptive statements of effective practice and highly effective practice. In the Baseline Report: Towards a Successor Digital Strategy for Schools to 2027 Butler and Leahy reported on findings from Digital Learning 2020: Reporting on Practice in Early Learning and Care, Primary and Post-Primary Contexts (DES, 2020) that: "The creation of new knowledge and digital artefacts was not a well-established practice in either primary or post-primary schools. In discussions with teachers and leaders, inspectors learned that this is an aspect of digital learning that many schools are finding challenging. Moreover, inspectors reported that where digital technologies were used in schools, learners sometimes experienced the same applications and activities in different classes and year groups without obvious adjustment for their ages or stages of development."

The Digital Strategy for Schools to 2027 was published in 2022 and an Implementation Plan is due soon.

Astronomy appears in the Irish curriculum at the Primary Level within Social Environmental and Scientific Education: Geography: Strand: Natural Environments, Strand Unit: Planet Earth In Space. The expected learning objectives are detailed and can be found in the NCCA Planning Tool, note that each learning objective covers a two-year period within the eight years of primary education. At the post-primary level, the three-year Junior Cycle Science Learning Outcomes include statements within 'Earth and Space.' Students in Junior Cycle are also expected to "organise and communicate their research … in a variety of ways fit for purpose and audience, using relevant scientific terminology and representations." Astronomy appears only tangentially at the Leaving Certificate level.

## 3.2 Greece

In Greece, the systematic introduction of ICT in schools began in the early 1990s. In the present day, the cornerstone infrastructure supporting Greek schools is the Digital classroom platform (https://dschool.edu.gr) while schools can interact online through (https://sch.gr). The digital classroom platform includes all the school books in digital format (http://photodentro.edu.gr), and a community platform for support has been developed (https://e-me.edu.gr). The Greek Ministry of Education has issued a large-scale teacher training program in ICT to support the development of digital competencies of teachers, while there is also an increased interest by Greek teachers to attend additional training workshops organised in the framework of EU initiatives and projects. The aforementioned programmes have witnessed a great increase of participants especially during the SARS-COV2 pandemic.

Regarding infrastructure, there is at least one digital workplace (computer + audio + projector) per school in Greece and all schools have at least one classroom with digital infrastructure and learning platforms enabled.

Regarding Astronomy education, Greek school curricula don't have a dedicated lesson for this topic. However, topics of Astronomy are taught in the framework of other lessons within the curriculum. More specifically:

- Kindergarten
  - Earth, Solar System and Space (Earth's position, seasons, day and night)
- Primary School
  - Modern Physics-Technology-Environment-Space: the Solar System, the Earth from Space, Mars (Natural Sciences, 6th Grade)
  - The Earth as a planet of our Solar System-Age and structure of the Earth (Geography, 6th Grade)
  - The motions of the Earth and their consequences on our everyday lives (Geography, 6th Grade)
- Junior high School
  - Earth's motions and time zones (Geography, 1st Grade)
  - Magnets-Earth's magnetic field (Physics, 3rd Grade)
  - Introduction to cosmology and relativity (Physics, 3rd Grade)
- High School
  - Telescopes and Microscopes (General Education Physics, 2nd Grade)

The aforementioned analysis showcases that the optimal age group for the implementation of DOME oriented activities is students in the 6th grade of primary school and the 1st class of the gymnasium in the framework of the geography lesson.

## 3.3 Portugal

The framework takes into account the Digital School initiative in Portugal and proposes pedagogical innovation as a necessary tool for the development of quality learning and to respond effectively to the needs of all students in the 21st century. Additionally, a strong connection between digital tools and hands-on activities, such as a DIY planetarium, is essential for forming new citizens.

Since 2021, Portugal has implemented a roadmap to assist Portuguese schools in managing the transformation of teaching and learning resulting from new digital technologies. This information is available through the General Directorate of Education (http://www.dge.mec.pt/aprendizagens-essenciais-0). The provided documents contain all the necessary information about competencies and curricular components.

Astronomy is included in various components of the Portuguese curriculum, as there is no dedicated section for this topic. Specifically:

- 1st cycle (6-10 years old)
  - Although Natural Sciences does not have a specific component on this topic, students begin to comprehend their position on the planet and the

Universe around them. This includes their first exposure to the formal scientific method.

- 2nd cycle (10-12 years old)
    - Once again, the Natural Sciences component provides students with an understanding of the Earth's movements and their impact on our daily lives.
- 3rd cycle (12-15 years old)
    - During this cycle, students will be formally introduced to Physics, as well as the structure of the Solar System and the Universe. The laboratory will propose a series of experiments, some of which will be conducted digitally.
- secondary (15-18 years old)
    - Now the student who decides to go to eh pathway of science will be in contact with many concepts about Physics and General Astronomy, with a large use of laboratory experience.

The D.O.M.E. Project is focused on students for the 3rd cycle, however in special cases, students from the 2nd cycle and secondary can profit from the experience of building their own planetarium as well.

# 4. The D.O.M.E. Pedagogical Framework

## 4.1 Activities for Teachers

The activities for teachers are focused on helping the students reach the final goal: building a DIY planetarium using cardboard. They can be on topics, such as:

1. Research: Start by having students research about different celestial bodies, their positions in the sky, and their significance. This will help them understand what they will be representing in their planetarium.
2. Design: Next, students can sketch out a design of their planetarium, deciding if they will paint the outside or use a projector system to show figures; if the session will be ‘live’ or using videos; and so on.
3. Mathematical Scaling: Have students use mathematical scaling to accurately dimension the triangles to build the dome. A great way to incorporate a little more maths into the project is scaling the representation of the distances between stars and planets.
4. Building: Students can then start building their planetarium out of cardboard. They can use tools and techniques from engineering to construct a sturdy and effective planetarium.
5. Technology Integration: Students should use a projector linked to a laptop, for example, to project their stars onto the walls of the dome. This brings in the technology component of STEAM.

6. Presentation: Finally, have students present their planetariums to the class, explaining the choices they made in their design and construction, as well as the solutions they decided to use in front of each problem during the building. This can help develop their communication skills.

Most importantly, the goal of these activities is not just to build a planetarium, but also to learn about astronomy, practice problem-solving, and develop creativity and critical thinking skills.

## 4.2 Activities for Students

For the students, besides the building of the planetarium, there are some additional activities that they can engage in:

- Star Identification: Once the planetarium is built, students can use it to identify different stars and constellations. They can research these celestial bodies and share their findings with the class.
- Storytelling: Many cultures have myths and stories associated with different constellations. Students can research these stories and present them to the class. This can be a great way to integrate literature and history into the project.
- Seasonal Changes: All planetarium software allows the date and time to be changed, this enables the students to show how the night sky changes with seasons. This can help them understand the Earth's rotation and revolution.
- Light Pollution Study: Students can discuss and research the impact of light pollution on our ability to see stars. They can think of ways to reduce light pollution in their local community.
- Artistic Expression: Students can decorate the outside of their planetariums with art inspired by space and the night sky.

In realising these additional activities, the students are provided with a hands-on, engaging learning experience that integrates multiple subjects and skills.

# 5. Expected Impact

The success of the project will enable the transferability of the learning experience to other similar actions. For instance, the construction of a school observatory, an environmental station, etc. Schools will learn how to implement STEAM activities and educators and students will easily take advantage of their newly acquired or improved competencies in other STEAM learning opportunities. D.O.M.E. will open a huge opportunity to bring STEAM to the schools integrate the experience as part of their regular teaching framework and increase the inner and outside schools' collaboration.

# References

Chappell, K., L. Hetherington,H. Ruck Keene,H. Wren,A. Alexopoulos,O. Ben-Horin,K. Nikolopoulos,J. Robberstad,S. Sotiriou, F.X. Bogner (2019) Dialogue and materiality/embodiment in science|arts creative pedagogy: Their role and manifestation Thinking Skills and Creativity, Elsevier, March 2019

Eidam, J. M, Pereira, A. J. L,; Pscheidt, A. C.; Lasieviz, A. Schneider, B.; Júnior, E. M. P.; Mazzaro, I.; Silva, J. B.; Samojeden, L. L.; Schip, L. J. B.; Pysklyvicz, L.; Rossi, L.; De Freitas, M. S.; Patyk, R. L.; Soares Schwab, S. H.; Vieira, R. G.; Chiandotti, V. & Emilio, M. (2014, October 21-24). O Planetário Móvel e a Popularização da Astronomia pelo Estado do Paraná. III Simpósio Nacional de Educação em Astronomia – III SNEA. Curitiba/PR, Brazil.

García-Campos, M. D., Canabal, C., & Alba-Pastor, C. (2020). Executive functions in universal design for learning: Moving towards inclusive education. International Journal of Inclusive Education, 24(6), 660-674.

Gohm, M. G. (2014). Educação Não Formal, Aprendizagens e Saberes em Processos Participativos. Investigar em Educação - II ª Série, 1, 35 - 50.

Gomes, C. H. Dsessart, R. L. Sperandio, D. G. Oliveira, J. G. Barroso, I. Xavier, C. F. O., Antunes, C. C. (2017). Praticando Saberes e Construindo Ideias em Geociências. Revista Conexão, 13(1). 110 – 119. Rev. Conexão. v.13.i1.0008

Hoffmann, S. M. (2021). Reconstruction of ancient constellations in the planetarium dome. The Planetarian.

Malchenko, S. L., Tsarynnyk, M. S., Poliiarenko, V. S., Berezovska-Savchuck, N. A. & Liu, S. (2021). Mobile technologies providing educational activity during classes. Journal of Physics: Conference Series. 1946, 1 – 12.

Marques, J. B. V., Carlin, A. P., Gomes, M., & Moutinho, R. (2021). Periodicity and change: Talking about time inside the planetarium dome. Science Education.

Oliveira, V. A. & Silva, M. A. (2015). Utilizando o Galileoscópio em observações astronômicas. Ciência e Natura, 37(1), 179 - 182.

Oliveira, V. A. (2016). Astronomy Like the First Contact with Sciences. International Educational Scientific Research Journal, 2(8), 1 – 2.

Redecker, C., & Punie, Y. (2018). DigCompEdu: The European Framework for the Digital Competence of Educators. The European Commission‘s Science and Knowledge Service. Joint Research Centre. DOI, 10, 159770.

Zimmerman, L., Spillane, S., Reiff, P., & Summers, C. (2014). Comparison of student learning about space in immersive and computer environments. Journal and Review of Astronomy Education and Outreach, 1(1), A5-A20