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The Outer Space as an Educational Motivation

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Abstract: STEAM is an educational approach to learning that uses Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking. The end results are students who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration, and work through the creative process. The Outer Space is a window to the past and the future of our travel around the history of the Universe and can be used as a educational tool in primary and secondary education. This paper talks about the integration of the resources of European Space Agency, Space Awareness, Nuclio, Scientix and Schoolnet as motivation to integrate STEAM methodology in secondary education. Keywords: STEAM, outer space, motivation, methodology

1 Introduction

There are a lot of di erent educational systems around the world. There are also di erente methodology to put in practice and resources to use in the primary and secondary school. The educational systems with a higher level of success are those who have changed from content-based methodologies to learner-centered methodologies. Society is changing and it demands changes in school to adapt training of students to future challenges. We do not know the kind of professions that society will need in twenty or thirty years and students need to acquire skills to face the unknown and to innovate and lead the neccesary changes.

STEAM is a developing educational model of how the traditional academic subjects of science, technology, engineering, arts and mathematics can be or-ganized into a framework of integrative curricula which implies a more holistic education. STEAM is based on STEM education, which can be de ned as the combination of Science, Technology, Engineergin and Mathematics education, evolved to formally include elements of the others within their own standards and practices linked to the concept of integrative education that includes the teaching and learning practices when the subjects are willfully integrated (M. Sanders, 2006).

STEAM is a way to teach how all things relate to each other, both in school and in life. This emergent methodology is more fun than traditional methodolo-gies and makes more sense to all types of learners as it is based on the natural ways that people learn.

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Humans are navigators of space and discoveres by nature. Since the origins of humanity the human being have been looking for explanations and trying to understand everything in their environment. Heaven and the Outer Space has always attracted the attention of the human being. Understanding the Outer Space is a huge undertaking and the school must help young explorers to be prepare to new jobs related to Outer Space and the exploration of the Universe.

In this paper, we present a model of integration of the resources of European Space Agency, Space Awareness, Nuclio, Scientix and Schoolnet in secondary education as motivation to STEAM methodology. This new proposal uses the scienti c resources of these european organizations and the materials developed by di erent groups of teachers and scientists to generate new questions to the students. They must look to and through the Space to develop their skills and their di erente competences. The paper has been structured as follows. In sec-tion 2 we present the principles of STEAM methodology and the state of the art of the application of this methodology in secondary school. Section 3 introduces the di erent scienti c organizations in Europe and the banks of resources they o er on the web. Section 4 describes the design and development of a learning situation based on STEAM and scienti c resources in Europe. Finally, conclu-sions are given in Section 5.

2 STEAM Methodology - The State of the Art

STEM Education was originally called Science, Mathematics, Engineering and Technology (SMET) (Sanders, 2009) and it was an initiative created in 1990s by the National Science Foundation (NSF), a United States government agency that supports fundamental research and education in all the non-medical elds of science and engineering.

This educational initiative focused on providing all students with crticial thinking skills that would make them creative problem solvers. Several studies have been proving that students who participate in STEM education programs

would have an advantage if they chose not to continue a post-secondary educa-tion or would have a greater advantage if they did attend college, particularly in a STEM eld [2] Originally STEM concepts were used in engineering to produce revolutionary technologies such as the wheel, the printing press, antibiotics, dif-ferent types of machines, etc. The history of science and engineering inventions surprise us with the education system of some inventors. Many of them were slightly educated of they made use of self-learning, because STEM in education was non-existent in thos times. For example, Thomas Edison did not attend college [1].

Interest in education involving the study of STEM subjects began in the colonial era when Ben Franklin wrote that "topics such as grafting, planting, inoculating, commerce, manufactures, trade, force and e ect of engines and ma-chines and mechanichs ought to be taught" [8].

The Napoleon's School for Industry (1806-1815) integrated Technology, Sci-ence and Math. The students had to study decriptive geometry, drafting, math and science and they practiced on marketable products according to the draw-ings and speci cations of the director of instruction.

The Rensselaer Polytechnic Institute (1824) was the rst University in the English - speaking world to teach the practical arts to the sons and daughters of the tenants of the van Rensselaer feudal landholding [11].

In 1862 were created several agricultural and mechanical institutions. Many of these Universities, such as Ohio State University devloped manual training teacher education as part of the engineering program. The programs integrated technology and led to much of the subject matter in today's curriculum.

The Smith-Hughes Act (Vocational Education Act) was designed in 1917 to provide federal assistance to states to promote vocational education. It was the rst time that state and local public institutions formed a partnership to provide vocational training in the areas of agriculture, home economics, and trade industrial education. [3]

The National Science Foundation was born in 1950 and it started with fund-ing for graduate school fellowships. It began funding summer institutes for sci-ence and mathematics teachers. The launch of Sputnik promoted innovative curricula in physics, chemistry, biology and mathematics. In 1960s it funded ap-plied research and in 1983 Nation and Risk began funding undergraduate lab equipment and courses.

Over the last 20 years, there has been growing interest in science education in most European countries, as well as around the world. Di erente policies in Eu-ropean countries have a dual purpose: promote science and technological literacy among young people and attract young people to science and the disciplines of technology in secondary and higer education, with the aim of encouraging them to move to sicence and technology professions and/or research-scienti c careers. [5]

According to the European Schoolnet (EUN), skills in science, technology, enginnering and mathematics (STEM) are becoming an increasingly important part for basic literacy in today's knowledge economy. As stated in the recent

Report of the European Commission \Science Education for Responsible Citi-zenship, knowledge of and about science are integral to preparing our population to be actively engaged and responsible citizens, creative and innovatibe, able to work collaboratively and fully aware of and conversant with the complex chal-lenges facing society."

STEAM is an approach to education that emphasizes the integral role of arts and creativity in the learning process for science, technology, enginnering and mathematics. Arts are included in the STEM acronym as a claim of Geor-gette Yakman in 2009: \We now live in a world where you can't understand Science without Technology, which couches most of its research and development in Engineering, which you can't create without an understanding of the Arts and Mathematics."[13]

As we shall see, there is a change in education systems around the world in the context of STEAM education, and there is a growing connection between the school and the science and technologycal industry as well as science institutions. It is expected that in 2020 the demand of stem jobs will increase much more than the rest of jobs.

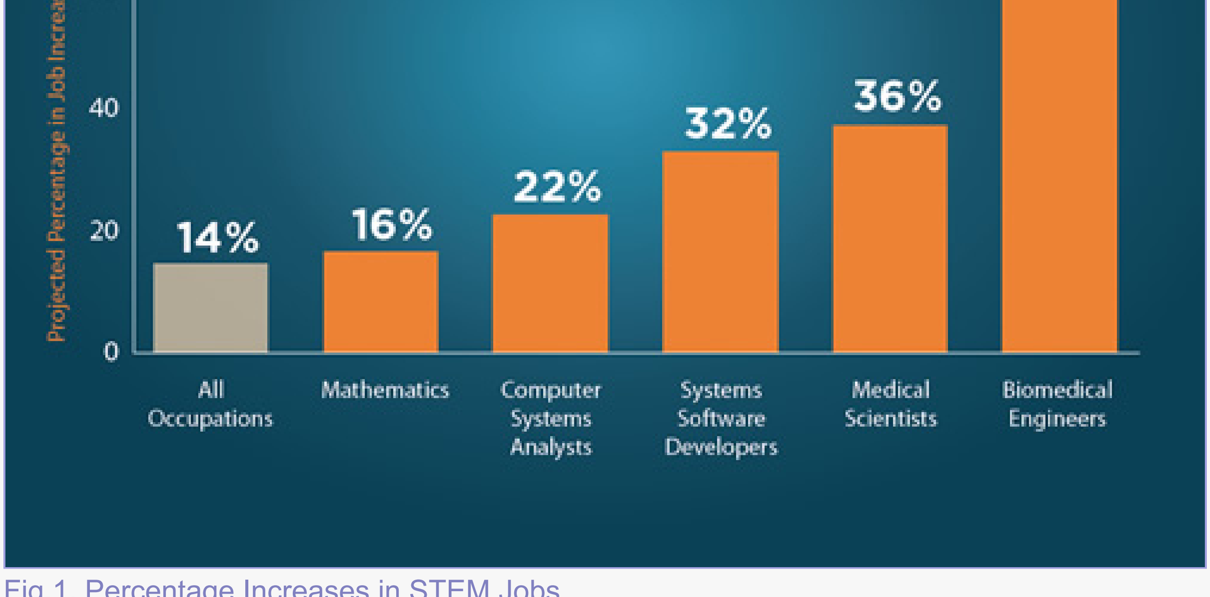

Fig.1. Percentage Increases in STEM Jobs

3 Implementation of STEAM Education

STEAM has been a increasing initiative in the last decades and there are policy movements in di erent countries to promote its implementation. Thanks to the rapid development of technologies, new professions appear and the demands for STEAM professionals grows universally.

Integrated instruction is any program in which there is an explicit assimila-tion of concepts from more than one discipline [12]. Integrated STEAM eduation programs apply equal attention to the standards and objectives of two or more of the STEAM elds - Science, Technology, Engineering, Arts and Math. There are di erent ways that a school or class can approach improving math and science education, but most of teachers address the topics as compartmentalized and separate from any other subjects. Students are more con dent and competent in these subjects when teachers help them to approach math and science in inter-active environments that develop communicationd and collaboration skills. This methodology provides tools for students to strengthen learning and contributes to a well-prepared society.

In most e ective STEM and STEAM models the objective is to provide students with the opprotunity to construct new knowledge and problem-solving skills through the process of designing artifacts [7]. They accomplish this through a series of open-ended, hands-on activities related to a thematic topic that ad-dresses important concepts related to STEM disciplines [12]. The main target of this process is involving students in de ning and optimizing a solution for a real-world authentic problem, starting with their precious knowledge and researching on the new knoledge required.

Scientists and engineers approach problem solving optimizing a solution to a problem. Science and math traditional curricula focus on well-de ned problems in which the answer is known, with only one solution, and the focus is on teaching students to get to the right answer. On the opposite side, real-world problems are not exactly de ned and do not have a single right solution. Through an education focused on real-world and authentic problems, students learn to re ect on the process and the learning is more e ective. Through explanation of hypothesis and ideas, they make connections between problem-solving goals and the processes to achieve those goals [9].

Everyone engages in problem solving and use di erent tools and materials. The approach to STEAM or "learning and creating by doing" is founded in construtivist theory [7]. The procedure that students must internalize is:

{ Re ection: Touch down with the problem's context and to provide inspiration for things the student have to investigate.

{ Research: Student research, teacher lessons in science, selected readings and other ways of gathering relevant information. Learning happens mostly dur-ing this stage. During the research phase teachers often lead discussions to determine whether students are developing appropiate conceptual under-standing [12].

{ Discovery: When students take control of the learning process and determine what is still unknown. On this stage it is a powerful strategy to work in groups, to collaborate with fellow students and to build on the strengths of their peers [7].

{ Application: To model a solution that solves the problem. In some cases, students test the model against requirements and the results can suggest them to repeat a previous step [4].

{ Communication: The nal stage is present the model and solution to peers and community. This is a very important stage because they develop com-munication and collaboration skilss and the ability to accept and implement constructive feedback [4].

4 ESERO - ESA Education Program

European Space Education Resource O ce (ESERO) promotes space as a theme to inspire and engage young people in STEM subjects. Space is fascinating to people of all ages, particularly young people. Space is all around us, inspires us in many di erent ways and it is a cross-curricular theme cutting across history, geograpnhy, science, maths, art, literature and even religious education.

ESERO is an education project of the European Space Agency (ESA), co-founded by ESA and by national partners active in the elds on education and space. This project provides a direc link between ESA and the education com-munity (students and educators). This allows ESA to support the education community with information, materials and activities geared towards science, engineering and space exploration.

Reaching millions of students and educators, with di erent languages and education systems throughout Europe is an impossible task for ESA. On this way, ESA decided to set up the ESERO o ces at each Member State, manned by an expert, well integrated into the local education system and networks.

The primary function of the ESERO o ce is to create and grow enthusiasm and excitement for European space exploration among students and inspire the next generation to pursue SET (Science, Engineering, Technology) careers.

Actually there are ESERO o ces in Austria, Belgium, Czech Republic, Ire-land, The Netherlands, Nordic Countries, Poland, Portugal, Romania and United Kingdom. Furthermore, ESA provides a resources store on the Teacher's Corner at ESA webpage (http://www.esa.int/Teachers Corner).

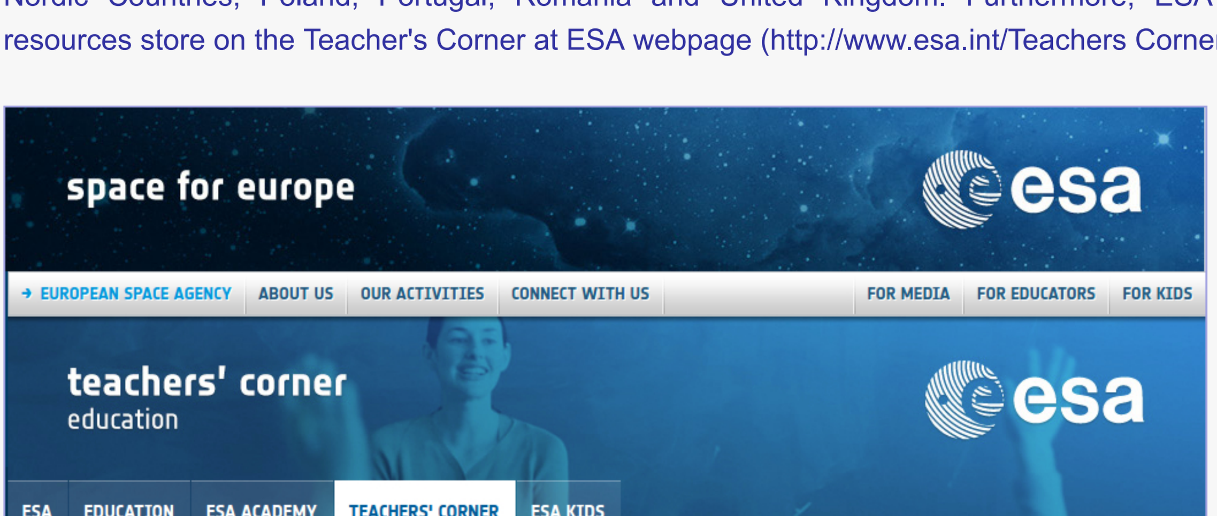

Fig.2. Teacher's Corner at ESA webpage

From the link to Teacher's Corner we can access to Classroom Resources clas-si ed in: Solar System and Universe, Earth and Environment, Astronauts and International Space Station and Rockets and Technology); training for teach-ers: Continuous Professional Development, Annual ESA Teacher Workshop and Galileo Teacher Training Programme; Hands-on Projects for Pupils: Cansats, Mission X and SPHERES Zero Robotics; and European Cooperation with oth-ers Scienti c European Institutions: Go-Lab and Science in School.

When we acces to Classroom Resources we obtain a well classi ed database to hundreds of didactic units which connect several subjects and include videos, expert demonstrations and di erent challenges. Before accesing the unit, we can know the subjects connected, the language the unit is wroten and the format of the content.

P LS HS HE

Hubble astronomy exercises

Subjects	physics & chemistry, mathematics
Languages	Deutsch, English, Español, Français, Italiano, Nederlands
Format	website with exercises in PDF

Fig.3. Example of summary of a didactic unit in Teacher's Corner

ESERO uses the outer space and related topics, as well as the genuine fas-cination felt by young people for space to enhance school pupils' literacy and competence in STEM and STEAM related topics. By using the space context to make the teaching and learning of STEM subjects more attractive and ac-cessible, pupils can feel more comfortable and familiar with sciences in general. The ESERO activities help bring STEM subjects within the pupils reach, demol-ishing the misconception that science is only for geniuses. Space, in particular, becomes not just a place of inspiration and future dreams, but also an everyday fact of modern life. [6]. On this way, there also Hands-on Projects for Pupils:

{ European Cansat Competition aimed at secondary school students, mainly addresses technology, physics, and programming curricular subjects. The CanSat activity provides students with the opportunity to have a practi-cal experience sorking on a small-scale space project and promotes teamwork. A CanSat is a simulation of a real sattellite, integrated within the volume and shape of a soft drink can. The challenge for the students is to t all the major subsystems found in a satellite, such as power, sensors and a commu-nication system, into this minimal volume. The CanSat is then launched by a rocket to an altitude of about one kilometer and the mission begins. This involves carrying out a scienti c experiment, achieving a safe landing, and analysing the data collected.

{ Mission X is an international educational challenge, focusing on tness and nutrition, that teaches students how to "train like an astronaut." Teams of students from the United States, Netherlands, Italy, France, Germany, Austria, Colombia, Spain and the United Kingdom are participating in this pilot project, while Japan hosts a modi ed version of the challenge.

In addition to all the programs and resources for students, ESA's Education O ce organises training courses for teachers interested in STEM Education. This courses are developed in three di erent ways:

{ Continuous Professional Development based on space-related resources and space facilities or training sessions during education conferences.

{ Annual ESA Teacher Workshop and organized every year in the Netherlands. One summer workshop in July and another one in October. The course is organized in a four-day programme and the teachers engage in a number of practical training sessions that demonstrate how space can be used as an inspirational and content-rich context for the teaching of STEM curricular subjects at school.

{ Galileo Teacher Training Programme emphasizes in introducing sci-ence teachers to the resources that can be used to teach astronomy and astrophysics. The programme aims to help teachers inspire young people to consider science careers.

5 Conclusions

There are di erent and varied academic articles that demonstrate the bene ts of the STEM and STEAM methodology. The outer space can be an enriching element for the generation of motivational learning situations with which to develop this type of methodologies. The European Space Agency, through its educational o ce, ESERO, o ers a good set of resources that can be used directly in the classroom or even serve as inspiration for the creation of new proposals that can be developed in the classroom through Project Based Learning And Cooperative Learning. In addition, on the ESERO website we can nd links to di erent educational programs and competitions that can also be used as a motivating element for students of all ages.

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