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GIS4SCHOOLS – PAVING THE WAY FOR THE SCHOOL OF TOMORROW: LEVERAGING ON SPACE TECHNOLOGY TO STIMULATE STEAM LEARNING AND TEACHING

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Abstract

Meeting the demand for STEAM skills in the job market is considered a priority in the European Union. The concerns related to the supply of STEAM skills rely on the educational offers from secondary schools and the propensity of pupils to follow a scientific course of study at the university level. Across Europe, every country is responsible for the definition and development of its methodological approach to enhance the teaching and learning of STEAM subjects. Because of its inspirational power, space can play a relevant role in attracting the young generation towards STEAM disciplines. Multiple projects have been developed at the European level to facilitate the familiarisation of pupils with STEAM topics by using space in combination with crucial challenges, such as climate change. An example of a project with such an objective is the Erasmus+ "GIS4Schools". The project aims to improve STEAM learning paths in secondary schools, by promoting an innovative approach to the teaching of scientific subjects, while introducing the teaching of GIS and EO applied to the topic of climate change. The project, with its activities and outputs, also aspires to become a game-changer in the definition of new shared curricula focused on the acquisition of skills related to STEAM subjects. This paper is conceived as a follow-up of last year's introduction to the GIS4Schools project to the global audience of the IAC. Leveraging in-depth interviews with the schools involved in the project and the data collected through the Digital Diaries, the paper will provide an analysis of the skills acquired by the pupils in the first half of GIS4Schools. In particular, the analysis will help to understand if the GIS4Schools products, as the Training Handbook and the use cases developed by each school, can constitute an autonomous teaching module to be integrated into existing teaching curricula. By retracing the latest developments of the GIS4Schools project, the paper will present the project as a case study for the development of future initiatives on the topic.

Keywords: STEAM, Climate Change, GIS, Earth Observation, secondary schools, education

Acronyms/Abbreviations

EO	Earth Observation
ESA	European Space Agency
ESERO	European Space Education Resource Office
EU	European Union
GIS	Geographic Information System
POLIMI	Politecnico di Milano
STEAM	Science, Technology, Engineering, Art, Mathematics
STEM	Science, Technology, Engineering, Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization

1. From STEM to STE(A)M: education adapts to global changes

Adapting education to a changing environment represents a goal to achieve for global educational systems. The existing challenges as climate change are shaping a different society and having consequences on the economic growth. [1]

Education can provide give the next generations all the tools to respond to such transformations fostering adaptability in a changing global economy and encourage reflections on the future. To provide the next generations with the needed skills to impact on the future of our society, STEM (Science, Technology, Engineering, and Mathematics) education proves to be the key to ensuring that young people are equipped to meet global challenges and to enter a labour market aligned with society's needs. Nevertheless, in secondary schools, STEM subjects are not always part or poorly taught in secondary schools, generating a distrust or disinterest in these subjects and a potential future in the sector among young people. [2]

In addition to this, another relevant aspect characterizing STEM subjects is the existence of a gender gap. Even if nowadays an increased number of

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girls have access to education than before, they often still do not have the same opportunities to choose, complete and benefit from a carrier in STEM. According to the UNESCO report "Cracking the code: Girls' and women's education in STEM", only 35% of STEM students are women. This percentage is quite alarming, considering that the future job market will be oriented towards more STEM careers.[3]

In recent years, STEM education has been seen only as a vehicle to form scientists and technicians, leaving out other disciplines that differ from science. Such limitations imposed by an old school STEM teaching do not fully reflect the idea that everything is interconnected, including subjects that apparently have nothing in common. For this reason, STEM education has been re-conceptualised, adding Arts subjects and transforming STEM into STE(A)M. STEAM-based curricula are not just focused on scientific concepts, but characterised by a learning approach using Science, Technology, Engineering, Mathematics and Arts to stimulate students' critical thinking, dialogue exchange and understanding. [4]

STE(A)M teaching relies on teachers' willingness to pursue new teaching methodologies and to push for new curricula. In this sense, teachers can be empowered to employ project-based learning that can cross each discipline, while fostering an inclusive learning environment in which all students are part of. The whole point of STE(A)M is to inspire inquiry and curiosity and to empower students to promote their creativity and connect their problem-solving skills to real world solutions. [5] A major obstacle to this is represented by skills and training: as today, while there is a sort of enthusiasm in approaching STE(A)M curricula, at the same time, adequate skills and training are missing and there is a general discourage from pupils' side towards pursuing careers in this domain. [6]

2. The need for a new narrative: space technology to support STE(A)M teaching and learning

Considering the low motivation of pupils in approaching future STE(A)M paths, it is crucial to find a way to inspire them in challenge themselves and look to the world around differently. A new narrative focused on the current societal challenges is needed to support a modernisation of the STE(A)M teaching and to stimulate pupils' curiosity. In this respect, introducing space technology in schools could be beneficial. [7]

Space has a fascination effect: from kids to adults dreaming about space and looking at space endeavours push them to look beyond what we know about the universe and to think bigger.

For the younger generation, talking about or explaining the benefits of space can lead them to push their limits and to inspire them in becoming part of the sector, pursuing in this way a career in STE(A)M. [8]

With space economy on the rise, bringing space into classes might have two consequences:

1- favour the preparation of future new professionals for the space industry, given the differentiation of professional figures required by the industry today; [9]

2- implement the knowledge of space-related benefits and how space technologies can be facilitators in mitigating or limiting the consequences of global challenges, one of them being climate change.

To support the teaching of space in schools, several initiatives have been launched. For the purpose of this paper, it is considered Europe as geographic area of interest. Across the region, space agencies or offices developed their own didactic materials and initiatives addressing teachers and pupils. One of these is the establishment of the European Space Education Resource Office (ESERO) project [10], launched by the European Space Agency (ESA), that today counts on an extensive representation across Europe. It uses space related themes and the genuine fascination felt by young people for space to enhance school pupils' literacy and competence in STE(A)M-related subjects. ESERO aims at making STE(A)M subjects more attractive and accessible. It offers annual training sessions for school teachers in collaboration with national partners active in STE(A)M education.

In addition to this, the work done at European level by the European Commission through the Erasmus+ funding programme, represents another crucial element to support innovative projects in the educational domain, giving the opportunity to connect different educational systems with key industries in the European economy, as the space industry.

3. The GIS4Schools project- Paving the way for the school of tomorrow

Currently, STE(A)M education represents a strategic priority for the European Union in the field of education and training. [11]

In this frame the Erasmus+ funded project GIS4Schools is poised to play a significant role: it addresses on a transnational basis, digital skills, in connection with climate change awareness- a hot topic for the young generation- and understanding for secondary schools' pupils and teachers. The ultimate project's goal is to generate curiosity around STE(A)M disciplines, by involving them in hands-on activities to enhance their knowledge and capabilities. The project

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has the ambition to introduce, for the first time in secondary schools, GIS and Earth Observation (EO) technologies. In this case, GIS and EO are linked to climate change effects on local communities. [12]

The innovative aspect of the project lays in the idea of setting up new education curricula for secondary high school leveraging on geospatial education. The testbed is represented by the four EU countries involved in the project- Italy, Portugal, Romania, and Spain- where the adoption of GIS technology into school education is very limited or null, and GIS curricula are not compulsory.

One of the strengths of the project is represented by the direct involvement of pupils. Through GIS4Schools activities, they are acquiring new specific knowledge while developing cognitive skills such as problem solving, critical thinking, etc. Involving pupils in the co-creation phases of concreate products for their local communities, as maps or reports on a specific climate-related challenge, impacts on the growth of their learning curve and on their motivation to follow a STE(A)M career. [13]

3.1 Training the next generation of teachers: the GIS4Schools Training Package and the E-learning platform

The GIS4Schools project kicked off in September 2020 and will be concluded in June 2023.

During this first project phase an important learning tool was developed to support teachers during the project: the Training Package. Designed and developed by the Politecnico di Milano (PoliMi), the Training Package aims at transferring to the teachers GIS and EO fundamentals, providing them with the skills to be shared autonomously with pupils. [14]

To accompany the teachers in this learning process, PoliMi's experts designed together with the handbook a training path for teachers divided into five days online training course structured into theoretical and applied modules. The training book, developed in HTML language using Sphynx and hosted on GitHub, combines theory and practice, in the form of step-by-step exercises following a learn-by-doing approach. Indeed, the theory has been complemented by hands-on exercises to show the application of the learned concepts and to lay the basis for the projects that the pupils will develop in the project framework. The exercises have been selected to show interesting cases related to the partners Countries and considering their interests for the development of the projects.

The training package has two main objectives:

1. providing the teachers with a new teaching methodology for GIS and EO;
2. facilitate the transferring of knowledge to the pupils.

The main challenge identified in the designing of the training package, was represented by the need to find a good balance between the technical information to be included in the handbook and the language to describe it. As a matter of fact, the handbook has been built based on the learning environment and learners' existing knowledge and skills which has been ascertained during the project meetings with the schools' teachers. [15]

The design of the training package has been done taking considering the mission of creating an international community of teachers with skills and competences in GIS and EO that will support the implementation of innovative educational curricula. For this reason, the handbook should be considered as a self-standing tool to be adopted and integrate as a teaching tool. The training package, namely the handbook, has been translated in the official language of the project: English, Italian, French, Spanish, Portuguese and Romanian. The objective is to push for a wide adoption of the package across Europe and beyond. [16]

The Training Package is downloadable for free from the project website since February 2022. It has been downloaded by 83 users, mainly from academia and secondary high schools:

Figure 1. GIS4Schools Training Package download, focus on the users' affiliation. Sources: GIS4Schools, Eurisy, Euronike

Most of the users are based in Europe, as shown by the table below. The rest of them downloaded the handbook from Ecuador, Mexico, Colombia and Argentina, Ukraine, Cameroon and Kenya.

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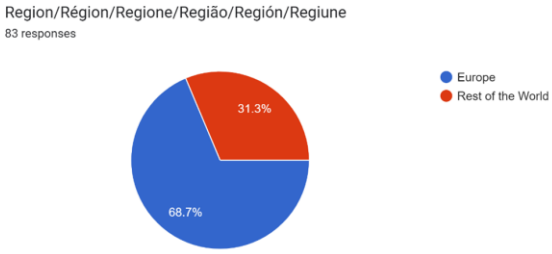

Figure 2. GIS4Schools Training Package download, focus on the users' geographic provenance. Sources: GIS4Schools, Eurisy, Euronike

According to the survey that accompanies the download of the book, not all the users that downloaded the Training Package are sure about using it. The reason can be found in the need to have an additional support other than the single handbook.

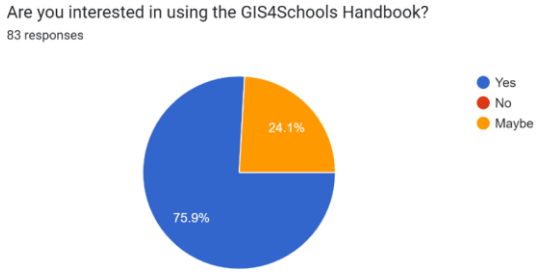

Figure 3. GIS4Schools Training Package download, focus on the users' interest in adopting the handbook. Sources: GIS4Schools, Eurisy, Euronike

For this reason, and to facilitate the adoption of the handbook, an E-learning platform has been created. It was conceived as a unifying technological tool that keeps all the different components of the project together and that assures the transferability of training and educational material developed during the project work frame.

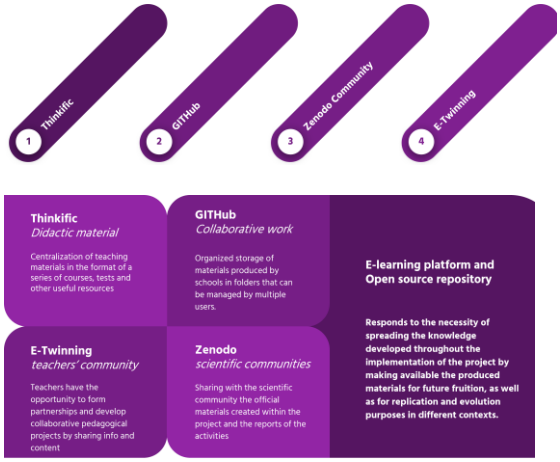

Figure 4. GIS4Schools E-learning platform elements. Sources: GIS4Schools, Urban2020. Graphic Elaboration: Urban2020

3.2 Pupils' and teachers' learning path after the teachers training

The innovative spirit of the GIS4Schools project is reflected also in the Digital Diaries tool, designed and developed as a fast, not expensive and scalable tool based on open-source digital technology. It provides real time monitoring and assessment on the development of the learning curve for both teachers and pupils.

The Digital Diaries, developed and monitored by Euronike, have been conceived as a "standard diary" where pupils and teachers can anonymously collect and share their impressions and progress with the evaluation group throughout the project's progresses. The Digital Diaries tool entails two elements:

1. A smartphone application to be installed by the project participants.
2. A scalable application (serverless) that is used to manage the entire communication path (sending diary pages / receiving responses), the analysis of compiled diaries, and two types of reporting:
    a. a dashboard for the staff to show the evolution of the main project indicators.
    b. a dashboard for participants to self-assess their path within the project and check the progress of the group they belong to. [17]

[18] After the training course organised by PoliMI, through the Digital Diaries it was possible to track the ex-ante and ex-post pupils' learning path: 21 surveys were carried out and submitted to pupils from March 2021 to June 2021. The response rate showed different results among the countries participating in the project.

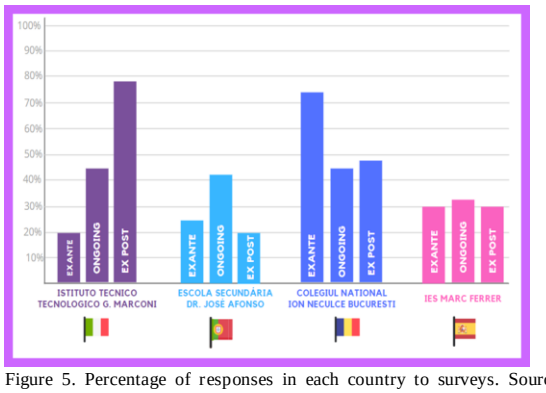

Figure 5. Percentage of responses in each country to surveys. Sources: GIS4Schools, Euronike. Graphic Elaboration: Euronike

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It emerged that in the four countries observed, the knowledge of STEM subjects is quite limited: pupils' involvement in subjects as Earth science, math and physics is relatively low, except in Portugal where earth sciences seem to be a bit more attractive for the students. On the contrary, in Spain, knowledge and interest in mathematics is quite low.

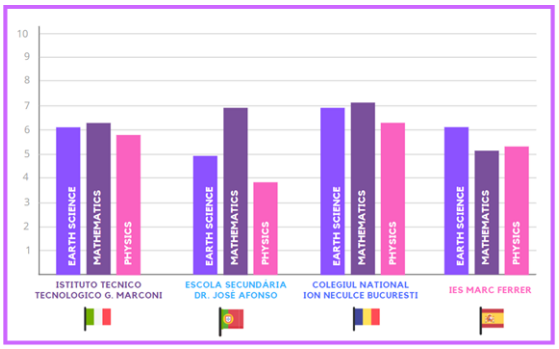

Figure 6. Average level of interest in earth science, mathematics and physics in each school. Sources: GIS4Schools, Euronike. Graphic Elaboration: Euronike

As far as the knowledge of programming tools- relevant for the purpose of the project- Italian and Romanian students declared to know at least one programming language, while many of the Portuguese and Spanish respondents affirm that they do not know any. It emerges from the initial situation of the students involved in the project is, therefore, extremely differentiated.

During the training performed by the teachers, the pupils were invited to provide their feedback in an ex-post survey. What emerged after the transfer of knowledge from the teachers to the pupils was an improvement in understanding the personal level of knowledge in all four countries, especially in Spain and Romania.

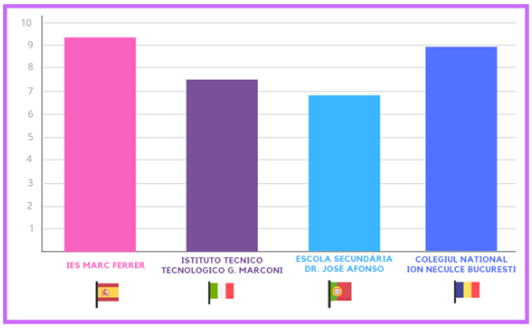

Figure 7. Pupils' perception of STEM knowledge's trend. Sources: GIS4Schools, Euronike. Graphic Elaboration: Euronike

The training helped the pupils in enhancing their understanding of local climate challenges and their contribution to the project objectives.

Also, teachers' improvement during the project was evaluated through the Digital Diaries ex-ante and ex-post the training course with Polimi. During the training held in March 2021, teachers filled their diary pages to assess their knowledge before, during and after about the course. Teachers showed a good understanding of the project's core topics: environment and climate change, while imagery analysis, EO, geospatial data management and GIS were not very familiar topics.

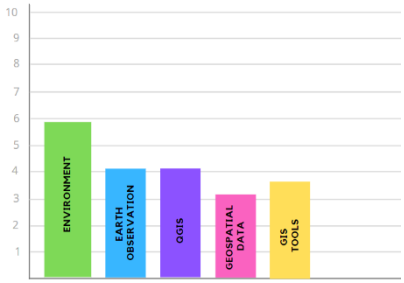

Figure 8. Teachers' average of knowledge entry-level on different topics. Sources: GIS4Schools, Euronike. Graphic Elaboration: Euronike

After the training course, through the Digital Diaries emerged a different picture with the teachers recording significant improvement in their skills, even though teachers had some difficulties during the course due to the fact it took place remotely because of COVID-19 pandemic. In addition to this, at the beginning the content of the course was considered hard- especially EO and Geospatial analysis for disaster management- as well as the language used by the trainers from POLIMI.

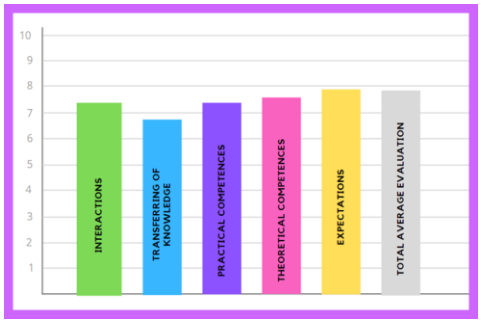

Figure 9. Teachers' ex-post evaluation of different aspects. Sources: GIS4Schools, Euronike. Graphic Elaboration: Euronike

4. Involving external stakeholders- the in-depth interviews

The project partners were also invited in identifying national stakeholders to evaluate the educational material developed by the project partners among universities, government structures or agencies, commercial companies and NGOs or cultural associations. Each of them was interviewed to introduce the project and to collect their views on STE(A)M education at national level and their impressions on GIS4Schools objectives and training material. [19]

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STAKEHOLDER	FRANCE	ITALY	PORTUGAL	ROMANIA
EDUCATION AND RESEARCH	MINES PARIS TECH	UNIVERSITY OF TRENTO	FCT/UNL	UNIVERSITY OF BUCHAREST
GOVERNMENT AND PUBLIC AUTHORITIES	GIS BRETEL	MUNICIPALITY OF ROVERETO	JUNTA DE FREGUESIA QUINTA DO CONDE	BRASOV METROPOLITAN AGENCY FOR SUSTAINABLE DEVELOPMENT
SMALL MEDIUM ENTERPRISES INDUSTRIES	KERMAP	TRILOGIS	VECTOR CRIATIVO DESIGN E MARKETING LDA THIS.FUNCTIONAL LDA	ESRI ROMANIA
NGO / CULTURE	CVA	MUSE – SCIENCE MUSEUM OF TRENTO	ASSOCIAÇÃO DE PAIS DA ESCOLA BÁSICA DA BREJOEIRA	IMAGO MUNDI ASSOCIATION, NATIONAL COLLEGE ZINCA GOLESCU

Figure 10. In-depth interviews, stakeholders distinguished by characteristics and Country. Sources: GIS4Schools, Euronike. Graphic Elaboration: Euronike

What emerged from these interviews is a general perception that not enough is done for the STE(A)M learning in schools and that this represents an obstacle not only for the pupils, but also for universities professors that often must deal with knowledge gaps. In addition to this, there is a general lack of awareness around the EU role and investment in promoting STE(A)M education. This might be related to the exclusivity that each EU member states has on education. This produces a silos effect, with countries working on their educational programmes autonomously.

Besides this, the interviewees recognized the relevance of the project's objectives for secondary school students. Acquiring geospatial skills can be key not just for those that are willing to follow a scientific university career, but also for the students that are following a different path and wanted to better understand the current mechanisms between many environmental aspects.

The in-depth interviews highlighted that project as GIS4Schools have a huge potential, also because they aim at creating a new community that put at the core younger generations and their future. It is, then, important to focus on the dissemination of project's outputs to a wide and diversified audience, try to outreach to multiple communities active in the educational domain. The mission should be to favour the adoption of innovative learning materials and its additional implementation.

5. Conclusions

The GIS4Schools project is the best example to explain how space technology can help to promote STE(A)M teaching across Europe. Bringing GIS and EO in secondary schools has a double value: on the one hand, it helps young people to acquire new skills useful for their future university career and the world of work, and on the other hand, it helps them to familiarise themselves with topics that are not easy to understand even at school age. By generating curiosity in GIS and EO, students may develop a greater inclination towards STE(A)M subjects, creating a domino effect with other peers.

A key role is also played by teachers. Through their interest and willingness to support the learning of STE(A)M subjects, they can leverage the material developed within the framework of the project. This can help promote new curricula or update school curricula for these subjects, introducing totally new subjects such as GIS, EO, climate change and, more broadly, space.

A bottom-up approach can also be significant in inviting institutions responsible for education to rethink school curricula and the learning of STE(A)M subjects from a more unified perspective. For example, a harmonisation of European educational curricula could be considered in order to update and adapt them to the needs and demands of future generations, who aim to better understand the world around them. To do this, it might be useful to work in cooperation with organisations not directly related to education, such as space agencies that in turn promote initiatives to support the spread of a more innovative school with space as an enabler.

The GIS4Schools project will move forward with its activities until June 2023. Currently, the schools are finalising the development of their local GIS products. The idea is to develop replicable solutions to be promoted in developing countries and share with local entities a new way to learn.

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