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GEO-ACADEMY: DEVELOPING TEACHERS SPATIAL SKILLS FOR CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT EDUCATION

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Abstract

Climate change and sustainable development are particularly challenging topics for teachers to teach due to their complexity and connection with many different school subjects, alongside the need to combine scientific content with green, digital, and spatial competencies. Spatial competencies are particularly important in this regard, as around half of the essential climate variables can only be adequately measured from space. Research indicates, however, a deficiency in teachers' knowledge of key climate and sustainability content, as well as the skills required to access, analyse, and then effectively convey climate change data, through using, for example, Earth Observation (EO) imagery and GIS technologies. Ultimately, available training offerings are often misaligned with teachers' schedules or curricular needs, based on outdated pedagogical models or technologies. Addressing these facts, GEO-Academy is an Erasmus+ Teacher Academy project transforming climate change and sustainability education throughout Europe by establishing a network of educators and providing a suite of cross-curricula resources and training to enhance their green, digital, and spatial skills. The GEO-Academy consortium features expertise from climate science, space applications, and education working together to empower pre- and in-service teachers from primary to upper secondary education to incorporate innovative digital technologies (EO, GIS, remote sensing, and geo-spatial storytelling) within identified curricula requirements in climate education. The consortium offers teachers national and international training courses across Europe, while building an online platform, called GEOBSERVE, hosting online courses, resources, and materials, and serving as a community of practice for teachers. Schools will be networked via GEO-Hubs, coordinated at national level, and connecting with other local stakeholders. Ultimately, GEO-Academy will foster a community of educators, training teachers to train other teachers, with all activities aimed at enhancing climate education across Europe. This essay will focus on preliminary results and experience from the project's first year in operation, presenting the project's methodology and outcomes so far. By introducing the project's evidence-based pedagogical model developed to actively train teachers alongside our GEO-Concepts as guiding topics through which training materials are structured, the essay will then demonstrate the GEOBSERVE platform, as a centre for resources and teachers to connect with. The essay will also present the project's teacher training events, focusing on the development of teachers' spatial competencies through the GEO-Academy resources alongside teachers' experience from learning and implementing them.

Keywords: Education, Sustainable Development, Teacher Training, Erasmus+ Project, Geospatial Technology

Acronyms/Abbreviations

EO	Earth Observation
ESD	Education for Sustainable Development
EU	European Union
GIS	Geographic Information Systems
GPS	Global Positioning Systems
RS	Remote Sensing
SDGs	Sustainable Development Goals
STEAM	Science, Technology, Engineering, Arts, and Mathematics
UN	United Nations
WSA	Whole School Approach

1. Introduction

The United Nations (UN) Climate Action identified many effects of climate change, such as hotter temperatures, more severe storms, increased drought, a warm and rising oceans, loss of species and more health risks [1]. In order to contribute to climate action, GEO-Academy recognised that a special emphasis should be placed on educating our youngest, and hence improving the education offer for sustainable development. In light of this, GEO-Academy thus aims to train teachers and help them develop the necessary digital, green and spatial skills so they can use new technologies and tools to be well-equipped for a change. This essay shows how the GEO-Academy project aims to develop teachers' spatial competencies over unparalleled opportunities for demonstrating the effects of climate change on our planet, and the power of space technologies to understand it. The essay first introduces GEO-Academy (section 1.1), its objectives (section 1.2), and methodology (section 1.3). This is followed by the presentation of the preliminary results of the project, including the Evidence-based pedagogical model (section 2.1) and the GEOBSERVE platform (section 2.2). At last, the essay outlines the project's trainings (section 3).

1.1 *About GEO-Academy*

GEO-Academy is an Erasmus+ project composed of a consortium of 12 partners in 7 EU countries. Beginning in June 2023, GEO-Academy is establishing over 36 months a network of teachers and teacher trainers and develop training resources as well as an international community advocating to enhance STEAM (Science, Technology, Engineering, Arts, and Mathematics) education through the inclusion of Geographic Information Systems (GIS), Global Positioning Systems (GPS), Remote Sensing (RS) and Earth Observation (EO) in Education for Sustainable Development (ESD). By targeting both pre- and in-service teachers, GEO-Academy aims to enhance educators' digital competencies, green skills, and spatial skills, enabling them to incorporate inspiring examples of environmental and climate phenomena using real-world data through digital storytelling across a range of subject domains.

GEO-Academy will accomplish this by focusing on five (5) GEO-Concepts as the foundations of the project's substantive ambition, and from these developing educational models for teacher training structured along the three competence pillars (Digital, Green, and Spatial). The 5 GEO-Concepts identified are: 1. Cartography and development of spatial skills; 2. GIS tools and techniques; 3. RS, EO and Satellite applications; 4. Visualisation and synthesis of information through map storytelling; 5. STEAM education, robotics and coding. Initial training courses through national training GEO-Hubs are then evaluated, modified and disseminated through the GEOBSERVE platform, a repository and community of practice developed by the project for sharing resources and best practices. The next stage involves scaling up training activities through local, national, and international events, from seminars to summer schools, conferences, and more. The results will be an expanding network of teachers and teacher trainers at the institute level (GEO-Labs) empowered with access to new and innovative teaching tools acting as social innovators, community leaders, and ambassadors in climate change education, with resources accessible beyond the project's physical and temporal boundaries.

1.2 *Objectives*

GEO-Academy aims to empower critical engagement with the complexity, contradictions, and uncertainty associated with sustainable development. Teachers should be supported in developing competencies that enable them to critically and constructively address the challenges associated with empowering our society to participate in sustainable development [2, 3]. Numerous relevant competency models or reference frameworks for ESD have been developed in the last years and it can be assumed that more will be created in the future. The various models have in common that they are based on a holistic approach to competencies, which considers not only cognitive but also motivational and volitional aspects [4] and, among other things, aims to develop key competencies for sustainable development such as interdisciplinary thinking. The growth of educators' professional action skills concerning ESD is crucial in the context of teaching and instruction. Integration of a critical-emancipatory ESD in the central fields of activity of educator education and training, as well as professional field-related research and development, is of special relevance for a structural anchoring of ESD at teacher training institutions.

In this sense, the GEO-Academy project responds within the context of the 2019 EU Green Deal Recommendation [5] of the EU, the 2030 UN Strategy and the 17 Sustainable Development Goals (SDGs) [6] as well as the Green Competence Framework [7] guidelines along with the Digital Education Action Plan, the DigiComp [8], and the GEO Initiatives [9] for enhancing sustainability competences. The targeted objectives are focused on:

- The development of environmental and climate change awareness activities such as ad hoc training to allow teachers to acquire new key competencies (digital, green, spatial) in order to prepare their students for a career in the geospatial and environmental fields in line with the scope of generating interest in students to follow a STEAM learning path (**GEO-Academy Unified Competence Framework**).

- The integration of digital skills related to the use of the current and future geo-technologies into the educational practices, to stimulate both success and participation in STEAM disciplines. Thus, different topics (**GEO-concepts**), incorporating cartography, GIS, RS and EO as well as map storytelling, robotics and coding, will function as the bridge for cultivating cross-cutting concepts across different disciplines.
- The utilisation of digital technologies (**Geospatial technologies**) through the creation and use of innovative GIS, RS, and EO tools, applications and modelling schemes, communicating in parallel digital content using different storytelling platforms.
- Provide teachers access to new and innovative teaching tools, as well as scale up their knowledge on challenge-, project- and problem-based educational approaches through teacher training and professional development programmes (**GEO-Academy Pedagogical Framework**).
- The enhancement of teachers' competences by supporting the school community to address the study of these phenomena in a holistic point of view, using interdisciplinary teaching with different subject teachers (**GEO-Labs as Living Labs for ESD**).
- The transfer of scientific and research knowledge by translating it into educational practices, making it accessible to teachers and educators via the **GEOBSERVE Platform**.
- The upgrade of the role of schools as social innovators and active partners in the efforts for social change towards sustainable development and climate change. As a result, the school as a unity, the teachers and pupils, are seen as green and geo-innovators, ambassadors and active citizens contributing to their community under the lenses of a **Whole-School Approach** [10].

1.3 *Methodology*

In Figure 1, the conceptual diagram of the GEO – Academy methodology is illustrated. The diagram highlights that in the era of "digital natives", open linked data, digital earth, ubiquitous mapping, citizen science, location-based services and geospatial intelligence, a new civil society of Spatial Citizens and Sustainability Citizenship is emerging, with the perception, consciousness, and ability to understand, map, communicate and design. This suggests two important ideas, on which GEO-Academy is focused: the use of digital tools for teaching (which requires teachers pedagogical and digital skills for using the technology), and the use of digital tools for learning (which requires pupils to develop skills for utilising the available technologies in geosciences in productive and sustainable ways). It is structured around scientific evidence and research results and their transformation into educational material for synchronous and asynchronous, formal and

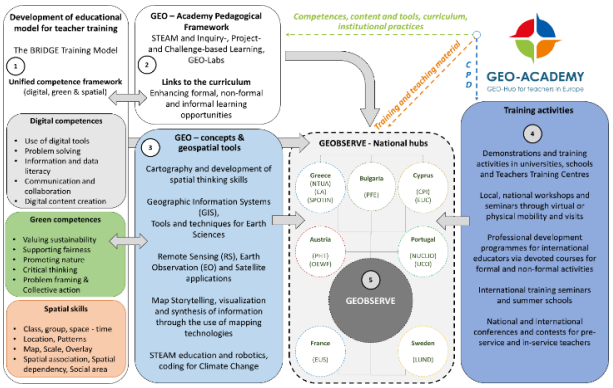

Figure 1 A conceptual representation of the GEO-Academy's Methodological Framework under the lenses of the key Whole School Approach (WSA) pillars

informal training tailored to the trainees. The GEO–Academy methodology is grounded in five different levels/cycles, as illustrated in Figure 1. The core of the project's line of action comprises of: (a) the design and establishment of the training model and of the unified competence and pedagogical frameworks (Levels 1 and 2 in Figure 6), (b) the integration of the scientific topics and the inherent geospatial tools to be used (Level 3), and finally, (c) the transformation of the scientific knowledge to educational material for face-to-face, virtual or blended training (Levels 4 and 5).

At the initiation stage of the project, desk and field research was conducted on the existing educational materials including a literature review on ESD initiatives, concepts and best practices. In this context, drawing on the key features, competences, and tools reviewed, the model for the teacher education and professional development (based on the **BRIDGE model**) of the GEO-Academy was developed. The Bridge Model focuses on creating a link between the curriculum on the one hand and student learning outcomes on the other. Existing offerings for this connection between curriculum and student learning outcomes often fall short by only addressing selected aspects of this teaching requirement. Particular attention is paid to the practical applicability of the tools and resources offered for teaching. The holistic approach to teacher training within the framework of the Bridge Model enables teachers to react quickly and with manageable effort to current requirements in the education system, such as the consideration of interdisciplinary aspects. This is achieved in particular through access to evidence-based teaching strategies and the establishment of routines in day-to-day school life. Furthermore, desk research and a comprehensive literature review were also conducted to identify teachers' needs to teach Geo-sciences. The primary objective was to collect background information on the (a) design of the **Geo-Academy unified -**

competence framework for skills development (digital, green and spatial), (b) use of different **GEO – concepts** in ESD covering different SDGs and societal, environmental and economic aspects, (c) development of teacher's guidelines and supporting materials, and (d) delineation of the strategies to assess sustainability competences (knowledge, skills and attitudes).

Based on the GEO-academy competence framework, the GEO-concepts and the geospatial tools to be used, the **GEO-Academy Pedagogical Framework** was grounded on the introduction of Project-, Challenge-, and Inquiry-Based Learning in school settings. All these pedagogical approaches provide an efficient and effective framework for learning while solving real-world problems and challenges related to different sustainability topics. The framework fuels collaboration to identify big ideas, ask thoughtful questions, and identify, investigate, and solve challenges, cultivating the green, digital and spatial skills necessary to thrive in an ever-changing world. When teaching and learning methods for a specific setting or topic are chosen, they have to match the needs of the learner group (e.g. based on age, prior knowledge, interests, and abilities), the context in which the learning takes place (e.g. space in the curriculum, pedagogical climate, and cultural traditions), and the resources and support available (e.g. teacher competences, teaching materials, technology, and funding opportunities).

To further support the above-mentioned learning methods, the Living Lab (LL) methodology will be adopted which is issue-driven and exists within rich, complex, and contested real-world problems and challenges [11]. To this end, the theoretical basis for the co-creation methodology is transdisciplinary and, in broader terms, defined as the attribution of knowledge from science in an issue-driven process [12]. The key principles of LLs are openness, continuity, empowerment, realism, and spontaneity in a methodological approach or a physical place [13]. Following the LLs added pedagogical value, GEO-Academy is planning to develop the necessary resources for successfully implementing GEO-Labs (i.e. Geospatial Living Labs) in schools. Hence, the **GEO-Labs** can act as LLs within the GEO-Academy project, providing an issue-driven, real-world environment where sustainable development and innovative teaching practices intersect. To succeed in this, GEO-Labs will include a GEO-kit, comprising digital materials and various technologies such as sensors and programmable boards (Arduino, Raspberry Pi, Micro:Bit). Possible experiments include building geophysical sensors like seismometers and acoustic monitors, meteorological monitors for temperature, humidity, and air pollution, and using drones for remote sensing.

At last, Levels 4 and 5 of the GEO-Academy methodology incorporate the large-scale teacher training professional development programmes – Teachers' Network. This process will be supported by all national hubs that will host training courses at local and national levels and three international training events, while the **GEOBSERVE platform** will host virtual events and webinars where the teachers will meet both face-to-face and virtually. After the familiarisation with the educational materials, the participating pre- and in-service teachers will implement them in their classrooms and will reflect on this implementation in order to provide the community of practice with the necessary feedback and proposals for further refinements. Furthermore, the unified competence– based framework will be used in the University and school curricula (in Sweden, Greece, Austria, Portugal and Cyprus), with appropriate modifications, when necessary, to support existing or new courses, strengthening geospatial technologies for ESD.

2. Preliminary results

2.1. Evidence-based pedagogical model

The concept for teacher training within the framework of the Geo-Academy envisages that the teacher retains the necessary flexibility in the selection of learning tools and resources in order to take account of the highly specialised situation in the respective classroom. Not only obvious parameters such as class size or the socio-economic background of the students influence the choice of a pedagogical tool, but also subtle differences in individual year groups of a school with regard to class structure and class community must be able to be adapted to the situation by the teacher. As the training within the Geo-Academy is not based on a pedagogical concept per se, but rather presents various implementation scenarios for specific learning tools as examples for teachers, it is up to the teacher to assess whether the specific pedagogical implementation appears suitable for their own situation. The only criterion for inclusion in the Geo-Academy Portal is that the proposed implementation scenario must have a corresponding evidence-based foundation and a corresponding data-based confirmation - either in a real implementation in the classroom or in a learning research laboratory.

The selection of learning resources within the framework of the Geo-Academy is also very much linked to the respective curriculum, which differs from country to country. Based on the desired learning outcomes on the part of the students and with clear reference to the required curriculum (in the respective country), the participating teachers are provided with a range of learning resources to choose from as part of the training. In addition, the training aims to embed the implementation scenarios in everyday school life and

firmly anchor them in the teachers' teaching practice by establishing routines [14, 15].

By creating learning communities within the Geo-Hubs, it is envisaged that teachers will support each other in this challenging task and share intelligent adaptations of the resources and tools offered on the Geo-Academy portal in order to further optimise the learning outcomes that students can achieve.

2.2. GEOBSERVE Platform

A pivotal milestone of GEO-Academy is the establishment of a common virtual community of practice. This is materialised as the GEOBSERVE platform (https://portal.geoacademy.eu/), a virtual meeting space for teachers where they can exchange best practices, and where new materials and lessons are stored and distributed through the GEO-Academy Hubs. Its objective is also to support the teacher's training events and initiate peer-to-peer training, therefore ensuring the sustainability of the GEO-Academy project.

The aims of GEOBSERVE are twofold: collect learning materials, and create a peer-to-peer community, where good practices can be exchanged. As such, the GEOBSERVE Platform serves as the entry point for teachers and schools, who want to interact with the hubs, whilst the GEO-Academy website will remain the main information channel of the project.

GEOBSERVE offers a variety of different features such as Tools, Groups, Courses, Events and Contact. In addition, there is a special feature through which the existing GEOBSERVE members can login and connect with the GEOBSERVE community, and a feature "Become a Member" through which new users can register and become members. GEOBSERVE also offers virtual events such as webinars and synchronous training activities. The platform is available in the following languages: Bulgarian, English, French, German, Greek, Portuguese and Swedish.

2. Teacher training events

Providing training opportunities to teachers, both face-to-face and online, is at the heart of GEO-Academy. The consortium is responsible for organising large scale training events.

The first international teacher training event took place between 7 and 12 July 2024, in Marathon, Greece. The GEO-Academy Summer School 2024 focused on exchanging knowledge and enriching the participants' understanding of site-specific problems linked to geospatial phenomena, such as population density, and flood susceptibility, as well as relevant methodologies, resources and geospatial tools. Through a range of lectures and collaborative workshops, the summer school aimed at fostering partnerships between teachers, students, innovators, researchers, and stakeholders in science-related fields, encouraging collaboration on real-life challenges and innovations, among other things. Different geospatial tools were presented, such as PurpleAir, EO Browser, GTIF and many more. Participants were also presented to the GEOBSERVE platform.

Two additional international training events will be organized by the collaboration: one in February 2025 in Vienna, Austria, and another one in July 2025 in Portugal. In addition to the summer and winter schools, GEO-Academy will also offer online training via the GEObserve platform, and local training via its national nodes. These training sessions will start on October 2024 and will be offered continuously until the end of the project.

3. Conclusions

This essay introduced the GEO-Academy project and its main objective to contribute to the development of teachers' spatial competencies over unparalleled opportunities for demonstrating the effects of climate change on our planet, and the power of space technologies to understand it. After the presentation of its 5-level methodology, the essay provided an overview of the preliminary results of the project, including the Evidence-based pedagogical model, the GEOBSERVE platform and the project's training activities.

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