

A REVIEW OF EARTH OBSERVATION RESOURCES FOR SECONDARY SCHOOL EDUCATION – PART 1

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Abstract

This article provides an overview of worldwide web and e-Learning resources for Earth Observation (EO) education for secondary schools. The main EO education initiatives supported by international, EU and national organizations. The article elaborates on future prospects of EO education in the education system its relevance for the society and its connection with STEM subjects.

Introduction

As space and remote sensing (RS) technologies develop and free spaceborne data abundance and availability becomes a fact, methods and approaches for information generation take advantage of the enhanced data quality offered and remote sensing applications gain value tackling societal needs and supporting economy. Spaceborne RS owes its origins to space exploration and military applications. It was used initially to serve strategic purposes for planetary research and wide covering earth exploration. The ending of the Cold War and the development of telecommunications shifted the emphasis from maintaining a strategic advantage to economic growth and environmental awareness.

In the 21st century the geospatial revolution generated a plethora of geospatial data. The need of standardization and homogenization has emerged to cope with credibility and user confidence issues. Addressing these on an international level was issued a draft K-12 strategy for earth observation (EO) education by CEOS [1]. On an EU level with the INSPIRE Directive, the European Commission set forth the goals of integration of geospatial data in the eGovernment. The initial operations of Copernicus services (formerly the GMES programme) have pushed developments forward both for data users and the governments to utilise and exploit the unprecedented availability of satellite data and products on an operational basis. The Copernicus programme is expected to boost up European economy, which is still recovering from the World economic crisis and now entering a new unprecedented COVID-19 crisis. It will create a new entrepreneurship opportunities in the space sector. Parallel to these scientific and technological developments the society shall be able to keep pace in understanding and adopting the latest products and make benefit from its investment in Earth Observation (EO). In this context, data and products must be provided in a comprehensible, easy to follow and accessible way. Users having the skills, knowledge and understanding may then use and incorporate them in existing production working chains or find new added value use cases. Users not having these skills shall at the same time understand what this information thesaurus brings along to embrace emerging changes, approve the work of the specialists and give their consent to support the EO investment in the future; thus, setting the foundation for a sustainable chain of services and products. In order to come up to this result fundamentals and understanding of EO must be integrated in an efficient manner within multiple disciplines or even stand-alone ones when necessary, in the already overloaded school training programmes. In this context citizens will be up-to-date with new data sources, remaining receptive to adopt spaceborne products and services, and understand the processing techniques and communication mechanisms that are relevant to their individual needs.

The wide variety of EO satellites, data sets (satellite and airborne), and application areas relevant to STEM subjects, has been reflected in the course of the years in the diversity of existing training initiatives and resources regarding secondary school education in EO. On a national level, the most structured approach towards mapping sciences and EO data use has the USA, which has carried out several studies on different aspects of this type of education. In 1981, the first comprehensive overview of the remote sensing education in USA was published in IJRS [2]. From this study it becomes clear that mapping sciences have been catalogued into a *Mapping Sciences Education Data Base*, which was to become operational and published on an annual basis as '*Directory of Courses and Programs in the Mapping Sciences*'. The authors of this work also emphasized on the standardization of RS education, which is at present also a hot topic in Europe. Although not yet implemented in the secondary-schools, it is a first attempt

towards a systematic view on geospatial sciences and education. On a European level, the first attempt to review RS education as a whole was performed in the 80s of the 20th century [3]. It is acknowledged that France has played a pioneering role in promoting remote sensing at the level of secondary schools. In France, the introduction of remote sensing to modernise teaching in primary and secondary schools has become official government policy. In the mid of 1980s, an Institute, the *Groupement pour le Developpement de la Teledetection Aerospaciale*, regularly organized courses for school teachers [4]. In June 1986, EARSeL in co-operation with the Council of Europe, ESA and the Commission of the European Communities (CEC), organized an European Workshop to assess the current situation of remote sensing education and training in Europe and recommended further action (Council of Europe, 1989) [5]. But, the first more comprehensive outlook on RS education on an international level came only in the beginning of 1990s with the ISPRS Commission VI Symposium *Modern Trends of Education and Remote Sensing* held between 13 and 16 September 1990 on Rhodes Island, Greece. One of the Commission VI goals is targeted to the school education: '(3) compilation of ideal syllabi and course layouts for undergraduate education on remote sensing and GIS' [6]. However, at that stage there were still no discussions or papers dealing with the RS education in schools. At a dedicated workshop in 1992, RS was put for the first time on the round table discussions as part of the National Curriculum for Science of UK [7]. In this article, the teachers' perspective from career development point of view was studied for the first time [8]. At the Frascati's EO Education Workshop (2014) [9] a number of barriers to effective EO education at different levels were identified. Among these were: (i) the difficulties in identifying and accessing data suitable for education at different levels, (ii) the relative lack of clear and intuitive example data and case studies suitable for learning about different applications or relevant to specific geographical regions, and (iii) the fragmentation of European education resources which leaves newcomers to the arena of EO education overwhelmed by the task of finding resources that suit their own needs. During the LearnEO! Workshop in Frascati was recognising the importance of embracing EO education; the European Space Agency (ESA) has taken the initiative to develop a Roadmap for EO Education. It keeps up with the structure established by the LearnEO! *Roadmap for EO education in Europe* (2015) [10].

The aim of the present review is to provide an overview of the available international, regional and national education resources in EO for secondary schools, to identify subjects which are not yet well represented in the curricula but would benefit from using remote sensing in the classroom, and to address several didactic aspects which could help establishing Earth Observation in school. In first part of this work the authors have selected and presented in an alphabetical order the institutions providing the resources – web-resources and e-learning, EU funded

projects. In the follow-up of this work we will present the national and international projects, outreach activities, and FOSS software tools for education.

Data and methods

Besides other resources the review integrates material presented at the Frascati EO Education Workshop 2014 [11] with other information obtained in the ESA LearnEO! Project, and ESA EO Open Science 2016. It is also based on experience obtained in the project *Science Education through Earth Observation for High Schools* (SEOS)¹ supported in the 6th FP-EU, FIS, and from the ongoing EO4GEO project (ERASMUS+). The authors from the EEOBSS project team also made use of their own experience when introducing Earth Observation into the curriculum of Bulgarian high schools in 2016–2019.

Earth observation resources for secondary school education

The main review items are presented in an alphabetical order of the material producer/provider in order to not give priority of a specific resource, rather to list it as is. Thus, it is expected that this will allow the reader to have a more objective view on the state-of-the-art. In this article, the EO education is organized in the following categories: 1) web-resources and e-learning, 2) initiatives supported by national funding bodies and international organizations, 3) outreach activities, 4) citizen science, and 5) software and tools. The last three categories will be covered in the second part of the review.

Web-Resources and E-Learning

Carleton University

The University of Carleton has developed the Earth Exploration Toolbook (EET, URL: <http://serc.carleton.edu/eet/index.html>). It is developed by teams of scientists and educators; the EET is a collection of online Earth system science activities. Each activity or chapter introduces one or more scientific data sets and analyses tools that enable users to explore some aspect of the Earth system. The chapters are written for the teacher, generally at the secondary and college level. However, the chapters can be used by other educators, students, citizens, and policy makers to guide their own learning, adapt to their own purposes, and enable them to answer their own Earth system science questions based on scientific data.

¹<http://www.seos-project.eu>

ESA

A dedicated website for *EO Education and Training activities* is published on ESA's EO portal [12]. This provides a comprehensive overview and easy access to all ESA programmes in EO education, training and capacity building. A section on primary and secondary level EO education includes descriptions and links to online tools, teacher training courses and material that can be ordered from the ESA education office. Another section includes summaries of EO training courses at University level with links to their respective webpages with access to presentations and ESA / Third Party Mission (TPM) data used for exercises. Similar material is available for advanced training at post-graduate level.

The *ESA Eduspace* multi-lingual website [13] is dedicated to secondary education. The aim of Eduspace is to provide attractive image data, information and tools suitable for teaching and learning a variety of topics in Geography, Physics, Environmental Science and related subjects, according to the curriculum of each country. The main value of Eduspace lies in the practical nature of its e-learning content. The website not only explains the theory and applications of EO in terms suitable for a secondary school audience, but also provides case studies that demonstrate practical examples of how EO data is used. Each case study presents the student with a real world problem, which one needs to address through hands-on processing of EO data using software designed for use in schools.

The *Eduspace Image Catalogue* [14] provides Eduspace users with a multi-mission catalogue of EO data over Europe. This offers teachers and students carefully selected example data for use in Eduspace case studies and allows them to adapt (personalise) the case studies with EO data from their specific region of interest. The *Interactive Meteosat on-line application* – a new online tool that shows satellite data combined with student measurements has been developed as an Eduspace module along with a case study on the interpretation of Meteosat images.

LearnEO! is an ESA project with partners such as the National Oceanography Centre (NOC), CLS, GEO-K, and UNESCO (Bilko) [15]. The project offers a holistic framework for EO education with lessons on different EO applications (200 data sets with description). The project is using the UNESCO Bilko software as a main application for the trainings. It also has a resource library with extra information and tools (hands-on materials, quizzes) and offers a support for lesson writers and lesson users.

In the field of e-learning, ESA has also developed "*Earth from Space: The living beauty*" [16] – the first electronic book showcasing EO applications, developed for Apple's iPad and available through iTunes. The 105 page book takes the reader on a scientific voyage that shows how some of the latest technology has changed the way we view the Earth. There are five chapters: Solid Earth, Oceans, Cryosphere, Atmosphere and Land, showing the most impressive results of ESA's EO missions. Electronic books on individual missions are also being developed.

In 2010, ESA jointly with Geospace GmbH issued a “*School Atlas: Geography from Space*” edited by Beckel, L. The Atlas presents a new way and outlook towards European EO education. It bridges the gap between the EO science and secondary school education through a tailored product built mainly on EO data. With this new approach the Atlas achieves one major goal – to prove that EO data and products can be used for virtually all class activities in Geography. The Atlas is available in German and English both in digital form and in print [17].

ESA Massive Online Open Courses (MOOC) has been specifically designed to overcome perceived ‘barriers’ to the use of EO by non-technical users. The *Monitoring Climate Change from Space* [18] MOOC, started in June 2015, provides basic information about the use of EO data to monitor and study climate variability and change. The course explores and addresses some of the problems related to the take-up and usage of EO data and demonstrates the benefits of using EO data in scenario planning. It encourages wider use of EO data by providing practical, real-world examples of how EO data are used to monitor and adapt to climate change, increase resilience to climate-related hazards, and provide decision support for sustainable development and resource management planning. In September 2016, ESA has started a new MOOC with topic *Earth Observation from Space: the Optical View* [19]. This free online course provides an introduction to optical Earth observation - monitoring our planet from satellites, using photography, imaging in various wavelengths, LIDAR and other optical sensing technologies. The SAR-edu [20] team is developed its own MOOC which was released in 2017, and provides the ‘Radar View’ on EO from space. The web-platform for MOOCs FutureLearn is the home of these MOOCs. However, the necessity to develop and host in one place as well as new and updated policy of ESA has led to the development of EO College where the first MOOC Echoes in Space: Introduction to Radar Remote Sensing is hosted [21].

Every summer, ESA’s Education Office welcomes about 40 secondary school teachers from across Europe to ESA’s European Space Research and Technology Centre (ESTEC) in the Netherlands for the *ESA Summer Workshop* [22]. In the course of over four days teachers participate in a variety of workshops that show how space can be used as a context for teaching different school subjects.

The *ESA Teacher’s Pack “Watching Over the Earth”* includes a selection of Remote Sensing/EO topics and is targeted to lower secondary level students (age 11–14). The pack is available in several languages (English, French, German, Spanish, Italian and Dutch) in hard copy, and may also be downloaded from a dedicated ESA website [23].

Copernicus (European Commission)

The EC and Copernicus programme published its first Copernicus MOOC in the beginning of 2020 as an effort to make the Copernicus data and its services accessible to everyone [24]. The MOOC consists of three chapters: “Chapter 1: Understanding Copernicus data and services”, “Chapter 2: Learning from success stories”, and “Chapter 3: Do It Yourself!”.

NASA

NASA has its own education programme and website – *NASA for Educators* [25], which offers free resources in STEM subjects from K-4 until 9–12 (secondary school education) and higher and informal education. Some of the education resources are well suited both for the STEM subjects taught in class and for EO data applications. One of the most exciting initiatives of NASA is KidSAT/EarthKAM student remote sensing programme [26]. Within this programme the students developed a camera system for the Space Shuttle, while at a later stage the EarthKAM continued onboard the International Space Station (ISS). The students have been developing a series of image acquisition requests based on approved science proposals that have been combined into a set of instrument commands that are uplinked to the ISS. In this context, a brand new programme is Expedition Earth and Beyond (EEAB). This programme is designed to motivate the students to gain interest in Science, Math, Engineering, and Technology (STEM) related subjects [27].

The goal of the NASA *Applied Remote Sensing Training (ARSET)* [28] is to increase the utility of NASA earth science and model data for policy makers, regulatory agencies, and other applied science professionals in the areas of Health and Air Quality, Wildfires, Water Resources, Eco Forecasting, and Disaster Management. As such, the training is highly specialized but some parts of it could be used also for education purposes in secondary schools. For instance, the topics are matching some of the Geography lessons in class and could serve as a supplementary material for extracurricular activities. The two primary activities of this project are webinars and in-person courses. There is also a recently added section for workshops. The user could also suggest a course, if it is not present on ARSET but is a topic of common interest.

European Spatial Data Research (EuroSDR)

European Spatial Data Research (EuroSDR) holds distance e-learning courses on EO and geo-information topics [29]. These courses can be followed over the Internet, allowing participants to update their knowledge with minimum disruption. Each course requires about thirty hours of online study and is completed in two weeks. However, these courses are not suited to secondary school students, but they could be used for capacity building of geography teachers.

University of Heidelberg

The Research Group for Earth Observation at the Heidelberg University of Education has developed two learning modules for secondary school education in web-based learning environment [30]. First, BLIF (“Blickpunkt Fernerkundung”) or *Satellite Image Learning Center (SILC)* [31] which provides online software to analyse remote sensing data independently and to answer first problem oriented geographical questions. Ten game-based learning modules allow students to test their existing knowledge of satellite images and pick up new information. The games are organised into easy and difficult ones. Second, “geo:spektiv” (www.geospektiv.de) which provides specific online learning modules (based on BLIF) to work on spatially and environmentally relevant questions. Both platforms have been developed to get secondary school pupils in touch with remote sensing data and to use satellite imagery in applied geographic tasks.

Initiatives supported by national funding bodies and international organizations

Challenger Center

The Challenger Center is an international organization dedicated to bring all students dynamic educational experiences and help inspiring future generations of STEM-conscious leaders. The Center organizes various training activities through online lessons and resources which partially cover the EO topics [32]. The lessons are interactive and engaging which help build motivation.

CReSIS Middle School Program

The Center of Excellence in Remote Sensing Education and Research (CERSER) continuously strives to provide education and research opportunities on ice sheet, coastal, ocean, and marine science. One of those continued an outreach effort is the *Center for Remote Sensing of Ice Sheets (CReSIS) Middle School Program*. Sponsored by the National Science Foundation (NSF) CReSIS Middle School Program offers hands on experience for middle school students. CERSER and NSF offer students the opportunity to study and learn about remote sensing and its vital role in today's society as it relates to climate change and real world problems. The CReSIS Middle School Program is an annual two-week effort that offers middle school students experience with remote sensing and its applications. Specifically, participants received training with GPS where the students learned the tools, mechanisms, and applications of a Garmin 60 GPS. As a part of the program the students were required to complete a fieldwork assignment, where several longitude and latitude points were given throughout campus [33].

EARSeL

The European Association of Remote Sensing Laboratories (EARSeL) organises a *Special Interest Group on Education and Training* [34] which holds Workshops and sessions at its annual Symposia for educational experts and secondary school teachers. These typically last 1–2 days, often associated with conferences or exhibitions of interest, and are supported by ESA.

EUROGEO

The principal goals of the European Association of Geographers (EUROGEO) are to advance the status of geography by: organizing events and activities for members, producing publications for members, supporting geographers in their jobs and careers, identifying and promoting good practice, lobbying at European and national level, giving advice on geography, making recommendations to decision makers. During the past few years, two projects implemented by EUROGEO have targeted the geography and GeoICT to transfer innovation to meet changing labour market needs and improve the quality of geo-education. These projects are intended mainly for university and vocational training level: *GeoSkills Plus* [35] and *YouthMetre* [36]. The latter one provides useful statistics for the education of the youngsters on a country level within EU27.

European Geosciences Union (EGU)

The European Geosciences Union (EGU) Committee on Education has organised *Geosciences Information for Teachers (GIFT) Workshops* since 2003. These 2.5-day teacher-training workshops are held in conjunction with EGU's annual General Assembly and typically host about 80 teachers. Their main objective is to spread first-hand scientific information to science teachers in primary and secondary schools, thereby shortening significantly the time between discovery and text-book. Teachers are provided with material that can be used directly in the classroom and many of the lectures from the GIFT workshops are freely available as videos on YouTube™ or EGU TV [37].

Global Learning and Observations to Benefit the Environment (GLOBE)

The *GLOBE programme* (<http://www.globe.gov>) is one of the few international programmes (the programme is sponsored by NASA, NSF and supported by NOAA and U.S. Department of State) offering free education resources, tools and training to students and teachers in STEM subjects. The network consists of GLOBE students, teachers and scientists. The activities are various starting from the annual GLOBE conference, virtual workshops, and various dedicated data-collection campaigns. The programme has its own highly-structured approach towards data collection following specific protocols since 1995

[38]. The field data collected by various schools is accessible through a visualization tool [39]. Although the data collected by schools is field data, many students and their teachers choose to work with NASA satellite data and products for their projects showing a synergistic approach towards field and satellite measurements [40–42]. One of the field campaigns co-developed with NASA scientists in 2016 was for field data collection to validate the SMAP mission [43].

Joint Information Systems Committee (JISC)

The Joint Information Systems Committee (JISC) funded *Landmap* service which ran from 2001 to July 2014 and collected, modified and hosted a large amount of EO data for the majority of the UK, including imagery from ERS, ENVISAT, ALOS, high-resolution Digital Elevation Models (DEMs) and Digital Terrain Models (DTMs) and aerial photography dating back to 1930. After removal of JISC funding in 2013, the *Landmap* service is no longer operational, with the data now held at the NEODC [44].

“Remote Sensing Environmental Applications” - a Greek test course

The structure of the educational material of the “Remote Sensing Environmental Applications” test course developed for Greek schools is presented through a MOODLE platform. The educational e-material is designed for an e-learning course in the field of remote sensing and environmental applications. The e-material is written in Greek language and it is addressed to students in the first year of Lyceums. The e-material is used in the terms of the “Project” course [45].

UNESCO

UNESCO and its network of *Space for Heritage* partners use results of various space projects to develop educational packages and to organize exhibitions for the general public. These bring space science and technology closer to society [46]. The UNESCO’s *Bilko* project [47] provides software, example data and tutorials for teaching marine and coastal applications of remote sensing.

University of New Hampshire

The University of New Hampshire has developed its *GLOBE Carbon Cycle* project (supported by NASA and NSF) [48]. The project is focused on bringing into the classroom the cutting edge research and research techniques in the field of terrestrial ecosystem carbon cycling. Students can collect data about their school field site through existing GLOBE protocols of phenology, land cover and soils as well as with protocols focused on biomass and carbon stocks in vegetation.

EU funded projects

Digital-earth Center of Excellence for the Geographical Education

The Greek digital-earth Center of Excellence for the Geographical Education was found in 08 June 2012 after the approval of the evaluation committee of the digital-earth.eu Centre of Excellence of the European Program Digital-earth (Comenius Network project). The Center has registered offices in the Faculty of Primary Education in the Aristotle University of Thessaloniki. An annex of the Center is operating in the Department of Geography of the University of Aegean in the island of Lesbos. The staff is composed by primary and secondary school teachers, PhD Students, postgraduate students, and students of the Faculty of Primary Education of the Aristotle University of Thessaloniki or the Department of Geography of the University of Aegean or other Greek Universities. The Center is expected to become an area of communication with teachers who work in schools abroad and it will support them in their work. There have already been initial agreements for future cooperation between the Centre for Research and Technology Hellas/Information Technologies Institute (ITI-CERTH) and EARSeL Education Department [49].

Science Education through Earth Observation for High Schools (SEOS)

The Science Education through Earth Observation for High Schools (SEOS) web-site [50–51] provides teaching modules that use remote sensing to support the science education curricula in high schools throughout Europe and beyond, with emphasis on Geography, Biology, Physics, Mathematics and Environmental Sciences [52]. Coordinated by the University of Oldenburg, Germany, 16 internet-based eLearning tutorials were developed on selected topics and tested in co-operation with European partner schools. These are available from the project web-site in different languages.

SAR-EDU

SAR-EDU [53] is a joint education initiative for Radar Remote Sensing, conducted and coordinated by the Friedrich-Schiller University Jena and the German Aerospace Centre (DLR) [54]. The project goal is to provide knowledge about the basics, methods and applications of Radar Remote Sensing to users and scientists.

FIS – Remote Sensing in School Lessons

Working with remote sensing data is postulated in the school curricula of several states in Germany. Moreover, the application of aerial, satellite, or even ISS imagery can be seen in the light of problem-based learning (pbl) fostering

competences and practice skills. These were and still are the main goals of the scientific projects “Remote Sensing in School Lessons” (FIS-I: 50EE0615, 2006–2009; FIS-II: 50EE0932, 2009–2015; FIS-III: 50EE1703, 2017–2019) funded by the German Aerospace Centre (DLR) and the Federal Ministry for Economic Affairs and Energy (BMWi). The project is carried out at the Universities of Bonn and Bochum. FIS established a close collaboration with several schools in Germany and has widened the reach through advanced teacher trainings all over Germany. Based on the elaborated and evaluated FIS-concept, a comprehensive, well-structured learning portal on remote sensing has been published comprising more than 30 digital learning units for 5 STEM subjects dealing with satellite data of ESA, DLR, and NASA missions (English: www.fis.uni-bonn.de/en). For FIS-I, a concept to demonstrate the value of remote sensing as a key technology within the scope of their standard education was developed. Since remote sensing is more than the simple visual interpretation of satellite imagery, this concept includes computer-based remote sensing methods [55]. The main task of FIS-II was to develop a comprehensive, well-structured learning portal to teach about remote sensing based on this concept. The learning portal was successfully implemented and can be accessed at www.fis.uni-bonn.de since 2012. It grants pupils and teachers alike a structured introduction into the topic by providing them with digital and interactive learning modules about all the important aspects of remote sensing [56]. Currently, Sentinel data and data of Copernicus contributing missions are integrated in existing modules. FIS-III also aims at the development of Massive Open Online Courses (MOOCs) in order to combine topics dealing with the sustainability of the coupled human-environmental systems. Additionally, augmented reality applications are tested for mobile learning as a possibility to overcome the technical limitations in German schools by mobile learning and the pupils’ smartphones [57].

Columbus Eye and KEPLER ISS

In the project Columbus Eye – Live Imagery from the ISS in Schools (funded by DLR and BMWi, 50JR1307, 2013–2017), which was started in 2013 in Bonn and is now carried out in Bochum, the combination of research in microgravity and earth observation is integrated into education – which is unique in Germany. The project’s initializer was the Blue Dot mission by astronaut Alexander Gerst and the NASA “High Definition Earth Viewing” (HDEV) experiment that begun around the same time. The astronaut and geophysicist’s perspective became accessible to the pupils through Columbus Eye. HDEV consists of four commercial off-the-shelf (COTS) cameras mounted onto the Columbus External Payload Adapter (CEPA) of the ESA Columbus Laboratory. The main purposes of the HDEV experiment are to test the robotic installation of external payloads and to examine the suitability of COTS HD cameras for

upcoming space missions to the Moon and Mars [58]. Columbus Eye acts as the exclusive European partner of the HDEV experiment. The project is in charge of filing and publishing the HDEV data in a web portal and, thus, making the data accessible to the public [59]. A concept for the pupils to perform complex image processing in an intuitive way was developed and implemented. Pupils and teachers have access to interactive learning modules about earth observation data from the ISS and its uses at <http://columbuseye.uni-bonn.de/english> [60]. Materials for M-learning and the realization of augmented reality applications are currently being developed in KEPLER ISS (50JR1701, 2017-2019). The project succeeds Columbus Eye and exploits not only HDEV videos but also other remote sensing instruments onboard the ISS. In 2018, KEPLER ISS will accompany the ESA space travel mission “horizons” where Alexander Gerst fly for a second time to the ISS in order to manage the astronaut staff as first German commander. Here, KEPLER ISS will carry out a national school competition called “self-eSTEAM”. It bridges the gap between space-related science, humanities, and the application of digital media. Finally, the project will use Moon and Mars digital elevation models implemented in virtual reality applications for pupils [61]. Learning materials of the mentioned projects aim at autonomous identification, handling and solving of problems by the pupils. The pupils’ active participation in the lessons causes a shift from being taught to learning themselves: The teacher’s role changes from presenter of knowledge to guide for autonomous learning, turning their main tasks toward giving directions and providing help for the learning process. Accompanying the Blue Dot mission, the DLR Space Administration held the “Beschützer der Erde” (“Earth Guardian”) national school competition. Former and current members of the FIS and Columbus Eye projects produced scripts for Alexander Gerst to perform in videos as well as teaching materials used in the contest. So far, more than 5,000 pupils and 500 teachers were approached directly through 36 school events and 41 “teaching-the-teacher” workshops dealing with interactive STEM education based on satellite imagery and ISS footage. This included teachers at both elementary and the high school level. Downloads of the projects’ over 53 classroom resources (digital teaching units, learning tools, experiments, augmented reality apps) in German and English language reach a number of ~1,500 per month.

Discussions and conclusions

Some of the most pronounced key issues yet to become perspectives are addressed here in short:

Lack of access to data and information suitable for non-experts

The problem is very much pronounced for non-scientific audiences with interest in EO education who do not usually have access to archives designed for

professional audiences. The lack of the necessary technical skills and the motivation to invest a large amount of effort required to identify and select relevant examples adds up to the barriers for employing EO education in schools on European level as in Bulgarian secondary schools. ESA and others have a number of initiatives to remedy this, with libraries that provide inspiring and often spectacular examples of EO images. As suggested in the EO Roadmap, to give students the opportunity to develop an intuitive understanding of EO, it is essential to give students and teachers easy access to relevant EO data instantly but on their own terms, both in school-based education and informal learning.

This is already done through ESA Academia (mostly European states), and GLOBE programmes (USA STEM programme with an international impact); although much effort is needed for a global impact. Teachers themselves do not have the time to be self-taught as it was noted in the EO Roadmap, requiring tailored teacher guidelines for EO education, which is the approach of EEOBSS.

Lack of relevant examples and case studies

This issue is to be addressed by revising the worksheets from different projects so as to make national case studies which will support the national STEM education strongly. If such examples are not present, they should be built from scratch based on best use-cases from the science or business practice which shall be adapted.

Fragmentation of EO education resources and initiatives

For a newcomer to EO, an impressive and wide array of information, websites and education related tools is available, which creates an information barrier where to start from and what is most important. The present article aims at addressing this issue by mapping the available resources to make an informed decision. More sustained efforts are provided, for example by the ESA portal for education and training [62] which provides access to resources for schools in EduSpace, as well as information about training courses and other resources provided by ESA for professional users.

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ОБЗОР НА РЕСУРСИТЕ ПО НАБЛЮДЕНИЕ НА ЗЕМЯТА ЗА СРЕДНОТО ОБРАЗОВАНИЕ – ЧАСТ 1

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Резюме

Тази статия предоставя преглед на световните интернет ресурси и ресурсите за електронно обучение по наблюдение на Земята (ЕО) за средните училища. Накратко се преглеждат основните образователни инициативи и проекти за ЕО, подкрепени от международни, европейски и национални организации. В статията се разглеждат проблемите и перспективи на ЕО образованието в образователната система, неговото значение за обществото и връзката му със STEM предметите.