European Journal of Geography

Volume 12, Issue 3, pp. 088 - 102

Article Info
Accepted: 10/11/2021
Corresponding Author: *bashkim.idrizi@yahoo.com
DOI: https://doi.org/10.48088/ejg.b.idr.12.3.88.102

Research Article

Lifelong training program on QGIS tools for earth observation sciences in south-east Europe

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Keywords

Earth Observation,
Lifelong Learning,
QGIS,
FOSS,
Open Data

Abstract

Earth Observation (EO) data are an indispensable source of useful geospatial information, which can be efficiently combined with other data within the latest released open-source QGIS software. This paper aims: i) to present a general overview of the QGIS EO plugins; ii) to promote the Lifelong Learning (LLL) courses for open-source QGIS software tools provided by the Geo-SEE Institute from Skopje; iii) to appreciate the advantages of open-source QGIS for developing and improving EO applications. The training objectives are to enhance the research, development tools and technologies of QGIS and stimulate the obtaining and disseminating knowledge to utilize the open-source GIS software. Furthermore, there is a growing need to increase the number of well-educated professionals on issues related to the EO sciences in South-East Europe (SEE), who are better prepared for the labor market in today's digital revolution by using QGIS tools and plugins combined with other related GIS software platforms provided by the OSGeo family.

Highlights:

-Use of open-source QGIS software to process data from Earth observations (EO)

-Hierarchical 3-level LLL training courses using spatial data and EO in QGIS

-Improving curricula in educational institutions and providing new knowledge

-Training of specialists to meet the current requirements of the labour market in the field of geosciences

The publication of the European Journal of Geography (EJG) is based on the European Association of Geographers' goal to make European Geography a worldwide reference and standard. Thus, the scope of the EJG is to publish original and innovative papers that will substantially improve, in a theoretical, conceptual or empirical way the quality of research, learning, teaching and applying geography, as well as in promoting the significance of geography as a discipline. Submissions are encouraged to have a European dimension. The European Journal of Geography is a peer-reviewed open access journal and is published quarterly.

1. INTRODUCTION

Earth Observation (EO) data obtained from satellite, aerial and terrestrial images are available for almost all areas of the Earth surface with high spatial and temporal resolution. There are dozens of authoritative free and openly accessible repositories with databases and catalogues that contain high-quality satellite images such as the USGS Earth Explorer, Sentinels Open Access Hub, NASA Data access viewer, Digital Globe, NASA Worldview (see, e.g., Filchev et al., 2020). In addition, the European Space Agency (ESA) and the National Space Agencies have taken significant initiatives to stimulate and encourage the active use of the Copernicus program active users and services to address real problems, e.g., environmental protection, effective management of natural resources, climate change, and others. Scientific and educational programs, specialized training, and e-learning platforms have been developed to overcome several challenges related to implementing EO's full potential. However, the main challenge is to provide an opportunity to expand the community of users of these data. Many university curricula and international initiatives are focused on raising awareness of the need for EO data and EO sciences, capacity development, and standardization on a global level.

The advancements in EO have also been an excellent benefit for education using various and impressive amounts of satellite images and data for planet Earth, being acquired from space (Mouratidis and Koutsoukos, 2016). In addition, the nonformal professional education system is an essential step toward using the newest GIS and EO technologies by active workers and adults in the private and public sectors. The overarching aim of the geoscience education and the training must therefore support Lifelong Learning (LLL), allowing users at all levels to remain EO technologies and communication mechanisms that are useful for their individual needs (Byfield et al., 2015).

The European Commission (EC) has already defined new policies for education and Training (ET, 2020) to support the activities at the level among the member states and address common challenges, such as skills deficits, ageing societies, and competition at a global level and technological developments. This initiative is designed to support action at the national level and help address common challenges defining a framework for EU cooperation in education and training. Vocational education and training (VET) and adult learning (AL) are the EC's focus, which pursues a targeted policy to take initiatives to participate in different age groups. The LLL concept involves everyone, regardless of their age, to provide education and training possibilities. Besides competitiveness and employability, the focus of LLL extends to personal development, active citizenship and social inclusion (European Commission, 2006).

At the beginning of this century, the development of open-source GIS systems is accelerated to develop applications for geographic information (GI) on the Internet and Web mapping. The successful implementation of the LLL in the efficient use of EO data for a wide range of applications is achievable using open data (OD), free and open-source software (FOSS) and open standards (OS). FOSS refers to computer programs available free of charge license via the Internet, allowing usage, copy, changing and distributing their source code under certain license rights (Shin, 2017). OS is a document created by consensus and approved by an official organization that provides rules and guidelines to achieve optimal order (interoperability) in a given context. Open standards denote the availability and accessibility of technical standards for others to review and implement (Woodall and Marius, 2013). For example, the Open Geospatial Consortium (OGC) adopts standards for working with geographic data and information, considering them as 'open', which meet particular conditions[1].

FOSS using EO has recently begun to play a vital role in Earth research from local to global time scales. In the last few decades, valuable products and services for industry, scientific and applied research, and a wide range of users have been developed. The development of open

[1] www.opengeospatial.org/standards (Accessed on 29 July 2020))

source GIS software has a very high growth rate and is increasingly used in various areas of public interest. The growing demand for spatial data and current trends of smart cities, knowledge-based management and business decisions, corporate mobility, location-based services, and many other applications using EO stimulate the rapid development of FOSS in GIS field applications.

Nowadays, a huge number of FOSS tools are available for EO data processing without giving details on the methodology used for coding such tools and plugins, which sometimes generate a diversity of output data quality. Users feedback opportunity on plugins functions, despite the impossibility for direct feedback on basic software tools, help users and software developers to obtain helpful feedback information from professional users on positive and negative sides, as well possibilities and limitations for usage of each plugin for specific purposes. Continued investigation and LLL on FOSS basic tools and plugins in GIS for EO provides scientific and practical knowledge for their proper use by professionals in the industry.

The inclusion of EOs, OD and FOSS, in lifelong learning programs excludes the cost of purchasing software licenses and training data and reduces the expenses of providing such courses by educational service providers. Support through this type of EU program training is a prerequisite for expanding the circle of professionals from different fields and social levels who can further develop their skills and competencies in geosciences. The traditional thinking that GIS and Remote Sensing are naturally paired is has been exceeded in QGIS with many tools/plugins as a part of the FOSS family to satisfy many EO workflows in analyzing GI.

Organizing the VET is a crucial element of LLL systems, which equip citizens with knowledge, skills and competencies required in particular occupations and the labor market (ET, 2020). However, there is a specific gap in the accreditation of geospatial specialities and VET courses on usage of FOSS for EO sciences in the region of SE Europe. The lack of accredited curricula in universities in the SEE region has been partially overcome by the QGIS course accredited by the Center for Adult Education and the Ministry of Education and Science of the Republic of North Macedonia (Izeiroski and Idrizi, 2020). The three-level course provides topics from data development to Web GIS. The training materials are written in Albanian, Macedonian and English languages. The training is carried out in two options: physical attendance and distance learning[2].

2. MODERN TRENDS IN EO AND LLL

2.1 Open EO data

As a part of the broader data economy, the EO industry is experiencing several factors driving change across the value chain. First, open data can be freely used, re-used and distributed by anyone subject to the attribution and sharing requirement[3]. Second, society could have benefited from its investment in EO by developing accessible and known data for the global professional community of users for using EO data in their everyday job. Third, the LLL program must be supported, allowing end-users to keep up with new data sources, processing techniques and communication mechanisms pertinent to their individual needs (Byfield et al., 2015). Finally, the content of educational resources is not intended explicitly only for VET and LLL purposes, and it does provide a wealth of educational possibilities.

Commercial and free and open-source software for geodata processing, editing, compilation and publishing are used as software platforms (Idrizi, 2013). EO turns raw data into knowledge through processing and analysis by creating value within and across related sectors. For example, EO and Remote Sensing (RS) data have significant potential to help us manage the modern world and natural resources (O'Sullivan et al., 2018). EO-related sciences

[2] http://qgis-geosee.blogspot.com (Accessed on 29 July 2020)
[3] (http://opendatahandbook.org/ (Accessed on 29 July 2020)

offer a substantial and wide range of opportunities for EO education, enabling teachers and students to explore EO data in a structured manner and embed it into curriculum delivery and formal teaching (Kapur et al., 2018). The digital integrated learning environments (ILEs) brings EO topics into education, intended to allow participants in the education process to solve problems with EO data by using the same means that professionals have at hand (Izeiroski et al., 2016; Hodam et al., 2020).

Global Earth Observations System of Systems (GEOSS) is an example of collecting portals that can interoperate as one system and allow users to collaborate across space and disciplines and use EO data freely. The EC and the ESA are involved in climatic change and environmental monitoring studies within two major EO initiatives: Copernicus Program (previous Global Monitoring of the Environment and Security (GMES) and Climate Change Initiative (CCI). In March 2016, the ESA initiated several educational, training, and capacity building activities to use EO. The ESA EO program includes numerous academic courses, ranging from training the next generation of Principal Investigators on state-of-the-art EO processing to more general information activities and EO education for schools (Mouratidis and Koutsoukos, 2016). The majority of education and training programs are designed for participants from ESA member states.

A significant increase in demanding graduates with geographic perspectives and technological competencies is experienced in many countries with the advent of the newest technological advances (Ruiz-Perez and Estrany, 2019). Recent trends in Geographic Information Systems (GIS), Global Positioning Systems (GPS), Remote Sensing (RS), photogrammetry, and communication technologies require changes in formal and informal education on EO sciences at all levels (Idrizi, 2019). According to Mihaly et al. (2017), the geospatial and EO-related industries are expected to continue to grow, generating high-tech jobs providing value-added products and services from local to global markets. Using spaced-based data saves time and costs to acquire valuable information otherwise difficult to obtain by conventional field mapping techniques alone (Woldai, 2020).

2.2 Free and open-source software for LLL on EO sciences

Modern computer processing of sizeable real-time EO data poses some challenges to GIS software developers. The trend in the development of GIS is to move from desktop systems to distributed systems. A community of volunteer programmers develops open-source software programs. Increased cost saving, innovation and empowerment of the citizens, reduced piracy, and improved intelligence security are the considerable benefits of societies that use FOSS. Open-source GIS software solutions are continually evolving around the world to meet these challenges. These are GeoMesa[4], a distributed, open-source spatial-temporal database, and GeoTrellis[5] for processing geographic data for high-end applications. Both developments were introduced in 2014 and allow big geospatial data (Big Data) processing through cloud technologies without requiring users' licenses.

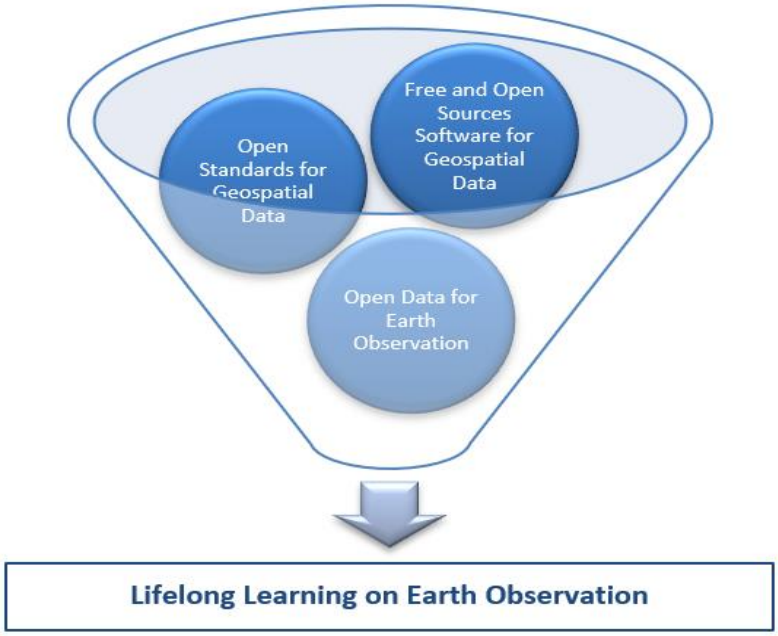
Tools available for EO data processing and modeling are essential for analyzing spatial phenomena conditions in the current stage and their changes in time /series. The Earth's rapid changes require up-to-date spatial data to support humanitarian actions, monitor and deploy natural resources, crisis management, spatial and non-spatial planning activities, and other activities. Meanwhile, software tools for EO data processing have a particular necessity for digital manipulation with EO data. Almost all GIS commercial and open-source software have developed dedicated tools, modules, and plugins to acquire and work with EO data and establish EO geodatabases. As the primary technology for capturing unmanipulated and undistorted spatial data from a distance for larger areas, the remote sensing methodology allows EO tools in GIS software, combined with administrative, social and economic data on multiple scales for comparisons between countries, regions and cities. In addition, geospatial

[4] https://www.geomesa.org Accessed on 29 July 2020)
[5] https://geotrellis.io (Accessed on 29 July 2020)

data can be generated, and complex periodic geospatial and geostatistical analyses can be performed to make decision-making processes cost-effective and sustainable. The international initiative GEOSS (Global Earth Observation System of Systems[6] is an excellent example of putting different existing systems such as tools and applications developed by various organizations for providing and managing EO data, which at the same time promote the importance of GI tools for EO.

As FOSS and open data are now widely used in the GI and EO sciences to create national databases and systems from systems to the development of continental Geoportals, their utilization for LLL courses is more than necessary. The main benefit of using them for LLL courses is eliminating the costs of purchasing software licenses and training data and open options for working with software source code. In LLL courses using commercial software, a free software license is granted for training purposes only and the training period, while the software source code is closed to users. Thus, participants in LLL courses with commercial software must apply for the software license, regularly upgrade the software license, and not change the software's source code. In contrast, participants in LLL courses with FOSS in the post-training period can use the software and modify the source code in daily professional activities (Fig. 1).

Figure 1. Usage of OD, OS, and FOSS for LLL on EO.



The European agencies and the ESA have taken significant initiatives to use the products and services of the Copernicus program. Users can create new Web mapping services (WMS) and develop innovative applications through the Sentinel Hub Web service, which provides free access to the Sentinel data with readable plugins in QGIS, facilitating access user-friendly GIS environment. Many new, even freely available, tools for analyzing EO data have been developed for experienced user groups (e.g., QGIS, SNAP, and the Science Toolbox Exploration Platform). Besides, a wide range of state-owned providers (e.g., the DLR and ESA), research institutes such as universities and private institutions (e.g., Tama Group and Geo University) offer e-learning courses (Dannwolf et al., 2020), massive open online courses (MOOCs) (Eckardt et al., 2020), and face-to-face Training (Palazzo et al., 2018) on EO topics for advanced users groups and higher education students.

[6] https://earthobservations.org/geoss.php (Accessed on 29 July 2020)

Several FOSS and OD databases have been developed and are applicable for EO, including GISs. The most popular among them are OpenGTS, Viking GPS data editor and analyzer, OpenStreetMap, GeoServer, Orfeo ToolBox (OTB), PolSARpro, SNAP and Sentinel Toolboxes, DIMITRI - Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison, ADAM API Toolkit, TauDEM - Terrain Analysis Using Digital Elevation Models, GRASS GIS - Geographic Resources Analysis Support System, SAGA - System for automated Geoscientific Analyses, Whitebox GAT - Geospatial Analysis Tools, MACCS/MAJA, Sen2Agri system, Open Layers, GeoTrellis, GeoMesa, gvSIG Desktop, QGIS, Get3Di, AHN-viewer, ESA Online Dissemination, GeoNames, HydroSheds, SRTM Data and GSAC, provided by ESA, together with the name of author/developer, format, and license[7]. Part of the list is QGIS software, developed by the QGIS community, is available for Linux, Unix, macOS and Windows operating systems, and GPL license.

Recently, scripting modules written in Python have become especially popular when working with open-source GIS (Rey, 2017). Thanks to the free available documentation, easy syntax, free tutorials, and good support for analysis and data processing through Numpy or Pandas program libraries, it is increasingly used. Python is included in ArcGIS, QGIS, GRASS GIS, gvSIG and many other open-source projects. Another widely used language for programming Internet applications is JavaScript. It is used to develop Internet mapping applications such as ArcGIS Internet API, MapBox, CARTO, Google Maps API, OpenLayers, Leaflet, etc. A modern trend is to offer 3D Internet-based applications CesiumJS, OSM Buildings and MapBox G, based on JavaScript language.

3. USAGE OF QGIS IN DIFFERENT APPLICATIONS FOR EO SCIENCES

EO data are geospatial, efficiently combined with other data within the latest released QGIS environment. QGIS[8] is one of the most popular and easy-to-use open-source desktop GIS software for viewing, analyzing and editing spatial data and compiling and export maps. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo)[9]. It is licensed under the GNU General Public License and runs on Windows, Linux, Mac OSX, UNIX, and Android platforms. Desktop QGIS provides flexibility and many functionalities by supporting many vector and raster data formats. According to the 2017 American Satisfaction Index survey, the QGIS tool/package is the second most used software after ArcGIS, which corresponds to 37% of respondents. Besides the financial benefit, QGIS gives users and developers more control and allows them to work in new, better and more effective ways.

QGIS is a part of the FOSS family for establishing the geodatabase (Idrizi and Idrizi, 2019), and it is applicable for developing suitable applications based on advanced GIS (Zaleshina and Zaleshin, 2017). It provides the technical opportunity for using open layers and downloading available data from many open geodatabases, including free satellite EO images. QGIS allows the data layers to be exported in various types of data formats, e.g. GeoPackage[10], GML (Geography Markup Language), KML (Keyhole Markup Language), which improves the data interoperability (Tcherkezova et al., 2019). Using effectively different raster and vector analysis tools, each user can receive other vector and raster maps via QGIS (Izeiroski et al., 2016). Training should not solely concentrate on technology but include best-practice examples for EO usages at the multidisciplinary level (Dannwolf et al., 2020).

QGIS has many tools/plugins to satisfy workflows using RS data, such as EO. Some plugins allow performing time-series data analysis using EO data from Landsat, Sentinel, MODIS, etc. Due to the frequent updating of QGIS plugins, it is necessary to periodically check

7 https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Radio_Frequency_Systems/Open_Source_Software_Resources_for_Space_Downstream_Applications (Accessed on 29 July 2020)

8 https://qgis.org (Accessed on 29 July 2020)

9 https://www.osgeo.org (Accessed on 29 July 2020)

10 https://www.geopackage.org (Accessed on 29 July 2020)

for corrections of detected errors in the provided open-source software. The available plugins for working in the QGIS environment allow downloading satellite images in different frequency bands, which can then be used to create composite images in different color ranges. During the preprocessing, there are possibilities to make appropriate atmospheric and other corrections, as the final images visualized in the QGIS environment are corrected accordingly, for example the Semi-Automatic Classification Plugin allows for the supervised classification of RS images, providing tools for the download, preprocessing and post-processing of images[11].

In the framework of EU FP7 projects MARSITE, RASOR and SENSUM, a suite of geospatial software tools for automatic extracting of risk-related features from EO data, especially exposure and vulnerability side of the "risk equation", has been developed. The tools are available open-source as QGIS plugins (SENSUM plugins, 2016), and their source code can be freely downloaded from GitHub (SENSUM QGIS code repository, 2016).

QGIS plugins for working with EO data enable all users free of charge tools for downloading and processing EO data from different open sources. Insofar as one of the purposes of this article is to provide a general overview of available QGIS EO plugins, their detailed study is outside the scope of this study. However, as most used QGIS plugins can be listed: Semi-automatic classification plugin, Mapflow plugin, Bit flag renderer plugin, EnMAP-Box plugin, EO time series viewer, Force plugin, GEE time-series explorer plugin, Virtual raster builder plugin, Open-EO plugin, Raster time series manager plugin, and Sentinel-Hub plugin. Developing and sharing plugins in QGIS software by society is one of the most significant benefits of using this software as ь part of FOSS by the geo community.

The QGIS plugins repository enables anyone who wants to contribute by developing and sharing plugins to receive feedback from the wider user community. This fact is one of the essential advantages of QGIS over commercial software. Furthermore, plugins as tools in QGIS, which can be installed and uninstalled as an external menu, if necessary, optimize the hardware requirements for manipulating spatial data, in this case the hardware requirements for using QGIS software.

4. CERTIFIED QGIS LLL COURSES IN THE REPUBLIC OF NORTH MACEDONIA

The South-East European Research Institute on Geo Sciences "Geo-SEE Institute" started with professional training courses for using free and open-source software QGIS in September 2013. This training aims to increase the understanding as well as awareness of the benefits of using QGIS software in the private sector, public institutions, NGO's, research and educational institutions. First professional training courses on QGIS have been started in the Republic of North Macedonia. In 2015, professional QGIS training courses were conducted in cooperation with local partners in the Republic of Kosovo and the Republic of Albania.

The Geo-SEE Institute's mission is to become a regional training center by providing comprehensive training programs for GIS education with professional fulfilment of the geo-community's career objectives in a GI field at all levels (Izeiroski and Idrizi, 2020). Geo-SEE's vision is to continuously increase the competence and improve the qualification of specialists from the geo-community through teaching, training, and learning open-source software. Several objectives of Geo-SEE in the area of LLL for EO are listed, such as research and development in the area of FOSS, implementation of FOSS tools and technologies, training and support, development of human resources in the geo/GI community. The training program includes topics related to regional and global initiatives in GI; the FOSS use as a tool for accessing and sharing data for multidisciplinary spatial analysis; utilization of open and free software and data for teaching lectures and research projects in universities and research institutes. The recommendations of international organizations for standardization in the field of GI, such as OGC, ISO and others, are observed[12].

[11] (http://gis.acgeospatial.co.uk/ (Accessed on 15 August 2020)
[12] http://qgis-geosee.blogspot.mk (Accessed on 29 July 2020)

Table 1. Summary of the two case studies

Level 1 - elementary	Level 2 – intermediate	Level 3 - advanced
- Downloading the QGIS software - Overview on QGIS functionalities and menus - Work with QGIS Browser - General settings of QGIS - Assignment of referent coordinate system - Coordinate system transformation of shapefiles - Adding and editing shapefiles - Saving project in QGIS - Navigation tools - Selection and SNAP functions - Distance, area and angle measuring - Identify features tools - Working with attribute table - Georeferencing of scanned-raster maps - Database structure - Creating new shapefile - Vectorisation and editing - Geometrical and topological data analyses - Add/export geometric data in/from the database - Importing points from a list with coordinates - Data symbolization - Data conversion to/from other formats - Map composing and printing	- Grouping and advanced visualization of layers - Creating data queries - Usage of the advanced CAD functions in GIS - Modeling new map symbols and creating a custom library with symbols - Join attributes from two tables by location - Mutual converting of line, polygon and point data - Creating point file – grid with specific criteria - Mutual converting of objects as single-multi part - Object simplification - Defining polygon centroids and mean coordinates of objects - Advanced selection of objects - Using geoprocessing tools - Finding the nearest and faster distance - Statistical data analyses of vector and raster layers - Analyses of points in a polygon, data with unique values, and between them - Merge and split shapefiles - Usage of Open Layers (Google Maps, OpenStreet Map, Bing Maps) in QGIS - Spatial analyses between two shapefiles - Spatial analyses of point and line data within the polygons - Adding and symbolization of raster data layer - Assignment and transformation of the spatial coordinate system to raster layer - Raster clipping - Use of DEM – slope, aspect, hill shade, relief analyses, TRI, TPI and ruggedness index - Automatic contours creating from raster layers - Developing raster layer based on vector objects by TIN, IDW and GRID - Raster calculator utilisation - Sampling data between vector-raster layers - Mutual conversions between raster and vector data layers - Data conversion to other raster formats - Conversion of image colours between RGB-PCT - Reformatting of raster layers based on other referent raster layer - Analyzing and interpolation of raster cells - Merging of raster layers	- Create and work with SpatiaLite layer - Using GPS units in QGIS - Line tracking with QGIS+GPS - Geographic databases: PostGIS & PostgreSQL - GRASS - Metadata - Hydrological analyses - Multicriteria analyses - 3D visualisation in QGIS - Create masks - Create Atlas - Creating forms – customization - Export QGIS to Open Layers - Geocoding - Creating Heat Map - Download and georeference Google Earth images - Download Landsat images - Reclassification of raster data - Land use classification and land-use change - Batch processing for automatic processing - Create python plugins for QGIS - Adding layers from map servers - QGIS server - QGIS Web client - QGIS cloud

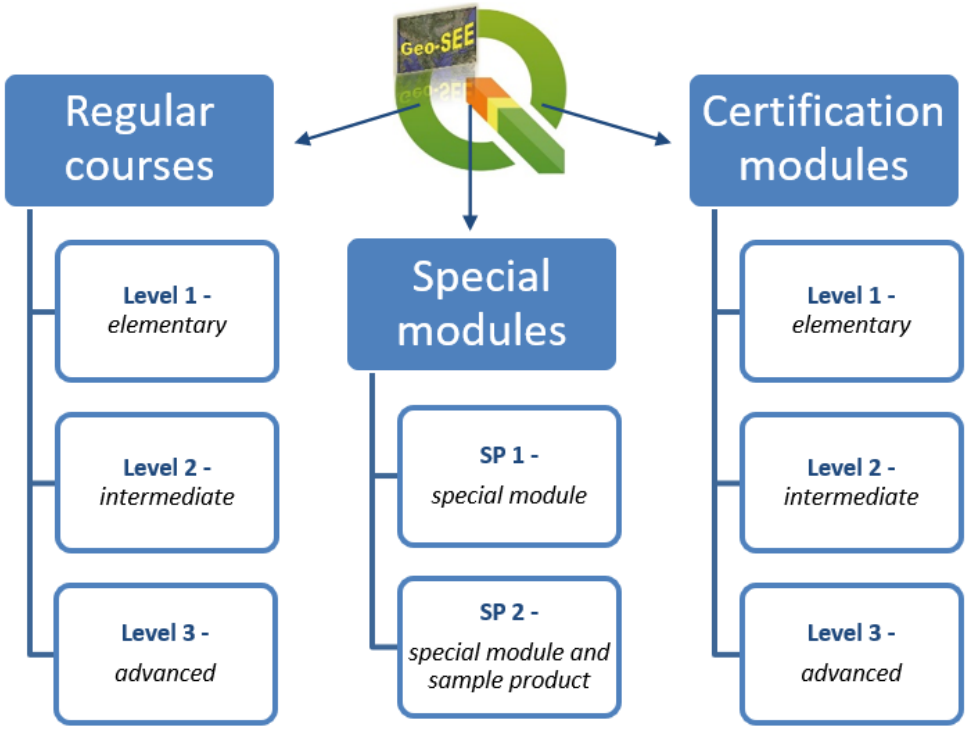
Professional training course on QGIS of groups from 5 up to 10 students is designed in three levels - elementary, intermediate, and advanced, given in Table 1. The curricula of three levels are systemized hierarchically from the data development steps to developing the Web GIS. The courses are currently conducted in Albanian and Macedonian, and the training program is also available in English. The training includes lectures of 20 academic hours at each level, accompanied by practical exercises with the latest stable version of QGIS. The teaching material for all classes can be downloaded free from the training website. Obtaining a certificate is after an exam is conducted, which consists of a practical test using a spatial data set. At the end of each training course, candidates who have successfully passed the last exam receive a certificate. The certificates are publicly available on the Web page[13] and on the official QGIS FB training page[14]. In addition, Geo-SEE Institute maintains a database of certified experts in QGIS training courses who have successfully passed them.

[13] http://qgis-geosee.blogspot.com/p/certificates.html (Accessed on 29 July 2020)
[14] https://www.facebook.com/QGIS.TrainingCourse (Accessed on 29 July 2020)

Geo-SEE Institute is the first organization with formally verified programs by the state public institution - Adult education center[15] for organizing professional training courses for QGIS Level 1 (Decision for verification No. 10-70 from 18th July 2019) and Level 2 (Decision for verification No 10-69 from 18th July 2019). The Geo-SEE Institute is the first organization that provides both verified programs as a certified institution for adult education by the Ministry of Education and Sciences of the Republic of North Macedonia. To the best of the authors' knowledge, the verification of training courses for QGIS is also unique in the SE European region. So far (December 2020), about 190 participants have completed training courses, and about 150 of them have received certificates with a successful final exam.

In addition to the three teaching levels, Geo-SEE Institute organizes the so-called special modular-SP courses for professional Training in QGIS related to specific needs for training individuals or organizations, such as Module SP1 and Module SP2 the implementation of a real example (Fig. 2).

Figure 2. Scheme of modules on QGIS courses provided by Geo-SEE Institute Skopje.



Besides basic curricula of three levels, at the third level additionally as elective topics, attendees can choose up to three plugins from the list of QGIS repository, i.e. per one for data processing, for EO, and for data representation/output, with an obligatory task to analyze them and respond feedback to developers. By this, participants are trained to use plugins and contribute as a part of the geo community to increase the quality of QGIS tools/plugins.

The Geo-SEE Institute aims to expand the application of free and open-source software in different fields and improve understanding and increase knowledge of using QGIS as one of the most popular open-source GIS software globally (Fig. 3). The Institute also seeks to increase well-educated students to learn about regional and global initiatives and GI issues. The manuals and training materials for the three levels are regularly updated, considering the latest version of QGIS, which is always available at the following link https://www.qgis.org/en/site/index.html. It also surveys the labor geo markets supply and demand, examining selected institutions from target groups concerning training programs.

[15] http://cov.gov.mk/en/members/geo-institut,(Accessed on 29 July 2020)

Feedback and evaluation of former participants' experience are sought, analyzing the relationship of market requirements with the training program and the knowledge gained during the training courses.

5. DISCUSSION

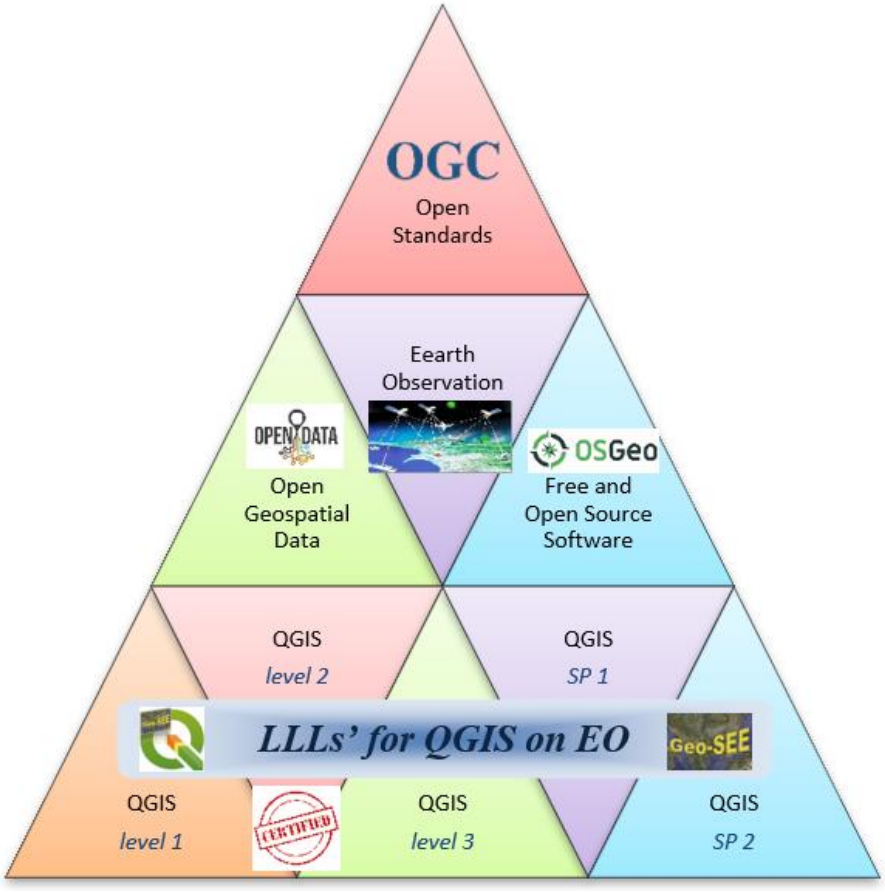
Open-source GIS is increasingly being adopted and used in many countries worldwide, including by large software corporations. For example, Google uses open-source GDAL on the Google Earth platform. AutoDesk offers program codes for MapGuide, FDO & MetaCRS; the ESRI uses GDAL and changes ArcGIS GeoPortal Server to open-source. Open-source GIS has excellent potential to develop in the future. More than 500 completed projects using such software products are known. Cooperation between software developers and GIS users, the free sharing of geospatial data and information and access to the computer and software resources are the main factors that stimulate this development. Open source GIS expands the possibilities for creating multiple applications in EO's socio-economic, research and educational fields.

Recently, the scientific-educational project "Academy "My Green City" (2019-2020), funded by the Bulgarian Ministry of Education and Sciences[16] was demonstrated the application of the methods for STEM (Science - Technology - Engineering - Mathematics) education, based on a multi- and interdisciplinary solution of real environmental problems. The main goal of the project was to get acquainted with scientific methods of research, application and dissemination of scientific knowledge and geoinformation technologies for visualization and analysis of scientific results in teaching students and teachers by formulating and implementing a research project integrating different subjects from environmental studied in the Bulgarian secondary school. A monograph was written in Bulgarian, including fundamental theoretical and practical instructions for working with QGIS (Dinkov et al., 2020). Three components of Sofia's urban environment – air, waters and urban green areas - focus on the educational process. The mapping with actual data in the QGIS environment makes the perception of natural phenomena easier and more accessible. The use of GIS is very suitable for problem-oriented learning and LLL by applying a classroom research approach. Students and teachers independently collect and process data, perform a wide range of analyses, make analytical conclusions and visualize results through open-source GIS about specific environmental problems.

The advantages of using open-source QGIS software are the possibility for a wide range of users to access a free (or almost free) license, saving money, computers, and other resources. Written program codes initially are improved continuously with the active support of well-trained programmers, leading to increased programs, security, and stability. The circle of specialists who support open-source GIS is expanding, as system support is supplemented with new programs, applications and utilities (plugins). Well-developed open-source GIS systems can quickly implement program codes in other programs, re-use developed algorithms, work and integrate these products with other programs, and develop plugins for usage only in a case as needed. The main advantage is making changes in the software codes, exercising complete control over a specific decision, and uploading externally developed codes known as QGIS plugins. In addition, QGIS software is straightforward to install, which means that anyone can easily download and install it on their computer and manage shared spatial data or information on the Internet and develop their applications or extensions to it.

Figure 3. Schema of standards, geodata, and FOSS for LLLs' on QGIS for EO by Geo-SEE institute.

[16] https://educationwithscience.online/(Accessed on 29 July 2020)



Sometimes, open-source QGIS is associated with difficulties in executing or compatibility of different versions of program codes. For this purpose, continuous support is provided to improve the software programs' compatibility for users' convenience and the documentation for working with open-source software. There are four pillars of the LLL Program[17], which include a) the Comenius program for students, teachers and schools; (b) the Erasmus program for students, scientists, teachers and universities, (c) the Leonardo da Vinci program for apprentices, workers and staff; and (e) the Grundtvig program for adults and teachers and related organizations. In addition, the Jean Monet programme is dealing with issues relating to European integration, European institutions and associations in the fields of education and training) and a transversal programme - for policy development, languages, information and communication technology. As EU member states, Greece[18], Bulgaria[19] and Romania[20] following the European policy adopted national strategies have been adopted national strategies for LLL programs. Non-EU countries in Western Balkan, North Macedonia[21], Albania[22], Montenegro[23], Bosnia and Herzegovina[24], and Serbia[25], following the European policy, have also adopted the national lifelong learning strategies. These strategies

[17] https://wbc-rti.info/glossary/78) (Accessed on 29 July 2020)
[18] https://eacea.ec.europa.eu/national-policies/eurydice/content/adult-education-and-training-funding-33_en (Accessed on 29 July 2020)
[19] https://epale.ec.europa.eu/bg/node/3373 (Accessed on 29 July 2020)
[20] https://eacea.ec.europa.eu/national-policies/eurydice/content/lifelong-learning-strategy-64_en (Accessed on 29 July 2020)
[21] https://eacea.ec.europa.eu/national-policies/eurydice/content/lifelong-learning-strategy-48_en (Accessed on 29 July 2020)
[22] https://eacea.ec.europa.eu/national-policies/eurydice/content/lifelong-learning-strategy_ro (Accessed on 29 July 2020)
[23] https://eacea.ec.europa.eu/national-policies/eurydice/montenegro/lifelong-learning-strategy_en (Accessed on 29 July 2020)
[24] https://eacea.ec.europa.eu/national-policies/eurydice/bosnia-and-herzegovina/lifelong-learning-strategy_en (Accessed on 29 July 2020)
[25] https://eacea.ec.europa.eu/national-policies/eurydice/content/lifelong-learning-strategy-66_en (Accessed on 29 July 2020)

include the LLL principles in policy documents as priorities in education, continuous training and employment. In this regard, several agencies and various public entities functioning at a national, regional, or local level were established and performed LLL activities. Besides, Western Balkan countries try to create a Lifelong Learning Network to identify alternative educational pathways beyond the formal educational system. The initiatives undertaken aim to integrate and reintegrate individuals in the labor market, work assurance, and professional and personal development.

The inclusion of OS, OD and FOSS in lifelong learning programs for EO sciences excludes the costs for purchasing software licenses and training data. The expenses for providing such courses by adult educational service providers reduce providing opportunities to a broader range of professionals from different fields and social levels for further developing their skills and competencies in geosciences for low-cost LLL training courses. Further usage of the free software license in a professional career in the post-training period makes such LLL courses attractive for individual professionals and project managers. They can establish the GIS department for low-cost training courses and FOSS usage and work on different geoinformation sciences projects. QGIS LLL training courses in three levels are certified. They are available for all interested individual professionals, private companies and other organizations, intended to provide opportunities for doing business by using QGIS as free and open-source software for EO and Geo-Information sciences.

6. CONCLUSIONS

Worldwide, with the development of research methods and technological tools, educational approaches are changing. It is generally accepted that education is acquired during high school and then further developed at universities. However, contemporary trends promote lifelong learning, which means that education does not end at university. New methods and educational approaches are currently being sought to ensure that future generations are provided with quality learning opportunities from early childhood to lifelong learning, supporting each individual's intellectual development and improvement. For the countries in the SE European region, EU programmes' participation is a crucial instrument for cooperation in a wide range of Earth sciences areas, including in LLL.

LLL policies, strategies, and regulations are almost defined in all countries available on national authorities' websites. To increase cooperation between LLL providers and develop international LLL courses, European Commission has released the Erasmus program[26] and Interreg Europe cooperation programme[27] for the period 2021 – 2027. Both programmes give mobility opportunities and provide joint LLL courses in EO and usage of FOSS for GI by financial support from the EU funds. Such chances are beneficial for establishing networks for collaboration between LLL course providers in countries of SE Europe by sharing experiences between EU and Non-EU countries in OS, OD and FOSS for GI and EO.

Lifelong learning is a process of constant deliberate acquisition of knowledge and skills. The Geo-SEE Institute's learning opportunities at any age are an excellent prospect for personal and professional development in geosciences. The educational system is changing, and professionals' qualification in GI and EO sciences is continuously enhancing, their skills to work with the most modern technologies and tools. For this purpose, it is necessary to improve the curricula at schools and universities and provide new knowledge required to develop specialists to meet the labor market's current requirements in the SE Europe region. It is also essential to update manuals and training materials by adopting the latest technologies, constantly survey the geo-market demand and supply for current training programs, and evaluate former participants' experience. These activities will support the

[26] http://lllplatform.eu/lll/wp-content/uploads/2019/02/Infonote_new-Erasmus-proposal-2018.pdf (Accessed on 29 July 2020)
[27] https://www.interregeurope.eu/fileadmin/user_upload/documents/Programming_Committee/2021-2027Interreg_Europe_Cooperation_Programme.pdf (Accessed on 29 July 2020)

analysis of the relationship between market requirements and the knowledge/skills acquired in the Geo-SEE Institute's training courses and will provide an opportunity to improve the lifelong training program.

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