

# Lifelong Learning on Digital Earth

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## Abstract

*Digital Earth vision (DEvision) is an initiative aiming at the integration of geospatial online and blended learning modules into curricula of multiple disciplines. The Austrian Development Cooperation with its APPEAR program managed by ÖAD therefore supports the DEvision initiative in partnership with academic institutions in Kyrgyz Republic and Armenia. Based on an extensive needs survey across multiple actors in these partner countries, learning modules on Digital Earth Basics, Geospatial Models and Representations, Geovisualisation and Communication, Remote Sensing and Image Analysis, and Spatial Analysis are under development. These modules are designed for bachelor or master-level programs according to requirements identified by partners as well as for qualification improvement training. Digital Earth and lifelong education are interconnected concepts that emphasize the use of digital technologies to support continuous learning. The synergy between Digital Earth and Lifelong Education provides access to a wealth of geographic and environmental data, which can be used for educational purposes. Digital Earth tools provide students with access to cutting-edge geospatial technology and data, which enhance traditional and introduce new ways of learning methods. The Razzakov Kyrgyz State Technical University hosted two "Digital Earth Qualification" training sessions and the feedback from the trainees was analyzed, which provided valuable insights into the effectiveness of the training programs and areas for improvement.*

**Keywords:** Digital Earth, GIS, Geospatial Models, Geovisualisation, Lifelong Learning, Remote Sensing, Spatial Analysis

## 1. Introduction

Geographic Information System (GIS) - an information system designed to collect, store, analyze and graphically visualize spatial data and related information about the objects represented in the GIS. GIS integrates various types of data and provides tools for analysis and visualization that help users understand spatial patterns and relationships. These capabilities make GIS a critical tool in numerous fields such as urban planning, environmental management, transportation, public health, and disaster response. Using modern means of remote sensing (RS), geographic information systems (GIS) are capable of delivering this information quickly and efficiently. Moreover, the modelling tools available in modern GIS software systems allow real-time forecasting of the development of a situation, for example, showing a consistent expansion of a flood zone or forest fire. These predictive capabilities are crucial for emergency management and disaster response, providing authorities with timely information to make informed decisions and take appropriate actions to mitigate risks.

Data sources for GIS are maps, plans, and diagrams, presented both in specific object formats and in traditional raster and vector formats. GIS content is carried out by entering various primary materials, including the results of measurements on the ground, geological surveys, mapping, aerial and satellite imagery, and special subject information [1]. The main goal of this research work is to analyze the development and integration of geospatial online and blended learning modules into lifelong learning systems in Kyrgyz Republic and Armenia. Training of professionals from different fields on Digital Earth (DE) vision and digital transformation concepts will have positive impact in societies, economies and environments. These training programs aim to equip individuals with the skills needed to leverage GIS technologies for addressing complex challenges such as sustainable development, resource management, environmental protection, and disaster risk reduction [2].

The research carried out within the project DEvision - “Digitally connecting real and virtual environments” funded by OeAD - the Austrian Agency for Education and Internationalization under the APPEAR program - the Austrian Partnership Program in Higher Education and Research for Development in 2022-2025. The project consortium coordinated by the University of Salzburg (PLUS), Austria with partners such as the National University of Architecture and Construction of Armenia (NUACA), the Yerevan State University (YSU), Armenia and the Razzakov Kyrgyz State Technical University (KSTU). The project partners have collaborated in multiple contexts for several years, identifying an urgent need and supply gap for education and open access to current digital, online and participative technologies.

## 2. Need Analysis

The GIS-related industry in Kyrgyz Republic and Armenia is currently experiencing significant pressure and demands, driven by several factors. These include a rapidly growing interest among young people, a general lack of development and environmental awareness, and the potential for innovation from a geographic and natural resources perspective.

To thoroughly understand the specific needs of the GIS industry in the region, a needs analysis was conducted using a questionnaire survey targeted at universities in the Kyrgyz Republic and GIS specialists. The results from these surveys provided critical insights into the actual requirements for developing capacities in both undergraduate and postgraduate education, as well as in geospatial research. Key findings of the needs analysis are:

- There is a need for more comprehensive geographical and environmental curricula at the undergraduate level including Digital Earth basics.
- Postgraduate programs need to offer more specialized and advanced courses that can prepare students for high-level research and professional roles in the GIS industry.
- Professional competences demanded:

*Technical Skills:* Proficiency in GIS software (e.g., ArcGIS Online, ArcGIS Desktop, QGIS), remote sensing tools, and spatial data analysis techniques.

*Analytical Skills:* Ability to analyze and interpret spatial data to provide meaningful insights and support decision-making processes employing Digital Earth vision.

*Field Skills:* Experience in conducting field surveys and using ground-truthing techniques to collect geodata and validate remote sensing images.

*Research Skills:* Capability to conduct independent research, including designing studies, collecting data, and publishing findings.

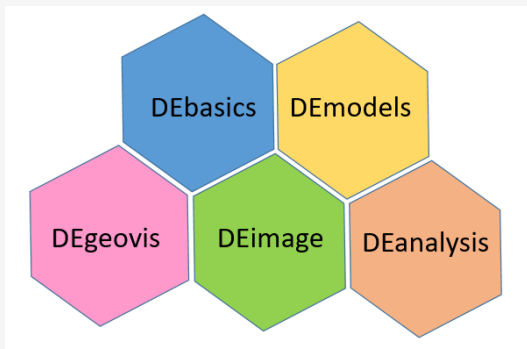
Based on the findings from the needs analysis, continuous professional development programs are needed to keep educators and professionals updated with the latest advancements in GIS technology and methodologies. Blended learning, which combines online digital media with traditional classroom methods, is becoming increasingly important in GIS education. This approach leverages the flexibility and accessibility of online learning while maintaining the benefits of face-to-face teaching, providing a comprehensive and adaptable learning experience [3][4][5] and [6]. The following strategies are proposed to address the identified gaps and challenges for higher professional and lifelong learning on Digital Earth:

- Introduce comprehensive GIS courses that cover basic topics on Digital Earth and incorporate hands-on training sessions using the latest GIS software and tools.
- Develop specialized postgraduate courses focusing on advanced Geospatial Models and Representations, Geovisualisation and Communication, Remote Sensing and Image Analysis, and Spatial Analysis.

The needs analysis highlights critical areas for development within the GIS industry in Kyrgyz Republic and Armenia. By implementing targeted educational programs and securing necessary resources, this initiative seeks to empower a new generation of GIS professionals who can drive innovation and sustainable development in their regions. This holistic approach will ensure that both countries can fully harness the potential of GIS technology to address their unique geographic and environmental challenges.

## 3. Module Development

Geospatial technologies are becoming increasingly crucial for various sectors and enhancing the professional educational programs in this field is essential. This project has developed learning modules on Digital Earth Basics (DEbasics), Geospatial Models and Representations (DEmodels), Geovisualisation and Communication (DEgeovis), Remote Sensing and Image Analysis (DEimage), and Spatial Analysis (DEanalysis) for Bachelor and Master levels (Figure 1).



**Figure 1:** DEvision modules

Recognizing the importance of integrating these advancements into educational frameworks, universities in Armenia and the Kyrgyz Republic have collaborated to develop online and blended learning modules aimed at both undergraduate and graduate levels. All these five DEvision modules are open for training and accessible online through the project website at: <https://www.devision.cloud/pages/modules>.

The Digital Earth Basics module has designed learning outcomes for the undergraduate, postgraduate and professional training courses in the wider fields:

- Geospatial approaches across disciplines and industries.
- Measuring global dimensions and local spaces.
- Spatial reference systems.
- Collecting georeferenced data.
- From maps to views: communicating and sharing spatial information.
- Getting started with the geospatial cloud.

Learning outcomes of the Geospatial Models and Representations module will form professional competences in the geospatial domain through postgraduate and qualification improvement courses:

- Acquisition and integration of feature data.
- Raster data and imagery.
- Accessing and managing services.
- Principles and practice of open data.
- Navigating Spatial Data Infrastructures.
- Creating apps for data collection.

Geovisualization and Communication is a module that focuses on the visual representation of geographic information and effective communication of spatial data with learning outcomes:

- Creating and sharing web maps.
- Classification, symbolisation and visual combination.

- Design for interaction.
- Perspective viewing and 3D visualisation.
- Storymapping and dashboarding.
- Creating app experiences.

Remotely sensed imagery is one of the most powerful instruments to monitor the state and dynamics of Earth's surface. The module is focused on exploring basic online platforms for working with satellite imagery and the diversity of imagery characteristics as well as application domains as:

- Exploring and integrating RS imagery.
- Fundamentals: from physics to visuals.
- Platforms, sensors and data.
- Imagery to thematic layers.
- Classification and feature extraction.
- Monitoring and detecting change.

While some geospatial use cases and application domains serve as 'systems of record' managing geospatial data for safe storage and access, it is likely a majority of needs where we need to create new information and sometimes information products from data. This module therefore aims at creating an understanding and first overview across the many analytical tools and processing workflows with learning outcomes:

- Creating information and value from data.
- Network analysis.
- Distance-based analysis.
- Spatial interpolation.
- Surface/terrain analysis.
- Multithematic analytics.

These modules are developed jointly by Austrian, Kyrgyz and Armenian partner universities and maintained as online cloud-based resources for educators and students [7]. The Digital Earth Basics module (DEbasics) is oriented to undergraduate programs in a wide range of fields with geospatial domains. This module covers various topics, introducing geospatial approaches, GIS and RS applications, defining spatially referenced data and contrasting the different types of data (raster and vector) as well as basic digital mapping skills.

ArcGIS Online is used as a powerful platform that supports lifelong learning by providing tools for creating, analyzing, and sharing spatial data and maps. It enables learners to explore real-world data and solve problems in various fields, users can share their projects and collaborate with others, promoting knowledge exchange and teamwork [8]. DEvision modules has offered several ESRI tutorials, online courses, and community resources to help users at all levels learn GIS concepts.

A broad range of topics in ESRI resources ensures that users with varying skill levels and interests can find relevant resources. The Central Asia and Caucasus GeoPortal (<https://www.cacgeoportal.com>) has been introduced to the trainees and its tools and training materials are well accepted by them. It has provided valuable resources and tools that complemented their learning and teaching experience. It offers access to regional data, visualization tools, and training materials that are crucial for both research and practical applications in GIS.

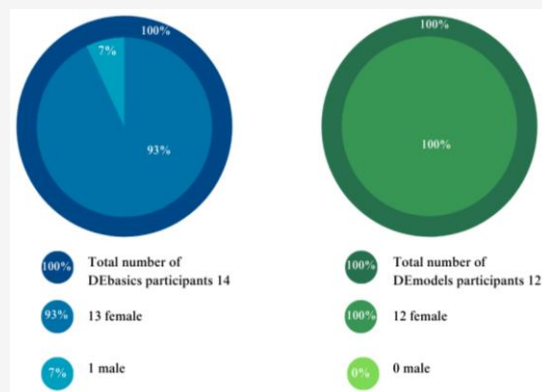
#### 4. Training Courses

From the beginning, the professional GIS education in the Kyrgyz Republic was mainly on the self-education base from the middle of the 1990s. Analysis of the past and current situation on GIS education allowed us to identify the problems, activities and prospective of higher and professional education in this field. The first Geographic Information and Remote Sensing applications started at the Kyrgyz Ministry of Emergency and Civil Defense with its first projects on using GIS for mapping, modelling and monitoring of tailing dumps, landslides and other natural hazards in the country. The purchase of GIS software (ArcView) and the first training of staff members of this Ministry have launched the increasing interest in such education within different government, academic and private institutions. At the beginning stage GIS training was completely within such international projects and provided by international training courses and visiting GIS specialists.

Specialized GIS education in the Kyrgyz Republic started in 2005 with the implementation of the academic program “Applied Informatics in Geography” with qualification “Geoinformatic” at the Institute of new information technologies, Razzakov Kyrgyz State Technical University. This program has been designed by considering GIS programs already implemented at Russian universities and with some of the new international spatial courses. More and more universities of Kyrgyzstan have implemented GIS courses into their curricula with different contents and orientations in 2000-2005s. Many academic programs in such fields as Ecology, Information Technology, Geography and Geology have included GIS courses. Training of GIS teachers have been started in this period and a number of Kyrgyz university teachers have passed trainings at the GIS Centres of international competence, such as the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) in India and Salzburg University Centre for Geoinformatics (Z\_GIS) in Austria.

Most GIS specialists in Kyrgyzstan with Master and PhD degrees have started GIS studies at these centers in 2000-2005. New research projects have started in the country, which involved more and more university teachers interested in teaching Geoinformation technology.

The shortage of experienced teachers in GIS in Kyrgyzstan is a challenge impacting the development of geospatial education and the wider use of geospatial technologies in various sectors. There are several key factors contributing to this shortage such as limited specialized education and training programs, outdated curriculum and resources, limited professional development opportunities, low awareness and incentives, and brain drain. To address the shortage of experienced teachers in Kyrgyzstan, developing advanced GIS courses can be a strategic solution. The most popular approaches are establishment of partnerships with universities abroad that specialize in Geospatial education, leverage the Digital Earth concept, design advanced GIS modules, Training of Trainers (ToT) programs, digital learning platforms, engage GIS professionals and industry experts. The qualification improvement training courses on the advanced DEvision modules are dedicated to train experienced teachers and specialists by implementing Digital Earth concept based on the digital learning platforms jointly with Austrian, Kyrgyz and Armenian educators and experts.



**Figure 2:** DEbasics and DEmodels modules gender distribution

The first “Digital Earth Qualification” training on the Digital Earth Basics module (DEbasics) was started at the Razzakov Kyrgyz State Technical University (KSTU) in March 2024 with 14 participants (13 female and 1 male) as shown in Figure 2. The trainees were from universities (11), state agencies (1) and National Academy of Sciences (2) in Kyrgyzstan and Kazakhstan.

Online video conference tools were used to involve trainees from the Osh city in the south part of Kyrgyzstan and Almaty city of Kazakhstan. 6 participants have successfully completed the study with submitted course assignments and tests in May 2024. This course has indicated the deficiency of online teaching methods resulted in no certificates granted to the online participants with limited internet access faced by some students during the training. This hindered their ability to engage in online learning, particularly during video lectures, causing delays in assignment submissions and preventing them from receiving their certificates [9][10][11] and [12].



**Figure 3:** DEvision training

The second DEvision training on the Geospatial models and representation module (DEmodels) is held in May-June 2024 at KSTU for 12 trainees (Figures 3 and 4). It can be mentioned that all trainees were female and most of them have completed the first Digital Earth Basics module (DEbasics). It was organized in offline mode for trainees by taking into account the negative experience faced during the DEbasics module training. DEvision courses are given by teachers of the Geodesy and Geoinformatics Department, Razzakov Kyrgyz State Technical University (KSTU) and the Department of Geoinformatics – Z\_GIS at the Paris-Lodron University of Salzburg (PLUS), Austria based on different online platforms.

## 5. Results and Discussion

The “Digital Earth Qualification” training is fostering a dynamic learning environment. Participants from diverse backgrounds bring unique perspectives and experiences, enriching discussions and collaborative projects. This mix can lead to innovative solutions and a more comprehensive understanding of Geospatial Science. If you’re involved in or organizing these courses, encouraging this diversity

and motivation can be key to achieving impactful and successful outcomes. The Body of Knowledge (BoK) for lifelong GIS training typically includes a structured framework of knowledge areas, skills, and competencies that guide professionals in understanding and applying GIS throughout their careers [13]. As GIS technologies evolve, lifelong education becomes essential to remain proficient. These training modules gathered people with different backgrounds who are highly motivated to learn and gain knowledge in the field of Geospatial Science. It can be highlighted that 10 participants successfully completed the DEbasics and DEmodels modules and are highly interested in participating at all modules of the “Digital Earth Qualification” training course.



**Figure 4:** DEbasics module certificate award

The analysis of questionnaire results from the “Digital Earth Qualification” training involves a thorough examination of participant responses to assess overall satisfaction, identify strengths and areas for improvement, and gather additional feedback. The following structured approach was used to evaluate the data:

*Overall satisfaction:* The overall satisfaction rating is derived from the average scores provided by participants. High ratings generally reflect those participants found the course valuable and engaging. Trend Analysis is realized by comparing these ratings to previous courses or industry benchmarks, we can identify any trends or recurring issues.

*Advantages and strengths:* Quality of Instruction with positive feedback has highlighted the instructors’ expertise and teaching style. Participants have praised the international trainers ability to clarify complex concepts and maintain engagement throughout the course.

Course Content is noted for being relevant and up-to-date. Participants appreciate the incorporation of current industry standards and trends. Practical applications were well-received with hands-on exercises and real-world examples. Participants value the opportunity to apply theoretical knowledge in practical scenarios. Participants found DEvision modules resources supportive and well-integrated into the learning experience.

*Skills and knowledge gained:* Comments suggest that participants feel they acquired valuable skills and knowledge applicable to their professional or academic pursuits. The effectiveness of the course in meeting learning objectives is reflected in these positive assessments.

*Areas for improvement:* Some participants have indicated that the course pace was too rapid, suggesting that the material was covered too quickly for thorough comprehension. Adjustments may be needed to better align the pace with participants' learning needs. Problems related to cloud based course materials, software access, and online platforms have been noted. Specific technical issues included difficulties in accessing resources or experiencing glitches during online components. Recommendations for improving course organization include adjustments to scheduling, communication practices, and administrative processes. Enhanced organization could improve the overall learning experience and participant satisfaction.

## 6. Conclusion

After conducting two modules of “Digital Earth Qualification” training courses, it was decided to continue other modules offline, since many online participants were poorly motivated and were unable to complete the assignments on time. The analysis of the first two DEvision learning modules on Digital Earth Basics and Geospatial Models and Representation show that, these modules originally developed for Bachelor and Master level studies have advantage as learning resources and GIS teachers and practitioners. Recognizing the importance of integrating these modules into educational frameworks of the Kyrgyz and Armenian universities have collaborated to develop online and blended learning modules aimed at both undergraduate and graduate levels as well as for the Digital Earth Qualification for teachers, researchers and specialists. The other three DEvision modules (DEgeovis, DEimage, and DEanalysis) are planned to be held at KSTU in 2024 and 2025.

It can emphasized that most of teachers completed the “Digital Earth Qualification” modules implement them in their academic and research activities as well as they are motivated to complete all DEvision modules.

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