Digital Earth Competences Across Disciplines

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Abstract
Based on an extensive survey of demand ('needs') and supply (existing study programs) a framework for trans-disciplinary capacity building in Digital Earth concepts, methods and technologies was developed by the authors. In collaboration with universities from the partner countries Armenia and Kyrgyzstan project funding from the Austrian Development Cooperation was acquired to support implementation. Recognizing the need for an explicit spatial approach from disciplines reaching far beyond the traditional 'geospatial' subjects like Geography, Geoinformatics, Geodesy or Planning, the DEvision project addresses study programs like Economics, Ecology, Engineering or Journalism through a focused set of foundational modules implemented as a minor subject or certificate. This vision of a Digital Earth is aligned with general digital transformation in society and business, with implementation of sustainable development goals, and a live-long learning paradigm. Based on modern curriculum concepts and pedagogical concepts like active and blended learning, the DEvision initiative provides a set of five modules as teaching and learning resources. These are primarily set up as open educational resources (OER) supporting teachers, and not intended as self-learning media. Instructors within the respective study programs are expected to guide, mentor and monitor students through assigned online learning materials, or using these resources within existing syllabi and curricula. Overall DEvision follows several clearly defined principles: (i) blended learning based on online resources, (ii) instructor-led pathways aligned with students' majors, (iii) a modern approach to GIS entirely based on cloud platforms, and (iv) orienting students towards a continuous professional development principle based on online communities.

Keywords: Blended Learning, Capacity Building, Geospatial Curricula, Digital Earth, Geoinformatics

1. Introduction

Digital Earth vision, in short, 'DEvision' is an initiative aiming at the integration of geospatial online and blended learning modules into curricula of multiple disciplines. It implements digital transformation concepts in societies, economies, and environments by addressing students and in-service professionals beyond the traditional 'geospatial' subjects: planning and conservation, logistics and ecology, tourism and agriculture. All these and more are inherently spatially organized, therefore benefit from an explicit spatial approach, and require inclusion of geospatial awareness and methods in their curricula [1] and [2]. By connecting and enhancing the real world with virtual representations, the vision of Digital Earth implements a transdisciplinary geospatial perspective. This will benefit the development of economies everywhere, particularly emerging ones. The Austrian Development Cooperation with its APPEAR program managed by ÖAD therefore supports the DEvision initiative in partnership with academic institutions in Armenia and Kyrgyzstan.

Based on an extensive needs survey across multiple actors in these partner countries as well as prior projects [3] [4] and [5], and also considering earlier work [6] [7] [8] and [9], learning modules on *Digital Earth Basics, Geospatial Models and Representations, Geovisualisation and Geocommunication, Remote Sensing and Image Analysis,* and *Spatial Analysis* with integrated elements for *Application Development* are jointly developed by the consortium, leveraging (partially) existing Open Educational Resources (OER) [10] and [11], thus creating an integrated syllabus covering one full semester's equivalent of student engagement. These modules are designed for bachelor or master's levels according to requirements identified by partners and support the award of specialization certificates, potentially offered as continuing education.

Within given educational frameworks, this concept based on open resources, online cloud environments and fully internationalized qualifications has been identified as an approach being equally feasible, high on desired impacts and trendsetting for digital learning. Module materials are intended as teaching resources, teachers are supposed to select and introduce the specific materials students are expected to engage with and complete. Included learning resources support the stated learning objectives, in most modules/sections more resources are referenced than any one student is expected to use - teachers must guide students based on prior knowledge, discipline context, level of study program and intended outcomes.

Coursework is based on an active learning paradigm: teachers are not expected to provide a major amount of lecturing and frontal instruction, but rather will guide- and mentor students through their tasks, consult and provide feedback, and ensure learning objectives are reached. DEvision modules are NOT designed for independent self-learning, though, there's always a teacher's responsibility for outcomes! A majority of learning resources are based on the Esri ArcGIS Online ecosystem and Esri Academy courses and tutorials. While this certainly builds platform-specific competences for students, the actual learning objectives and outcomes are independent of any vendor and technology as long as a 'modern GIS' paradigm is being followed. A modern GIS is understood as a web GIS that revolves around data services [12], cloud architectures, configurable applications, and automation. However, GIS education has not always kept pace with these changes. Looking at the skills required in the field today, there is a clear mismatch with the desktop-centric GIS curriculum that is still the foundation of many GIS courses. DEvision therefore will incorporate the changes in industry driving the need for changes in GIS education, allowing educators and students to learn modern GIS concepts and workflows. DEvision is designed for blended learning: synchronous online or classroom orientation and instruction are mixed with individual coursework based on online resources and practical activities leading towards learning objectives.

All coursework is built on online cloud computing (only), i.e., no local installation or desktop licensing is required. Students are provided with ArcGIS Online organizational licenses, require a 'decent' internet connection, and will work with web browsers (only). By showcasing and fully implementing a role model for digital transformation in education and ultimately in professional practice, the collaborative DEvision initiative is expected to have substantial impact within and beyond all participating institutions: "*The future is not something to predict. The future is something to build.*"

2. Digital Earth Core Competences

Attempts to define and potentially standardize geospatial curricula originated back in the 1980ies [13] and [14] and have recently reached their current state-of-the-art documented in the UCGIS (University Consortium for Geographic Information Science) GIS&T Body of Knowledge [1] and the European EO4GEO Body of Knowledge [15]. Based on these foundations, and decades of experience with curricula at the University of Salzburg and within the worldwide UNIGIS association [2], a framework for 5 foundation modules was developed (Table 1). Within the constraints of a one semester specialization or minor program [16], or an equivalent professional certificate, these topics and related competencies were identified as a trans-disciplinary common denominator for basic qualifications for Digital Earth applications. An additional set of skills related to web-based application development was introduced as a cross-module objective and intended learning outcome. This initiative with a strong focus on trans-disciplinary capacity building and target competencies across traditional disciplines is also aiming to facilitate the support of a digital geospatial citizenship mindset as well as professional ethics. Both are urgently needed to support roles and participation in a networked information society.

3. Blended Learning

Within the DEvision initiative, specific educational methods and guiding principles are being followed to enable implementation in different countries, academic frameworks and disciplines, and a variety of learning levels and phases. Blended learning serves as the key principle, merging online learning with traditional classroom activities using digital interfaces. Teachers and students meet in physical classrooms and online through interactive media. Blending learning allows students to accelerate their individual learning process while maintaining a community of learners setting. This also implies a substantial degree of individualized learning: personalized and tailored learning processes created to help and encourage individual learning. Personalized learning experiences are targeted towards students set to benefit from an individual learning path.

Table 1: DEvision modules

Digital Earth Basics	DEbasics	1. Geospatial approaches across disciplines and industries 2. Measuring global dimensions and local spaces 3. Spatial reference systems 4. Collecting georeferenced data 5. From maps to views: communicating and sharing spatial information 6. Getting started with the geospatial cloud
Geospatial Models and Representations	DEmodels	1. Acquisition and integration of feature data 2. Raster data and imagery 3. Accessing and managing services 4. Principles and practice of open data 5. Navigating Spatial Data Infrastructures 6. Creating apps for data collection
Geovisualisation and Geocommunication	DEgeoviz	1. Acquisition and integration of feature data 2. Raster data and imagery 3. Accessing and managing services 4. Principles and practice of open data 5. Navigating Spatial Data Infrastructures 6. Creating apps for data collection
Remote Sensing and Image Analysis	DEimage	1. Exploring and integrating RS imagery 2. Fundamentals: from physics to visuals 3. Platforms and sensors 4. Imagery to thematic layers 5. Terrain and surface / feature analysis 6. Monitoring and detecting change
Spatial Analysis	DEanalysis	1. Exploring and integrating RS imagery 2. Fundamentals: from physics to visuals 3. Platforms and sensors 4. Imagery to thematic layers 5. Terrain and surface / feature analysis 6. Monitoring and detecting change

Personalized learning requires designing a learning journey curated specifically for a particular group of learners and/or learning objectives. Active Learning is strongly emphasized over lecturing with students in a passive role. Teachers implement various active learning strategies in online courses, providing new ways for students to interact, participate, and collaborate. Active learning combines practice with feedback, peer learning, and clear structure of student activities. All these principles and approaches are embedded in a modular curriculum design as a flexible framework for trans-disciplinary learning supporting different pathways intersecting at certain well encapsulated, mutually independent modules. This creates learning continua with a flexible and modular environment according to student group potential and skills, infrastructure of school, timing of the learning, abilities of teacher and technological opportunities.

4. Platform and Organizational Framework

With learning objectives and supporting materials structured into 5 modules with 6 sections each, all these resources are managed on a platform facilitating open access. For this purpose, a hosted Moodle LMS instance is provided with '*guest'* access enabled. Direct URLs are published for the entire collection of modules (https://geoinformatik.at/course/index.php?categoryid=13) as well as for individual modules. Sections within modules can be expanded to present the complete list of links to teaching and learning materials. While these are structured in a sequence from basic to more advanced, they are not intended to be covered and completed entirely – rather teachers are expected to guide students towards a selection of activities in a progressive sequence.

To support instructors, 'hidden' folders and elements are available within each module containing resources like teacher manuals or extensive resources requiring guidance and selection by teachers in order not to overwhelm students. For access to these resources, teachers can request passwords. Teachers and students alike are encouraged to use a structured forum within each module for feedback, comments, and questions. In the initial testing and evaluation phase, these channels are intended to provide input for enhancements, improvements, and corrections. Later, they are supposed to facilitate continuous updating and additional support for instructors.

Each module and section start from a set of stated learning objectives communicating expectations. In each section this is followed by an introductory story map-based short lecture for orientation, which might be available as recordings in the future. The bulk of each section's resources is then based on links to openly available learning media. This again is followed by proposed activities in the form of exercises and case studies – both providing an opportunity for regional and discipline-specific experiences. As a final element per section, assignment suggestions and quiz questions are shared as examples for formal student assessment and self-assessment.

5. Educational Framework

The (5) DEvision modules are designed and developed for a clearly defined educational framework, the below outlined approach to teaching and learning therefore serves as a guidance for instructors and learning management and is communicated in exactly this wording to teachers and reviewers.

- DEvision aims at bringing 'Digital Earth' competences into an array of disciplines and are not primarily focused on 'core' geospatial study programs like Geoinformatics, Geodesy / Surveying, Cartography etc. (while it is of course perfectly ok to use DEvision resources in such curricula as well).
- Modules are designed as teaching resources, we anticipate a teacher to select and introduce the specific materials students are expected to engage with and complete.
- Modules predominantly are based on learning resources supporting the stated learning objectives, in most modules / sections more resources are referenced than any one student is expected to use - teachers will guide students based on prior knowledge, discipline context, level of study program and intended outcomes.
- Coursework is based on an active learning paradigm: teachers are not expected to provide a major amount of lecturing and frontal instruction, but rather will guide students through their tasks, consult and provide feedback, and ensure learning objectives are reached.
- DEvision modules are NOT designed for independent self-learning, though - just to clarify there's always a teacher's responsibility for outcomes!
- A majority of learning resources are based on the Esri ArcGIS Online ecosystem and Esri Academy courses and tutorials. While this certainly builds platform-specific competences for students, the actual learning objectives and outcomes are independent of any vendor and technology.
- DEvision is designed for blended learning: synchronous online or classroom orientation and instruction are mixed with individual coursework based on online resources and practical activities leading towards learning objectives.
- All coursework is built on online cloud computing (only), i.e., no local installation or desktop licensing is required. Students are provided with ArcGIS Online organizational licenses and require a 'decent' internet connection and will work with web browsers (only).
- Modules can be taken in a sequence or independently based on students' prior skills. A logical sequence, though, would be DEbasics - DEmodels - DEgeoviz followed by DEanalysis and/or DEimage.
- All modules are structured into 6 sections and aim at a total workload corresponding to 6 ECTS if all learning objectives are to be reached.
- Module sections start with stated learning objectives and a section overview corresponding to a brief (15min) orientation lecture, which in the future might be provided as a recording. This is followed by a list of 'active learning' resources for which teachers serve as a guide.
- Sections end with an 'Activities' section, suggesting student tasks supporting the attainment of learning objectives. These tasks typically are completed individually, either as homework assignments or in a lab setting. Teachers advise and check outcomes for completeness and correctness.

- In most sections, suggestions for 'Assessment' are provided. These are a combination of test questions and practical assignments. Teachers are also encouraged to use modified 'Activities' for assessment.

At this time, DEvision learning resources = modules still are under development and are expected to be tested and validated from the beginning of the 2023 summer/fall term. Any kind of feedback therefore is much appreciated during this period and beyond.

6. Challenges and Insights

With DEvision being an ongoing development project about to start evaluation and rollout, all insights are considered preliminary. General feedback and perspectives towards uptake are positive, but require a strong investment in communication, (teacher) training, and curriculum accreditation initiatives. Current challenges are perceived all around teacher motivation and skills. This initiative very consciously aims at always having a teacher 'in the loop' for guidance and for consultation. The current practice of either frontal lecturing and click-through labs is deeply ingrained in partner institutions, with active and blended learning paradigms being mostly beyond teachers' experience and more importantly, institutional as well as students' expectations. Such, as any, kind of cultural change requires time and hopefully not generational change.

First steps towards course accreditation are currently being taken and most certainly will not pass without one or another obstacle. This also applies to the credentialing of continuing professional education credits and certificates, which most likely will be based on international frameworks above and beyond national educational frameworks. Issues faced with past educational initiatives in the field of Geoinformatics [17] and [18] are largely bypassed by the 'modern GIS' cloud-based approach. Available of and access to high-spec desktop computing, local licensing and frequent version changes are 'not applicable' anymore, as are problems related to data access and dissemination thanks to the pervasive and ubiquitous access through open data and services portals. Thus, as a preliminary assessment of the DEvision initiative, this approach does not only hold strong promise towards a next generation of educational opportunities for the digital natives not encapsuled in the little boxes of traditional disciplines, but also pursues the aim of a fuller digital transformation of an open society. For further reference, access to open resources and current status of the initiative, readers are referred to https://www.devision.cloud.

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