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Chapter II

Developing a higher education e-learning GIS course for 3D analyses in geography

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Abstract

In this paper, we are showing how we designed and implemented a graduate-level GIS e-learning course for 3D analyses in GIS and geoinformatics. This work was done in the GIS project work course in the Department of Geosciences and Geography, University of Helsinki. In the developed e-learning course students can study independently on the e-learning platform. We based a lot of own prior experience towards the design of the course, and we justified our decisions with topical pedagogical scientific knowledge about GIS teaching. The main aim was to make a challenging but interesting overview of the topic 3D in GIS. The course combines readings, practices, and final essay on a chosen topic. The course is divided into six different areas under 3D. After these, the final essay measures the learning within a form of deeper thinking skills. Course's goal is to teach the student to use their own knowledge and skills on data processing methods later the future in their working life. In addition, self-motivated learning is highly encouraged throughout this e-learning course.

Keywords: 3DGIS; distance studies; e-learning; geography teaching; higher education; online studies

1. Introduction

1.1 Background

We wanted to design a new GIS course for graduate geography students. The aim was to fulfil a need to introduce geographers into the possibilities of three-dimensional (3D) GIS and its analyses. The requirement for the project work was to make the course completely into an online-self-study course that can be completed as distance studies at any time depending on a student's own preferences. In this way, they will have a less formal studying atmosphere with the course, since they can complete it from anywhere at any time (Harris 2003; Şeremet & Chalkley 2015; Robinson et al. 2015). The course uses one of the four approaches of the usage of ICT (information and communications technology) based learning, called fully online learning (Lynch 2008). The course does not need attendance at the campus, but students will follow an online curriculum. Due to an increased need for 3D GIS analyses skills in general, we decided to create an online course about the topic, and we also decided that the course would use an e-learning platform Moodle and the completion would be up to the students themselves. We created a course that would be interesting for the present and future graduate-level geography students. The "non-cookbook" practical style encourages deep learning within the students (Şeremet & Chalkley 2015; Argles 2017). One of the goals was also to create a course that can last at least some upcoming years without too drastic changes or need for updating into the structure of the course. Naturally, this course will be improved in the future due to the rapid improvements in the field of GIS, 3D GIS, and computer sciences.

The course is divided into six sections of practical topics and into a final scientific essay (see Figure 1). The topics of the course will guide the student through different topics of 3D GIS and the possibilities of 3D visualization in mapping. These topics were notified to be the core of this theme. The overall goal was to give a good overview of interesting topics in the field of the 3D GIS analyses and visualisation in geography.

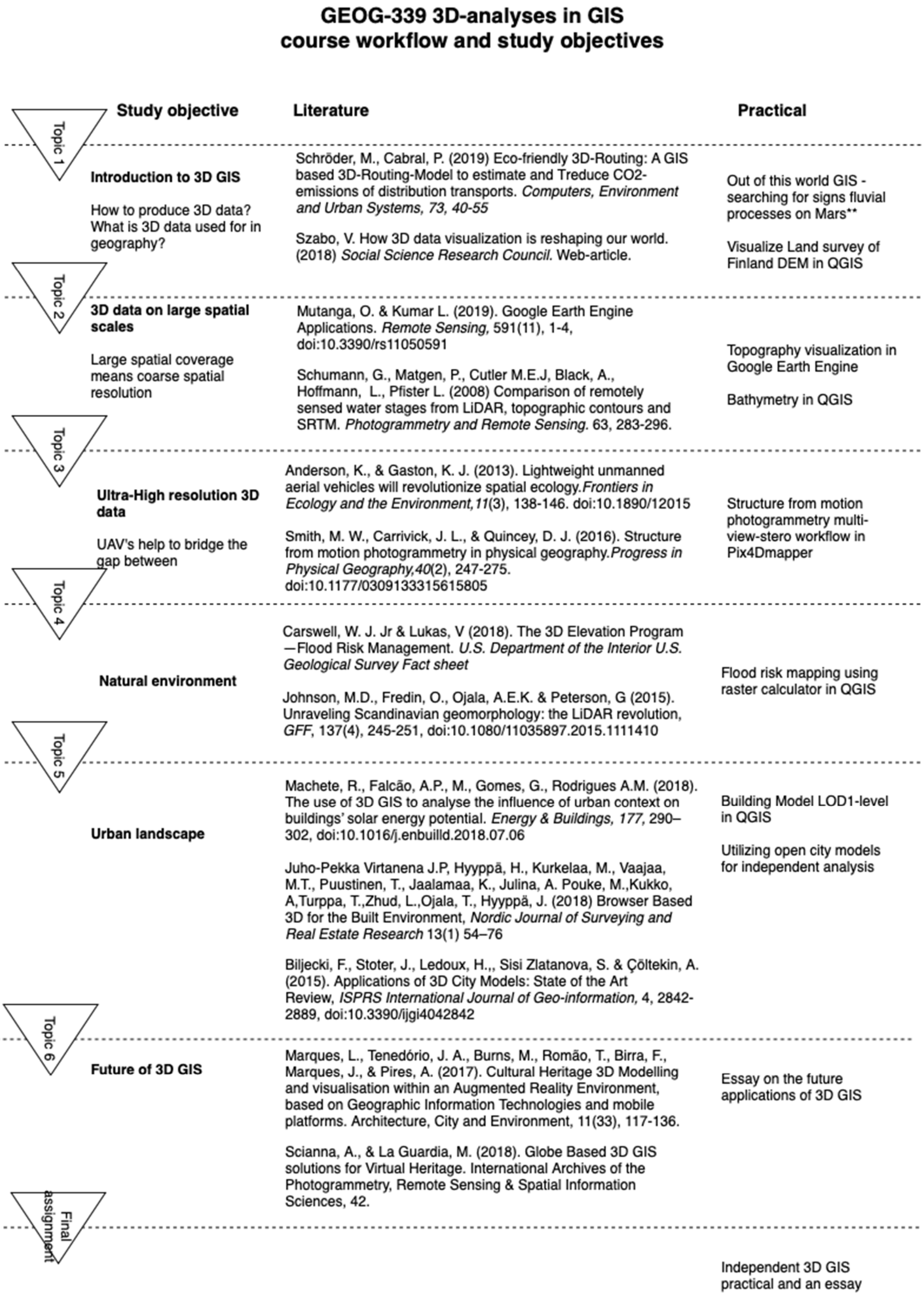

Figure 1. Workflow and course literature of the 3D course.

This 3D GIS course is a five-credit (5 ECTS) course that requires a good basis of existing extensive knowledge of geoinformatics, GIS, and its systems. Pre-course requirements for completion of this course are at least Introduction to Advanced Geoinformatics at the University of Helsinki, however, any other more advanced GIS courses give a valid basis for completion of this 3 D course. Students will work independently a lot, so it's recommended to have confidence in doing their own research with materials and methods in the field of GIS. The learning outcomes for the course are in a way that the students will have a broad overview of varied topics in 3D GIS. Students will also have increased skills in searching for more information and using open software in their research. Each study credit is equivalent to approximately 27 hours of work, in total, the course is designed to take approximately 135–140 hours of working time consisting of readings, practicals (material research, GIS analysis, and writing), and a final essay. It is intended that each practical would take approximately 8 to 10 hours to complete, and a student can use the remaining time to do the final project and essay that takes a little bit longer to complete.

1.2 Why do we need a 3D GIS online course?

We perceive our surroundings in three dimensions; the Earth is not flat, and neither are the events occurring on it. Three-dimensional (3D) data is essential for accurate descriptions, analysis, and predictions of both natural and man-made phenomena. In a typical GIS application, it is usual that at least two of these dimensions (x and y) are spatial extents in a known coordinate system and the third (z) is elevation data. The third dimension can, however, represent some other attribute as well, e.g. the concentration of a chemical or the literacy rate of a given area.

3D data can be divided into two main types: surface and objects (Abdul-Rahman & Pilouk 2007). A surface is a representation of an attribute in three-dimensional space, and its format is most commonly raster, triangulated mesh or some other continuous digital surface. An object is discrete and is usually represented in a vector format. These vectors can be a point, polygons, and polylines in a three-dimensional space.

A need for different 3D applications methods is increasing in the field of GIS. This course will improve student basic knowledge from 2D to 3D. The study program of geography, University of Helsinki, is currently lacking a course that will study GIS purely from the viewpoint of 3D. Now, the array of GIS courses offered by the department is scattered from the standpoint of 3D. This new online course offers a clear-cut and more in-depth perspective to 3D data and 3D analysis in GIS.

2. The study material of the course

2.1 Study structure

Each topic is based on different spatial extents or perspectives of 3D data applications, were learning the objective is to deepen knowledge in separate 3D spatial data areas. The course includes six topics:

1. What is 3D GIS?
2. Large spatial scale 3D mapping
3. Ultra-high-resolution 3D
4. Natural environment
5. Urban landscape and urban environment
6. Future of 3D

Each topic introduces applications within the main topic where some are scientific articles, and some are practicals. The course workflow is categorized by accurate spatial extents: spaceborne for large spatial extents, aerial for landscape, and in-situ and unmanned aerial vehicles or a low aerial for local spatial extents.

The course uses the Moodle e-learning platform. This platform was chosen because it is familiar to the students of the University of Helsinki and it is suitable for varying number of participants.

2.2 Topic 1: What is 3DGIS

The first topic introduces the basic elements of 3D data and its main types: surfaces and objects. The student is challenged to think outside-the-box by scientific reading. For example, the article by Schröder and Cabral (2019) introduces 3D visualization of CO^2 emissions of transport. The aim of this is to underline that the z-coordinate can represent other parameters than the only elevation. The main aim is to teach basic knowledge about 3D GIS and the vast array of different data types, and how they relate to the spatial extent of coverage. Different platforms are described briefly in Figure 2. Students will get familiar with several observation platforms that can be used when producing 3D GIS data (Figure 2).

The first practical will be an easy visualization practical using the 2-meter resolution Lidar-derived DEM provided by the National Land Survey of Finland. The data is open access data and it is free to use. The student will also learn basics through question list. Answers should be included to report.

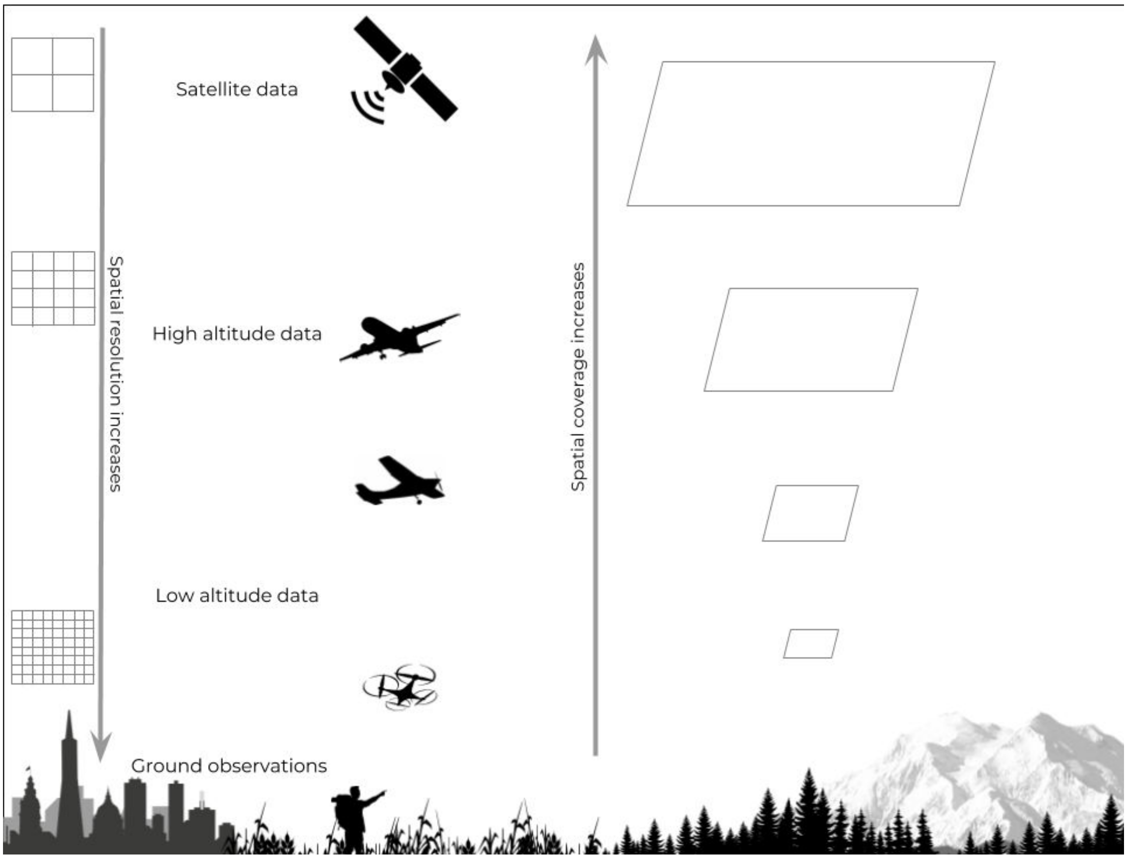

Figure 2. Different 3D data gathering platforms and their relation to spatial coverage and spatial resolution. (drawing: A-M. Määttänen)

2.3 Topic 2: Large spatial scale 3D mapping

Here we introduce the main data sources for near-global scale topographic data and discuss the trade-offs in data quality versus spatial coverage. The main data source discussed is the near-global coverage Shuttle Radar Topographic Mission (SRTM) by NASA. Global investigation of topography is crucial because elevation constitutes one of the most important boundary conditions (Schumann et al. 2007). The global coverage topography data enables investigation of different fluxes of material and understanding global patterns of for example species distribution. It is evident, that these large scale and large extent data sets require a lot of storage space and processing power, the students will go through a demo of Google's Earth Engine (GEE) remote sensing data processing interface. GEE is a geodatabase with an impressive assemblage of different remote sensing data, i.e. the complete LANDSAT archive (Mutanga & Kumar 2019). Students will use GEE to run a short script that visualizes SRTM topographic data using Google's processing resources. The practical will introduce students to bathymetry and underwater 3D applications.

2.4 Topic 3: Ultra-high-resolution 3D

UAV (unmanned aerial vehicle) methods have closed the resolution gap between field observations and remote sensing data (Anderson & Gaston 2013). Together with novel computer vision algorithms, these methods have democratized the availability of 3D spatial data. This topic is focused on Structure from Motions (SfM) and its potential in ecosystem-scale GIS problems. The literature introduces SfM and the practical is a basic SfM workflow. The practical is carried out with a commercial software Pix4Dmapper. The rationale behind the decision of using commercial software instead of an open one is that there are licences available for this software in the department and the graphical user interface logical.

2.5 Topic 4: Natural environment

We wanted to differentiate the 3D GIS applications for urban areas and the natural environment because the modelling of the movements of energy and metrical on the earth is different in natural landscapes compared to environments that have been heavily shaped by humans. Furthermore, the questions that arise are usually different between the two environments. We acknowledge, that human activity is a pronounced geomorphic process and this division simplifies complex systems (Tarolli & Sofia 2016). This division was made on the account of simplicity and because students might want to treat these environments as separate due to their field of specialization under the geography discipline.

The natural environment topic introduces some focal applications of 3D GIS like geomorphometry, 3D change detection (Quin et al. 2016), and risk evaluation, especially from flood map point of view (Carswell & Lukas 2018). These topics are approached in the literature via different datasets. Johnson et al. (2015) review how LiDaR has revolutionized the way Scandinavian geomorphology is studied. The practical is a sea-level rise risk map using OpenTopography data and raster calculator. A simple analysis of how the coastline will be submerged in different sea-level rise scenarios.

2.6 Topic 5: Urban landscape and urban environment

Urban areas are also a big topic in the 3D GIS. Several cities have created detailed 3D city models which are improving their decision making and urban planning. Through this section, the student will deepen their knowledge about 3D city models and cityGMLstandards. Additionally, the students will learn how to gather 3D data from urban areas, depending is it object-based or more detailed model. Practical includes basic building exercise, where learning outcome is to create LOD1 (Level-of-detail) model from the city. Another practical task is to create own urban application analysis, which depends on the student own interests. The student will have a few tips on how to do their own analysis.

2.7 Topic 6: Future of 3D

The topic of the future of 3D GIS was chosen on the basis that the rapid technological evolution will take the field of 3D even further into different fields in science. We wanted to have the last topic to be a bit different from other practicals so we decided to make a freeform essay on a chosen field of possibilities of 3D GIS in the future.

Marques et al. (2015) utilized 3D GIS application in AR (augmented reality) for cultural heritage modelling and Jazbinšek and Hren (2018) also used AR and 3D GIS to create a new way to visualize GIS data. In the practical, the students will read about three different uses for future 3D GIS and one ESRI article on the usage of their CityEngine in research (Fabricius 2018).

2.8 Topic 7 – Final assignment

The main learning objective of having a final assignment is to have students to prove their knowledge on gathered concepts and realize learning in the form of a written report. By writing the assignment on free-to-choose topics we can ensure that the students are motivated and interested in their own topic. Şeremet and Chalkley (2015) also found out that by using GIS on bigger phenomena the students improve other skills aside from GIS as well. For example, students showed an increase in spatial learning and ecology knowledge after producing maps on forestry. Final essays are also a common way to assess the combined knowledge from learned theory and finished practicals, although it had also been argued that the students experience the essay-based assessments to be not as useful as other course practicals (Şeremet & Chalkley 2015). Despite this, after a small survey and discussions with graduate-level geography students we decided to apply some essay-based elements to this course.

2.9 Providing course feedback

After the course, students are required to fill out a feedback questionnaire before the completion of this course. The e-learning nature of the course demands that course should evolve and grow to fill into the users' needs. It is obvious that feedback is required and needed for the future of the course. Sack and Roth (2017) used the term exit survey to describe their online course feedback survey. According to the survey of Sack and Roth (2017), students answered several questions on the topics relating to the content of the course and possible improvements to them.

The first questions ask students how well they felt that the learning objectives were articulated and how well the provided literature and practicals helped to reach these targets. The next questions were aimed at finding out if the students liked how the course was organized and whether the independent form of studying was considered to be helpful in terms of learning. These questions are essential for course development and will be used as the initial measure of how well we, as a group, performed in creating an online 3D GIS course.

The next three questions in the survey are meant for self-reflection. One asks if the amount of work required for completion of the course corresponding to the five credit. The other two questions ask if the student felt that the topics were interesting and if they felt that they gained some useful knowledge and skills during the course.

All the questions described above were scaled from ***Completely agree*** to ***Completely disagree*** on a four-point scale. At the end of the survey, there are two open questions. These are aimed for any feedback or course-development ideas that may have arisen during competition of the course.

Before launching the course available to all students, we used the initial feedback from the few students who tested the course. Feedback was a pivotal part of course development. In addition, it was important because this course was developed as project work in the graduate-level course. Therefore, the role of feedback in the early stages of the developing was even more pronounced.

3. Discussion

Lynch (2008) argued over ten years ago that technology will change the future and work life, which it indeed did. A rise in the popularity of e-learning within and outside of higher education institutions has been increasingly noticeable in recent years. We argue that this is since information is more accessible now than ever and, in addition, learning is becoming more scattered.

One possible threat to e-learning is that students are dropping e-learning courses more often than traditional lecture-based courses (Robinson et al. 2015). Our goal was to avoid this by making the topics varied and this way more suitable for students with varying interests in the field of 3D GIS. Students are also given the freedom to decide their final report from different topics throughout the course to work on.

The students not having excessively detailed instructions to the practicals might cause some students to end up having to go through several unproductive searches online for help and answers to the practicals (Lynch 2008). However, this varies a lot from student to student, since it's tied to their prior skill level and knowledge on GIS programs and open data search. The solution for this could be turning the course into a larger open MOOC (Massive Open Online Course) course, where students could learn more from each other as Robinson et al. (2015), found out in their research. One possible solution would also be to encourage students to create study groups for the completion of the course.

It was discussed a lot within the team that our project group had almost no prior knowledge of how to produce a university course other than from the student's perspective. We conducted several overlooks to the methodology of GIS teaching on the university level and found that our own views on a good lecture series matched to scientific research in several cases (Harris 2003; Lynch 2008; Robinson et al. 2015; Şeremet & Chalkley 2015; Argles 2017).

It was discussed that there might be problems with some used programs during the course, for example, our program of choice, QGIS, changes very rapidly (Argles 2017), which could turn out to be problematic for the completion of some of the practicals. However, this should not be a big problem since the instructions to the practicals are not too detailed. In case the software will change during the course or during the next years, we highly encourage students to search additional information from the user forums of the programs since they have proven to be very reliable in most of the cases. In the case of bigger problems with completion, the students can always turn to the help of the course instructor. To preserve the integrity of the learning materials we created them to be more open and leaning towards self-studying methods. Our aim was to find as new articles as possible that will stay actual longer. Topic 6 was left a bit more open since it is almost impossible to predict the future possibilities of 3D GIS, but the topic was included since we believe that 3D GIS will be more prominent in the field of GIS.

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