GeoS4S – Second Generation Geospatial Education: Principles and Design

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Abstract
The first generation of geospatial education was implemented in two flavours: full-fledged dedicated programmes like Surveying, Cartography and (to a limited degree) in Geoinformatics. More frequently, a range of geospatial methods and technology courses like mapping, remote sensing and image analysis, spatial analysis or geostatistics were inserted as curricular elements into traditional programmes like Geography, Resource Management or Planning. The emerging 'second generation' of geospatial educational strategies addresses previous shortcomings: outreach into a wider set of disciplines (healthcare, public administration, construction engineering and journalism, to name but a few), support for lifelong learning, and full leveraging of opportunities afforded by online elearning. The modular approach to learning resources development implemented in GeoS4S aims to enhance all of the above through a set of Open Educational Resources.

1. Introduction

Geospatial education currently is undergoing substantial changes. Some of these are linked to general paradigm shifts in tertiary education, others are specific to the geospatial domain. Most traditional programmes of study pursue one discipline (optionally) over cycles like bachelor, master and doctoral levels. Today, building an academic qualification from different domains is more prevalent, and not primarily focused on just getting one's MBA when evolving into managerial roles. Developing a spatial perspective, alongside conceptual, methodological and technical competences, is not only useful but highly relevant across numerous disciplines. A qualification in eg Geoinformatics therefore is attractive complementary to a base subject, like resource management, transportation and logistics, ecology, marketing or sociology. Some of these disciplines even experience a 'spatial turn', like currently observed in the domain of digital humanities.

In other words, Geoinformatics is considered less meaningful as a standalone qualification, but rather in combination with domain-specific expertise. The author therefore does not aim this subject at an undergraduate level, but rather prefers students to first understand any, 'their', domain before subsequently obtaining qualifications in digital spatially oriented methods and techniques. Professionals need to first understand a problem from the respective domain perspective before attempting to tackle it with geospatial methods. Geoinformatics therefore is argued to be best placed on a master's level, or squarely in continuing or in-service education, whether as a certificate or a degree. Starting from such a diversity of academic programme formats, designing a framework supporting the obvious variety of curricular structures is difficult. The GeoS4S project therefore started from a rigidly modularized approach: components (i.e., modules) are largely self-contained, abandoning traditional curricular ideas like prerequisites and hierarchical structures. The definition of learning outcomes rather focusses on separate competences which can be selected according to professional needs, with a minimum of common grounding (one obvious example for the latter being 'spatial referencing'). A discussion of guidelines and design principles within GeoS4S explores several themes expanded upon below:

- Support for different learning contexts and frameworks
- Modular, self-contained courses
- Problem-oriented and active learning
- Integration of concepts, methods and technological 'tools'
- Learning within an educational ecosystem

Clearly, an approach in the quest for maximum flexibility and adaptability is not without problems. In any strictly sequential curriculum framework prior competences are established, and assumptions about existing

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conceptual contexts in students' minds will be largely valid. Cross referencing with related topics can be used to build higher level understanding. Students feel that they are progressing, not only accumulating. A professional qualification can be communicated with a known reference ('surveying engineer'), not only with an individual smorgasboard of competences.

However, predefined sets of competences consolidated in a 'named' qualification today correspond less with professional needs and practice. Professional roles are more diverse, technologies and subsequently professional practices evolve rapidly, and demands for competences cannot be foreseen over a career spanning several decades. Educational frameworks therefore must be more flexible, more granular, applicable in a variety of learning settings and able to address on-demand learning. The GeoS4S initiative has worked hard towards addressing these changing contexts of knowledge acquisition.

2. Learning Contexts and Frameworks

Academic teaching and learning happens not only in complete degree or certificate programmes, and the variety of learning contexts certainly is increasing. Lifelong learning today is not only a buzzword, but a professional necessity in most of domains. Academic institutions, at least a majority of them, have been rather slow with adopting frameworks granting more flexibility beyond traditional degree programmes. Lifelong learning implies that learning happens not only in designated periods of life (e.g. as a fulltime student after graduating from high school), but necessarily also while holding down a job, growing a family, moving to places away from academic institutions and while attending to many other obligations. Educational offers therefore need to be designed for piecemeal consumption in a variety of settings (see below, 'modularization').

Learning not necessarily happens in classrooms, set at institutions of higher learning. Online learning in asynchronous modes and over a distance bridged by the internet as well as blended forms of residential and elearning need to be accommodated. While the learning for anyone, anywhere and anytime proposition of elearning seems to be the hallmark of online education, it actually leads to another, sometimes overlooked aspect: learning is getting more individualized, thus requiring more explicit methods of communication, motivation and feedback. Connecting with an argument from above, it should be made clear, though, that individualized on-demand lifelong learning setups require a certain level of maturity and sense-of-purpose. These will not typically be given in undergraduate levels and are primarily considered adequate for graduate and in-service contexts.

3. Modularity

While 'modularization' is a concept used in different contexts, it can mean a lot of different things – just as a strictly sequential and fully integrated curriculum leading to an established and well understood degree qualification can be structured in building blocks named 'modules'. Within the GeoS4S initiative, modules are largely self-contained and are defined with an absolute minimum of prerequisites and common ground. Each module shall be accessible by any student aiming at acquiring a specific set of competences, based on a basic prior understanding of spatial concepts, reference systems and a general computational orientation. These typically are considered as given through the professional or disciplinary background either from a 'spatial' discipline like planning, resource management or logistics, or the specific problem setting motivating the student to get involved in geoinformatics education.

Any 'complete' geospatial programme of studies will be expected to cover sub-disciplines like data acquisition, GNSS, remote sensing, geovisualisation, geospatial analytics and statistics, geocomputation / simulation, and others. Making these sectoral competences independent from each other and encapsulating the acquisition of the respective competences in a way that modules can be completed independent from each other is a clear objective which has been successfully achieved in GeoS4S. This entails a certain degree of overlap between modules, as well as coordination in the underlying philosophy – e.g. an emphasis on services-based architectures and thus a general web-centric approach. In addition, modules have to be designed in a way that they can be 'taught' in classroom settings as well as serving as a core resource for online-based individual self-learning.

A special role is given to application domain – oriented modules, like 'Business Geographics', 'GIS in Logistics' or 'Spatial Ecology'. These connect the problems and the language of a particular (application) domain with specific data models, analytical approaches and often also visual communication traditions of the respective discipline. These modules are facing the challenge of two entirely different target audiences: some students will have a background in the respective discipline (e.g. from an undergraduate education in logistics) and look for a bridge into the digital geospatial methodology. Other students already will already have a broader understanding of geoinformatics and intend to better understand a particular application domain, to better work with people in this field or perhaps even to professionally transition into this field. The jury still is out on the question whether both groups are equally and reasonably well addressed through this kind of module.

4. Problem-Oriented Learning

Learning an abstract concept and set of fundamentals and methods based on the promise that these would be useful at some later time does not really motivate students, be they already mature or not. Modules therefore are better not structured into first accumulating a host of 'knowledge' to be ultimately applied, but typically will start with obvious, clearly understood problems broken down into manageable tasks. Based on the motivation generated through a problem setting, students are led through a process of dissecting, understanding contexts and input requirements for solution strategies. Essentially, students will need to be qualified as problem solvers for identifiable tasks – either by adequately applying generic methods available through existing software functionality or by coding specific solutions. Typically, tackling a problem will require the establishment of a workflow, demanding strong analytical skills.

It needs to be acknowledged, though, that the above indicated option of individualized studying of learning modules has its weaknesses and limitations. These become obvious where group work is an effective means of addressing a problem with subsequent division of labour into different roles and tasks, reflecting the realities of professional environments where more complex problems are rarely (successfully) faced by an isolated individual. In general, though, a problem-oriented approach will be a superior way to acquire the intended competences. It leads to a more natural and intuitive assessment of learning outcomes – no need to test for isolated items and factoids, students present, document and argue a solution to a stated problem or situation, and will have a solid, self-assessed understanding of their performance and achievements as well. Problem-based learning needs feedback and discussion, it needs a social setting and discourse, and these have to be warranted within the framework of a chosen learning setting

5. Integration of Learning Objects

Educational modules aim at achieving defined learning outcomes, often stated as competences. This will require different types of learning objects to support students' competence development along the established pathway of absorb – do – connect. Learning objects can be study texts, lectures, practical exercises, assignments or tutorials, set in a communication framework of discussions, peer reviews, blog posts, quizzes and many more – altogether defined in a learning object model assembled from objects and their inter-relationships. To keep students engaged the type of activity will vary, will be adjusted to intended learning outcomes, and will offer students continuous feedback, eg through the achievement of given tasks or through peer interaction. A common thread through the design of all modules is the paradigm of active learning: by working on problem solutions through phases like analysis, design, implementation and evaluation of results students actively build understanding. Lectures and reading assignments therefore take the back stage, but still have their place in the 'absorb' stage.

Many learning objects will be resourced from existing media and materials. It therefore is essential to recognize the importance of open access enabling a pervasive develop once – use multiple times approach. Instead of reinventing materials where already excellent learning objects exist the development effort can focus on filling any gaps and more importantly, on the design of learning pathways. In the geospatial domain students invariable will need to leverage software functionality for the completion of tasks. Instead of requiring the acquisition of software and platform skills beforehand, in GeoS4S these are built within problem and application contexts – no modules are dedicated to separate development of technology skills, but they evolve as a response to manifest needs recognized while working on problems within a domain.

While modules aim at defined learning outcomes, the approach to assessment and grading will be decided by the respective course instructor depending on the given learning context and framework. Assignments and other activities are provided, which -if any- of these are used to assess students' achievement of learning objectives is left to instructors. Peer assessment, self-assessment or no assessment all are valid options, too.

6. Towards a Geospatial Education Ecosystem

Education, and capacity building from a broader perspective, is not only a task for academic institutions. While universities by definition take the lead in awarding formal qualifications like degrees, learning and the development of competences happen in a broader context. This is particularly true in a technically oriented field like Geoinformatics. Important stakeholders like industry actors, professional organisations and media contribute to the web of an educational ecosystem which is navigated by learners along different and variable pathways. Some learning instances like formal classes are defined by universities, while experiences during internships, summer schools, technology trainings or mentorships add contributions from industry.

This education ecosystem establishes the broader context for lifelong learning, for transitions between learning and professional practice, and for providing direction to learning by exposing students to professional demands and requirements. By developing a set of self-contained learning modules, GeoS4S follows the ecosystem paradigm by designing and supplying a range of teaching / learning resources which can be used in different contexts and settings. We anticipate, and have tested, the use of modules in residential full-time as well as in-service distance learning contexts, in mentored group settings as well as for individualized experiences, or simply as a short course to acquire specific competences.

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