LEARNING GEOINFORMATICS

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Abstract
Geoinformatics is a new science, however has roots thousands of years. It integrates three traditional geosciences (firstly geodesy and surveying as the science of measurement and representation of the Earth, science of precise spatial data acquisition methodologies; secondly geography as the science of studying, analysing and modelling human and physical aspects of spatial processes; finally cartography as the science of making maps, in ways that communicate spatial information effectively, geography and cartography). The integration is based on the results of informatics, in the frame of rapidly evolving computer science. The author aims to share experiences in learning and teaching geoinformatics, and to summarize some lessons learned in implementation of educational development projects. The first part will briefly introduce the trends of joint developments in the last decades and present the current status on the field of GI education. The main focus here will be on the results of the running EU project, which is an advanced successor of the NCGIA CC. The second part is focusing on curriculum and learning material development methods. The competency matrix will be introduced here, as a tool, used to document and compare the required competencies for graduates.

Keywords*: geoinformatics education, curriculum development methods, competency matrix, life-long-learning*

NEED TO KNOW

The economy of information society is based on the creation, dissemination and exploitation of data, information and knowledge. This will be one of the dominant features of the next decades, and will play a fundamental role in generating a recovery in growth and an increase in employment. The extended use of the potential offered by information and communication technologies (ICT) created new service markets; will speed-up administrative and decision-making procedures. ICT infrastructure also had a huge effect on the learning environments.

1. Introduction

The roots of Geoinformation Science and Technology (GISc&T) go back to the late 1950s. GISc&T is evolved together with the computer science and information technology (IT). One of the pioneering institutions in scientific foundations was the Harvard Laboratory for Computer Graphics and Spatial Analysis. In 1970 Tobler published the first law of geography and the literature expanded exponencially in the 70s. The educational background delayed the extensive applications of GIS till early 90s, however, the first textbook was published in 1986, written by Peter Burrough.

The National Center for Geographic Information and Analysis (NCGIA, founded in 1988) recognized the gap in educational field. One of its first successful projects was on **Core Curriculum** development in GIS. The project was lead by Michael Goodchild and Karen Kemp. In 1990 the NCGIA CC provided fundamental assistance in course content for educators world-wide. The CC was introduced on the first European GIS Conference in Amsterdam by Karen Kemp, who invited countries for adaptation of it (Kemp, 1991).

By the end of 1980s Hungary was in the middle of political, economical and cultural changes. There was a strong demand for international cooperation developing GIS teaching materials in Hungarian (Markus et al., 1989, 1993).

This chapter will briefly introduce the trends of joint developments in the last decades and present the current status on the field. The main focus will be on the results of the running EU project, which is an advanced successor of the NCGIA CC.

2. Core Curriculum and its adaptation in Hungary

A national Technology Transfer Centre (TTC) was founded in 1992 involving GIS experts from the whole country. According to TTC members' opinion the hardest obstacle of application of GIS technology in Hungary was the lack of technical-professional skills. Meanwhile, the interest for the Core Curriculum was growing, and not only from the side of the traditional GIS society. Because of the strong demand, the first project of the TTC's GIS Section targeted the NCGIA CC **Hungarian adaptation** (Markus,1993).

The curriculum was divided into 12 parts and it translated preserving the structure, but suited the contents to the Hungarian environment by 18 most appropriate experts from five Hungarian universities, four research institutions and three GIS companies. In the revision and refinement phase the involved experts covered the whole spectrum of GIS society. Using their feedbacks the final version was completely published in June 1994. The three original volumes were expanded with a forth one. The forth volume presented 16 publications on advanced **GIS applications in Hungary**.

The adaptation project received good appreciations from the Hungarian GIS community. The interest is very high not only from the side of educational institutions but from the side of GIS firms too. By the end of 1994 more than 800 copies of the 4 volumes were sent to applicants.

3. Body of Knowledge

The new geographic technologies developed over the last decade created far-reaching opportunities. Due to rapid changes in technology (internet, location based services) and in educational methodology (from teacher-centred to learner-centred approaches) the renewal of CC was started. The new Model Curricula initiative called **GIS&T Body of Knowledge** (BoK) aimed for collaborative, cross-sectoral, and interdisciplinary research, it encompassed a wide array of themes, such as dynamic modeling, change studies, environmental assessments and interventions, and many more.

The first version of GIS&T Body of Knowledge has been revised by a team of seven editors in consultation with a fifty-four-member Advisory Board. The topics were classified into the following ten knowledge areas:

1. Analytical Methods
2. Conceptual Foundations
3. Cartography and Visualization
4. Design Aspects
5. Data Modeling
6. Data Manipulation
7. Geocomputation
8. Geospatial Data
9. GIS&T and Society
10. Organizational and Institutional Aspects

The GIS&T BoK includes 329 topics organized into seventythree units. Each topic is defined in terms of formal educational objectives from which instructional activities and assessment instruments can be readily derived (DiBiase et al., 2006).

From the evaluation point of view there is a shift from self-evaluation questions to expected learning outcomes. Briefly, aims are broad purposes or goals; objectives are specific intentions in measurable terms; and learning outcomes are specific measurable achievements. The main difference between the last two is that objectives are stated as the intentions (of the teacher/tutor) and outcomes are stated as the achievements (of the successful student). While we have mainly used objectives in the past there has been a gradual move towards learning outcomes.

4. GI-N2K in a nutshell

The current version of the GIS&T BoK is a paper-based document published in 2006, whereas a new advanced version should be dynamic and up-to-date, easy to use, in line with the constantly evolving science and technologies. It should reflect recent developments and needs of the public, private and academic geospatial sector.

The "Geographic Information – Need to Know" (GI-N2K) project was funded by the European Union referring to the above mentioned needs. GI-N2K has a consortium of 31 partners from 25 countries, it runs from October 2013 to October 2016.

The main aim of GI-N2K is to develop an up-to-date dynamic GIS&T BoK which is in line with the latest developments taking into account the European dimension by deploying the multidisciplinary knowledge and expertise of the partners of the multilateral network. This aim can be reached by realizing the following objectives:

- to **analyse** the current situation with focus on the demand of private and public sector as compared to the existing academic and vocational training offer;
- to **revise** the content of the Body of Knowledge to bring it in line with technological developments, emphasizeng new knowledge areas and European context;
- to **develop** the toolsets and guidelines to allow the maintenance and use of the BoK to define vocational and academic curricula, define job profiles;
- to **test** the BoK, its toolsets and guidelines through participation of dedicated target groups from the private, public and academic sector;
- to **promote** and disseminate the use of the dynamic GI S&T BoK, toolsets and guidelines.

The **target groups** are mainly the providers of higher education and vocational training in the domain of GIS&T, the geospatial recruitment sector (companies, governmental organizations, research institutions, etc.), geospatial professionals, and students studying, or with an interest in GIS&T.

5. Demand and supply survey

The first project activities focused on the demand for and the supply of education and training in the GI domain. The Demand side target group consists of organisations and companies with a need for geographic information competences: private companies, public administration, non-governmental organisations and academic institutions. On the Supply side the survey was directed at organisations that offer teaching in the GI field.

The analysis of the survey outcomes focussed on three aspects:

- **Awareness** and use of the GIS&T BoK. The relevance of this aspect is that a more demand-driven teaching supply requires the Demand and Supply sides to use the same terminology. And the first requirement for use is awareness;
- A **teaching gap**. The need for more demand-driven teaching presupposes that there is a gap between needs for GI competences on the Demand side and the GI teaching on offer.
- A GIS&T BoK **content gap**. A domain reference document should be up-to-date, covering the latest developments in the width of the domain. Missing subjects will make it harder to have the GIS&T BoK accepted among users and educators. Such acceptance is an important condition for achieving a more demand-driven teaching offer.

The benefits of the project are mainly related to the two main outputs, the revised, dynamic version of the BoK and the VirLaBok system, which will both be made available to all stakeholders (Rip at al., 2014).

6. VirLaBok

The new Body of Knowledge should be a dynamic "knowledge base" rather than a static book. Dynamic means that the BoK should be regularly updated following an ontology based approach. The BoK will be continuously refined in a participatory way, involving the GIS&T and related communities. Therefore, there is a need for a series of toolsets in an open environment to design, develop and document a BoK repository. This environment is called Virtual Laboratory for the BoK (VirLaBok).

The VirLaBok will consist of the following components:

- A **knowledge repository** including the BoK itself, metadata and the results of the use of VirLaBok such as already defined courses, job profiles, etc.
- A **dynamic platform** to define and update knowledge areas, units and topics including a wiki that allows discussion between GIS&T ex-perts and users of the BoK.

- A series of **tools** to use the BoK repository to define courses, learning paths and job profiles.

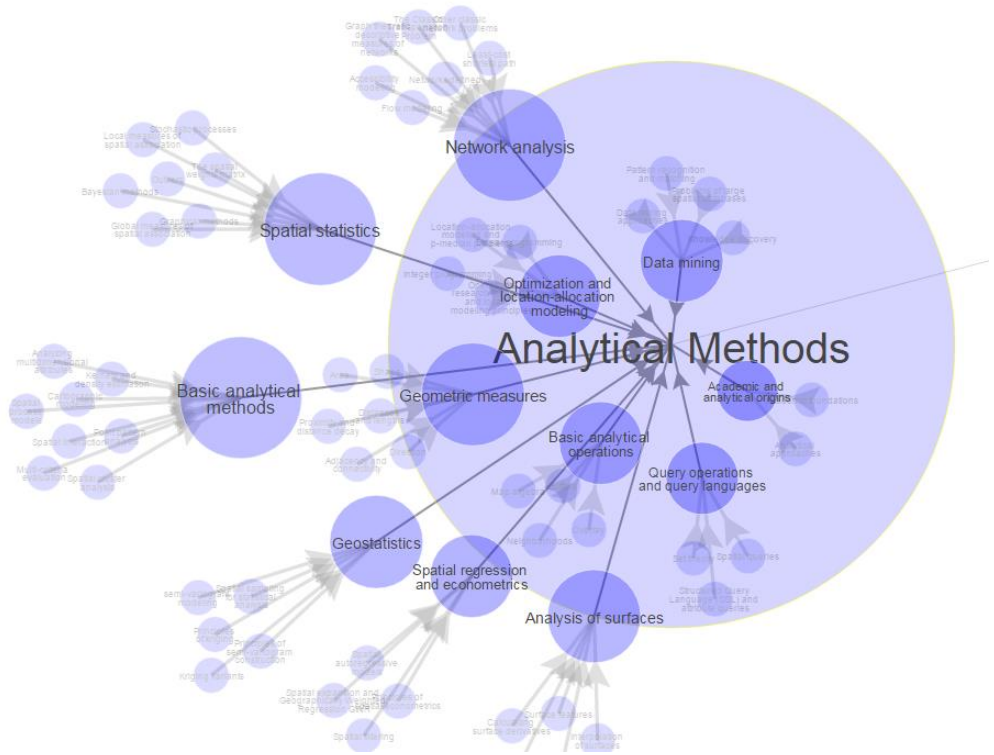


Figure 1. Map of Knowledge Area: Analytical Methods (Source: http://gin2k.bigknowledge.net/bokwiki/)

One of the primary functions of the VirLaBoK is to support **curriculum design**, which is the basis for defining courses, course modules and lectures. The toolset will allow to explore the BoK using query methods and visualize the selected concepts, topics and units, especially the relationships between them.

The GI S&T BoK should support fulfilling various learning outcomes. A student may acquire the knowledge and skills needed to achieve a particular aim. The VirLaBok should allow to define **learning paths** by browsing the BoK, selecting concepts, topics and units from different knowledge areas.

Private and public sector stakeholders are expected to have major interest in exploring the BoK for preparing "**job profiles**" or to analyse existing competencies within their company/organization. Although many 'typical' profiles exist, the VirLaBoK will provide a set of tools to define in a flexible way specific profiles, or to adapt existing ones.

7. Summary

The NCGIA Core Curriculum (1990) defined the standard of GIS&T teaching in many countries. The fast changes in geoinformatics demanded continuous updates. The GIS&T Book of Knowledge (2006) meant renewal from both content and methodological point of view. The GI-N2K EC Life-Long Learning project developing a new advanced version, which aims to be dynamic and up-to-date, easy to use, in line with the constantly evolving geoinformation science and technologies. In different educational institutions many parallel learning content developments are running, where VirLaBok tools can improve the effectiveness of courses.

HARMONIZED COURSE DEVELOPMENT

The chapter is focusing on curriculum and learning material development methods.

1. Needs analysis

Usually the first task in educational development is a needs analysis. The analysis should be designed in order to measure the needs of the academic and industrial stakeholders. Stakeholder is a person, group, or organization that has direct or indirect stake in the development because it can affect or be affected by the organization's actions, objectives, and policies.

Stakeholders in an educational programme development including

- faculty leaders, professors, teachers, administrative staff members;
- students, potential BSc students and their family, student unions;
- relevant ministries, accreditation institutes, other universities as competitors or possible partners;
- employers, government (and its agencies), suppliers, unions, and the professional community etc.

The needs assessment should cover the whole spectrum of the current situation within

- internal environment (university, faculty, staff, students, existing courses, projects, infrastructure);
- specific environment (labour market, other universities, companies – staff development, data infrastructure);
- external environment (legal, social, economic, technical, cultural, ethical).

The needs analysis should

- describe the problems - What gaps exist?
- determine the needs for training/learning.
- find out what are the driving forces of the needs.
- evaluate existing courses/trainings by the competitors.
- assess the potential learning possibilities.
- discover information about logistical concerns and constraints.
- define the expected skills and competences.

The acquisition of needs can be done in different ways through questionnaires, interviews or group meetings, where the participants are selected to represent the interests of the larger community.

2. Stakeholder analysis

Stakeholder analysis is a technique used to identify the people or organisations that have to be won over (Archer, 2003). Stakeholder analysis helps with the identification of the following:

- stakeholders' interests,
- mechanisms to influence other stakeholders,
- potential risks,
- key people to be informed about the project during the execution phase,
- negative stakeholders as well as their adverse effects on the project.

After identification, it is useful to map out the stakeholders on a Power/Interest Grid (as shown in Figure 2), and classify them by their power over the project delivery and by their interest in the project.

Someone's position on the grid shows the actions how to manage them. The aim of stakeholder management is to enhance their interest and to use their support within the project implementation:

- High power, highly interested stakeholder: we must fully engage them and make the greatest efforts to satisfy their expectations.
- High power, less interested group: inform them about the project aims and progress; keep them satisfied.
- Low power, highly interested group: keep them well informed. The efforts of these people or organizations can be very helpful.
- Low power, less interested group: monitor them as needed.

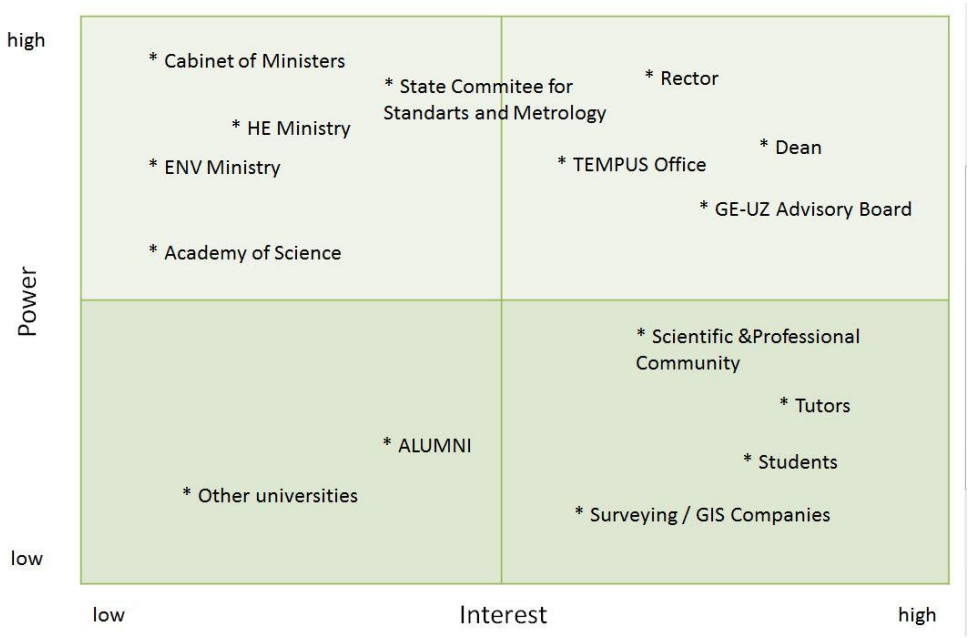


Figure 2. Power/interest grid of stakeholders (Source: GE-UZ)

The benefits of using a stakeholder-based project implementation are that:

- We can use the opinions of the powerful stakeholders to shape our projects at an early stage. Their input can also improve the quality of our project.
- Gaining support from stakeholders can help us to win more resources – this makes it more likely that the project will be successful.
- By communicating with stakeholders early and frequently, we can ensure that they understand the benefits of the project – this means they can support us actively when necessary.
- We can anticipate what people's reaction to our project may be, and build into our plan the actions that will win stakeholders' support.

We can summarize the understanding gained on the stakeholder map, so that we can easily see which stakeholders are expected to be blockers or critics, and which stakeholders are likely to be advocates and supporters of the project. A good way of doing this is by colour coding: showing advocates and supporters in green, blockers and critics in red, and others who are neutral in orange.

Based on the careful analysis a strategy can be composed for engagement of stakeholders. Stakeholder management supports the course planners by interpreting and influencing any person or organization who can be positively or negatively impacted by, or cause an impact on the course and by creating positive relationships through the appropriate management of their expectations.

3. Module development

The third part of the paper is focusing on module development methods. The competency matrix will be introduced as a tool used to document and compare the required competencies for graduates. It is used in a gap analysis for determining where critical overlaps between courses are or which skills/competencies are not taught deeply enough.

We should make distinction between learning outcomes and knowledge, skills, competences to distinguish the different roles of the most relevant players: educational development staff, learners and other stakeholders (iCOPER, 2011).

Learning outcomes are categorized as: knowledge, skill, and competence. Depending on the level of understanding the learner is obtaining:

- Knowledge: the outcome of learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of study. It's being able to discuss the specific field with a peer, or read technical papers about it.

- Skills: means the ability to apply knowledge and use know-how to complete tasks and solve problems. Skill is all about being useful; it's only about being able to do things.
- Competencies: means the proven ability to use knowledge and skills in work or study situations and in professional and personal development.

In a sense, knowledge is the absence of skill and skill is the absence of knowledge. They are complementary. Regarding competences: the university education is only the starting phase in the professional carrier. Desired learning outcomes of a process of learning are formulated by the educational development staff, preferably involving project representatives in the process, on the basis of input of internal and external stakeholders. Professional competences will be reached by life-long learning (LLL) and life-long experiencing. Universities should support their graduates in LLL with different kind of education and training.

The curriculum is a crucial component of any education/training activity, it is a road map to knowledge, and it builds knowledge topology. Curriculum design includes consideration of aims, intended learning outcomes, concise content, learning and teaching methods, and assessment. The curriculum must be based on the needs of stakeholders, founded on clearly defined skills and competences. The outcome will be a complex material about the new curriculum. It will contain all the required and necessary information for the accreditation.

The syllabus is the detailed content of the programme; the topics, issues or subjects that will be covered as it proceeds (UM, 2013). In selecting content for inclusion, we should bear the following principles in mind:

- It should be relevant to the programme. An effective curriculum is clearly focused on the planned competences. The inclusion of irrelevant topics, however interesting in themselves, may confuse students.
- It should be appropriate to the level of the programme. An efficient curriculum is progressive, leading students onward and building on what has gone before. Material which is too basic or too advanced for the student in current stage erodes motivation to learn.
- It should be up to date and should reflect current trends.

4. Competency matrix

The learning material developers are working on their own module specification. This process needs of course a cross-functional implementation. In the design of detailed content the competency matrix can help to harmonize the work of the development team. The first column of competency matrix contains the name of modules; the competences are listed in the header. Identifying competencies was one of the most important issues in needs analysis. Filling the matrix needs a group meeting of module developers. The first step is to build a draft competency matrix revising and completing competencies.

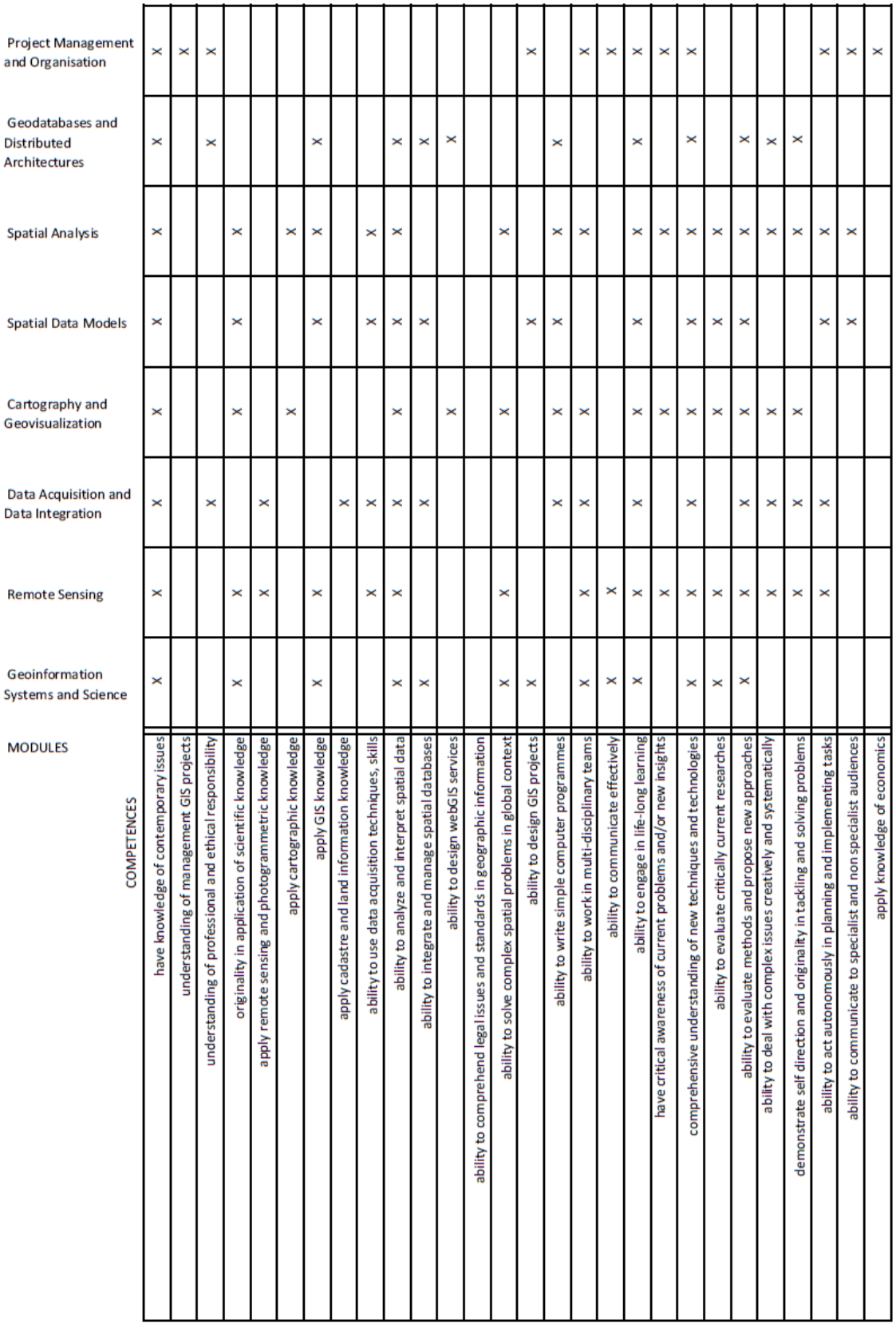
After the matrix drafted each development team has to check their module against the competences and mark the relevant table cell. Creating the competency matrix will enable the development team to see at a glance, what competences their graduates will possess. The matrix is functioning as a gap analysis tool, and as a discovery instrument of unnecessary overlaps. Any development team can reconstruct their own row in competency matrix to increase cross-functionality and include competencies it might be lacking.

The resulting matrix (Figure 3) contains a consensus between module developers. After creating it requires refinement of module specifications, which support the developers in writing harmonized learning materials. During the development phase the competency matrix may need periodical updating.

To regularize the workflow of the module development general guidelines are useful to ensure that all the partners are following the same schemes and ease the monitoring of the module development activity. In addition to the rules, templates can provide the common schemes for module specification.

5. Summary

- When we plan any educational development, we should consider carefully the current needs of the society, but look into the future too.
- The curriculum must be based on the needs of stakeholders, founded on clearly defined skills and competences.
- The competency matrix is useful in course harmonization based on academic curriculum specifications or meeting market-driven job profile requirements.



MODULES / COMPETENCES	Geoinformation Systems and Science	Remote Sensing	Data Acquisition and Data Integration	Cartography and Geovisualization	Spatial Data Models	Spatial Analysis	Geodatabases and Distributed Architectures	Project Management and Organisation
have knowledge of contemporary issues	x	x	x	x	x	x	x	x
understanding of management GIS projects								x
understanding of professional and ethical responsibility			x				x	x
originality in application of scientific knowledge	x	x		x	x	x		
apply remote sensing and photogrammetric knowledge		x	x					
apply cartographic knowledge				x		x		
apply GIS knowledge	x	x			x	x	x	
apply cadastre and land information knowledge			x					
ability to use data acquisition techniques, skills		x	x		x	x		
ability to analyze and interpret spatial data	x	x	x	x	x	x	x	
ability to integrate and manage spatial databases	x		x		x		x	
ability to design webGIS services				x			x	
ability to comprehend legal issues and standards in geographic information								
ability to solve complex spatial problems in global context	x	x		x		x		
ability to design GIS projects	x				x			x
ability to write simple computer programmes			x	x	x	x	x	
ability to work in multi-disciplinary teams	x	x	x	x		x		x
ability to communicate effectively	x	x						x
ability to engage in life-long learning	x	x	x	x	x	x	x	x
have critical awareness of current problems and/or new insights		x		x		x		x
comprehensive understanding of new techniques and technologies	x	x	x	x	x	x	x	x
ability to evaluate critically current researches	x	x		x	x	x		
ability to evaluate methods and propose new approaches	x	x	x	x	x	x	x	
ability to deal with complex issues creatively and systematically		x	x	x		x	x	
demonstrate self direction and originality in tackling and solving problems		x	x	x		x	x	
ability to act autonomously in planning and implementing tasks		x	x		x	x		x
ability to communicate to specialist and non specialist audiences					x	x		x
apply knowledge of economics								x

Figure 3. Competency matrix (Source: GE-UZ, edited by course developers). Core competences adapted from (Greenfeld, 2010).

OUTLOOK

Universities are under a pressure of continuous changes, transforming all traditional way of learning, working to prepare our learners for their future. The ability of students to connect with "classmates" around the world, opens new opportunities for learning and professional development. Whatever the revolutionary changes in technology, learning is the vital element. Teaching is not enough, it is the active learning, which is essential. Ubiquitous IT infrastructure opens lots of new possibilities. Ubiquitous learning (u-learning) is far beyond e-learning, it has similarities to some form of simple mobile learning, but in the u-learning environment students become totally absorbed in the learning process, moreover, can become active participants in the cloud. The other challenge is open education. Information technology was reached by the idea of open systems in early 1980s. It arrived to our profession in the mid-90s in the initiatives of OpenGIS Consortium (http://www.opengeospatial.org/). Now "Open education" is a collective term that refers to forms of education in which knowledge, ideas or other aspects of teaching methodology or infrastructure are shared freely over the internet (Markus, 2013).

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REFERENCES

Archer, L. (2003): Stakeholder Management Guideline, http://archerid3.com/wordpress/wp-content/uploads/2013/03/guideline-stakeholder-management.pdf , [last accessed 8 August 2015].

DiBiase, D. et al. (2006): Geographic Information Science & Technology Body of Knowledge, Washington, D.C.: Association of American Geographers, p. 174.

Greenfeld, Y. (2010): Surveying Body of Knowledge, FIG Congress, Sydney, Australia.

iCOPER (2011): Competency based educational eContent, http://www.open.edu/openlearnworks/course/view.php?id=1153, [last accessed 8 August 2015].

Kemp, K.K. (1991): The NCGIA Core Curriculum evaluation program: a review and assessment, Cartographica 28(3), pp. 88-93.

Markus, B. et al. (1989): Agricultural, Forestry and Environmental monitoring systems (in Hungarian), National Science and Technology Committee report, Budapest, p. 145.

Markus B. (1993): NCGIA Core Curriculum in the Hungarian GIS/LIS education, Computers, Environment and Urban Systems 17(3), pp. 277-283.

Markus B. (2004): Curricula development in Bologna Process, FIG Working Week, Athens.

Markus, B. (2014): Managing curriculum development and enhancing quality, Congress of International Federation of Surveyors, Kuala Lumpur, Malaysia, p. 14.

Remetey-Fülöpp, G. et al. (1993): GIS and its applications (in Hungarian), National Science and Technology Committee report, p. 168.

Rip, FI. et al. (2014): Integrated analysis of the demand for and supply of geospatial education and training: Results of the GI-N2K Surveys, http://www.gi-n2k.eu/publications/, p. 37.

UM (2013): Manual of Academic Procedures, http://www.tlso.manchester.ac.uk/map/ [last accessed 8 August 2015].

BIOGRAPHY

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