GI2NK Geographic Information: Need to Know Towards a More Demand-Driven Geospatial Workforce Education/Training System

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Abstract. The paper presents GI-N2K (Geographic information: Need to Know), a European project aiming to improve the way in which future GI professionals are prepared for the labour market. Its main goal is twofold: updating the existing Body of Knowledge on the basis of the new technological developments and the European perspective, and realizing advanced tools to define curriculum, training opportunities and courses. This project focused on foundational research into the creation of a transformational, dynamic environment for pedagogy, knowledge construction, discourse, collaboration, and research in the domain of Geographic Information Science and Technology (GIS&T). After an initial integrated analysis of the demand for and supply of geospatial education and training, the revision of the BoK and the design of the Virtual Laboratory for the BoK (VirLaBok) are currently under investigation. In particular, the Consortium is now involved into the recognition of a proper revision strategy, in terms of content and its usability through an e-platform. The goal of this paper is to discuss preliminary results of this phase and illustrate problems due to a possible overlapping among different knowledge areas. Finally, a prototyping version of the ontology underlying the VirLaBok is presented.

Keywords: GIS · Body of knowledge · GIS job market · Ontology · Geospatial education · Geospatial professionals

1 Introduction

The geospatial industry is a rapidly growing industry and involves high value/high tech jobs, innovative services and fast evolving technologies. In the European context, the need to prepare Europe's GI S&T workforce competently to answer to the requirements

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of the rapidly evolving, innovative European knowledge society is driven by the objectives of several European strategies and policies, like Europe 2020, Horizon 2020, the Digital Agenda for Europe, the Smart Cities initiative, the INSPIRE directive and the European Location Framework and many other initiatives. While in 2000 the Pira study [1] estimated the economic value added by geographic public sector information to the economy in 1999 at € 36 billion, the US Department of Labor's High Growth Industry Profile – Geospatial Technology report came to the conclusion that the geospatial market is "growing at an annual rate of almost 35 %, with the commercial subsection of the market expanding at the rate of 100 % each year." The same Department identified geographic information system technology "as one of the three most important and evolving fields, along with nanotechnology and biotechnology".

On the basis of such assumptions, it is clear how important it is to build professional profiles based on the analysis of current demand in relation to required and existing knowledge in the field of GI. The goal is to create an easy integration of industry experts in the labour market.

To address this challenge, GI S & T BoK [2] (GI Science and Technology Body of Knowledge) realized for the USA University GIS Consortium in 2006 has been considered as reference. GI S & T BoK is the tool and the repository containing data, instructions and information on how to develop knowledge in the GI sector, considering demand and supply at the same time.

The aim of BoK is giving greater coherence and effectiveness to the academic education offered by American universities, aimed at satisfying users' demand (government agencies, enterprises and NGOs). This version of BoK was able to combine, for a long time, quality of academic educational offer with demands from the labour market.

Nevertheless, in 2014 the document appeared outdated, considering the latest conceptual and technological breakthroughs in the field of GI from academic and professional sectors.

In order to answer this demand, an European project aiming to improve the way in which future GI professionals are prepared for the labour market, has been proposed. The European project Geographic information: Need to Know GI-N2K (http://www.gi-n2k.eu) has been proposed and financed.

2 Geographic Information: Need to Know (GI-N2K)

The project was commissioned by the European Union (Lifelong Learning Program of the Education, Audiovisual and Cultural Executive Agency of the European Commission) to a consortium of 31 partners from 25 countries (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Greece, Hungary, Ireland, Italy, Lithuania, Macedonia, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia Spain, Sweden, UK), its objective being an improved version of the GIS&T BoK, including tools to use and maintain it.

The project started in October 2013 and it will finish in October 2016.

The consortium has been carefully composed bringing together the demanders for and suppliers of the revised BoK (and tools) through the involvement of academic,

private and public partners in the domain of GI S&T. An important strength of the consortium is the involvement of networks and associations in many countries, e.g. Italy (AM/FM Italia), the Netherlands (Geonovum and Stichting Arbeidsmarkt Nederland) and Belgium (AGORIA).

The involvement of these partners ensures that the project development and results are endorsed and applied by the wide GI community not only during the project period but also beyond the project period.

The project will be developed by the full partners - mainly composed of European Academic Institutions including the European academic network AGILE. The testing and validation of the project outcomes will also involve the associated partners – mainly composed of demanders for a revised BoK who then can help with the further dissemination of the results when successfully applied.

The network of networks idea behind GI-N2K is illustrated in Fig. 1. The revised BoK and tools will be mainly developed by the full partners of the project (1st circle). The project outcomes will be tested, validated and distributed by the associated partners of the project (2nd circle).

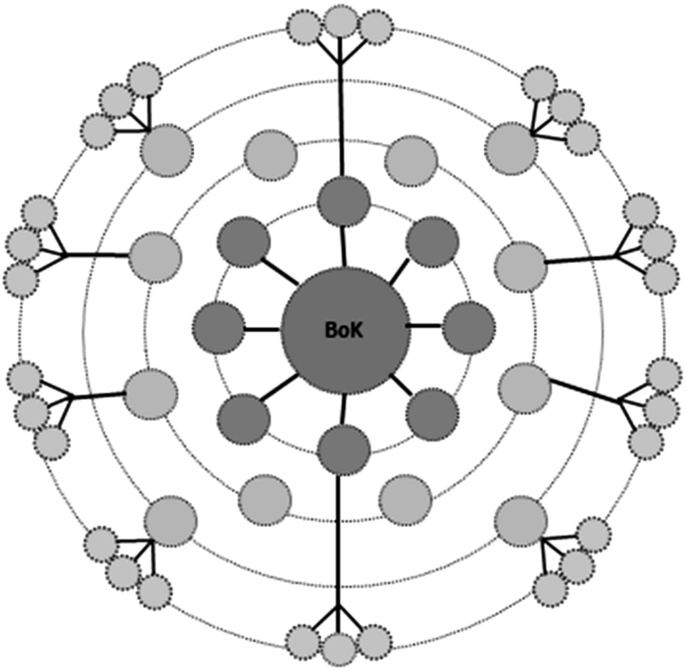

Fig. 1. The network of networks idea behind GI-N2K

The 3rd circle of involved entities consists of representatives of different GI communities like Open Geospatial Consortium Europe, University Consortium for Geographic Information Science and the Joint Research Centre of the EC, who are involved in the project as members of the advisory board.

Each of these circles consists of several partners that are participating and/or managing a broad network of relevant stakeholders (4th circle). The ambition of the project is to strengthen existing relationships and build relationships to new stakeholders in order to broaden and strengthen the network of GI S&T stakeholders.

The European project Geographic information: Need to Know GI-N2K is based on the methodology of the Body of Knowledge (BoK) which is basically the agreed ontology of a specific professional domain. GI S&T sector is linked with a lot of disciplines and knowledge areas consequently it is fundamental to develop a BoK be able to cover and describe all disciplines and knowledge areas.

In particular, it was shown that a major cause is a significant mismatch between training in the field of GI S & T and current demands from the labour market.

A lot of postgraduate courses on GIS strand are mainly based on geography topics, as well as many computer courses do not provide the necessary geographical knowledge. To address this important issue, the proposed solution is the design and the realization of a support system to the formation of figures with geospatial skills.

The first version of the GI S & T BoK was based on a hierarchical organization including 10 Knowledge Areas (KA), 73 units (26 defined as "core unit"), 329 topics, and more than 1600 educational objectives.

As an example, Fig. 2 shows KA Geospatial Data (GD) with its twelve units (GD1 GD12 ÷) and associated topics.

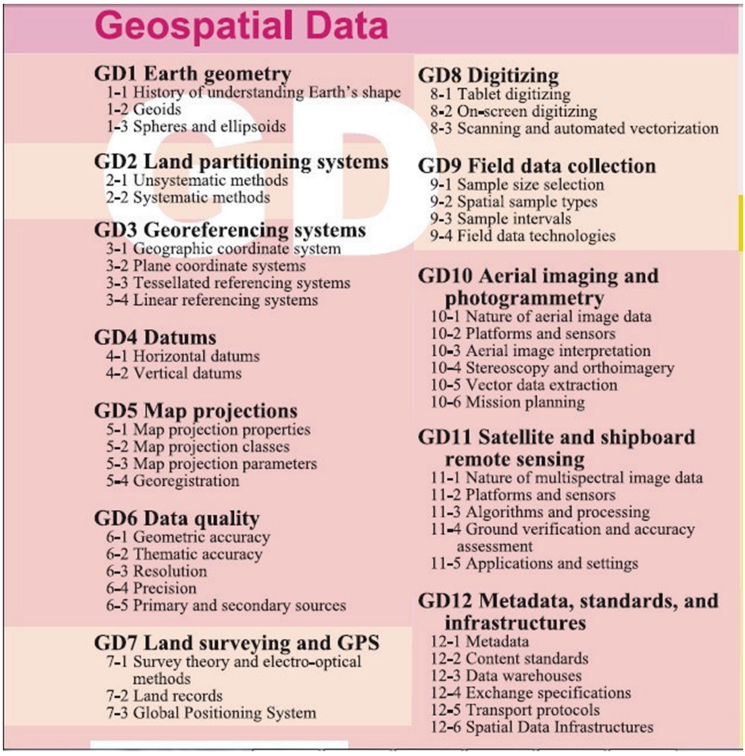

Fig. 2. Knowledge area geospatial data and its units

Subsequently, each KA is briefly introduced and each unit is detailed in terms of topics and learning objectives.

Table 1 (row 1) shows the initial description of GD, while educational objectives of a single topic GD3-1 (geographic coordinate system) are shown in Table 1 (row 2).

Table 1. KA geospatial data and GD3 georeferencing systems with the topic GD3-1.

Knowledge area: Geospatial Data (GD)	Geospatial data represent measurements of the locations and attributes of phenomena at or near Earth's surface. Information is data made meaningful in the context of a question or problem. Information is rendered from data by analytical methods. Information quality and value depends to a large extent on the quality and currency of data (though historical data are valuable for many applications). Geospatial data may have spatial, temporal, and attribute (descriptive) components, as well as associated metadata. Data may be acquired from primary or secondary data sources. Examples of primary data sources include surveying, remote sensing (including aerial and satellite imaging), the global positioning system (GPS), work logs (e.g., police traffic crash reports), environmental monitoring stations, and field surveys. Secondary geospatial or geospatial-temporal data can be acquired by digitizing and scanning analog maps, as well as from other sources, such as governmental agencies. […]
GD3- Georeferencing systems (core unit) GD3-1 (Geographic coordinate system)	Distinguish between various latitude definitions (e.g., geocentric, geodetic, astronomic latitudes) Explain the angular measurements represented by latitude and longitude coordinates Locate on a globe the positions represented by latitude and longitude coordinates Write an algorithm that converts geographic coordinates from decimal degrees (DD) to degrees, minutes, seconds (DMS) format Calculate the latitude and longitude coordinates of a given location on the map using the coordinate grid ticks in the collar of a topographic map and the appropriate interpolation formula Mathematically express the relationship between Cartesian coordinates and polar coordinates Calculate the uncertainty of a ground position defined by latitude and longitude coordinates specified in decimal degrees to a given number of decimal places Use GIS software and base data encoded as geographic coordinates to geocode a list of address-referenced locations

Since 2006, BoK has been used for several initiatives. Each initiative highlighted the potential of this instrument in the process of creation and exploration of GI S & T BoK content [3–5].

GI-N2K will incorporate results and findings of the offer and demand analysis and will take advantage of the network that was created in VESTA-GIS. The overall aim of VESTA-GIS (www.vesta-gis.eu), was to pool knowledge in the GIS domain (technology, applications), to share experience and foster innovation (new approaches) in vocational training by bringing together experts, organizations and users of GI.

The project is divided into 8 work packages:

- WP1 – Analysis of demand and supply
- WP2 – Revision of the Body of Knowledge
- WP3 – The Virtual Lab for the BoK: VirLaBok
- WP4 – Testing & Validation
- WP5 – Quality assurance
- WP6 – Dissemination
- WP7 – Exploitation and Sustainability
- WP8 - Management

WP1, WP2, WP3 and WP4 are the implementation work packages of the project, in which the project outcomes are prepared, developed, tested and validated. The activities in these work packages deal with different methods:

- In WP1 survey research and in-depth interviews will be used to identify the knowledge areas (KAs), units, topics and concepts that should be included in the revised version of the GI S&T BoK. In addition, an analysis of the current supply of GI S&T education and training will be made based on the approaches and results of previous initiatives.
- WP2 focuses on the examination and improvement of the existing GI S&T BoK. After the definition of the structure of the BoK, i.e. the knowledge areas that will be part of the BoK, the structure, concepts, usability, relevance, and up-to-dateness of the content will be further developed in different expert teams, in which key experts of a specific knowledge area are represented.
- WP3 involves the design and development of an online BoK repository supported by several tools for updating and using the BoK. In order to gain insight in the requirements with regard to the functionalities of the toolsets and the characteristics of the data repositories, a survey and interviews will be conducted and a workshop will be organized. An additional workshop will be organized to demonstrate and test the repository and toolset.
- In WP4 the new BoK and the developed tools will be applied on several real world cases, in order to gain insight on how the output of WP2 and WP3 can be modified and improved. The selection of use cases will be based on the results of a survey and interviews. The selected set of use cases will be presented and discussed during a series of workshops. Integrated tests of different cases will also take place in workshops organized in different countries.

3 The Results of the BoK Evaluation Process

WP1 was completed in May 2014. WP1 results include:

- an overview of awareness of the GIS&T BoK and its use among respondents of the surveys in at least the 25 European countries that participate in the project;
- a comparison of employer's demands with the supply of GI teaching;
- an overview of subjects to supplement GIS&T BoK with.

At the end of these activities, an interesting report has been prepared (www.gi-n2k.eu/surveys-results/) where results of questionnaires and interviews, later on used to carry out the review of BoK, were presented and discussed. It is based on reports on the outcomes of surveys about the Demand side [6] and the Supply side [7], that were held early in 2014 as part of this work package. Generally, the evaluation has been focused on:

- awareness and use of GIS T BoK by expert communities,
- teaching gap between demand and supply of skills,
- content gap: incompleteness of GIS & T BoK.

From the demand point of view, the analysis highlighted three fundamental requests. It is important to shift the focus from the acquisition of primary data to the management of large amounts of spatial data. The lack of skills in programming and application development should be taken into account. And finally it is important to increase the role of the Web in all its forms, divulgative, support for the education, training, etc.

Regarding the importance of the content of BoK compared to the request of skills, the different KAs were evaluated in a different way.

The highest average rating was achieved by KA Geospatial Data, followed by Cartography and Visualization and Design Aspects. At the lower level there is Geocomputation KA (Fig. 3). In a consistent way also the units within the same KA were evaluated generally with different ratings. For example, while the basic operations such as measurement of geometrical properties and execution of queries were considered "very important" in Analytical Methods KA, advanced methods such as spatial regression or mathematical optimization were evaluated "less relevant" (Fig. 4).

Consequently, the Geocomputation KA, which is entirely composed of these advanced units, obtained generally the lowest rating (Fig. 5).

Finally, other KA, like GIS & T and Society, have achieved a significant number of "somehow relevant" which indicates that GIS & T is still mostly seen as a technical discipline (Fig. 6).

Regarding general trends and needs, the most popular keywords in GIS & T domain, in terms of trends, needs (educational objectives) or deficiencies are GIS, Data and Analysis.

In general, the expected outcomes are mainly oriented to web and mobile applications, to the management of big and open data, and programming (Fig. 7).

The completely missing concepts in BoK, generally, are related to the development of applications (E.g., API, GeoJSON, python, javascript), to WebGIS (e.g., HTML5, smartphone, Wireless, GPRS, RESTful, semantic web), to SDI - Spatial Data

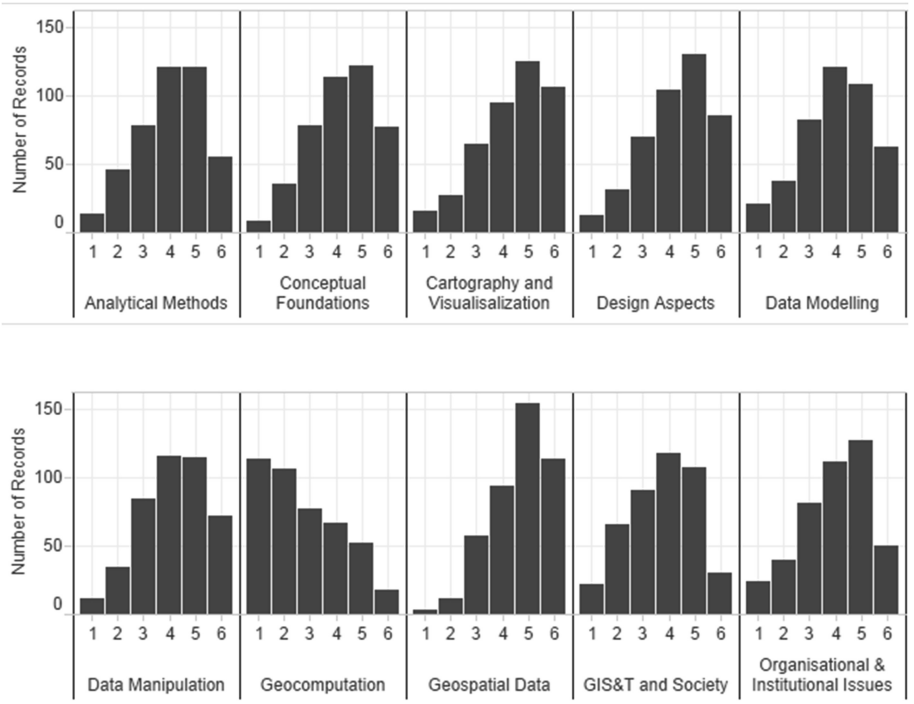

Fig. 3. The ratings by European GI professionals of the overall relevance of individual GIS&T BoK knowledge areas on a scale of 1-6 (Wallentin et al. [6]).

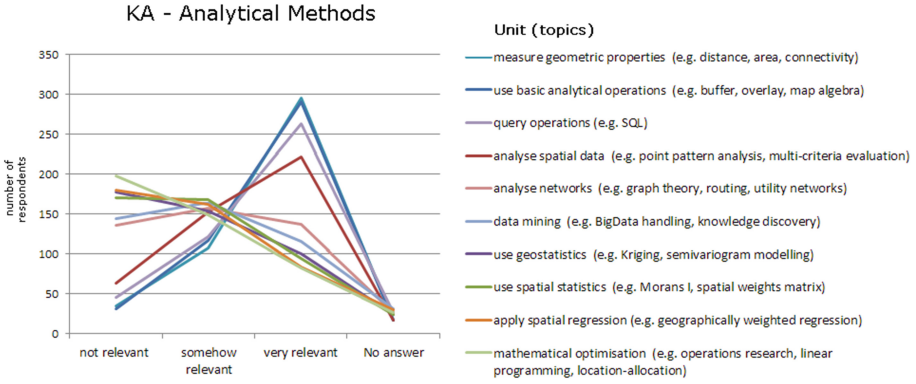

Fig. 4. Analytical methods - how relevant have the following competences been in your professional work in the last year? (Color figure online) (Wallentin et al. [6]).

Infrastructure (e.g., INSPIRE, Harmonization, GeoPortal) to data acquisition (e.g., UAVs, VGI, crowdsourcing), and other topics such as big data, augmented reality and standards for 3D modeling such as CityGML.

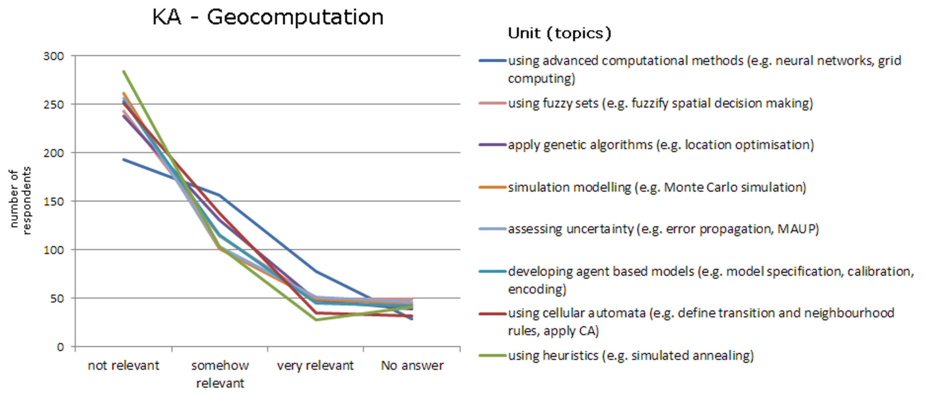

Fig. 5. How relevant have the following competences been in your professional work in the last year? - geocomputation units are seen very relevant in professional work only by every tenth respondent (Color figure online) (Wallentin et al. [6]).

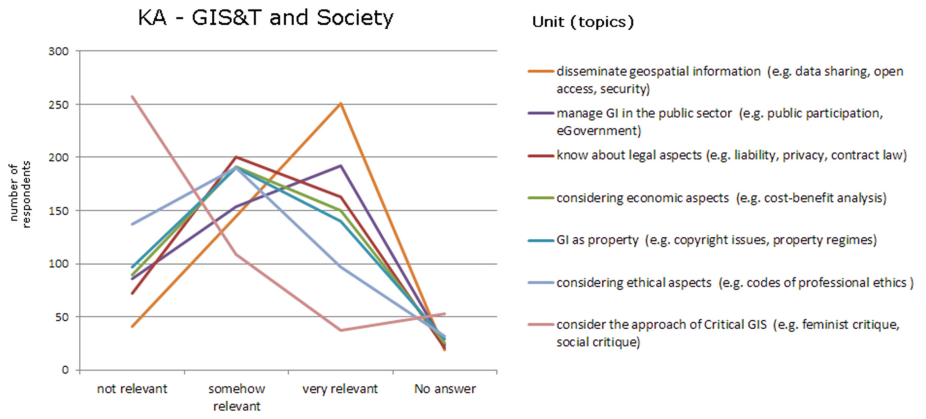

Fig. 6. GIS&T and society - how relevant have the following competences been in your professional work in the last year? (Color figure online) (Wallentin et al. [6]).

Finally, some interesting comments from GI experts regarding future competencies expected by professionals were collected.

In summary, there is broad consensus on the need for qualified staff in the field of sensors and mobile applications, as well as a relevant aspect is the integration of huge masses of data and the use of NoSQL databases.

Furthermore, it is always stronger the tendency to distinguish two different types of professional roles: works technically oriented to the realization of GI services, and work-oriented projects that require a deeper understanding of the fundamental concepts and specific domain requirements.

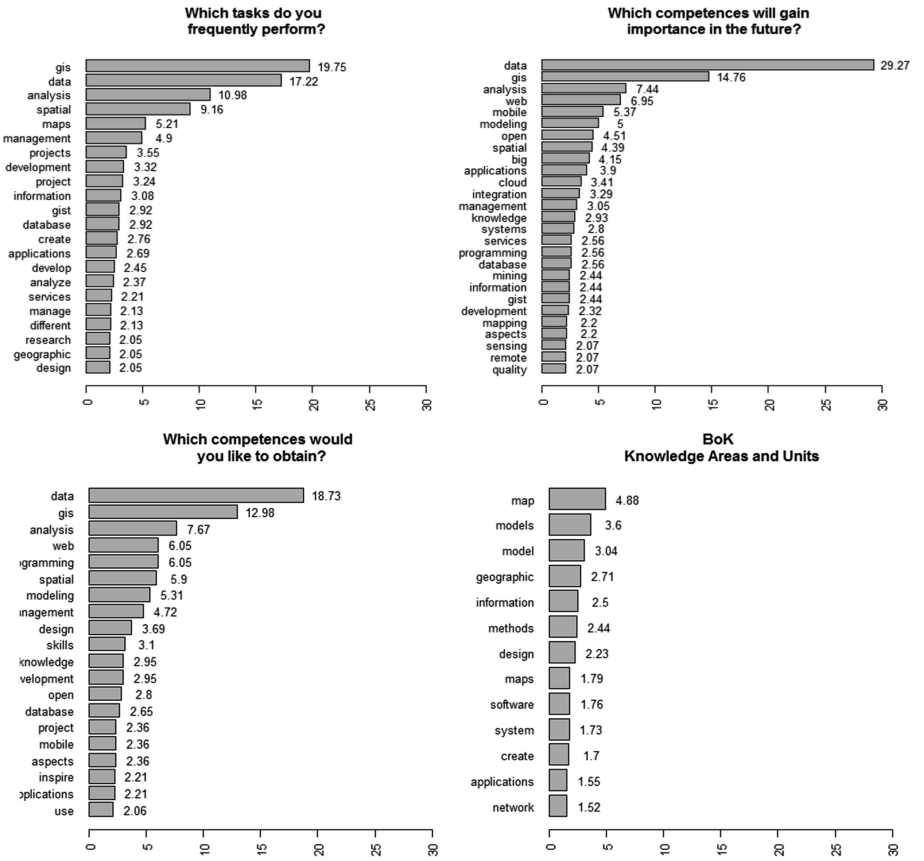

Fig. 7. Word frequency counts for keywords that are mentioned at least by 2 % of responses (Wallentin et al. [6]).

4 An Ontology for the Revisited BoK

In May 2015, a two-days workshop was held in Lisbon with the aim of defining a revision strategy for BoK. The consortium partners have agreed on a revision method which provides to add to the 10 KA of the original BoK an additional KA concerning the latest technological developments, completely absent in the 2006 version of BoK.

Simultaneously, 11 groups of experts were defined, from the consortium partners and from other experts in specific fields.

In this first phase, each group will work on different subjects and units in order to decide which ones have become obsolete in the meantime, which ones will have to be modified, and finally which concepts will be introduced as new topics or units.

Meanwhile, a first transposition of the content of BoK into an ontological structure (Fig. 8) has been carried out. Each KA is hierarchically connected to the corresponding unit, and then to the topics.

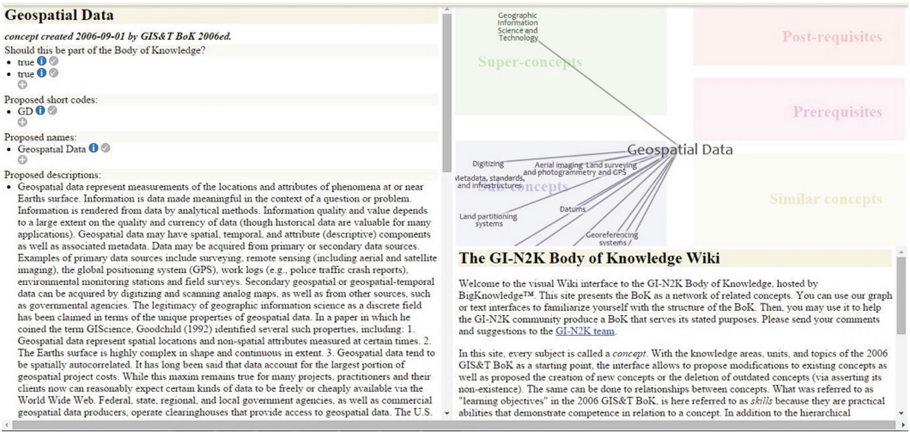

Fig. 8. The ontological structure of the BoK.

The results of upcoming activities of WP2, will enrich the ontology with the semantic relationships between useful concepts. This aspect is important to ensure interoperability between them.

In particular, a network of concepts linked by different types of relations, Hierarchies, Super-concepts & Sub-concepts, Similarity, Dependency, etc., will be built. Moreover, each concept will have attributes (properties) - e.g. a name and a description.

With the conclusion of WP 2 it will be possible to have an updated version of BoK to test with real use case, to arrive at the definition of a body of knowledge within the GI actually adhering to the needs of the labour market, able to support the definition of profiles that have the right methodological and technological response to the sector demands.

5 Conclusions

The current supply of geospatial professionals is inadequate and the geospatial workers appear to be inadequately prepared to answer to the challenges and opportunities of this field.

For the identification of the specific knowledge areas that a professional needs to master for proficiency and success in its field or profession, it is proposed to use the methodology of the Body of Knowledge (BoK) which is basically the agreed ontology of a specific professional domain (reference framework).

The goal of GI-N2K is to build upon this discussion and an advanced European-authentic and dynamic GI S&T BoK.

This project focused on foundational research into the creation of a transformational, dynamic environment for pedagogy, knowledge construction, discourse, collaboration, and research in the domain of Geographic Information Science and Technology (GIS&T).

Central to the project was a transformation of the GIS&T BoK into a core ontology for the field (BoKOnto).

The project built a computational system that exposes this ontology to various end user applications via web services.

The BoKWiki application allows exploration and editing of the GIS&T BoK.

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