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# Workforce Demand Assessment to Shape Future GI-Education – First Results of a Survey

Barbara Hofer
University of Salzburg/ Department of Geoinformatics – Z_GIS, Schillerstr. 30, 5020 Salzburg, Austria
barbara.hofer@sbg.ac.at

Gudrun Wallentin
University of Salzburg/ Department of Geoinformatics – Z_GIS, Hellbrunnerstr. 34, 5020 Salzburg, Austria
gudrun.wallentin@sbg.ac.at

Christoph Traun
University of Salzburg/ Department of Geoinformatics – Z_GIS, Hellbrunnerstr. 34, 5020 Salzburg, Austria
christoph.traun@sbg.ac.at

Josef Strobl
University of Salzburg/ Department of Geoinformatics – Z_GIS, Hellbrunnerstr. 34, 5020 Salzburg, Austria
josef.strobl@sbg.ac.at

**Abstract**

Geographic Information Science & Technology (GIS&T) is constantly evolving in scientific and technological terms. In 2006 the GIS&T Body of Knowledge (BoK) initiative has provided a domain inventory that serves as a structured basis for curriculum development. The content and structure of the BoK are currently undergoing revision. One of the projects addressing an update of the BoK is the project Geographic Information: Need to Know. In this project an assessment of current and future workforce demand and educational supply in the geographic information (GI) domain provide the basis for revising the BoK. This article reports on first results from a survey regarding GI workforce demand in Europe. People working in the GIS&T domain were asked to rate BoK knowledge areas related to their relevance in a professional working context. These ratings are differentiated by types of organizations and educational backgrounds of respondents. The report is rounded off with an outlook to the results on future competences identified by respondents.

*Keywords*: Geographic Information Science and Technology, Body of Knowledge, education.

## 1 Introduction

An inventory of key topics in a domain can provide the basis for composing educational programmes. A prerequisite is that the inventory is kept up-to-date. In the Geographic Information Science & Technology (GIS&T) domain, such an inventory is the Body of Knowledge (BoK). This article presents first results from a survey that aimed at evaluating the current fit between BoK knowledge areas and professional tasks of the GI workforce.

As the domain of Geographic Information Science and Systems has matured over the last decades, its educational foundation has also evolved. Under the lead of David DiBiase the University Consortium for Geographic Information Science (UCGIS) developed the GIS&T BoK [1]. This UCGIS initiative was the first comprehensive attempt to provide a domain inventory in a strictly hierarchical list of knowledge areas, units, topics and related learning objectives. The intention of the GIS&T BoK initiative was to provide a comprehensive and structured basis for curriculum development. The BoK aimed at allowing the design of adaptable curricula that define individualised pathways through its 1,660 educational objectives [2]. Further uses were expected to closely link to the geospatial industry, including programme accreditation, professional certification and the design of job descriptions. However, although the GIS&T BoK has been a milestone achievement and still is the main reference document for the geospatial domain, the document is largely unknown outside academia and its potential has not been fully exhausted.

The GIS&T domain is constantly developing further due to scientific and technological advances. An overview of GIScience developments as contributed by Blaschke and Strobl [3] highlights among other topics the potentials of larger data availability in comparison to earlier days of GIScience. Camara et al. [4] discuss the elements of a GIS of the 21st century in comparison to the GIS of the 20th century. They stress the increased importance of sensor networks, mobile devices and remote sensing on the technology side as well as semantics, time and cognition on the concepts side. Their observations include the demand for training GI engineers, who are focused on GI technology development and can collaborate with GI scientists [4]. Their work shows that shaping a domain requires reacting to new developments and adapting educational programs to the requirements of the domain respectively the market.

The BoK cannot be static as technology and science evolve. Several initiatives are working on an update of content and format of the BoK [5-8]. A major joint effort in this direction is currently made under the framework of the European Project "Geographic Information: Need to Know" (GI-N2K). GI-N2K contributes a European perspective to the development of a demand driven GIS&T BoK.

The basis for re-designing the BoK in the GI-N2K project is an assessment of current and future workforce demand and educational supply in the GI domain. This article presents the preliminary results of a survey focusing on workforce demand and aims towards an analysis of the match between the knowledge areas of the current BoK and today's geospatial workforce demands as well as presumed future market trends. Workforce demands are thereby differentiated for different types of organizations and highlight the diversity in levels of expertise in different knowledge areas required by employees.

## 2 Knowledge Areas of the GIS&T Body of Knowledge

The BoK divides geographic information science and technology into ten Knowledge Areas (KAs) [2]. Each KA covers a set of units that are further subdivided into topics. For each topic the BoK lists learning objectives that are taking four knowledge types into consideration: factual, conceptual, procedural, and meta-cognitive knowledge. The types of knowledge can be related to different levels of cognitive processes such as remember, apply, evaluate, etc., which allows the adaptation of learning objectives for educational programs on different education levels as for Europe defined in the European Qualifications Framework[1]. The level of detail of topics covered by the BoK is extensive. The table below provides only an overview of KAs (first hierarchical level) with some examples of according units (second level) (Table 1). A full version of the BoK can be downloaded from the web[2].

Table 1: Knowledge Areas of the GIS&T BoK (after [2]).

| Knowledge Area | Example units included |
|---|---|
| Analytical Methods | geometric measures, analysis of surfaces, spatial statistics |
| Conceptual Foundations | philosophical foundations, domains of geographic information, relationships |
| Cartography and Visualization | data considerations, graphic representation techniques, map production |
| Design Aspects | project definition, database design, application design |
| Data Modeling | database management systems, vector and object data models, tessellation data models |
| Data Manipulation | representation transformation, generalization and aggregation, transaction management |
| Geocomputation | computational aspects and neurocomputing, cellular automata, heuristics, genetic algorithms |
| Geospatial Data | map projections, satellite and shipboard remote sensing, land surveying and GPS |
| GIS&T and Society | legal aspects, dissemination of geospatial information, geospatial information as property |
| Organizational & Institutional Aspects | origins of GIS&T, managing the GI system operations and infrastructures, coordinating organizations |

## 3 Workforce Demand Assessment

### 3.1 Aims and Approach

Updating the Body of Knowledge requires a detailed insight in current requirements of the GI job market and foreseeable future developments. An online survey was run by the GI-N2K project in order to assess GIS&T workforce demand. The target group of the survey was people actively working in the GIS&T domain. These people were asked to rate the importance of BoK KAs within their professional life. The intended outcome was job profiles that show required competences and skills of GIS&T in public, private, academic and non-governmental organizations.

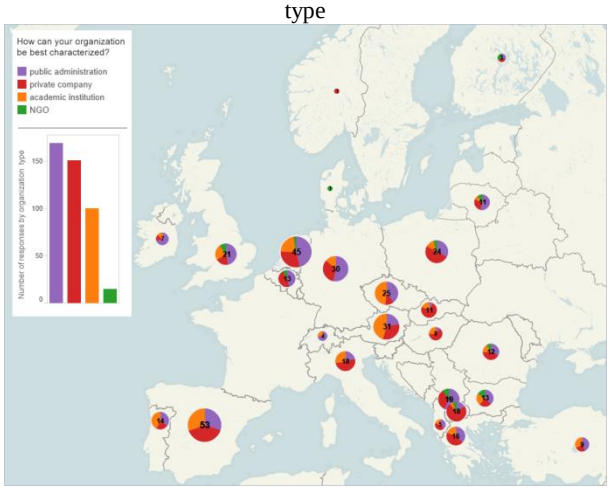
As survey participants were introduced to the BoK by listing KAs, units and exemplary topics (3rd hierarchical level), previous knowledge of the BoK was not required. In terms of content the survey strictly followed the existing KAs in order to avoid predetermining potential adaptations to the BoK. However, within the online survey the KAs itself were presented in random order to ensure approximately equal attention to each KA given the overall length of the survey.

Participants were also asked to name their current job tasks, presumed tasks in five years and individual learning objectives. The collective description of currently performed GIS&T tasks aimed at giving a broad overview of today's workforce, whereas the judgment of future directions was expected to provide opinions on trends in the field. Finally, the educational aims should help to link the workforce demand to an eventual reshaping of educational offers.

### 3.2 Facts and Figures about the Survey

The online survey was distributed through 31 project partners and networks such as the Association of Geographic Information Laboratories for Europe (AGILE). In total more than 1000 questionnaires were returned out of which 435 were completely filled. Contributions came from over 33 mostly European countries and people working in different types of organizations (Figure 1).

Figure 1: Number of Responses by Country and Organization type




Also the highest level of education in the GI domain was specified by respondents. Following the European Qualifications Framework (EQF) seven levels of expertise

[1] http://ec.europa.eu/eqf/home_en.htm
[2] http://www.aag.org/galleries/publications-files/GIST_Body_of_Knowledge.pdf

were differentiated: beginner, user, competent user (self-trained), competent users (extensively trained), Bachelor, Master and Doctorate. One third of respondents hold a Master's degree in GIS&T. About 12% each are either competent users (self-trained or extensively trained) or have a PhD in GIS&T. The remaining participants hold a Bachelor's degree in GIS&T, are beginners or plain users. The gathered information on organizational affiliation, job description and the educational level of respondents allows a differentiated view regarding the rated importance of KAs.

## 4 First Survey Results

The presentation of first results focuses on the ratings of the KAs regarding organization type and education level of respondents. The following figures present the mean rating of each KA by category.

Figure 2 shows the mean rating of KAs per type of organization. The mean ratings are similar over organization types for most KAs. The rating given by respondents working in academic institutions differs most from the other categories (the discussed ratings from the academic field are marked with a filled circle). This becomes apparent when on the one hand looking at *analytical methods* and *geocomputation*, which are rated higher by people from the academic field. On the other hand, the two KAs of *GIS&T and society* and *organizational and institutional aspects*, are rated lowest by respondents from the academic field. A detailed interpretation of these results and an assessment of statistical significance yet have to follow.

Figure 3 presents the mean ratings of KAs by people with different levels of educational training in the GIS&T field. The results indicate that the importance of KAs increases with the level of education of the respondents. That means that respondents with a doctorate consistently rate KAs higher than respondents with a Bachelor degree or even lower levels of (mostly informal) GI-education. We attribute this fact to the larger knowledge and experience of highly qualified professionals regarding the topics covered in each KA. This result seems correlated with the rating of KAs through people working at academic institutions.

Some KAs are not rated highest by people with a doctorate, but by Bachelor or Master degree holders. An example is the KA data manipulation. However, statistical testing showed that this difference in the rating is not significant.

Comparing the overall ratings of KAs, three KAs are rated considerably less important: *geocomputation*, *GIS&T and society*, and *organizational & institutional aspects*. In the KA *geocomputation*, the concepts and methods covered relate to heuristics, uncertainty, fuzzy sets, cellular automata, agent-based modeling, neurocomputing and others. It can be hypothesized that the sometimes quite advanced concepts covered by this KA are too specialized for tasks in a non-academic yet professional working context.

The other observation is the rating of the KAs *GIS&T and society* and *organizational & institutional aspects*. The ratings differ more across types of organizations and again the overall ratings are lower in comparison to the other KAs. This might be an indication that GIS&T is still primarily seen as a technical discipline.

Figure 2: Rating of knowledge areas by organization type (NGOs have been omitted due to unstable means because of the small sample size).

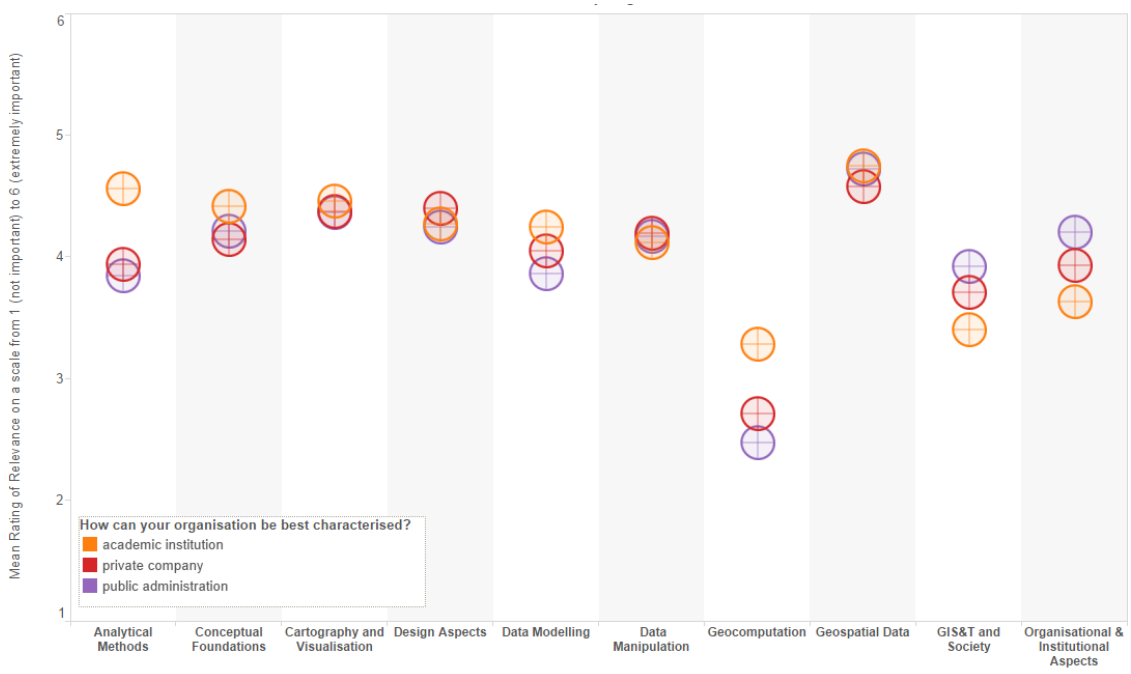
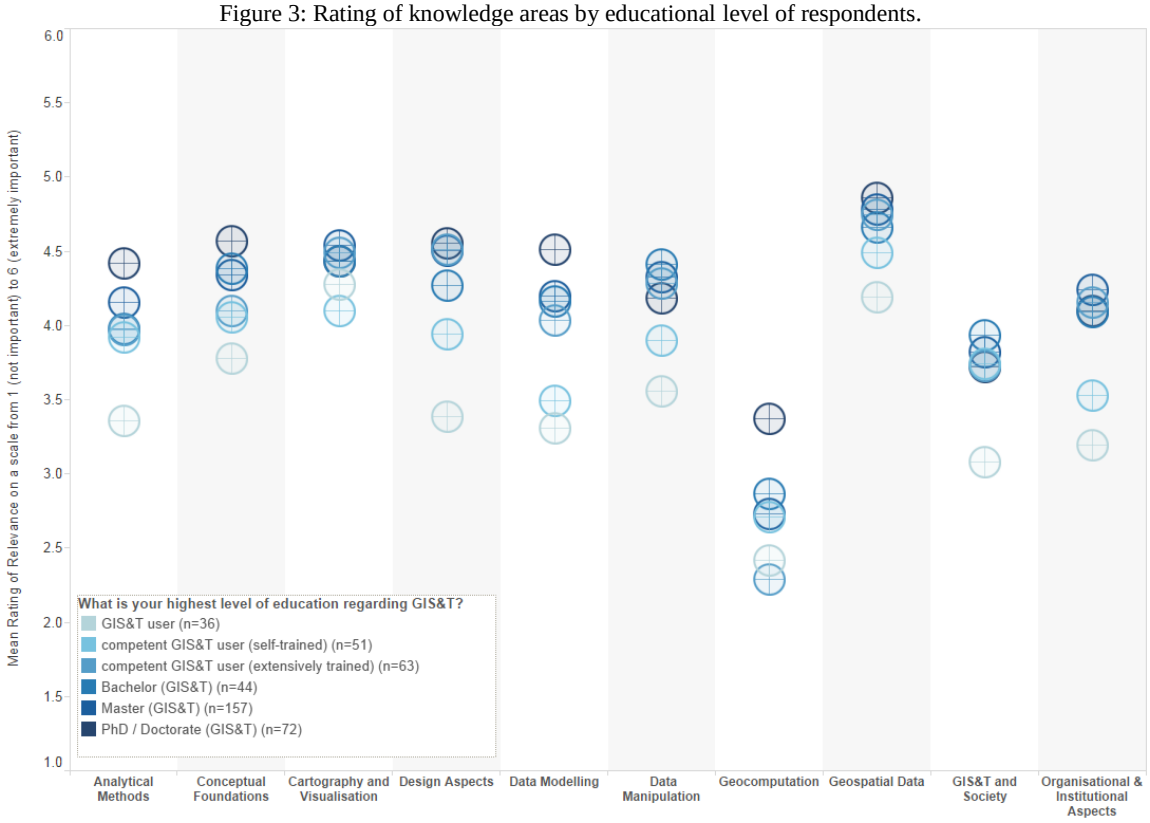


Figure 3: Rating of knowledge areas by educational level of respondents.




The following figure (Figure 4) shows a word cloud created from free-text replies on the following question: *Which competences will gain importance in the next 5 years?* The keywords GIS and data were removed before generating the word cloud as they dominate the result otherwise. The replies largely point into the same direction that was indicated by [4]. Mobile and web technologies gain importance as well as related topics like applications and development. Analysis, which could mean spatial analysis or data analysis, is expected to continue as important part of GI expertise.

Figure 4: Future competences identified by respondents (the keywords *GIS* and *data* have been excluded from the word cloud).


## 5 Conclusions and Further Work

The results presented here are preliminary and only indicate the direction in which the detailed analysis of the survey could lead. Clearly and not surprisingly, the competences used in the professional life vary for professionals with different levels of education in the GIS&T domain. Education on different levels clearly steers the profiles of graduates (cf. [9]).

The analysis yet has to dwell deeper into the ratings of knowledge areas and associated units. The detailing of the analysis will include testing for statistical significance for observations made.

The quantitative survey is currently complemented by qualitative interviews with highly reputed representatives of academic, private and public administration organizations across Europe. These qualitative interviews provide insights into required competences on the GI market on a general level.

Next steps are the extended analysis of survey results and the consolidation of findings. The extended analysis will also look into the free text answers given on tasks, trends and learning objectives.

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