GI-N2K – Geographic Information Need to Know

LLP – Erasmus Academic Network
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Analysis of the demand for geospatial education and training

Results of the GI-N2K Demand Survey

Towards a more demand-driven geospatial workforce education/training system

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WP 1 Analysis of demand and supply (Task 1.1)

Short Description:

This report presents the results of an in-depth analysis of the workforce demand. It reviews the knowledge areas of the current GIS&T BoK with respect to 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. The report is designed to complement the analysis on educational offers by current programmes and curricula in the GI domain, which is covered in parallel by task 1.2 of this work package. Together these two tasks will provide a sound basis for re-designing the GIS&T BoK in the GI-N2K project. The final report of WP1 will then give an assessment of the match between workforce demands and current offers in educational programmes.

Keywords:

Workforce demand, GIS&T Body of Knowledge, Geospatial education and training, knowledge and competences

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1 Introduction

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' (Geographic Information Science & Technology Body of Knowledge) (DiBiase et al., 2006). 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 GIS&T BoK aimed at allowing the design of adaptable curricula that define individualised pathways through its 1,660 educational objectives (DiBiase et al., 2007). 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 yet 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 (2010) highlights among other topics the potentials of larger data availability in comparison to earlier days of GIScience. Câmara et al. (2009) 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 (Câmara et al., 2009). 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 GIS&T BoK cannot be static as technology and science evolve. Several initiatives are working on an update of content and format of the GIS&T BoK (DeMers et al., 2013, Hossain and Reinhardt, 2012, Painho and Curvelo, 2011, Rip and Verbree, 2012). 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.

This report presents the results of an in-depth analysis of the workforce demand. It reviews the knowledge areas of the current GIS&T BoK with respect to 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. The report is designed to complement the analysis on educational offers by current programmes and curricula in the GI domain, which is covered in parallel by task 1.2 of this work package. Together these two tasks will provide a sound basis for re-designing the GIS&T BoK in the GI-N2K project. The final report of WP1 will then give an assessment of the match between workforce demands and current offers in educational programmes.

2 Knowledge Areas of the GIS&T Body of Knowledge

The GIS&T BoK divides geographic information science and technology into ten Knowledge Areas (KAs) (DiBiase et al., 2007). Each KA covers a set of units that are further subdivided into topics. For each topic the GIS&T 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 (Blaschke and Strobl, 2010). The level of detail of topics covered by the GIS&T BoK is extensive. Table 1 provides only an overview of the first hierarchical level (KA) with some examples of according units (second level). A full version of the GIS&T BoK can be downloaded from the web (DiBiase et al., 2006).

Table 1 Knowledge Areas of the GIS&T BoK (after DiBiase et al., 2007).

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

With view on the concerted effort to develop a market-oriented update of the GIS&T Body of Knowledge, this research aimed to evaluate current workforce demands and to identify presumed future directions. For three reasons, we focussed on the current GIS&T BoK as the main point of reference in the design of this research. First, we believe that the current GIS&T BoK is a comprehensive document that still covers the vast majority of aspects of GIScience and technology, so that an update would primarily target at shifting its foci and reorganising its structure. Second, we did not want to predetermine changes of the GIS&T BoK by our survey design, but rather deduce suggestions for such changes from the results of the survey. Third, we conceptualised the GIS&T BoK as the 'common denominator' between this workforce demand assessment and the analysis of the educational offers (Task 1.2. of this work package, WP 1). This integrated view will be needed for the gap analysis in the final report of WP 1.

A twofold approach was taken to adequately identify the relevant aspects of the GIS&T workforce demands in Europe. On the one hand a quantitative online survey was widely distributed with help of the GI-N2K project partners throughout Europe and beyond. On the other side, semi-structured interviews with leading experts in the field from selected geographical regions provided deeper insights to complement the survey. In the remainder of this chapter, we will further detail these two approaches of acquiring information on the European workforce demand and the methods for its analysis.

3.2 Quantitative online survey

The intended target group of the quantitative survey was professionals actively working in the GIS&T domain, who were reached with help of the network of GI-N2K project. The online survey was distributed through 31 project partners and its associated partners such as the Association of Geographic Information Laboratories for Europe (AGILE). The language of the survey was English for practical reasons. However, some partners took advantage of professional meetings, where they offered assistance to interested colleagues in national languages, e.g. by providing survey offline versions that were annotated or translated into national languages.

The survey was designed as an online questionnaire (Table 2) that was implemented in LimeSurvey. Its main objective was to rate today's relevance of individual Knowledge Areas and Units of the existing GIS&T BoK, giving exemplary Topics (3rd hierarchical level). Further, additional and potentially new areas should be identified with help of free-text questions. The relevance of the GIS&T BoK should be differentiated for specific job types (public, private, academic and non-governmental organizations), job roles (GIS&T user, GIS&T analyst, GIS&T project manager, GIS&T department leader) and educational levels (European Qualifications Framework - EQF level). Despite its purpose, the survey did not assume the respondent to be familiar with the GIS&T BoK and even avoided direct reference to the GIS&T BoK to minimise biased responses. For the same reason, a free-text question that related to currently performed tasks preceded the main body of GIS&T BoK ratings. This collective description of currently performed GIS&T tasks aimed at giving a broad overview of today's workforce. The GIS&T BoK ratings were organised in ten blocks, one for each Knowledge Area. The blocks were presented in random order to ensure approximately equal attention to each KA given the overall length of the survey. Following the section of structured ratings, two additional free-text questions asked for competences that presumingly gain momentum in the future and for personal learning intentions. The judgment of future directions was expected to provide opinions on trends in the field that can point at potential gaps as input for WP2. The educational aims should help to link the workforce demand to an eventual reshaping of educational offers and this way offered the explicit link to Task 1.2 (educational offers) and the integrated gap analysis of workforce demands and educational offers of Task 1.3. Finally, the respondents were given the opportunity to provide contact details to receive information on survey results and further project outcomes and activities.

Table 2 Questionnaire design of the quantitative online survey on the European GIS&T workforce demand.

Section 1	Information about participant and workplace (structured questions)
Section 2	Current demand in job of GIS&T competences (free-text question)
Section 3	Weighting of importance of GIS&T BoK knowledge areas (structured questions)
Section 4	Future trends regarding GIS&T competencies (free-text question)
Section 5	Optional – contact information for information about survey results

Ad Section 1: Section 1 provides metadata about the respondent, his/her education, work organization, role in organization and geographic location. A target respondent is an individual person who is concerned with GIS within his work at a company or institution. The questionnaire is not intended for managers to answer for his / her entire GIS&T personnel.

Ad Section 2: Section 2 asks for frequent tasks in the respondent's job. This free-text question is optional and it is thought to return important GIS&T tasks before the respondent is exposed to and thus potentially biased by the existing GIS&T BoK KAs. The respondent can list up to three tasks.

Ad Section 3: Section 3 is the core of the survey. The respondents are asked to rate the importance of GIS&T BoK KAs **in their job** on a five items evenly spaced likert type scale between 1 (*not relevant*) and 6 (*extremely relevant*). Each KA is introduced through its hierarchical subsets, the so-called *Units*, in order to provide context for the KAs and facilitate the rating of importance of KAs. The wording of the units is extended for action verbs to better relate to the practical usage of the various methods and concepts. Action verbs also link to the Bloom taxonomy of learning objectives and thus allow a link to educational aspects. These action verbs are, e.g., *apply*, *use*, *consider* and *understand*. Since the names of the units can be quite abstract, we listed explanatory examples for each Unit. Units that are exclusively referring to knowledge of no practical use were dropped. For example, the Unit '*academic and analytical origins*' of the KA Analytical Methods could not be translated to a competence in the job (and hardly has practical relevance) and is therefore not listed. The rating of individual units as '*not relevant*', '*somewhat relevant*' or '*very relevant*' is optional, whereas the rating of each of the ten KAs is compulsory.

Ad Section 4: In section 4 we ask the respondent for an outlook on competences that will gain importance in their opinion as well as three competences that he/she would like to acquire in the future. Each of the two free-text questions offers the possibility to list up to three competences.

Ad Section 5: Section 5 serves the purpose of providing contact information in case the respondent would like to receive further information on project results.

3.3 Survey analysis – closed questions

The analysis of the structured closed questions like the rating of KAs or the educational level and job roles of respondents aims to identify characteristic patterns in the data. Such patterns should provide insight in the perception of the GIS&T BoK and its thematic subdivisions for different groups within the GI-community. Furthermore the analysis should evaluate the status quo of the perceived overall relevance of KAs from an applied (job-related) perspective. Resulting information will provide valuable input for the GIS&T BoK adaption process starting in WP2.

Closed question analysis was predominantly done with Microsoft Excel, the visual analytics software Tableau and the statistics package R. Excel was used for data pre-processing like the elimination of unfinished survey entries or the homogenization of country spellings. The pre-processed data was further analysed in Tableau using geocoding, various techniques of aggregation, visualization in diagrams and maps and basic statistical analysis like the computation of average ratings, confidence intervals and standard deviations. R was used to perform additional statistical tests and text analysis. Given the visually evenly spaced scale to rate the relevance of KAs between the two extreme positions "not relevant" and "extremely relevant" and the large number of responses, we treated the resulting data as being interval scaled (Brown, 2011). However, to be on the 'safe side' non-parametric testing on an ordinal data level was additionally performed to parametric tests.

3.4 Survey analysis – free-text questions

The free-text analysis had three main intentions: (1) to identify shifts from currently performed tasks to presumed future workforce demands, (2) to characterise explicit educational 'demands' by the European workforce, and (3) to extract 'gaps' in order to contribute to the identification of concepts that are demanded in the European workforce but not covered in the current version of the GIS&T BoK. The analysis was preceded by a pre-processing of texts. All steps were realised in R and its text mining ('tm') package (Feinerer et al., 2008). For pre-processing, the free-text responses were loaded into R as separate text files for each of the three questions: 'frequently performed tasks', 'competences needed in the future' and 'individual learning aims'. As a fourth document, the GIS&T BoK with its full hierarchy of all three levels including the learning objectives was loaded. The texts were converted to lowercase letters and common language terms, such as 'and', 'or', 'the' etc. were deleted. Further, all non-English texts were removed, spelling mistakes corrected and all words converted to the American spelling. Finally, the word stemming function was used to reduce words to their stem for better comparability, e.g. 'analyze', 'analyzed', 'analyzing', and 'analysis' were all reduced to 'analy'.

The subsequent text analysis aimed to identify and characterise present and future competences to be covered by the GIS&T expert community. In an exploratory text analysis we compared the free-text responses with help of word clouds and term frequency counts and contrasted them between various respondent groups and against the GIS&T BoK hierarchy. For a quantitative comparison of the texts we computed cosine similarity indices (CSI). The cosine similarity index is a well-established data mining technique for text analysis (Salton and McGill, 1986). First, the CSI algorithm computes word frequencies and then compares them pairwise, where one pair refers to the same term, e.g. "GIS". From these tuples, one vector is computed for each document that has as many dimensions as there are unique terms in the documents. The similarity between two documents is then expressed as the cosine of their angle, where equal documents would have a similarity index of one. We used the implementation of the similarity index in the R software package 'tm' (Anderberg, 1973), which actually computes the dissimilarity. For this research all results are transformed to reflect similarity by subtraction from 1, i.e. similarity = 1 - dissimilarity. Thus CSI=0 stands for no match at all and CSI=1 characterises equal texts.

Finally, the gap identification aimed at highlighting potential mismatches between workforce demands and the current GIS&T BoK. To identify such potential gaps each set of collected and pre-processed responses to one of the free-text questions was subtracted with the content of the GIS&T BoK. The resulting terms were inspected visually to further exclude terms that related to a specific application domain or geographic context. The final set of terms represented keywords that were not mentioned in the GIS&T BoK and thus could be considered highly relevant as complimentary, additional and potentially new concepts for the update of the GIS&T BoK.

3.5 Semi-structured interviews

To complement the online survey and facilitate interpretation of the predominantly quantitative data, semi-structured qualitative interviews were conducted with key representatives of the GI-community within Europe. The interviews were conducted by seven selected project partners, who represented multiple regions in Europe (Austria, Belgium, Bulgaria, Germany, Hungary, Netherlands, Spain). Each of the selected project partners was provided with the interview guideline (Info Box) to conduct in-depth discussions about the current situation of the workforce demand with key representatives in the GIS&T community in their respective regions. Each project partner was to select at least three interview partners, who have a broad view on the topic one for each of the workforce 'types': private company, public administration, academia. The suggested target length of an interview was about 30 min – 1 hour. The interviews were conducted in the respective national languages and the answers translated to English. In total, 28 in-depth interviews were conducted.

Info Box: interview guidelines

1. Needed competences: Which GIS&T competences are currently required in the job market in your country? E.g. which competences are listed in a job description in your institution?
2. Future competences: Do you think that the focus shifts? which competences will gain momentum and what will be less important?
3. Fit between educational supply and workforce demand: Do companies/organizations have difficulties in finding adequately educated GIS experts? Do required job qualifications (workforce demand) match with current GIS&T education? in which aspect are job applicants well educated/trained? What are competence deficits you frequently encounter and if so: which? And are there any competences in current GIS&T education that a GIS expert is unlikely to be able to apply in the 'real world'?
4. Initiatives to better match supply and demand: What initiatives are taken in your organization / country to better align GI S&T education and training with the needs of the GI job market? What other initiatives would you suggest?
5. Knowledge, use and usefulness of the GIS&T BoK: Do you know the GIS&T BoK yourself? Do you make use of the GIS&T BoK? For which purposes? Do you believe the GIS&T BoK is useful?

For the content analysis, the interviews were arranged into five blocks for each of the guiding questions and further organised by organisations type (column) and provenance (row) of the interview partner (see Annex II). This way, the assessments of the stakeholders could be compared and contrasted to provide a larger context of the GIS&T workforce demand that complements the quantitative survey.

4 Results

4.1 Facts and figures about the online-survey

In total, more than 1000 questionnaires were returned out of which 456 were fully completed. Reducing the number of fully completed questionnaires by respondents not involved in GIS&T in their jobs, leads to a subset of 435 responses for further analysis. The average completion time for the survey was around 17 minutes, with a median at 13 minutes.

The number of 435 fully filled questionnaires is overwhelming given the project target number of 200 filled questionnaires for Tasks 1.1 (workforce demand) and Task 1.2 (educational offers) together. The distribution of the survey through project partners and international networks like the Association of Geographic Information Laboratories for Europe (AGILE) was very successful (Figure 1). The survey reached interested people throughout Europe and beyond, with highest numbers contributed by Spain (53 responses) followed by the Netherlands (45 responses). Responses came from people working in 33 mostly European countries. Interestingly, there is no answer from France, which may be related to the fact that there is no project partner from France. The percentage of responses from non-EU countries respectively non-EU-candidate countries is around 4%.

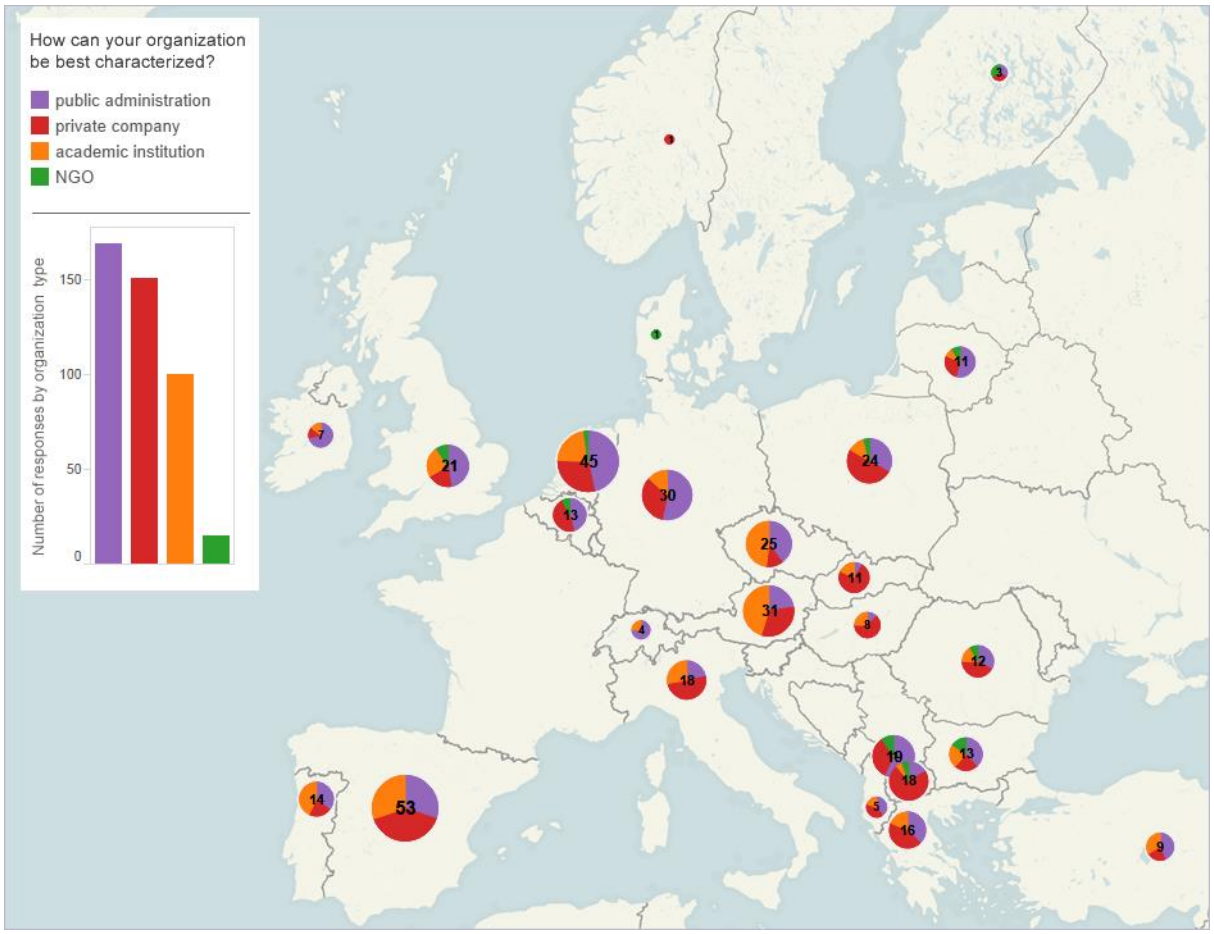

Figure 1 Number of Responses by Country and Organization type

The target group for the survey were people working in the field of GIS&T. This target group was well reached with the survey. Table 3 shows the distribution of job roles of respondents and

Table 4 summarises the distribution of respondents over organization types.

Table 3 Respondents' roles in their organizations

Role in the organization	#	%
GIS&T user	77	17,7
GIS&T expert (analyst, researcher, educator)	197	45,3
GIS&T project manager	71	16,3
Manager of a GIS&T group (department, company,..)	90	20,7

Table 4 Responses per organization type

Organization Type	#	%
Academic institution	100	23,0
Private company	151	34,7
Public administration	169	38,9
NGO	15	3,4

The educational level of respondents can be seen in Table 5. More than one third of respondents holds a Master's degree as their highest educational attainment in GIS&T. 10% hold a Bachelor's degree and nearly 17% a PhD degree. In total around 25% of respondents are competent GIS&T users who are either self-trained or extensively trained. The remaining 10% were 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 (with the exception of NGOs and GIS&T beginners with too small numbers of respondents to provide statistically useful results).

Table 5 Educational level of respondents according to the European Qualification Framework (EQF)

Educational Level		#	%
IS&T beginner	EQF 2	12	2,8
GIS&T user	EQF 3	36	8,3
Competent GIS&T user (self-trained)	EQF 4	51	11,7
Competent GIS&T user (extensively trained)	EQF 5	63	14,5
Bachelor (GIS&T)	EQF 6	44	10,1
Master (GIS&T)	EQF 7	157	36,1
PhD / Doctorate (GIS&T)	EQF 8	72	16,6

4.2 Workforce demand – status quo, trends and education

Tasks that the European GIS&T workforce frequently performs are distinctly dissimilar from competences that respondents think to be relevant in five years. The cosine similarity index (CSI) for the two respective free-text responses to the online-survey exhibits a similarity of CSI=0.82 (Table 6). This finding not least quantifies the rapid development of the GIS&T domain. However, there is a semantic difference between 'task' and 'competence' that might further accentuate this dissimilarity. In contrast, presumed future trends in the GIS&T domain are quite closely related with individual learning aims (CSI = 0.93). This plausibly reflects the intention of professionals to keep up to date in their domain.

The GIS&T BoK itself exhibits the strongest dissimilarity with the keywords collected in the survey. It has a similarity index CSI around 0.7 with each of the three free-text responses of the survey. This difference might be explained with the structural difference between a generic reference document and a collection of individual tasks and objectives. The similarity index thus needs to be interpreted cautiously. It is less suited as an absolute value, but has a potential to serve as a relative benchmark for a comparison of different respondent groups amongst each other and in relation to the GIS&T BoK.

Table 6 The cosine similarity index (CSI) characterises the similarity between free-text responses and the GIS&T BoK

	Frequent tasks	Future competences	Learning aims
Future competences	0.82		
Learning aims	0.84	0.93	
GIS&T BoK hierarchy	0.70	0.68	0.68

Word frequency counts of terms provide a better understanding of the nature of the above relations and dissimilarities (Figure 2). Three terms lead each of the three lists of survey responses, i.e. of currently performed tasks, future trends and learning aims. These three stable core concepts in the GIS&T domain are: *gis*, *data* and *analysis*. Differences become tangible when considering concepts with diverse frequency counts. Four specifically diverse, thus interesting concepts are discussed further: '*data'*, '*web – mobile – cloud*', '*application – development – programming*' and '*integration – SDI – INSPIRE – web services*'.

The term '*data*' is highly frequent in all free-text responses. However, it clearly is most dominant in the assessment of future trends, where 30% of respondents mentioned '*data*'. Of these 4% are related to '*big data*', another 4% to '*open data*' and 3% to '*data integration*'.

Interestingly, the term '*web*' is on the fourth rank for both, future trends and learning aims with 7% and 6% of answers respectively, whereas it accounts for only less than 2% of currently performed tasks. A less clear match between future trends and learning aims relates to the term '*mobile*' that is mentioned in 5% of answers to be important in the future, but only 2% list it as learning aim. Similarly, the term '*cloud*' was identified as important future competence by 3% of answers, but only 1.5% of answers defined it as personal learning objective. However, this is still a remarkable number, considering that today only 0.1% are frequently dealing with '*cloud*' GIS.

The semantically related terms of '*programming*', '*application*', and '*development*' account for around 7% to 8% of current and future tasks and even more answers (11%) identify application development as learning aim.

Terms related to the field of data harmonisation and spatial data infrastructures are not frequently mentioned as a current task, only 2% of responses listed the term '*services*'. However, the GIS community thinks that it will become more important in the future, where around 6% mentioned '*integration*' and '*services*'. In contrast, only 2% of responses referred to SDI and related concepts as a learning objective, most of which explicitly named INSPIRE.

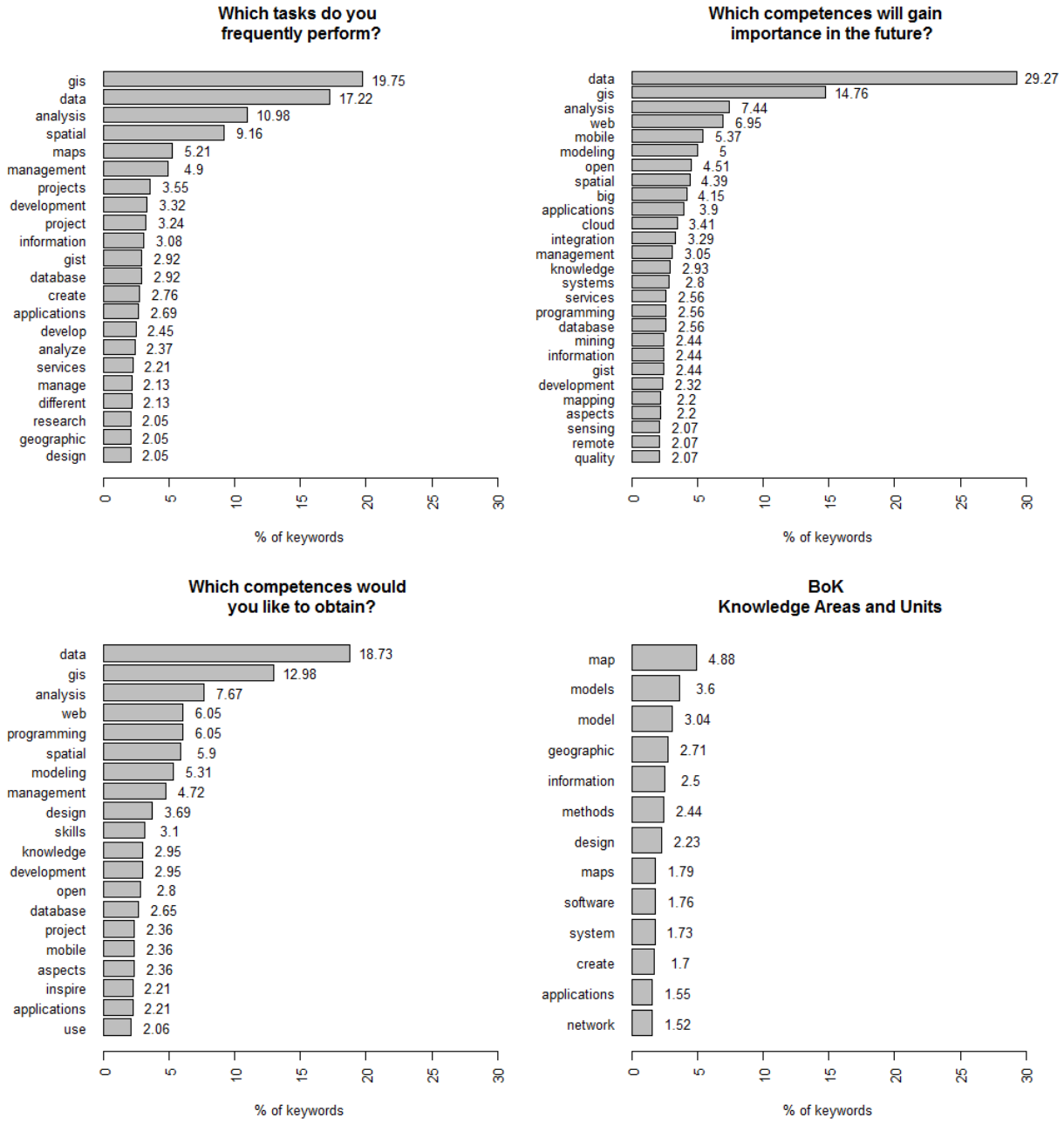

Figure 2 Word frequency counts for keywords that are mentioned at least by 2 % of responses

Word clouds are good visual tools for the further exploration of differences (Figure 3). For the generation of word clouds, the most common and somewhat obvious keywords '*data*', '*gis*', '*spatial*', and '*analysis*' were removed as they dominate the result otherwise. In the GIS&T BoK document verbs dominated that reflected Bloom's taxonomy of learning objectives, e.g. '*understand*', '*explain*', or '*discuss*'. These terms were also excluded from the visualisation.

Whereas today's tasks concentrated around map making, project management, databases and application development, future competences are thought to strongly include web- and mobile applications as well as big- and open data handling. Individual learning aims pick up on these trends, but strongly focus on programming and (data) management. Finally, the GIS&T BoK word cloud again seems widely unrelated to the survey responses.

Figure 3 Word clouds that show the most frequent terms in the free-text fields of the workforce demand survey and the GIS&T BoK document.

4.3 Overall rating of GIS&T BoK Knowledge Area importance

Results from the main body of the workforce demand survey show the relevance of the current GIS&T BoK with respect to its usefulness in the professional work of respondents. The granularity of the analysis targeted at Knowledge Areas (mandatory ranking) and Units (optional). Figure 4 gives an overview of how the relevance of individual Knowledge Areas is rated by the GIS&T community. The average of ratings on a scale between 1 (not relevant) and 6 (extremely relevant) were highest for *Geospatial Data* (4.7) followed by *Cartography and Visualization* (4.4) and *Design Aspects* (4.3). At the low end *Geocomputation* (2.7) was assigned by far the lowest relevance; *GIS and Society* (3.7) and *Organisational and Institutional Issues* (4.0) were rated significantly higher ($p < 0{,}001$) in Bonferroni corrected Welch- and Wilcoxon-Tests. For the distributions of individual KA-ratings see Figure 4.

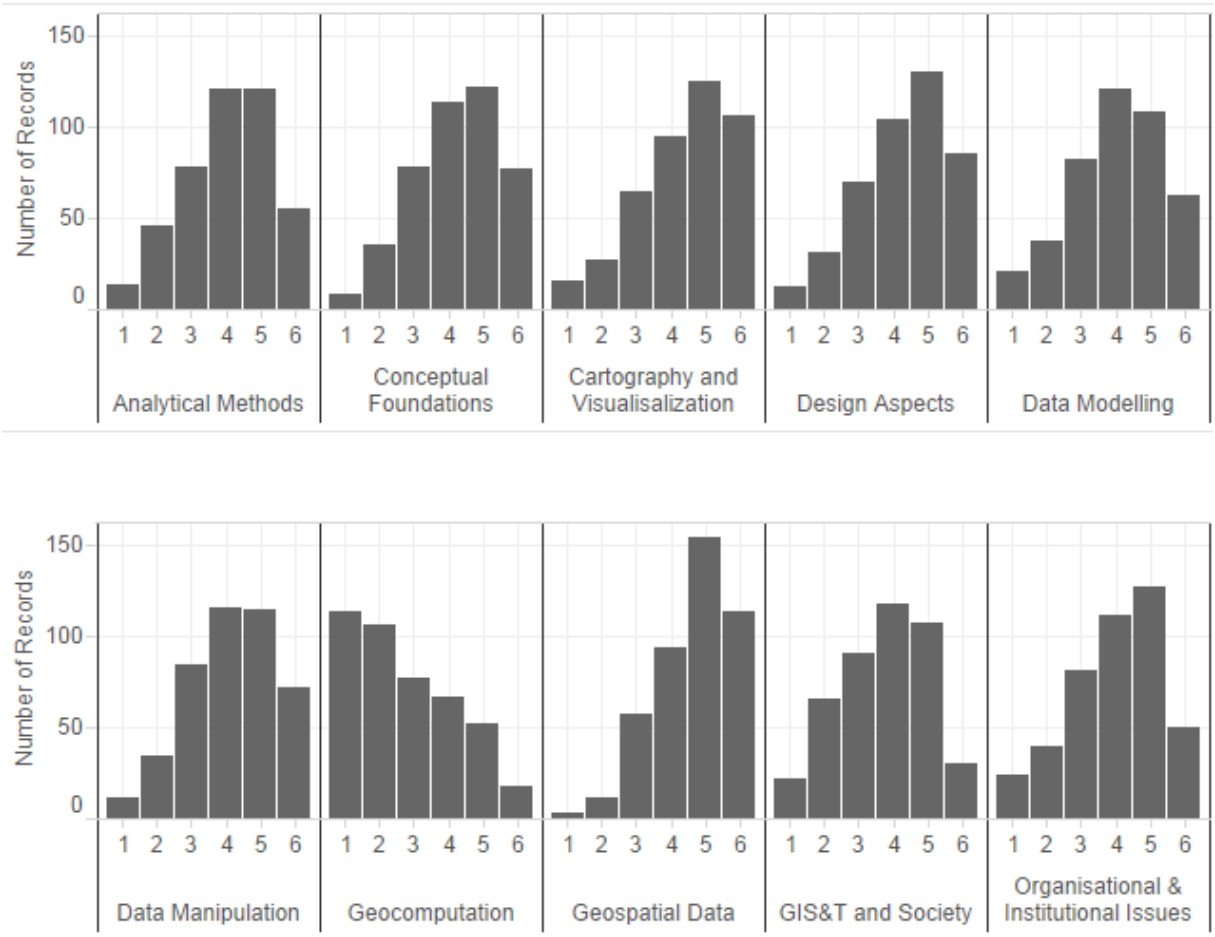

Figure 4 Please weight the overall relevance of Analytical Methods, Conceptual Foundations, etc. on a scale between 1 (not relevant) and 6 (extremely relevant)

A detailed view on the unit level "How relevant have the following competences been in your professional work in the last year?" revealed that topics often not covered in basic GIS&T-programs and/or requiring advanced skills in programming, mathematics or statistics were rated to be of minor relevance in professional GIS-work. This was especially visible in the KA *Analytical Methods*: While basic GIS operations as measuring geometrical properties, performing queries or applying "classical" analysis methods like buffering were rated "very relevant" by a majority of respondents, concepts like spatial regression or mathematical optimization were seen less relevant (Figure 5). Since the KA *Geocomputation* is entirely composed of such "advanced" units (Figure 6) its overall low rating on the KA-level is consistent.

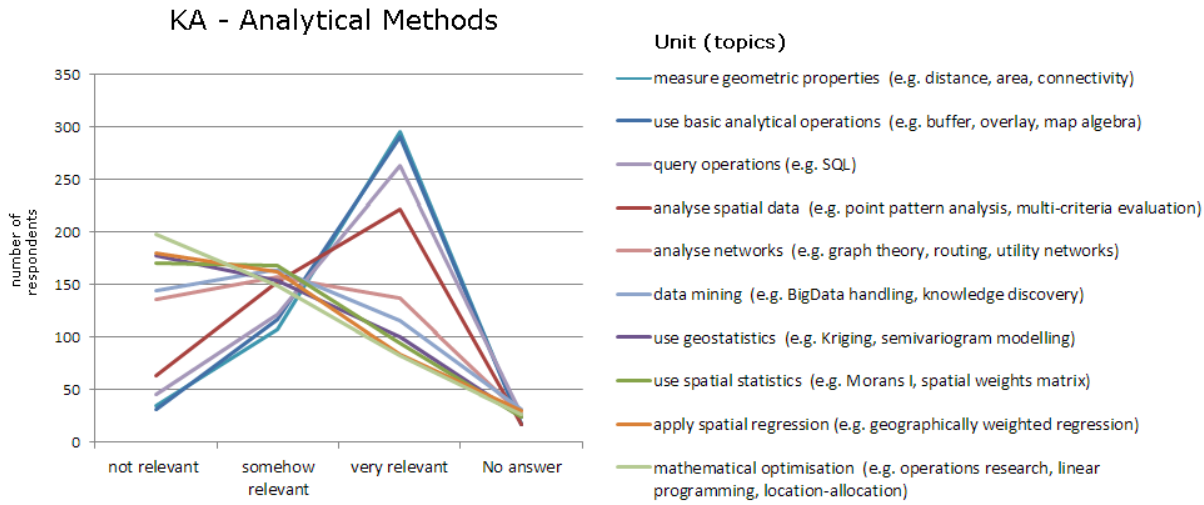

Figure 5 *Analytical Methods* - How relevant have the following competences been in your professional work in the last year?

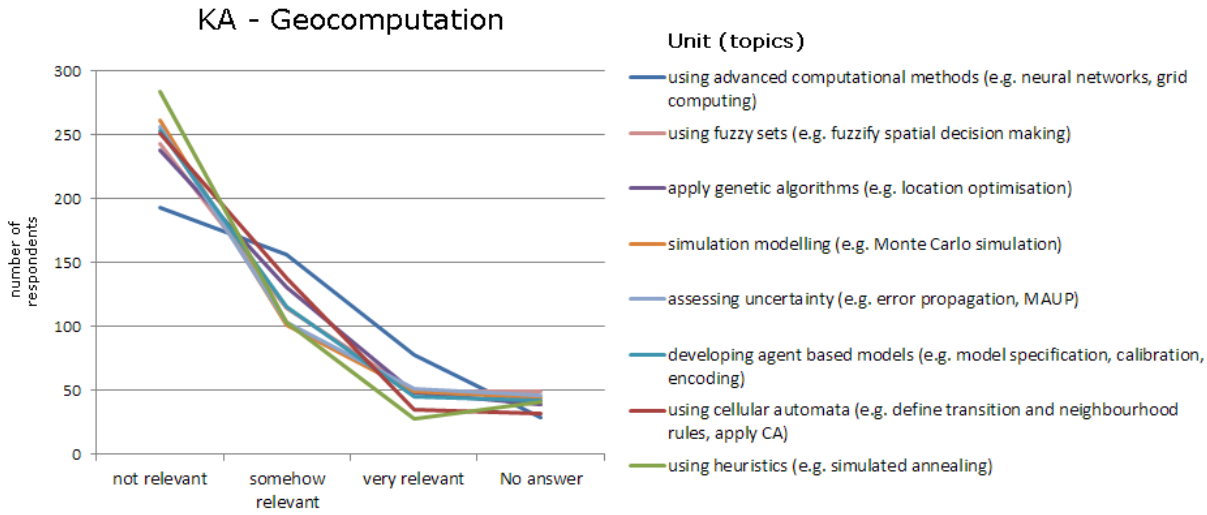

Figure 6 How relevant have the following competences been in your professional work in the last year? - Geocomputation units are seen very relevant in professional work only by every tenth respondent

From the Unit ratings of the overall highest rated KA *Geospatial Data* it can be hypothesized that classical data acquisition techniques lose ground in favour of data handling and related concepts (Figure 7). This aligned well with expert opinions from qualitative interviews, expecting a further decline of importance of data acquisition due to automation and in situ sensor data.

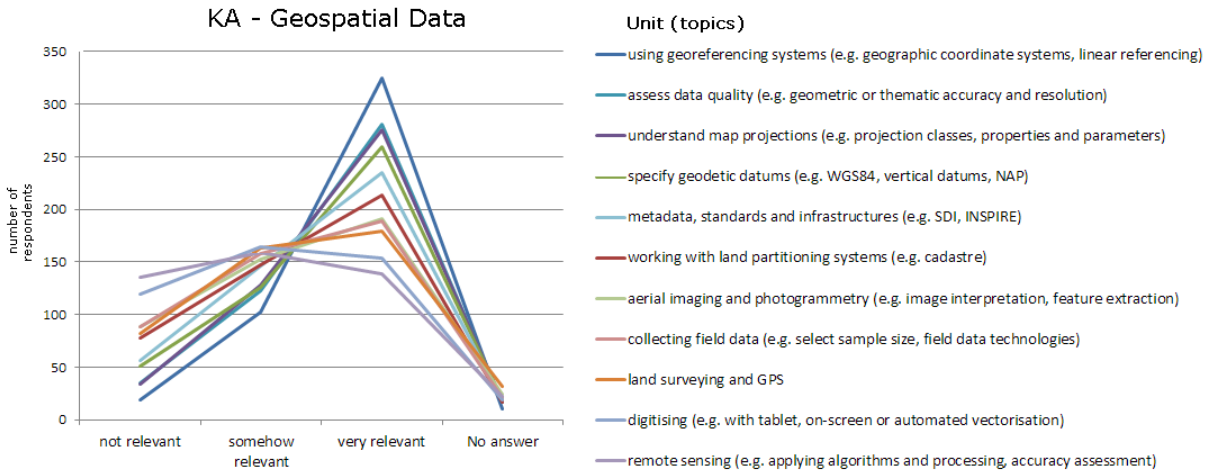

Figure 7 *Geospatial Data* - How relevant have the following competences been in your professional work in the last year?

KAs like *Cartography and Geovisualization* or *Organizational and Institutional Issues* show quite homogeneous relevance ratings on the Unit level. In contrast there was a highly diverse Unit rating in the *GIS&T and Society* KA (Figure 8): While dissemination aspects of geospatial information were considered very relevant in practice, Critical GIS seemed to be hardly relevant for most respondents. It is also notable, that most units in the KA had the highest respondent numbers in the "somehow relevant" category. This could be seen as indication for a rather implicit than explicit consideration of this KA (or the respective units) in typical GIS-work and an indication that GIS&T is still primarily seen as a technical discipline.

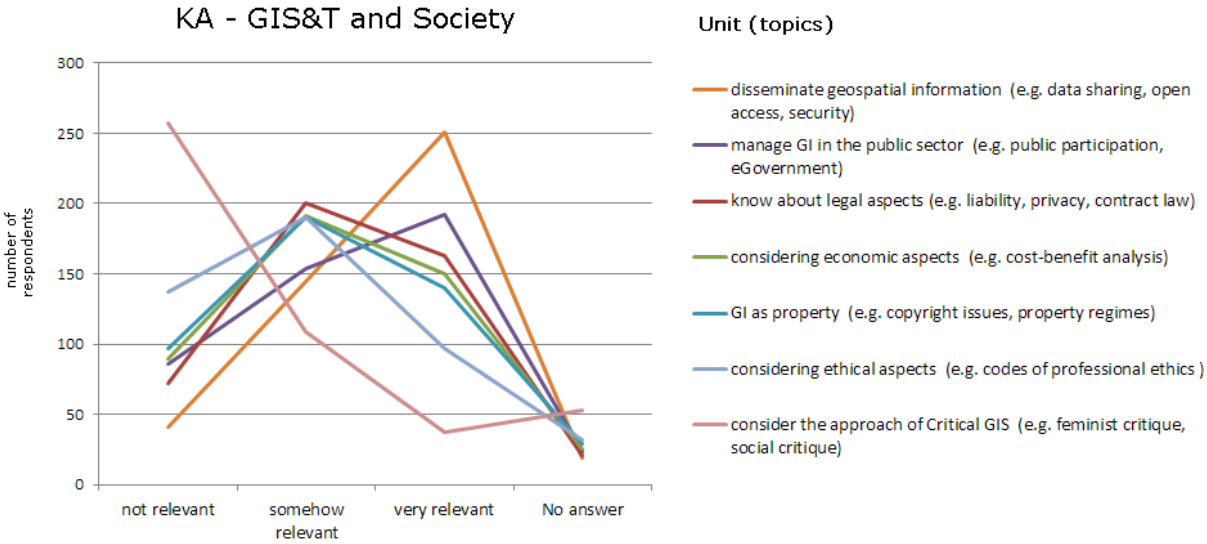

Figure 8 *GIS&T and Society* - How relevant have the following competences been in your professional work in the last year?

4.4 GIS&T BoK ratings in specific organisation types

GIS experts working in different organisation types (academia, public and private organisations, NGOs) rate the overall relevance of the GIS&T BoK (global average of all individual KA ratings) quite similar at 4 on a scale between 1 (not relevant) and 6 (extremely relevant) with Standard Deviations around 1 - see Figure 9.

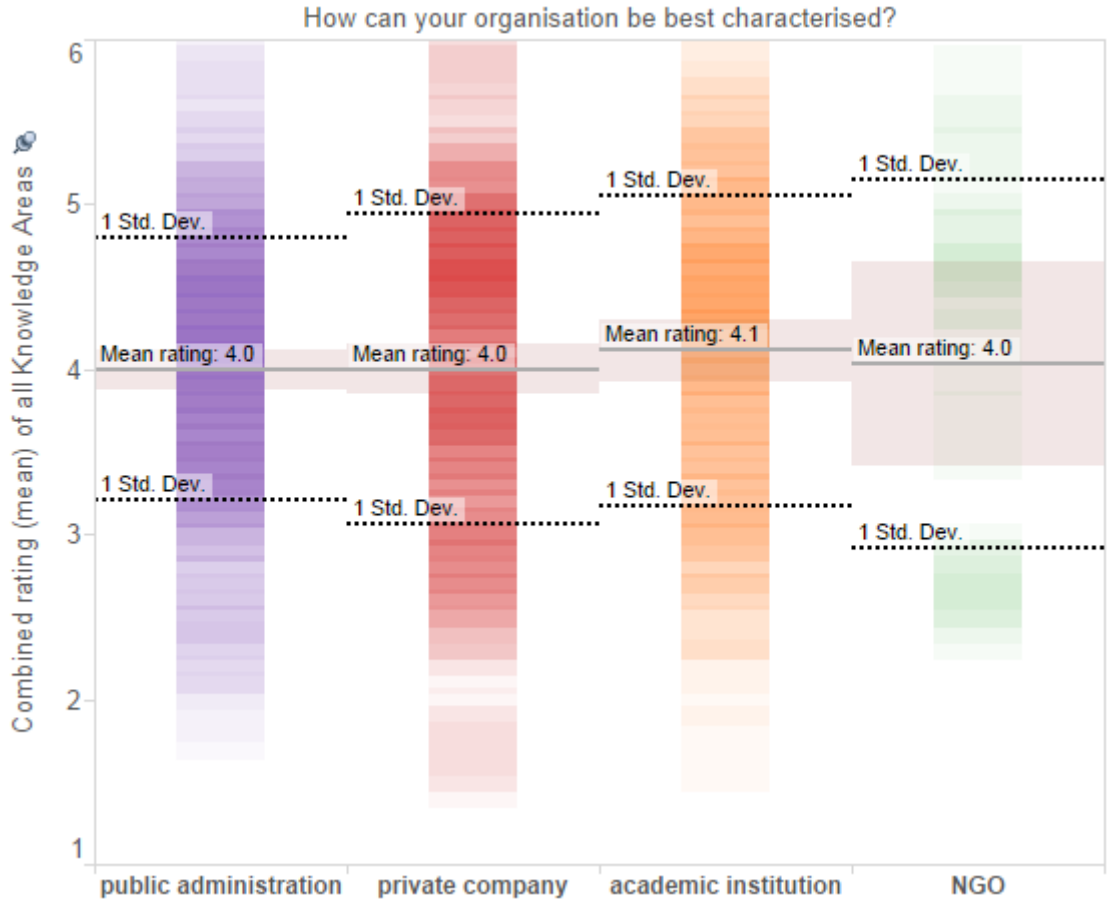

Figure 9 Hardly any difference in the overall rating of the GIS&T BoK KAs by different organization types. The shaded area around the means represents the 95% confidence interval of the mean location. Strong, saturated colours indicate many ratings at the respective averaged value.

Looking at specific KAs the mean rating given by respondents working in academic institutions differed most from the other categories (Figure 10). *Analytical methods* and *Geocomputation* were rated significantly higher ($p < 0.01$, Welch and Wilcoxon Tests) by people from the academic field compared to other organizations. On the other hand, the two KAs of *GIS&T and society* and *organizational and institutional aspects* were rated lowest by respondents from academia. While the mean respondents rating from academic institutions for *GIS&T and society* is significantly lower ($p < 0.05$, Welch and Wilcoxon Tests) compared to the mean rating of respondents from private companies, the difference in means between academia and private companies is not significant for *Organisational & Institutional Aspects* (indeed it is significantly different between academia and public administration).

Higher ratings of *Analytical Methods* and *Geocomputation* by the academic community could be explained by the predominantly usage of some of the advanced methods within research. As will be shown below, this is consistent with the relatively high ratings of those two KAs by respondents holding a PhD - half of them (36 of 72) worked in academia, representing the largest respondent group over there in terms of highest achieved educational level.

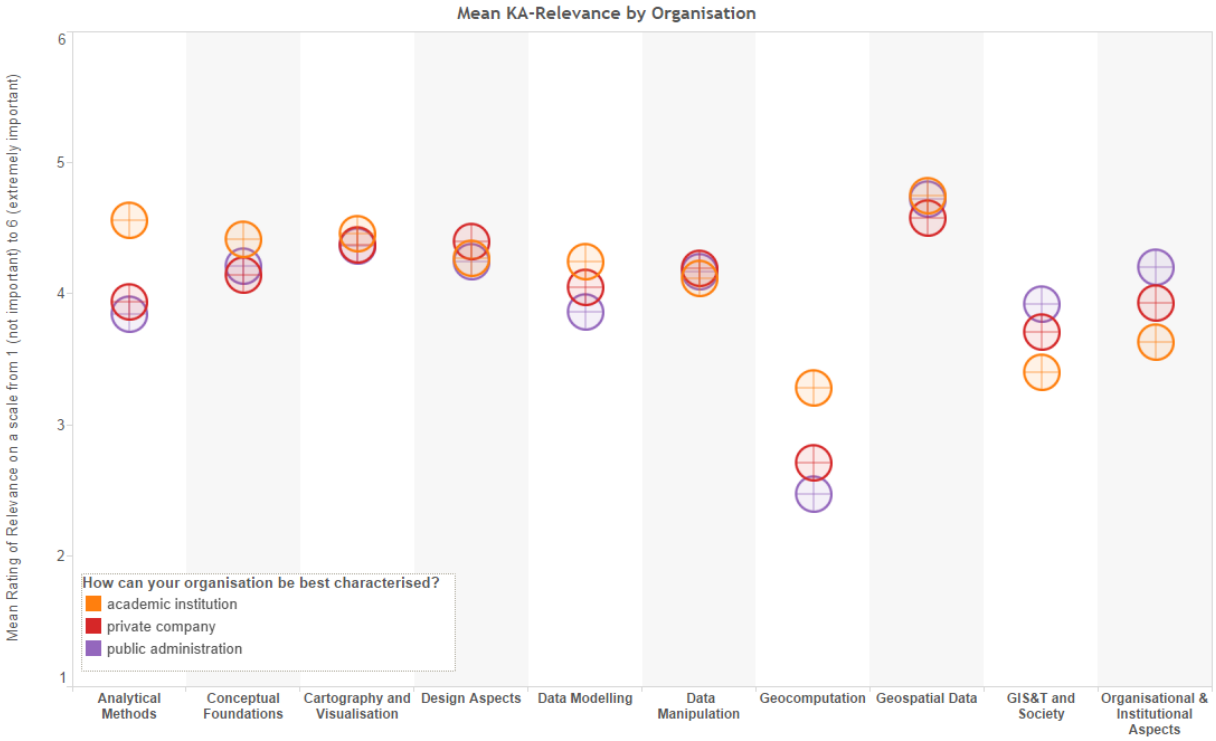

Figure 10 Rating of knowledge areas by organization type. The 15 responses from NGOs are omitted due to their unstable means in regard to the small sample size

Table 7 shows the similarity between free-text responses related to frequent tasks differentiated for the four considered sectors (academia, private, public and the here also included NGOs). Not surprisingly, GIS experts in the four analysed sectors perform different tasks. Interestingly the text similarity analysis indicated that academics perform quite similar tasks in their everyday work compared to the private and the public sector (CSI=0.88 and 0.85). The strongest similarities could be observed between the private and the public sector (CSI=0.9), whereas NGOs were clearly different from all other institutions (CSI=0.6 to CSI=0.7). However, NGOs need to be interpreted with caution, because there were only comparatively few text contributions from this sector available (77 terms) compared to the other sectors each of which contributed about 500 to 600 terms. Interestingly, their relation to the GIS&T BoK was consistent for all sectors, despite their internal differences (CSI=0.65 to 0.68). The only exception was the NGOs that have only a weak relation to the GIS&T BoK (CSI=0.44).

Table 7 CSI similarity of frequently performed tasks in different organisation types

	academic	private	NGOs	public
private	0.88			
NGOs	0.60	0.69		
public	0.85	0.90	0.65	
GIS&T BoK	0.68	0.65	0.44	0.68

Considering the word clouds, it was again the academic sector that had the most distinct job profile (Figure 11). To visualise the distinct characteristics of each sector, common and 'obvious' GI-terms were removed ('GIS', 'data', 'analysis' and 'spatial') before computing the word clouds. Respondents who work in public or private organisations had a focus on maps, development and (project) management. Staff in academic organisations focused mainly on teaching and research. For NGOs 'information' was most important, which might be a hint that these organisations serve as a communication platform of and between stakeholders rather than 'doing' GIS&T. The similarity with the GIS&T BoK was very low for NGOs (CSI=0.44) and only slightly larger for all other sectors (CSI = 0.65 to 0.68). There

was no exception for the academic sector as it could have been hypothesised for a document that was primarily developed by universities.

Figure 11 Word clouds of free-text responses for the question "Which tasks do you frequently perform?" show that employees in different organisation types perform different tasks in their everyday work.

4.5 GIS&T BoK and educational level

Figure 12 presents the mean ratings of all KAs by respondents with different educational levels in the GIS&T field. The results suggested that the overall importance of KAs increases with the level of education of the respondents. However, rather conservative (= Bonferroni corrected) statistical testing showed only significantly lower mean ratings by the GIS&T users (EQF 3) compared to persons at EQF 5-8. We attribute this fact to the larger knowledge and experience of highly qualified professionals regarding the topics covered by the GIS&T BoK.

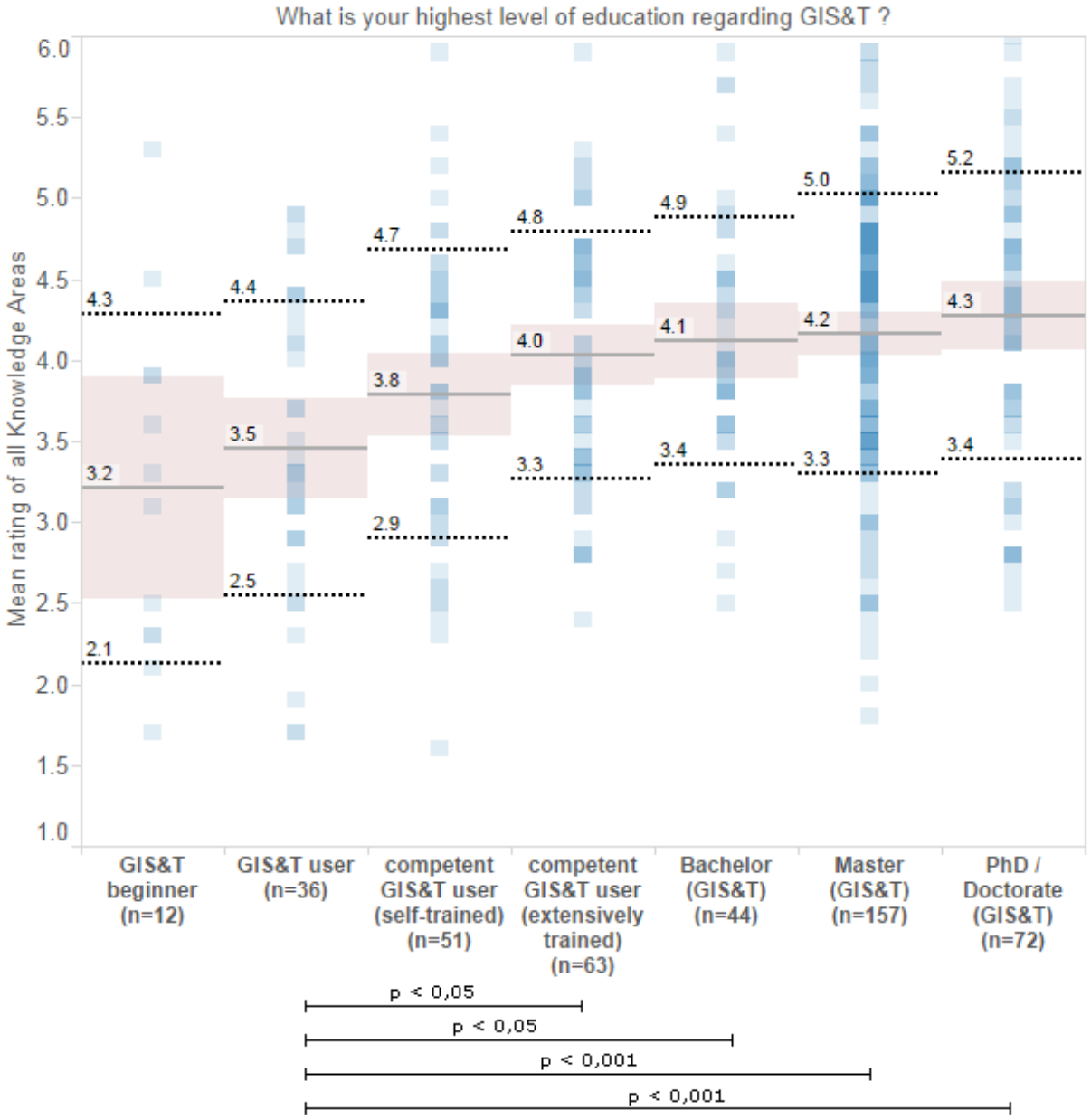

Figure 12 Mean rating of KA averages by educational level of respondents. Shaded areas around the means represent the 95% confidence interval for mean locations, dotted lines show plus/minus one standard deviation from the mean. Strong, saturated colours indicate many ratings at the respective averaged value. In the bottom significance levels for significantly different means of EQF-pairings are indicated.

On the individual KA-Level the general trend of the overall higher ratings by better educated people is clearly visible again (Figure 13). Exceptions of this general trend can be seen in the KA data manipulation that was assigned the highest importance by respondents with a Bachelor degree, followed by Masters, extensively trained GIS&T users and PhDs only on the 4th rank. Although this result is not statistically significant, there might be still a relation to typical job profiles present.

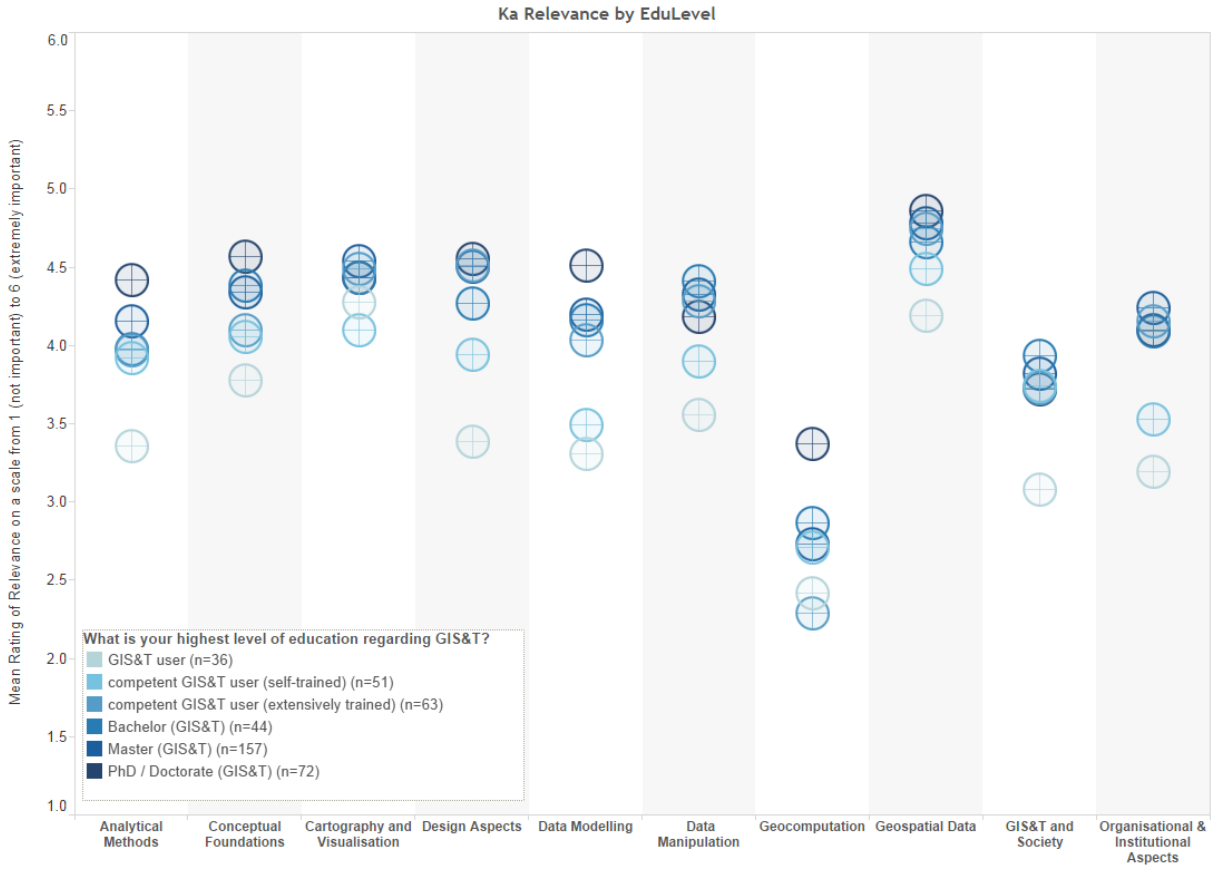

Figure 13 Rating of knowledge areas by the educational level of respondents. GIS beginners (EQF 2) are not shown here due to their small sample size.

A detailed look at the Unit level revealed that especially more technically oriented competences like DB transaction management are rated less important by PhD holders (EQF 8) compared to respondents of lower EQF levels (Figure 14). The latter are predominantly working in public administrations or private companies, where such issues might be of higher relevancy.

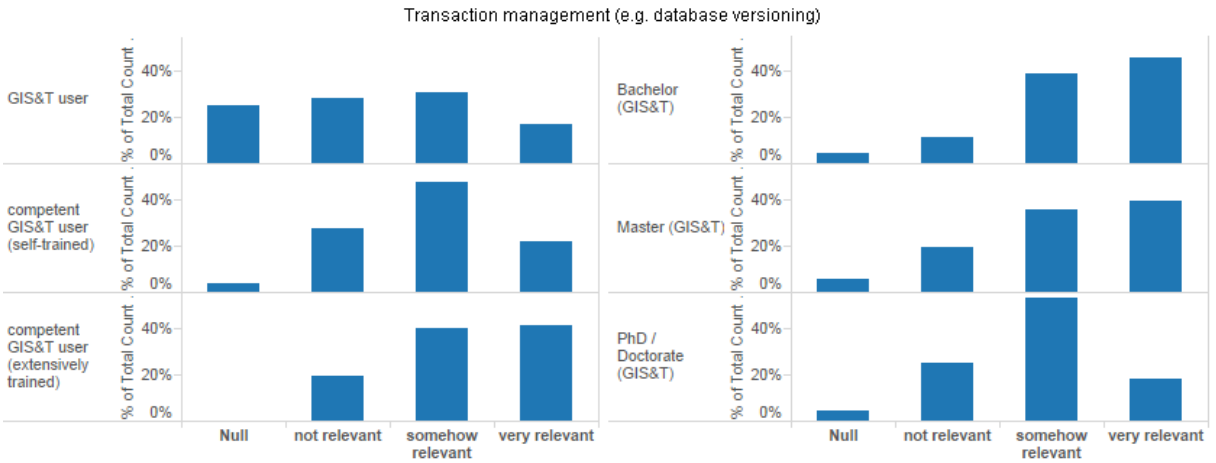

Figure 14 Rating of the unit "Transaction management" from the KA Data Manipulation (How relevant have the following competences been in your professional work in the last year?)

In contrast *Geocomputation* and *Data Modelling* were significantly higher rated by PhD holders. As discussed this might be related to the relatively high percentage of that respondent group working in academia and the too specialized tasks of several methods covered by this KAs for typical non-academic yet professional working contexts. For example in Data Modelling half of EQF 8 respondents rated the unit "modelling 3D, uncertain and temporal phenomena" as "very relevant" for their professional work, whereas only every fourth respondent on lower EQF levels shared this opinion.

The free-text analysis provides a complementary view on the profile of GIS workforce at different educational levels. Table 8 shows the similarity of frequently performed tasks. Not surprisingly, the daily working routine for a doctorate holder was clearly different compared to a GIS beginner and it got more and more similar the higher the educational level was. Interestingly, the difference between two succeeding educational levels diminished at higher levels. Whereas work tasks of a GIS beginner (EQF 2) compared to a GIS user (EQF 3) only had a low similarity (CSI=0.4), the tasks of GIS professionals, EQF 7 and EQF 8 were very close (CSI=0.89).

A very similar pattern could be observed for learning aims of professionals at different educational levels (

Table 9). Here, the learning aims of a GIS beginner (EQF 2) had only marginal similarity to the ones of a GIS user (EQF 3). The GIS&T BoK had greater similarities to the learning aims of higher educated professionals: the similarity index was low for EQF 2 professionals (CSI=0.46) and comparatively higher for EQF 8 professionals (CSI=0.66).

Table 8 Frequently performed tasks - EQF level

	EQF2	EQF3	EQF4	EQF5	EQF6	EQF7	EQF8
EQF3	0.40						
EQF4	0.44	0.68					
EQF5	0.51	0.72	0.78				
EQF6	0.53	0.66	0.70	0.82			
EQF7	0.54	0.73	0.78	0.91	0.86		
EQF8	0.53	0.68	0.74	0.84	0.80	0.89	
GIS&T BoK	0.50	0.49	0.55	0.64	0.65	0.69	0.66

Table 9 Learning aims & GIS&T BoK - EQF level

	EQF2	EQF3	EQF4	EQF5	EQF6	EQF7	EQF8
EQF3	0.25						
EQF4	0.33	0.42					
EQF5	0.33	0.56	0.66				
EQF6	0.28	0.49	0.61	0.66			
EQF7	0.38	0.51	0.76	0.78	0.72		
EQF8	0.41	0.44	0.73	0.68	0.67	0.86	
GIS&T BoK	0.46	0.39	0.60	0.54	0.53	0.63	0.66

Word clouds provide a better understanding of the nature of the differences between tasks performed by professionals of different educational levels (Figure 15). GIS beginners (EQF 2) showed a clear grounding in various application domains (forest, water), whereas GIS users (EQF 3) performed tasks more related to classical GIS (maps, cartography, database), and professionals with a PhD (EQF 8) had a focus on academic tasks (teaching and research).

Figure 15 Frequently performed tasks are highly dependent on the qualification level; There is a significant difference in frequently performed tasks between EQF 2, 3 and 8.

Learning aims of GIS beginners (EQF 2) have a wide range, with a common denominator of 'statistics' (Figure 16). The slightly more advanced GIS users (EQF 3) want to learn more about (data) management and Inspire, whereas PhD holders (EQF 8) placed their learning objectives in advanced fields such as modelling, Web(GIS), application development and geocomputation.

Figure 16 There is a significant difference in learning aims between EQF 2, 3 and 8.

4.6 GIS&T BoK - future trends and potential gaps

Future trends of the GIS&T domain as foreseen by survey respondents are reflected by the collected answers to the survey question: '*Which competences will gain importance in the next 5 years*' (see word cloud in Figure 3, top right). The replies largely point into the same direction that was indicated by (Câmara et al., 2009). Mobile and web technologies are expected to gain importance as well as related topics like applications and development. However, '*analysis*' is expected to continue as an important part of GI expertise.

At first sight, the gap analysis pointed at a strong mismatch between the current and future workforce demand and the GIS&T BoK. Almost one quarter of keywords that were mentioned with respect to frequently performed tasks were not covered by the GIS&T BoK. Not surprisingly, the gap between the GIS&T BoK and prospectively important competences and individual learning aims is even larger. About one third of keywords mentioned in the survey are absent in the GIS&T BoK.

Table 10 Free-text responses yielded a high quantity of terms, of which some not mentioned in the GIS&T BoK.

	Unique terms after pre-processing	Unique terms, not in the GIS&T BoK
frequent tasks	685	167 (24 %)
future competences	741	256 (35 %)
learning aims	574	184 (32 %)
GIS&T BoK	2768	-

However, upon closer inspection the gaps are not so dramatic when it comes to actually missing concepts. Many keywords of the gap analysis relate to abbreviations, to a specific geographic region (e.g. Reykjavik, Pristina, African, Dutch), an application domain (e.g. meteorology, railway, hydraulic, forest, agriculture, wastewater), to teaching (e.g. student, advisor, BSc, MSc, postgraduate, curricula) or to specific software tools (e.g. shapefiles, ArcGIS, R, Oracle, LAStools). The remaining keywords point at topics that are not or only partly covered in the current GIS&T BoK, including programme development, WebGIS, SDI, data acquisition and other 'hot' topics such as augmented reality or the 3D modelling standard 'CityGML' (Table 11).

Table 11 Gap analysis: Terms in the free-text responses that are not mentioned in the GIS&T BoK.

Frequent tasks	Future competences	Learning aims
	Programme development	
data archive	plugin	object oriented programming
frontend	javascript	java
API	API	python
geojson	VGI (voluntary geographic	javascript
python	information)	
	WebGIS	
webgis	webgis	web GIS
web application	html5	RESTful
geoprocessing	smartphone, mobile	semantic web
	GPRS	
	SDI	
Inspire	harmonization	INSPIRE
harmonization	19107, 19109	
geoportal		
	data acquisition	
UAV	OSM	open data
	UAV	crowd sourcing
	drone	VGI
	GNSS (Global Navigation Satellite	big data
	System)	UAV
	mass data, big data	GNSS
		Radar Remote Sensing, SAR
	other 'hot topics'	
geomarketing	semantics	augmented reality
2D	OBIA (object based image analysis)	indoorGML / City GML
	geomarketing	4D
	4D	OBIA (object based image analysis)
	BIM (building information model)	
	data archive	

4.7 Expert interviews

Stakeholders have diverging opinions on currently needed competences on the GIS&T job market, where those from the private sector seem to be least coherent in their expectations towards GIS&T professionals. Some of them primarily expect profound IT skills *'If we get applications from classically trained GIS students, we have to reject their job applications',* others are explicitly looking for job applicants that *'understand the power of location'* and have the ability to *'translate business processes into GI applications'.* While skills in software development and DBMS are expected qualifications, some respondents point out that there are also jobs requiring *'a more operational, general knowledge'* or are more focused on the understanding of an application domain and consultancy in this respect. In the public administration sector the link between needs of application domains like environment or traffic and GIS knowledge combined with a respective set of skills was highlighted by one third of the interviewed stakeholders. One of them explicitly distinguished two job roles: technically oriented jobs to deliver GI services and project oriented jobs requiring more understanding for underlying concepts. Another respondent expressed this as follows: *'cooperation is important, with the GI people as a spider in the middle'*. Apart from lists of typical GIS&T skills like spatial analysis, data handling, cartography etc., programming skills are playing a role in public administration jobs as well. From the perspective of academia it seems necessary to have a good understanding of spatial databases as this was mentioned by 5 of 7 stakeholders. In addition to master recent GIS&T concepts and their practical application in an interdisciplinary manner, competences in the provision of GIS in mobile application and the design of web services are needed as well.

In the assessment of competences needed in the future the interviewees of the private sector do express quite different opinions. This might be due to the small sample in relation to the variety of company profiles and the diversity of markets within different parts of Europe. While the need for qualified personal to integrate *'massive amounts of data'* making use of *'noSQL databases'* seems to be a rising issue in the private GI-business of central Europe. In addition competencies in software development were explicitly mentioned by three representatives. In contrast the interviews with stakeholders from Eastern Europe stress the importance of project management skills and the combination of GIS&T knowledge with knowledge on subject areas. This *'emphasis of interdisciplinary knowledge', 'project management abilities'* and other soft skills were also mentioned to be increasingly important by Hungarian and Bulgarian representatives of public administration. A shift of skills form proprietary to open source software was noted as well from this side. From the interviews of public administration representatives from Central and Western Europe a relatively homogeneous view of the future can be extracted: It is widely expected that mobile sensors and applications will need qualified personal that can handle the related technologies as well as the resulting, highly dynamic data. Huge amounts of sensor data must be integrated, processed and delivered via user friendly devices and interfaces. The need to handle data from *'ubiquitous sensors'* in *'real time'* was also expressed by most representatives from academia. The GIS&T workforce will therefore '*be less needed to acquire (primary) data'* but to process remotely or in situ sensed data and '*make it usable to the society'* by '*using new technologies (e.g. HTML5)*'.

The job market appears to vary considerably throughout Europe. However, there was a common denominator in terms of gaps between workforce demand and educational offers. Representatives of the private sector evaluate the job market differently, ranging from '*no problem to find employees*' and '*slight oversupply features the market'* to '*industry needs more good graduates*' and a plain '*it is difficult to find GIS&T experts*'. Three major deficits are described repeatedly, i.e. IT skills, the competence of applying theoretical knowledge to real-world problems and soft skills such as command of (English) language and team working. The situation in the public sector appears to be a bit more critical. All but one of the stakeholders, who are affiliated to the public sector, describe difficulties in finding adequate GIS&T staff: "*In general it is not easy to find well prepared people with the skills we need*". In accordance with the private sector it is the deficits in '*experience in working with reals world data',* and soft skills that are missing. A lack of *'programming knowledge'* was also mentioned by one representative, but it seems to be a less important competence in administration. In the academic world the job market is perceived as '*good*', which means that GIS&T graduates '*find a job relatively easily*'. One interview partner specifically pointed at deficits in the current GIS&T education in terms of combining '*geo competences*' with '*IT competences*'. Along the same lines several interview partners spotted '*programme development*' and '*software engineering*' as deficits in current GIS&T curricula. Generally, representatives from academia agreed that job opportunities are increasing with the level of education. One academic interview partner expressed this point as follows: '*on the long run, an academically educated person*

will do a much better job than a graduate from a polytechnic institute, because he / she understands underlying concepts much better'.

Several initiatives to better match education with workforce demand were suggested and actively pursued by the interviewed GIS&T stakeholders with no major differences across organisations types. Frequent references were made towards further promoting internships as integral part of an academic degree. Further, several stakeholders believe that academia should strengthen its role in life-long-learning offers, and some companies offer in-house training courses. Additionally to explicit training initiatives, 'learning by doing' is also perceived as an important factor: '*we would not expect a university to teach students a specific software – this is something they will learn on the job*'. Especially representatives from private companies report on their engagement in awareness raising campaigns amongst school children and teachers such as GIS Day and alike. Many stakeholders perceive communication and networking as the basis of working towards a better match of educational programmes with the workforce demand. One representative of a private company reported to '*provide feedback to the GI-institute and thus influence education*'. A representative from academia in turn mentioned an existing joint network of regional GIS companies with university that was specifically founded '*to facilitate contacts*'.

Only 6 of 21 interview partners were aware of the GIS&T BoK, where only three make (or made) active use of it. Each of the three interview partners work in academia and used the GIS&T BoK in the context of curriculum development. However, some further potential uses were identified by stakeholders outside academia, if '*it was more practical oriented*'. Several representatives from private sector perceive the GIS&T BoK '*strongly academic*' and '*way too theoretical*', where private companies '*rather need an easy-to-use and more straightforward tool*'. A suggestion from the academic sector related to using the GIS&T BoK for student self-assessment. A stakeholder from Germany, who represented the public sector, suggested using the updated GIS&T BoK as a foundation for the new competence-oriented salary system in the German public administration.

5 Conclusions and links to other tasks in GI-N2K

As a remarking result on its own the high number of survey respondents throughout Europe needs to be highlighted. This can be attributed to a high-quality network of partners and a general interest in the topic. The results presented in this report are thus grounded on a sound basis.

The survey confirmed GIS&T to be a highly dynamic domain. The GIS community identified an accentuated shift in focus from map making and local database handling towards online and mobile technologies based on spatial data infrastructure with a massive amount of data to be integrated. Application development is expected to play an increasing role in customising individual solutions. The survey results showed a strong interest of the GIS&T community in obtaining the respective competences.

The GIS&T community evaluated the relevance of the content of the current GIS&T BoK in their professional work differently. Geospatial data and Cartography was considered most relevant, whereas advanced Geocomputation methods had the lowest rating. The KA *GIS&T and Society* had the highest respondent numbers in the "somehow relevant" category and a weak rating of 'Critical GIS' – an indication that GIS&T is still primarily seen as a technical discipline.

The three main sectors – public administration, private organisations and academia – evaluated the GIS&T BoK Knowledge Areas congruently. Although frequently performed tasks differ across sectors, they show a consistent similarity when compared to the GIS&T BoK. This finding is congruent for the ratings of KAs and the free-text analysis, only the NGOs seem to have a diverging focus. Differences appear only upon a more detailed analysis of the 2nd hierarchical (Unit) level, where academia had a somewhat specific profile; academics tend to rate Geocomputation and Analytical Methods higher.

The assessment of the GIS&T BoK's relevancy is related to the educational level, where the rating increases with the level of education of respondents. PhD holders generally rate the importance of Knowledge Areas highest. However, technically oriented competences like DB transaction management are rated less important. Whereas GIS beginners use GIS as a tool in various application domains, more advanced users have a stronger focus on GIS&T-specific tasks. Accordingly, the similarity with the GIS&T BoK hierarchy increases with the educational level.

Finally, the gap analysis point at topics that are not fully covered in the current GIS&T BoK, including programme development, WebGIS, SDI, data acquisition and other 'hot' topics such as big data and augmented reality.

From a complementary view, the semi-structured interviews confirmed the above results and embedded the findings in a broader context. Generally, leading GIS&T experts rarely know the GIS&T BoK and even less make use of it. Currently, the use is restricted to curriculum development in academia. However, the role of a demand-driven GIS&T BoK to guide educational programmes was appreciated. Further potential applications were identified, such as a tool for student self-assessment, or a benchmark for competence-oriented salary schemes in public administration. In terms of content-related gaps between workforce demands and GIST&T education the discussions largely evolved around the integration of 'geo' with 'IT', where a general lack of IT-related competences was stated.

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Annex I – Survey questionnaire

GI - Need To Know

Help us to make GI education fit for the future!

Geographic Information: Need to Know - towards a more demand-driven geospatial workforce education/training system
European project under the Life Long Learning Programme

Help us to make GI education fit for the future!
Our domain - Geographic Information Science & Technology (GIS&T) - is constantly changing. To keep up to date with market demands, GIS&T education needs to closely follow technological development and societal issues.
The aim of this survey is to identify today's and future workforce needs to educate GIS&T experts accordingly.

We need YOUR help in reaching this aim :) !

For the GIN2K survey team,
Dr Barbara Hofer, Mag Christoph Traun, Dr Gudrun Wallentin
University of Salzburg | Interfaculty Department of Geoinformatics - Z_GIS
Hellbrunnerstrasse 34 | 5020 Salzburg, Austria

Privacy statement
We respect your privacy. Only non-identifiable data will be stored and answers will not be connected to email addresses.

There are 38 questions in this survey

You and your organisation

[]In which country do you currently work? *

Wenn Sie 'Sonstiges:' auswählen, spezifizieren Sie bitte Ihre Auswahl im entsprechenden Textfeld.

Please choose only one of the following:

- ○ Austria
- ○ Belgium
- ○ Bulgaria
- ○ Croatia
- ○ Cyprus
- ○ Czech Republic
- ○ Denmark
- ○ Estonia
- ○ Finland
- ○ France
- ○ Germany
- ○ Greece
- ○ Hungary
- ○ Ireland
- ○ Italy
- ○ Latvia
- ○ Lithuania
- ○ Luxembourg
- ○ Malta
- ○ Netherlands
- ○ Poland
- ○ Portugal
- ○ Romania
- ○ Slovakia
- ○ Slovenia
- ○ Spain
- ○ Sweden
- ○ Turkey
- ○ United Kingdom
- ○ Other

[]How can your organisation be best characterised? *

Please choose only one of the following:

- ○ academic institution
- ○ public administration
- ○ private company
- ○ NGO

[]

How can your role in your organisation best be described?

*

Please choose only one of the following:

- ○ GIS&T user
- ○ GIS&T expert (analyst, researcher, educator)
- ○ GIS&T project manager
- ○ Manager of a GIS&T group (department, company,..)
- ○ I am not involved with GIS&T in my job

* GIS&T = Geographic Information Science and Technology

[]What is your highest level of education regarding GIS&T? *

Please choose only one of the following:

- ○ GIS&T beginner
- ○ GIS&T user
- ○ competent GIS&T user (self-trained)
- ○ competent GIS&T user (extensively trained)
- ○ Bachelor (GIS&T)
- ○ Master (GIS&T)
- ○ PhD / Doctorate (GIS&T)

Most important GIS&T competences in your job

[]

Consider your job: which GIS&T related taks do you frequently perform? Describe with keywords.

For example, asked about his job, a medical doctor could answer "establish a diagnosis by physical examination"

Please write your answer(s) here:

Task 1	
Task 2	
Task 3	

GIS&T competences - "Analytical Methods"

[]

How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
apply query operations (e.g. SQL)	○	○	○
measure geometric properties (e.g. distance, area, connectivity)	○	○	○
use basic analytical operations (e.g. buffer, overlay, map algebra)	○	○	○
analyse spatial data (e.g. point pattern analysis, multi-criteria evaluation)	○	○	○
analyse surfaces (e.g. viewsheds, cost surfaces, calculate slope)	○	○	○
use spatial statistics (e.g. Morans I, spatial weights matrix)	○	○	○
use geostatistics (e.g. Kriging, semivariogram modelling)	○	○	○
apply spatial regression (e.g. geographically weighted regression)	○	○	○
data mining (e.g. BigData handling, knowledge discovery)	○	○	○
analyse networks (e.g. graph theory, routing, utility networks)	○	○	○
mathematical optimisation (e.g. operations research, linear programming, location-allocation)	○	○	○

[]Please weight the overall relevance of Analytical Methods (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Conceptual Foundations"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
Understand elements of geographic information (e.g. discrete entities, fields, events)	○	○	○
Understand relationships (e.g. topological, geometric, geneological)	○	○	○
Understand imperfections in spatial information (e.g. vagueness, uncertainty modelling, fuzzy sets)	○	○	○

[]

Please weight the overall relevance of Conceptual Foundations (summarising the above topics) on a scale between 1 and 6.

*

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Cartography and Visualisation"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
preparing data for map production (e.g. classification, generalisation, map projection)	○	○	○
designing maps (e.g. symbology, typography, colour schemes)	○	○	○
choosing adequate graphic representations (e.g. thematic maps, interactivity, web mapping)	○	○	○
producing maps (e.g. map reproduction, colour separation)	○	○	○
using and evaluating maps (e.g. map interpretation, usability evaluation)	○	○	○

[]Please weight the overall relevance of Cartography and Visualisation (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Design Aspects"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
define projects (e.g. problem definition, user assessment, requirements analysis)	○	○	○
planning project resources (e.g. feasibility analysis, data costs, funding)	○	○	○
designing databases (e.g. conceptual-, logical-, physical modelling)	○	○	○
analysis design (e.g. defining analytical procedures, coupling scientific models)	○	○	○
application design (e.g. user interfaces, workflow analysis, CASE tools)	○	○	○
implementing system (e.g. implementation planning, system testing and deployment)	○	○	○

[]Please weight the overall relevance of Design Aspects (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Data Modelling"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
know about storage and retrieval structures (e.g. hash-tables, binary trees, indices)	○	○	○
understand database management systems (e.g. relational DBMS, OO-DBMS)	○	○	○
know about tesselation data models (e.g. raster, TIN, hexagonal grid, hierarchical models)	○	○	○
differentiate vector and object data models (e.g. topological model, network model)	○	○	○
modelling 3D, uncertain and temporal phenomena (e.g. spatio-temporal GIS)	○	○	○

[]Please weight the overall relevance of Data Modelling (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Data Manipulation"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
transforming data representations (e.g. data model conversion, format conversion)	○	○	○
generalise and aggregate data (e.g. scale-dependent generalisation, transformation of attribute measurement levels)	○	○	○
transaction management (e.g. database versioning)	○	○	○

[]Please weight the overall relevance of Data Manipulation (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Geocomputation"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
using advanced computational methods (e.g. neural networks, grid computing)	○	○	○
using cellular automata (e.g. define transition and neighbourhood rules, apply CA)	○	○	○
using heuristics (e.g. simulated annealing)	○	○	○
apply genetic algorithms (e.g. location optimisation)	○	○	○
developing agent based models (e.g. model specification, calibration, encoding)	○	○	○
simulation modelling (e.g. Monte Carlo simulation)	○	○	○
assessing uncertainty (e.g. error propagation, MAUP)	○	○	○
using fuzzy sets (e.g. fuzzify spatial decision making)	○	○	○

[]Please weight the overall relevance of Geocomputation (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Geospatial Data"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
working with land partitioning systems (e.g. cadastre)	○	○	○
using georeferencing systems (e.g. geographic coordinate systems, linear referencing)	○	○	○
specify geodetic datums (e.g. WGS84, vertical datums, NAP)	○	○	○
understand map projections (e.g. projection classes, properties and parameters)	○	○	○
assess data quality (e.g. geometric or thematic accuracy and resolution)	○	○	○
land surveying and GPS	○	○	○
digitising (e.g. with tablet, on-screen or automated vectorisation)	○	○	○
collecting field data (e.g. select sample size, field data technologies)	○	○	○
aerial imaging and photogrammetry (e.g. image interpretation, feature extraction)	○	○	○
remote sensing (e.g. applying algorithms and processing, accuracy assessment)	○	○	○
metadata, standards and infrastructures (e.g. SDI, INSPIRE)	○	○	○

[]Please weight the overall relevance of Geospatial Data (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "GIS&T and Society"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
know about legal aspects (e.g. liability, privacy, contract law)	○	○	○
considering economic aspects (e.g. cost-benefit analysis)	○	○	○
manage GI in the public sector (e.g. public participation, eGovernment)	○	○	○
GI as property (e.g. copyright issues, property regimes)	○	○	○
disseminate geospatial information (e.g. data sharing, open access, security)	○	○	○
considering ethical aspects (e.g. codes of professional ethics)	○	○	○
consider the approach of Critical GIS (e.g. feminist critique, social critique)	○	○	○

[]Please weight the overall relevance of GIS&T and Society (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

GIS&T competences - "Organisational & Institutional Aspects"

[]How relevant have the following competences been in your professional work in the last year?

Please choose the appropriate response for each item:

	not relevant	somehow relevant	very relevant
managing the GI system operations and infrastructure (e.g. system revision, user support)	○	○	○
set up organisational structures and procedures	○	○	○
develop GIS&T workforce (e.g. offer training, education, staff development)	○	○	○
connecting institutions' GIS&T (e.g. technology transfer, data sharing)	○	○	○
coordinating organisations (e.g. organise professional organisations, edit GIS&T publications)	○	○	○

[]Please weight the overall relevance of Organisational & Institutional Aspects (summarising the above topics) on a scale between 1 and 6. *

Please choose the appropriate response for each item:

1 - not relevant	2	3	4	5	6 - extremely relevant
○	○	○	○	○	○

[]Additional comments?

Please write your answer here:

Future demand of GIS&T competences

[]

In your opinion, which three competences will gain importance in GIS&T in the next 5 years?

Please write your answer(s) here:

GIS&T competence 1	
GIS&T competence 2	
GIS&T competence 3	

[]

Which GIS&T competences would you personally like to obtain / enhance?

Please write your answer(s) here:

GIS&T competence 1	
GIS&T competence 2	
GIS&T competence 3	

Annex II – Semi-structured interviews

Semi-structured interviews: GIS&T workforce demand

	Private	Public	Academic
	Needed competences: Which GIS&T competences are currently required in the job market in your country? E.g. which competences are listed in a job description in your institution?		
AT	Primarily we need developers: persons who have a background in IT, who are trained in programme development, UML, system architectures and also database management. And they should have also an understanding of the geospatial domain. However, if we get applications from classically trained GIS students, we have to reject their job applications. In the private sector, classical GIS analysis might still be relevant, but not for Grintec.	Common sense and solution oriented thinking is most important! A good understanding of spatial data and creative approaches to make use of them set them into the right context. Two types of jobs in this organization: - more technical oriented (Server side GIS, GDI, programming) - more project oriented (Spatial analysis, modeling complex questions in GIS, project management)	- Ability to provide services for geodata and analysis results as well as for (public) participation and interaction. - Services for mobile applications with the user experience in mind - Competence in spatial DBs, data mining and big data analytics
BE	Not all GI professionals need to be GI specialists, several jobs in GI job market require a more operational/general knowledge; not all GI professional needs to know the underlying concepts and technologies behind certain solutions/software, some of them just need to be able to work with them. Additional information (smeSpire project) available	Analysis of the Flemish geo-information sector was performed in 2013, based on a survey among 488 (public and private) organizations in Flanders.	Geospatial data management as the core area of competences, but also Online GIS, (mobile) geo-application development, web-service development, (vehicle) tracking and tracing, navigation (GPS, Galileo,…) are important areas.
BU	- The importance and the usefulness of GIS&T is still unconscious need for the business in Bulgaria and as a consequence in the job market. The GIS&T competences required are not well defined as there is not enough knowledge about the area. - Good knowledge in geodesy, cartography, geodata management (subject area of a company or administration), and general knowledge on GIS as an instrument.	Knowledge currently is required in two areas: GI Science: understanding the nature of geospatial data and information and the theory of geo analysis, GI Technologies: geo databases, database relationships, data structure and organization, GIS, programming in computer languages, working with GI applications A job description includes: base knowledge on geodata, GIS, GIS analysis, processing and developing cartographic materials, working with geodatabases	Along with knowledge in the professional field it is required to have computer literacy, working and management of databases in their area.
BU2		There are different requirements for different positions but in general it is required to have good competence with IT in general and skills on ArcGIS	Well educated and qualified specialists, which can practically use professional GIS and Open source GIS software. Also, they should to have

		or relevant software. In my job description it is indicated to have good knowledge and skills on specific GIS software.	theoretical and practical knowledge about geodata base, ability to combine them and perform different analyses. In our institute incoming students have completed education and familiar with GIS. They should have the skills to using modern GIS&T software, to have a thorough knowledge in this area and to have computer skills to solve problems in interdisciplinary research.
GE	Scientific competences: - scientific methods (not only referring to GI); - concepts of modeling and processing GI Technological competences: - to know up-to-date technologies and tools (e.g., GIS, databases, web technologies) - architectures and solutions (which is more than just technologies, also including human components and engineering components for achieving solutions - standards, e.g., OGC, INSPIRE - project management and other soft skills in my institution: depending on the area we are looking for candidates; competences as described above, but in addition - soft skills more relevant, e.g., communication skills, motivation, management skills - domain know-how, e.g., water, air - varying GI skills, such as geo-databases, web services, location-based services, standards	Required competences: - GIS - Concepts of spatial data - Know-how in data analysis - Spatial data infrastructures - OpenGIS - Standards (ISO, OGC) - Thematic cartography - Visualization - (spatial) data acquisition/surveying and photogrammetry - Scanning geodata - Project management - Personnel management - Teamwork in my institution: - depending on the area we are looking for candidates - specialized know-how, e.g., German cadaster (ALKIS)	Required competences: - Basic know-how in computer science, mathematics, geography - Soft skills - Up-to-date GI technologies and applications, such as web technologies - Ability to develop GI applications - Ability to adapt existing GI components - Interdisciplinary understanding of space and time in my institution: As above, but additionally - Man-machine interaction - Extended soft skills
HU	Advanced GIS and related competences (handling of large spatial databases, queries, Basic programming in SQL, script languages, analytical operations, data mining, network analysis, time domains, elements of GI, geospatial data, georeferencing systems, metrical and topological relationships, fuzzy sets, cartographic visualization, DB design implementation of a specification, Data modeling, data manipulation, Project management, legal aspects – data copyrights, geopolitical issue handling, geo data administration All of the fields mentioned above are important; GIS specialist should solve various GIS data conversion problems. The most important five fields: topological relationships, queries, data	Competencies supplied by universities are adequate from professional aspect, despite fast development in technology. Contribution with industry is very important! A practical semester is reasonable in higher education, where students have the opportunity to work in projects. Competencies from other aspects are not so satisfying, such as communicational skills (i.e.: preparation of technical or managerial documents, using legal frames).	

	manipulation, analytical operations, visualization. And English language is very important.		
HU2	General, political, legal environment is important. Compared to developed countries in GISc&T aspect, for example the USA, Hungary is at the beginning of a strong developing phase. Graduated students use only a small part of learned knowledge in practice, but this knowledge is not necessarily suitable with concrete requirements. Knowledge of widely used software is usually not a problem, but manipulating databases proves to be difficult. GI companies in private sector often implement work for export, in such situation professional partner usually assign the workflow itself, therefore training is ensured if needed. Trainings are great opportunities to measure competencies. Flexible competencies are favourable, i.e.: working on Windows or Linux platform, using several different GIS software. Basic knowledge is essential, for instance digital image processing knowledge, while using software like eCognition or ERDAS; Mapping knowledge like projections, reference systems; knowledge in connection with reliability. Development is not a necessity, as private sector hardly ever expects this kind of knowledge. Very simple tasks like screen digitalisation is a frequent task for graduated professionals, as a result of labour market and current crisis.	- having wide range knowledge on information technology - high level user experience on data acquisition - high level skills on data base development - high level skills on data handling - high level skills on analyses	
ES	our company has more than 100 job openings, ranging from marketing to software development. the competences vary, but overall we are looking for technically competent people who are pasionate about using gis to help solve real problems for real people. an important competence these days is programing, both as expert software engineers and less expert customizers or scripters. exeprtise in spatial analysis is a big plus, as is database experience. competence in decision making and in group collaboration is also important.	knowledge and experience in web programming, GIS libraries, java and other languages, basic knowledge in spatial analysis.	- GIS development for Web and mobile platforms - Data modeling - Geospatial database administration - Data analysis
NL	Spatial awareness and spatial thinking. Understand the power of locations and the added value of an approach that	- Technical: focus on knowledge about geographical analytical options and about geo databases.	The HAS as educational institutes lists the following competences as they are in their curriculum:

	incorporates the spatial perspective and the importance to notice spatial patterns. This asks for a multi-disciplinary approach. Also, competences are needed to translate relevant business processes in GI relevant applications (GI technical skills). About data, the skills are needed to recognize what data is needed and available for specific solutions. In general, skills are needed to apply standard GI techniques as well as to think of new concepts or existing concepts in new environments. For hard core IT skills recruitment is possible outside GI-world, although they as well should be able to think spatially.	Besides, knowledge/skills linked to specific software used at location. - Contents: knowledge about major discipline related projects. - Organisations: consultancy skills and the ability to create a sense of geo awareness with your customers.. - Application of geo-information in work processes; be able to link contents (problem at hand, policy) and GI-technique. Most GI-consultants start from the technical viewpoint, instead of the real needs of the customer. Links also to the primary need to raise geo awareness in an organization.	- Competence 1 Design and application GIS - Competence 2 Design and development of digital geo-information - Competence 3 Geographical thinking and working - Competence 4 Geo-visualization and visual interaction - Competence 5 Sustainable development of rural areas - Competence 6 Initiating and supervising creative and innovative processes - Competence 7 Entrepreneurial and successful work - Competence 8 Project work - Competence 9 Communication Important is spatial awareness in relation to applying GIS for a whole range of disciplines. GeoICT is needed, but HAS students rather use than build GI systems. It is linking IT and GI with "green" application. They deliver "smart GI-people", data collection is less important than visualization, the importance of GI analysis is growing. Teamwork/co-operation is important, with the GI people as a spider in the middle. This explains the importance of project work.
NL2	TNO hires not often personnel right from the university. Tool building is a prominent activity, "standard" GI(S) work is less important, only as part of a project. Next to people able to develop tools, TNO looks for people able to understand mathematical models . Next, a disciplinary background is needed, with a critical, academic attitude, with a quality-oriented mindset.	- Basic GIS knowledge in analytic functionality and techniques - Be able to link basic GIS knowledge to substantive knowledge fields (environment; traffic; planning; etc)	
		-	
	Future competences: Do you think that the focus shifts? which competences will gain momentum and what will be less important?		
AT	In the future, we will have to deal much more with data integration from multiple data sources. There will be massive amounts of data to be handled: BigData. In the same direction, we need to integrate these data and build SDIs. Standards will become much more important.	Gain momentum: - Mobile Applications (incl. Geodata management) - Integration of GIS with other (non spatial) systems - Standards, data interfaces, legal aspects Less importance: - Nothing (classical GIS Skills are still important)	Gain momentum: - Ubiquituous sensors (in situ sensors, floating car data) - Realtime process monitoring and control Less importance: - Primary data aquisition, surveying, photogrammetry (since much is coming from sensors ...) - coding as a professional skill (it is

			still important to understand how a process can be modelled as code in general (and having some practical experience), but not to master several computer languages)
BE	Due to technological developments, certain traditional aspects become less relevant and less important (i.e. surveying). Combination of Geo + Informatics considered to become more important Another competence that will become more important: processing of satellite data Difficult to determine the future competences due to rapid rate of new developments	-	Real-time applications, location-based services and (remote) sensing are areas that become more important. As a result, basic 'geospatial data management' competences in many cases become less important, although these basic knowledge remains necessary (as it is the core of GI S&T)
BU	a) Yes, I think so. At the moment the companies more rely on the GIS specialists to solve the technical problems in their fields. The problem is, that the GIS is only a tool. Much more important is the specific knowledge in the concrete area. That required the knowledge of different professionals to be enlarged in GIS&T and it to become as basic competence. b) Competences in subject areas as geodesy, cartography, urban planning, statistic and others combined together with competences in GIS&T will gain momentum. The knowledge about technical details in IT for self developing of GI applications (for company use) will be less important because of the rapid development of GI S&T globally and introducing them in the business.	The focus shifts mostly in the direction of GI Technologies with the emphasis on interdisciplinary knowledge The GI market in Bulgaria is quite narrow and as consequences the competence in selected GI applications and interdisciplinary knowledge will gain momentum.	a) I definitely think that the universities undertake efforts to introduce GIS&T in the curricula. For example our university recently approved the course "Information Technology in ecology" of Master graduate programs. The representative of the National Agency of Education and Accreditation showed undisguised interest to this course and proposed and encouraged the university to create a new Master Degree program on GIS&T. For this the university needs expertteachers in Photogrammetry and Remote Sensing. b) Mainly knowledge of cartography, statistical methods for data processing. Knowledge on satellite data processing is increasingly necessary. It is not enough to have only appropriate tools in a GIS software, but to know what, why and how to use them. For example, a huge selection of projections does not mean you can choose what you like or you can choose the interpolation process that is not suitable for data that are available. Always, there is a moment when you do not expect, it turns out that "learned something" is not redundant. As students we were wondering why we were harassed "Satellite Geodesy" with a million coordinate systems. Well, the time of GPS, right?
BU2		The focus will shift from competences in commercial software such as ArcGIS or MapInfo to open source software competences.	In our country it is difficult to make such a conclusion, due to unclear situation in GIS&T market. Of course, everyday life imposes to resolve different interdisciplinary problems which require more qualified GIS&T

			specialist with good professional competences and good communication abilities. The ability to apply knowledge to complete tasks and solve practical problems related to GIS&T applications. Maybe the less important at that moment is a person's ability and readiness to act in an independent and responsible manner when have to work in a team.
GE	Gain momentum: - noSQL databases - web of things and open systems - semantic web less important - classical GIS	Gain momentum: - Usage of spatial data, e.g., information retrieval - Visualization - Web GIS - 3 D - Linked data, systems, and organizations for better exploitation of GI less important: - (spatial) data acquisition, e.g., vectorization	Gain momentum: - It is quite normal that in future other GI products, programming languages, and also new concepts (such as web GIS) will pop up – whatever these will be - Big data - Making GI solutions usable in society, which also involves additional competences such as man-machine interaction or communication with non-experts - Real-time processing - Natural interaction with GI less important: - classical GIS
HU	In our company: usage of GIS methods and problem solving based on GIS software functionality and basic programming (mapbasic, sql, script languages) becomes more important. Beyond that, project management basics are good to know, because GIS specialist is a project team member (or leader) and should be familiar with workflow of a project (user requirement, resource planning, time management, risk management)	It's quite hard to keep up with development of new technologies, therefore improvement of these competencies are essential, during educational period. Language skills (first of all English), international experiences, and enabling mobility regarding projects are also important.	
HU2	Automatisation is a great trend currently. The aim is an unmanned system; on the other hand, special (human) knowledge is necessary (i.e.: thematic mapping). There is a gap between service providers and users in cloud computing knowledge and competencies, for example in disaster management. Awareness building is important as fear of new, unknown systems is a general phenomenon. Thinking in systems will be an essential competency in the near future.	The applicants can have excellent technical skills in managing GIS software, but they have no knowledge on - economic issues, - project management, - life cycle of a whole project, - quality assurance and - ISO standards, - organisational and - communicational skills. - Another important issue is metadata handling	
ES	there seems to be less focus on cartography and data collection, and more on programming and data analysis.	These competences (see current competences above) will remain a long time as the most demanded in the GIS&T market, and will be progressively complemented with new	- application of geospatial technologies to smart environments (smart cities) - application of geospatial technologies in multi-disciplinary

		knowledge requirements in mobile apps, sensor web technologies, distributed and federated systems…	fields - cloud deployment of geospatial solutions - integration of geospatial solutions using new technologies (e.g., HTML5) - new human computer interaction techniques for innovative devices (e.g., wearable devices, smart phones, embedded sensor systems, …)
NL	The market for GI innovators will grow strongly. GI will be of use in a growing amount of sectors.	- With municipalities, the focus is often on registration and management of (large) data sets. But the focus should be more on generating information, using it, answer questions. - It is expected that the "big data" issue will grow in importance and will enable research on micro-level. This will have impact on the GI professional, but what kind of impact is not known yet. The same applies for the use of sensor technology. - Map tables are and will be used more often. It supports the content driven discussion. - Exemplary of the shift in focus: one year ago, there was a department Geo-information, now it is part of the department Information	- Focus will shift more to applications of spatial information systems (competency 1 and 3) - Also more analytical applications. - Data suppliers will become less important because of "cloud" developments. Issues such as data quality and accuracy will gain importance. Other issues for the future are geo-marketing, big data, privacy, sensors (precision farming). Issues such as Inspire and DURP are not that important.
NL2	TNO works from a system perspective (such as "sustainability") and in that context, employers should be able to (develop tools to) integrate datasets.	- Besides basic GIS knowledge the registration and dissemination of geo-data is becoming much more important. Therein the linkage to working processes is important. As a consequence of the new legislation 'Leefomgevingswet', the timeframes of procedures will be shortened substantially, so answers to external questions will be given much sooner. To accomplish this a clearinghouse in which data of diverse sources in the right formats (imro; inspire; durp; etc) is becoming extremely important. Besides, knowledge of what data are of relevance in a certain procedure, how to deal with these data, how to be able to combine these data, how can we make sure these data fit to the working processes (e.g., legal procedure for permit provision), what the quality is of these data, and how to present these data are all questions of importance.	

		The graduate should have knowledge of GIS and of semantic standards and of a substantive field of relevance to be able to combine these knowledge fields and to make sure that working procedures will get smooth and quick. - Dynamic data en sensors are becoming more of importance. For instance, mobility data (see open data on www.ndw.nu). The linkage with GIS is important, so how to deal with these kind of data in a GIS environment to get suitable information out of it? - Users are getting more and more acquainted with GIS, however not in a GIS-interface. Much more GIS will be used via mobile phones or map based touch-tables. The interface should be simple and interactive, in which you start from the way of thinking of the user instead of the position from the programmer. So, user-friendly devices and interfaces are becoming more of importance.	
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	Fit between educational supply and workforce demand: Do companies/organizations have difficulties in finding adequately educated GIS experts? Do required job qualifications (workforce demand) match with current GIS&T education? in which aspect are job applicants well educated/trained? What are competence deficits you frequently encounter and if so: which? And are there any competences in current GIS&T education that a GIS expert is unlikely to be able to apply in the 'real world'?		
AT	Alumni from classical GIS programmes are not relevant for us. We need IT people. Alumni with no work experience can often not cope with complex process workflows – we would want to see universities train their students in having the big picture: how to approach a real world problem, starting from data integration, data modelling, system architecture design, to come up with a working solution. Of course, we would like our staff to have experience with software – students should be exposed to different tools, mainly also open source, where they have to develop small solutions to customize something. For example to build mashups and make use of open data.	Many people with general GI competences available but the skill level variation within this group is huge. Many job applicants have too little experience with real world data, often important geoprocessing knowledge is missing as well. Job applicants from tecnical oriented studies are often well trained in programming but often have a poor unterstanding of the modelled processes in reality. Natural science backgrounds are better in this respect.	The match between demand and offer is not bad actually, but companies tend to search for the wrong people: They tend to hire not enough qualified personel having technical skills but too little theoretical background to understand the underlying processes/concepts/problems. Often an academic educated person will do a much better job than a "HTL-Absolvent" in the long run. However, GIS&T education should focus more on following topics to be better in line with needs : - DB-Design - Decision Support, Modelling, Geodesign - Geo-Communication (in a much broader sense than making maps)
BE	Difficulties to find candidates for certain job profiles in Geo-IT domain, especially 'specialist' in certain	-	From the perspective of the academic sector, students that are involved in the GI S&T programmes at the

	domains are difficult to find. Belgian companies are more and more recruiting in other countries Interviewee has some concerns about the ability and willingness of academic institutions to adapt their education programmes and courses to new technological developments and changing demands of the job market		university, relatively easy find a job in the geo-IT sector, or in related sectors. In many cases, they are the only students that have the (basic) skills and competences that are required for these jobs. Students that are involved in the GI S&T programmes are well-educated in GIS and Remote Sensing for land management, surveying. But GIS & Remote Sensing experts are all trained in the context of land management, global change, spatial planning, etc. So they're not trained to develop the technology. From the perspective of the university as an employer, students with the necessary skills and competences are provided by the own education programmes, at both these programmes and the research/teaching activities focus on the combination of 'geo skills' and thematic skills. However, from the perspective of the (non-academic) job market, these students do not have all the skills and competences that are needed, and current GIS&T education insufficiently matches with the demands of the job market: - GI S&T education pays little attention to IT-solutions for mobile/real-time applications - Sensors are addressed in civil engineering programmes, but without emphasis on 'geo' - IT-applications are addressed in informatics programmes, but without emphasis on 'geo'
BU	Difficulties to find well educated GIS experts? - Yes, it is difficult as there is little knowledge about the importance of GIS&T implementation in the different businesses and in that less interest. Do workforce demand and GIS&T edu match? - The current GIS&T education is behind the new technology development. Teachers should increase their awareness on recent achievements in GIS&T and their use in certain fields. - In general the GI S&T education in Bulgarian higher education is not	Difficulties to find well educated GIS experts? - Yes, the market is narrow and there are few students who have interest to study GI area. Do workforce demand and GIS&T edu match? - Not fully. Students have quite good theoretical knowledge but not good practical skills. Are applicants well educated/trained? - Job applicants are well educated/trained in the data processing. Deficits - There is deficit in programming knowledge and skills and working in a team for developing GI	Difficulties to find well educated GIS experts? - Definitely, yes. - So far job positions in state institutions are taken by engineers graduated as surveyors. In the early 90s they started with GIS as mainly making digital models. But the tendency is a decreasing interest in Geodesy especially among young people. - There is a shortage of well-trained experts in GIS&T area in local administration especially in the country. Do workforce demand and GIS&T edu match? - No. The majority of job applicants

	sufficiently appreciated. The courses on Geodesy, Cartography, urban planning and others cover very little of the area of GIS&T. The most common is the teaching on GIS as such, mostly from the technological point of view - architecture, functions and functionality. They do not teach students how to use GIS as instrument in a certain area. There is a lack of real knowledge and skills how to implement GIS in real work. Are applicants well educated/trained? - The job applicants have good theoretical education on common models, procedures, general knowledge on data and GIS and the like. deficits - Deficits in knowledge and skills how to implement GIS in practice. There is a lack of competence in data management and analysis, result interpretations, decision making and similar while working with GIS. Companies invest a lot of resources in training new applicant and when he/she (applicant) gets knowledge enough leaves the company.	applications. unlikely to be applied in the "real world": - There are too much theoretical disciplines in the university courses.	for GIS positions do not have proper education and training in the area of GIS&T. Are applicants well educated/trained? - Job candidates are well prepared in their specialization they have graduated. The problem is that job applicants come from such specializations where GIS&T is not enough thought or even not at all. Deficits - There is lack of mathematical literacy and low level of English language knowledge. For example, for some of the university students it is very difficult to work with scales. While working with software applications where everything is written in English, students cannot communicate with the application and cannot understand the processes. For example ArcGIS is translated in Russian language although Russians also have their own good software products. unlikely to be applied in the "real world": - The students of South-West University "Neofit Rilsky", geographers and ecologists, get base knowledge on GIS as working with already done map layers, creating their own database in attribute tables, making simple analysis and creating thematic statistical map. They cannot use this knowledge only in case they do not get appropriate job in the area.
BU2	-	Difficulties to find well educated GIS experts? - Yes, the need for adequately educated GIS experts is high and a lot of companies have difficulties in finding educated and skillful staff. Do workforce demand and GIS&T edu match? - Not completely. Compared with other sectors, I think the situation in GIS sector is better but still there discrepancies between the needs companies and the education in the universities. Part of the reason is the lack of good communication between the education institutions and the	Difficulties to find well educated GIS experts? - In most cases, yes. But demand for professionals previously communicated the necessary skills to have. But in demand for professionals it is announced previously the necessary skills which they should to have. Better qualified persons are better placed in companies/organizations with foreign participation. Do workforce demand and GIS&T edu match? - In most cases, not. It is needed an additional education or training of current GIS&T graduated students

		companies. Are applicants well educated/trained? - Most applicants have good theoretical basis and knowledge in various disciplines. Deficits - The students usually have less practice because the universities have not enough equipment for practice. unlikely to be applied in the "real world": Nothing.	or specialists. Are applicants well educated/trained? - In most cases using GIS software and performing data processing. Deficits - The educated students and young specialists don't have ability to apply knowledge in practice and use know-how to complete practical tasks. They have a weak programming knowledge and skills to use GIS&T methods, tools, and instruments in practical applications. unlikely to be applied in the "real world": - In some universities the GIS&T curricula includes many theoretical disciplines, but too small practical exercises.
GE	No major problems to find employers with GI skills, because there are several adequate GI study programs in Germany, furthermore graduates from computer science programs can be appropriate, too. But: it is more difficult to find candidates with required soft skills. Match between workforce demand and GIS&T education: more or less. Well educated in - basic concepts and technologies - practical applications of technologies but often lacking - scientific and engineering methods in order to build solutions - ability to analyse clients' requirements and be conscious of business value and value creation unlikely to be applied in the "real world": - some aspects of basic research, which are not appropriate for companies. But which are also a logical part of the university education, because universities not only educate for industry.	No major problems to find employers with GI skills, because there is the competitive advantage having a GI institute with many graduates in town. Match between workforce demand and GIS&T education is ok. Well educated in - In general in GI competences - As well as in teamwork and practical work in projects but often lacking - nothing unlikely to be applied in the "real world": nothing.	There are potential employers with required GI skills, but the market is small, so there are not many. Match between workforce demand and GIS&T education: more or less. Well educated in - Use of GIS - Basic concepts in cartography - Analysis and evaluation of geodata with standard procedures but often lacking - programming skills - technically not up-to-date, e.g., web services
HU	There are some different GIS educational institutes/universities in Hungary, and each school has strong points of education, for e.g. some job applicants have strong software, database and programming skills, others are well educated in visualization or in design, etc.	More and more professionals in geoinformatics are trained in Hungary every year, but in general knowledge of graduated students covers a narrow spectrum. Our country with 10 million residents needs 30-50 advanced specialists. The price for their work is unaffordable, usually they leave the	

	Therefore a GIS specialist team of people from different schools could be very effective. I often encounter low English language skill as a competence deficit. Understanding database or product specifications and requirements in English is very important. English sources could be used in education in Hungary. Competences in current education are OK, they are used in real world. Priorities could be changed: some 'GIS-related' fields and competences are over-prioritised in current GIS education (for e.g. georeferencing, projections, data gaining) and therefore there is not enough time for more important fields, for e.g. database-manipulation and design.	institute here they gain the required knowledge. Workplaces offer trainings for colleagues, after which retaining colleagues is difficult. It's impossible to ensure carrier scopes, which is important for young professionals paid from projects. Lack of English language skills, other communicational skills. Broadening knowledge spectrum is also important.	
HU2	Slight oversupply features the market. Quality of professionals is satisfying, unfortunately many leaves the country, and works abroad, mostly the most valuable specialists. Competence deficits: - Lack of general literacy, communicational skills are typical, - ability to work as a member of a team, - thinking in systems and - language skills.	There is no difficulty to find educated GIS expert, because supply is much higher than the demand. Deficits are: lack of knowledge on project management; communication skills; lack of foreign language knowledge	
ES	there are some good graduates however the industry needs more. we do have difficulty finding gis graduates who are techncally competent as well as possessing verbal and social skills. students who study gi science theory are perhaps better prepared for university research careers, but often oare not prepared for gis industry jobs. e are finding more qualified candidates in the start-up and entreprenuerial clusters and hubs, than from traditional uniiversity graduates with 2 or 3 degrees but without practical portfolios.	In general it is not easy for companies to find well prepared people with the skills they need. Many GIS experts have a lack of IT knowledge, while most programmers are not interested in GIS specialization. GIS education is mainly focused to the use of current software for geographic and spatial analysis, not to develop programming and other technological skills. It is difficult to achieve a correct balance in the education programs between the academic level which is supposed necessary and the competences that are mostly demanded by the real word.	Difficulties in finding educating GIS professionals Job qualifications do not match education job applicants well educated in: - Desktop GIS experience - topography and cartography - remote sensing deficits - technical skills: programming, software engineering, database and system administration (e.g., server administration) - multi-disciplinary skills unlikely to apply in real-world - static map production, paper-based maps
NL	New employees should score on interest in GI discipline as such. Most are at the academic level or other types of higher education. Expected skills are critical thinking, creative thinking and entrepreneurship, which are not often part of a GI curriculum. Often, the specific skills are part of the in-company training. Each employee starts with a 3 months training, later	There is problem in hiring employees that can bridge the gap between technique and content. Such people should have sufficient technical skills to interpret the problems and take care of a (technical) solution. The problem is more in understanding the application area than the technical skills	- Labour market has difficulty to define the needed competencies. Easy way is to refer to software skills or general project management skills - There are no vacancies for jobs that bridge gap between software skills and management skills.

	on, a choice has to be made among career paths such as technical developer, consultant, project manager, data specialist, implementation specialist.		
NL2	TNO does not hire often GIS specialists. New employees should have working experience, be able to work independent. In the context of tools development, employees work on the overlap between computer science and GI, aware of new devices to be used for data collection and analysis and new developments such as "serious gaming". Employees should be able to work in multi-disciplinary teams.	- The scope of many graduates is pure technical. Of course, it is important to have basic technical GIS knowledge, but besides that to be able to link this to a substantive field of knowledge is much more becoming of importance. In fact, in substantive fields of education much more GIS knowledge is needed to be acquired. - At the moment most graduates don't have much knowledge on semantic standards, clearing houses, broad standards like imro, durp, inspire, etc and how these are translated into products. This kind of knowledge is becoming very much of importance. - It is good when graduates have a bit of knowledge on and experience in computer programming and programming languages. However, this can still be very restricted, because the real programming is done by ICT-firms. However, the person should be able to translate the substantive question to the ICT-programmer and the other way around.	
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	Initiatives to better match supply and demand: **What initiatives are taken in your organization/country to better align GI S&T education and training with the needs of the GI job market? What other initiatives would you suggest?**		
AT	What I would not expect a university is to teach students a specific software – this is something they will learn on the job. There are so many software packages out there – nobody can be expected to handle all of them. Of course universities often use ESRI – this is ESRI's business model, but students tend to know the software, but cannot customise it for specific problems. That is what they should have learned at uni.	no structured activities like pre-defined in-house education/training program. Training on the job. Experience is developing by project work	- Engagement in vocational education & lifelong learning ensures a good connection to the market -> proof of concept - ZGIS Jobbörse as sensor for moving market demands - Joint initiatives between academia & industry: GIS cluster – to facilitate contacts, External initiatives - Erasmus + (Sector Skills Alliances, Knowledge Alliances)
BE	AGORIA is involved in several initiatives for realizing a better fit between workforce demand and supply. The organization has started an	-	Refers to the activities of the working group on 'fit between GEO education and job market' (see interview Public sector representative)

	awareness raising campaign for young students about the opportunities to find a job as a 'digital expert'. Geo-IT is also addressed in this campaign. Students are also informed about which programmes allow to become such a 'digital expert' and which university/high schools offer these programmes. The Flanders Social and Economic Council (in dutch: Sociaal-Economische Raad van Vlaanderen (SERV)) is working on the development of a database of job profiles (www.competent.be). It is based on an existing database (ROMEv3, Répertoire Opérationnel des Métiers et des Emplois), but adapted to the Flemish context. For each job, a description is provided of the job content, the activities, and the knowledge and competences needed for this job. The database also includes some GI-related jobs, and AGORIA is involved in the valorization of the GI-related job descriptions. The organization also supports many other initiatives taken at Flemish level to better fit the demand for GI and supply of GI professionals: the 'Geo-Mobiel', to inform students at secondary schools about the opportunities to study GI-related courses/programmes and to eventually find a job in the GI-related job market; the establishment of a professional bachelor on GI; the creation of an overview of all available internship positions in Geo-IT companies, etc.		Both education programs at KU Leuven in which interviewee is involved (Master of Land and Forest Management and Master of Earth Observation) now include an internship at a company or other organization Key initiative according to interviewee is to set up a professional bachelor programme or a 'BaNaBa' in 'Geo-ICT', which is currently non existing in Flanders. A first step to realize this bachelor, might be the organization of a Summer School on Geo-IT, together with different university in Flanders.
BU	To raise teachers awareness of the new developments of GIS&T and its/their implementations in real practice	meetings and round tables between GI S&T academia and the business; presentation of the GI S&T business about themselves in front of the students; practical assignments to students that should be realized in companies; universities should present continuing education on GI S&T in order to improve the qualification of working people; companies could deliver evening training for the students in the universities to ; to run in-training workshops of the staff in an organization.	In our university the students of specialties of Geography, Ecology and Environment protection study courses on Cartography and GIS. GIS as technology to be included in all disciplines where location is important as geography, cartography. This should be done in all universities. Most of the university teachers are not well prepared for teaching GIS.
BU2		There are GIS courses organised in my institution which are available for all staff. There are also student practices that my institution is involved in. It will be good to have more events	Our institute performs additional theoretical and practical training of young specialist and PhD students. It should to organized very regularly more meetings and round tables

		where people from education and bushiness can meet and exchange ideas.	between GI S&T academia and the business; practical education of the students and young specialists that should be realized in GI S&T academia and GIS companies; universities and academia should present continuing education on GI S&T (like life-long learning initiatives) to improve the qualification of working people.
GE	Existing initiative in Germany: - GI curriculum of the "Gesellschaft für Geoinformatik" (Association for Geoinformatics) Internal initiative: - Being in contact with the university, thereby also providing feedback to the GI institute and thus influencing education Suggestion: - Intensify the model of an "external semester" = internship within companies as part of the study program. This intensifies the contact between companies and universities, and also students provide feedback to the universities.	Existing initiative in Germany: - GI curriculum of the "Gesellschaft für Geoinformatik" (Association for Geoinformatics) Suggestion – very specific for Germany and administrations: - Within the public sector, the salary system switched from the old "BAT" to the new "TV-ÖD". The salary system bases on skills, competences, tasks, and responsibilities. This update could be used for aligning GI education with the job market's needs. Maybe also to be used as an application field for BoK usage.	Existing initiative in Germany: - Geonetzwerk Münsterland (geonetwork Münster region), networking/exchange between university, industry, and government - Institut für angewandte Informatik (Institute for applied computer science), networking/exchange between university, industry, and government - GI curriculum of the "Gesellschaft für Geoinformatik" (Association for Geoinformatics) Internal initiative: - direct contacts with companies, e.g., by the internship of students within these companies. Suggestion: - ok as is
HU	There are some educational programs (GIS-days, presentation in schools) in which the company takes part.	Partnership between industry and higher education is essential. At the same time concurrency among universities causes problems in GI education. Practical semester during studies is useful.	
HU2	Private sector is waiting for professionals for practical work. Several projects are running parallel in a company, where routine work is required to be done. Companies with international management need professionals for market seeking, organising meetings, participation in meetings, obtaining management knowledge and communicating it.	A new initiative can be the widening the practical part of the education in a sense that the students have to work minimum one year before getting their degree, but not only at one company	
ES	i do not see many initiatives to bring together the education and the job market. because of this, a minority (20%?) of graduates are really well prepared, and many of those have sought extra skills outside the traditonal university system.	I only know some efforts in specific GIS Masters from Academy, which try to accommodate constantly its curriculum to the market demands.	Currently: - developing degrees which are focusing on multi-disciplinary education - combining traditional GIS with new technologies and (mathematical) analysis - trans-university degrees to obtain a full skill package Other initiatives: - more trans-university degrees to obtain a full skill package

			- longer master degrees to integrate multi-disciplinary skills
NL	No real complaints. Rather easy to hire new personnel. Need for (GI) skilled partners in business, who understand what GI is all about.	They connect to education by way of internships and assisting students with their thesis work. They are eager to support initiatives that come from educational institutes. They would underline the need for policy officers and alike to understand that they should incorporate GI-specialist early in the process (project) and not only at the end for the map-making part.	- This is the reason why the HAS started the new course - In general, university and school programmes should better indicate what their students learned; the "market" should better formulate what knowledge/skills they expect. So far they end up a list with some specific skills. - The HAS asks private and public companies what they need. Also, internships and small projects together with external partners are a way to exchange information on supply and demand of GI skills. These experiences serve the students, teachers and the clients. These type of contacts should take place on a permanent basis.
NL2	Ad hoc courses for own employees, hardly in pure Computer Science. Message is to keep up to date in your own field of expertise and more specific, keep up to date on data issues, developments are fast.	The best way to handle this is by offering internships	
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	Knowledge, use and usefulness of the BoK: Do you know the BoK yourself? Do you make use of the BoK? For which purposes? Do you believe the BoK is useful?		
AT	Do not know the BoK	Bok is not known	Yes, used for curriculum matching
BE	Interviewee knows the BoK, because he is involved as associated partner in the GI-N2K project He supports the idea behind and the objective of the BoK: need to develop a common language Interviewee mainly sees the BoK as a tool for developing and re-designing (update) education programs He has the feeling that the BoK is strongly academic, while private companies rather need an easy-to-use and more straightforward tool He also underlines the importance to take into account the demands and requirements of the private sector, when updating the BoK. BoK should be demand-driven.	Awareness of existence of the BoK, but no active use of it. Study on the workforce demand uses 9 basic categories of competences: data collection, data processing, image processing, visualization, databases, programming, geo web development, management, service delivery	Interviewee knows the BoK, but only made use of it in the period 2008-2011. Interviewee was involved in the EduMapping activities of Wageningen University: exploratory curriculum mapping and comparison with other GI-MsC programmes throughout Europe Interviewee also used the BoK as a benchmark to characterize his own MSc Programme of Earth Observation (presented at AGILE Conference 2009). Conclusion: *"The present exercise illustrates the applicability of the BoK, established in a US-context, as a framework to assess independently conceived European programmes where it regards the GI S&T-related dimension. Adaptation of some of the US-only topics, incorporation of a KA on Geo-ICT, making provision to deal with applied GI S&T-programs and explicit consideration of the various*

			roles which GI S&T-professionals may play in the European context is recommended for a next and/or European version of the BoK."
BU	No, I do now know about BoK before this interview.	No, I do now know anything about BoK, only now from the project GI-N2K. BoK would be useful if it is more practical oriented, easy to use, understandable for no specialists.	I could confess, so far, not. BoK is not used.I hope, it will be useful.
BU2		No – Bok neither known nor used.	I heard about this BoK participating as a member of the Bulgarian partner team. Yes, of course is used. After it's reading, everybody, which is GIS&T specialist, but not only, should use it in everyday work. Definitely, yes the BoK is useful
GE	BoK is not known and not used. Potential use: - Internal use for personnel management: with the help of an internal skill database, a company can better evaluate their capacities and can, e.g., evaluate if the company could or should apply for a specific project by matching required skills and the available skills within the company, or can make mid-term decisions about hiring additional staff with specific skills. - Very specific use case: matching of competences between EU looking for reviewers for Horizon 2020 and experts interested in becoming reviewer.	BoK is not known and not used. Potential use, if the respective tools are available: - Comparison/matching of job profile with applicants profile	BoK is not known and not used. Potential use for universities: - Analysis and design of study programs - Accreditation procedures (to be used for argumentation and evaluation) - Design of examinations' content Potential use for students: - Choosing an appropriate study program - Self-controlling during the study program
HU	I didn't know BoK before this survey. BoK seems to be a good theoretical source, but quality of education is up to execution.	The interviewed was unfamiliar with body of knowledge before, but the Institute builds his own book/body of knowledge for internal use based on Wikipedia.	
HU2	He was unfamiliar with body of knowledge before. There is a gap between educational and practical side. For users the body of knowledge seems to be way too theoretical.	No, I never heard about BoK.	
ES	yes i know the bok, but have never used it. i think the bok is a reference document that has mostly academic uses.	No. I don't know what the BoK is.	Knows & uses BoK For developing syllabi for the master degree & to assemble the curriculum BoK is useful? YES, and it will remain useful as long as it's keeping up with current developments in the field (up-to-date!).
NL	Not familiar with BoK.	No, but is interested in what it can offer	- BOK is well known to interviewee, but not everybody at the HAS sees the usefulness. - The BoK does not answer questions such as on what type of

			skills students will be selected. Job profiles are missing. - BoK is probably too much developed from the GI Science viewpoint, not from an application viewpoint and what this means for a GI curriculum. - BoK should be more accessible. A good approach is the "comprehensive competency model for Geospatial Technology - About the BoK, culture is an important factor, to what extent you allow the "market" to decide the contents of a curriculum? - And to conclude, do not forget that often the personality is more important than knowledge and skills in getting a job.
NL2	BoK perhaps a handy tool, also as a type of "quality assessment tool".	No knowledge on the BoK	-
			-