Perceived supply and demand for GISc knowledge and skills in South Africa

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Abstract

The implementation of the South African spatial data infrastructure (SASDI) commenced in 2010, but indications are that there is a lack of relevant expertise in the country. Much work has been done on understanding and implementing SDIs all over the world, which has resulted in best practices and various training resources. However, there is a need to understand the requirements of the local community. In this paper, results are presented of a survey distributed in South Africa to determine the perceived demand for GISc skills and knowledge. The results are compared to an earlier study on the supply of GISc skills. This comparison is useful for workforce and curriculum planning, not only in South Africa, but worldwide.

1. Introduction

The South African Spatial Data Infrastructure Act of 2003 (South Africa, 2003) established the South African Spatial Data Infrastructure (SASDI) and the Committee for Spatial Information (CSI). The Directorate National Spatial Information Framework (NSIF) in the Department of Rural Development and Land Reform acts as Secretariat for SASDI. South Africa has a lack expertise to help guide the implementation of SASDI (Makanga & Smit 2010). At the first CSI meeting in 2010, it became apparent that there is also a lack of SDI expertise in the GISc sector and on the committee itself (CSI 2010). Despite world wide research on the matter, understanding the local community requirements is critical in the development of locally relevant education and training initiatives.

To improve this understanding, questionnaires were administered at a series of workshops held throughout South Africa under the auspices of the CSI sub-committee on Education and Training, the NSIF and the Geo-information Society of South Africa (GISSA). These included a workshop at the Geomatics Indaba 2015 conference in Johannesburg and a number of regional workshops at major urban centres throughout the country. The questionnaire was also distributed online by e-mail invitation to the broader GISc community.

This paper presents the results of the questionnaire-based survey and highlights the perceived knowledge and skills requirements of the GISc sector. Section 2 describes how the survey was done. Section 3 presents results of the survey about the perceived demand for GISc skills . In section 4, these results are discussed and compared to the earlier survey on the supply. Section 5 concludes.

2. Method

The purpose of this survey was to characterise the demand; the aim was not to quantify the demand. The questionnaire was distributed in four ways: 1) hardcopy questionnaires were handed out at the Geomatics Indaba 2015 conference in August 2015; 2) email invitations to participate in the survey were sent to GISSA members in August 2015; 3) hardcopy questionnaires were completed by participants at nine regional workshops (one in each province) held by the NSIF in October and November 2015; and 4) attendees at the NSIF workshops were invited to complete the questionnaire online. Table 1 shows the number of responses received.

Table 1. Responses to the survey on the demand for GISc knowledge and skills

Source	Types of response	Number of responses
1) Geomatics Indaba 2015	Paper questionnaires	65
2) GISSA email invitations	Online responses	56
3) NSIF workshops	Paper questionnaires	348
4) Invitations at NSIF workshop	Online responses	4
	Received	**473**
	Spoilt	20
	Analysed	**453**

The survey comprised of four sections, each with a number of questions:

Section 1 – Characteristics of the organization;

Section 2 – Characteristics of the organizational unit;

Section 3 – GISc knowledge and skills requirements in the organizational unit; and

Section 4 – Various.

The questionnaire distinguished between an organization and an organizational unit within the organization. For example, 'Department of Rural Development and Land Reform' is the organization and the 'Directorate: NSIF' is an organizational unit within the organization. In a private sector example, 'Aurecon Consulting Engineers' is the organization, while 'Asset Management' and 'Environmental Management' are two organizational units within the organization. Respondents were requested to answer questions relating to the demand in the organizational unit (not the entire organization).

3. Results of the GISc demand survey

3.1 Characteristics of survey respondents and their organizations

The majority of respondents (62%) worked in the public sector, followed by the private sector (17%) and state-owned enterprises (14%). The top five industries in which respondents were active were surveying; land administration and/or land information systems; environmental; public utilities; and urban and regional planning. Respondents could select more than one industry. These industries correspond to themes in SDI implementations and research elsewhere in the world (Coetzee & Wolff-Piggott, 2015). There was an approximate 40/60 split between respondents employed at management level (top, senior and middle management) and those employed in an operational or supervisory

capacity. A smaller representation at management level suggests that the survey response is an appropriate sample of the employees in the organizations.

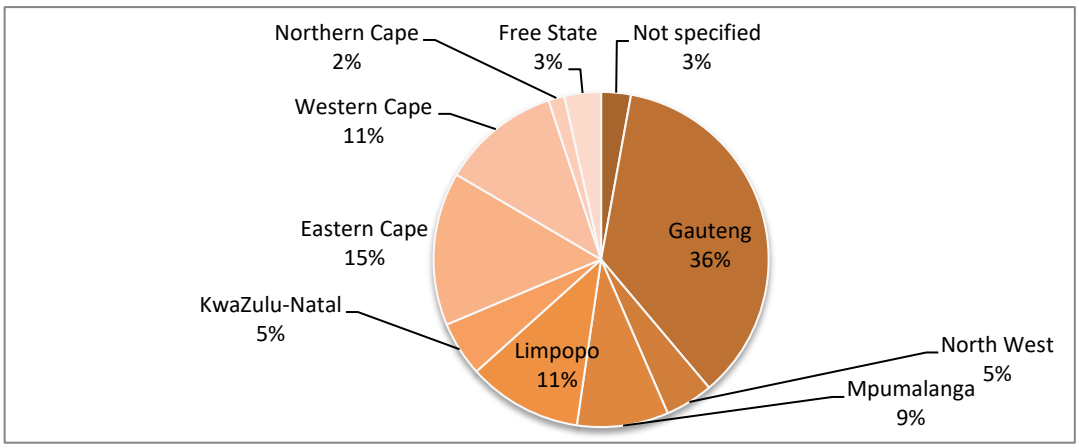
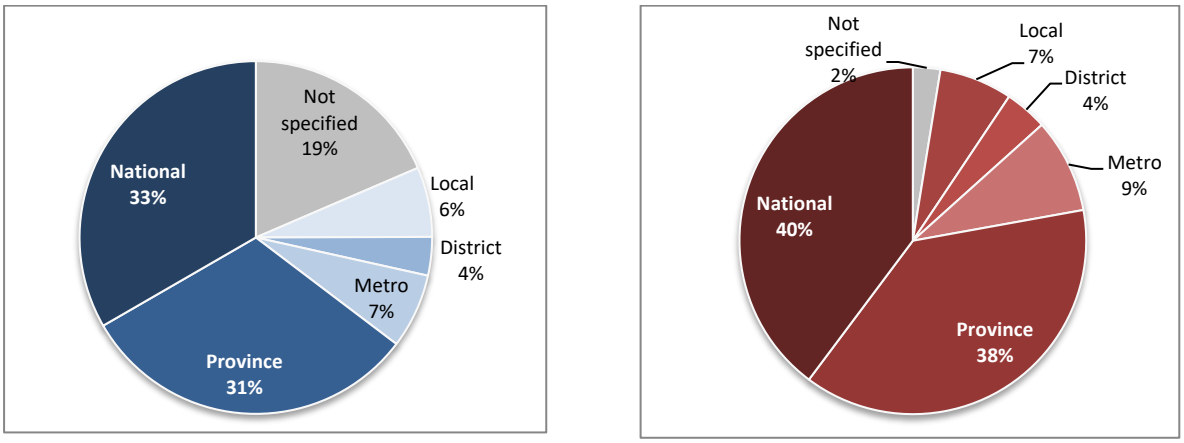


Figure 1. Province in which the primary offices of organizational units are located

Figure 1 shows the provincial distribution of primary offices of the organizational units. This distribution largely follows the distribution of provincial contributions to the South African GDP within a threshold of 5% (www.statssa.gov.za). It is therefore a representative sample of the GISc industry in the different provinces of South Africa.



a) All respondents (n=453) b) Public sector respondents (n=343)

Figure 2. Area of jurisdiction of the organizational units where respondents work

Figure 2a shows the distribution among different areas of jurisdiction of the organizational units where respondents work. 19% of the respondents did not specify the area of jurisdiction; most of these are employed in the private sector. In the public sector, the split between national, provincial and local government is more or less 40/40/20. See Figure 2b. The provincial representation in the survey responses is 20% lower than the provincial proportion of the South African public sector; the national representation in the survey responses is 16% higher than the national proportion of the South African public sector (Van Wyk, 2014). This suggests a very strong presence of GISc skills in national departments and a very low representation of GISc skills in provincial departments.

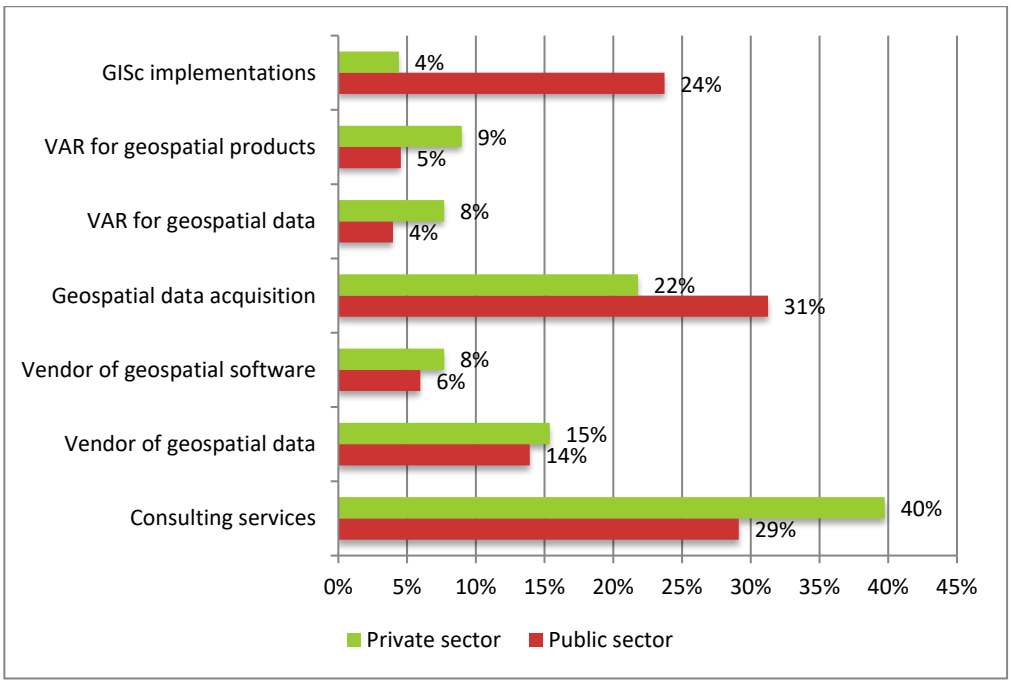


Figure 3. Type of business that organizational units 'Mostly' engage in

Respondents were asked to indicate in which type of business their organizational unit engages. A respondent could indicate more than one type of business and specify a weight for each (only, mostly, partially, or not applicable). The organizational units of public sector respondents engage mostly in GISc implementations (24%), geospatial data acquisition (31%) and consulting services (29%). In the private sector, organizational units engage mostly in consulting services (40%) and geospatial data acquisition (22%). A small percentage of organizational units are engaged mostly as value-added resellers (VAR) or vendors of geospatial data and products. See Figure 3. Very few organizational units engage in a single type of business (3% or less). These results show a strong focus on consulting, data acquisition and GISc implementations, which is to be expected among role players in the SDI environment.

3.2 Current demand for GISc knowledge and skills

In this sub-section, responses to questions about the demand for GISc knowledge and skills in the respondent's organizational unit are presented. Firstly, respondents were asked whether GISc professional registration is compulsory for certain posts or jobs in their organizational units. The responses in the public sector (Yes: 63%, No: 33%) and private sector (Yes: 36%, No: 60%) were more or less the inverse of each other. The results confirm the government's drive to professionalize the public service (South Africa, 2015).

Next, respondents were asked to specify the number of posts in their organizational unit for which more than five years of experience and less than five years of experience in GISc knowledge and skills are required. In the private sector, the proportional distribution between the median number of posts requiring more experience and those requiring less experience was close to 50/50. In the public sector, this ratio was closer to 40/60 between more experience and less experience. This could be an indication of a more hierarchical organizational structure in the public sector and a 'flatter'

organizational structure in the private sector. 38% of respondents reported that GISc internships were available in their organizations.

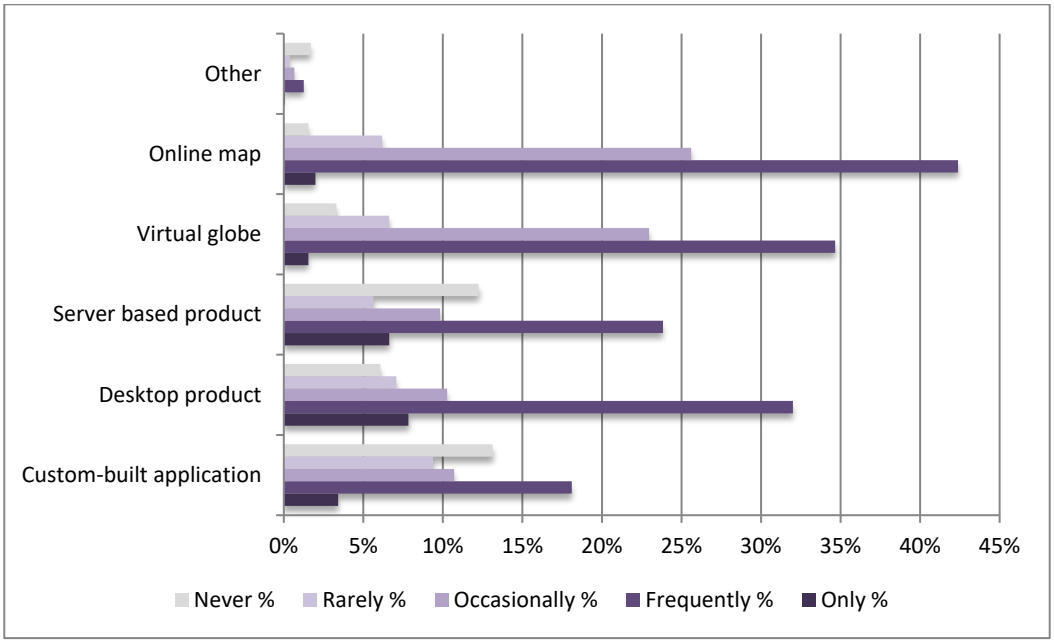


Figure 4. Geospatial platforms used in the organizational units

In a subsequent question, respondents were asked to indicate the frequency (never, rarely, occasionally, frequently, or only) with which different geospatial platforms were used in their organizational unit. Results are portrayed in Figure 4. In most organizational units, more than one platform is used. Virtual globes and online maps are used most frequently, followed by desktop products and server based products. Desktop products and server-based products have the highest percentage of use as the only platform in an organizational unit (8% and 7% respectively), but in some organizational units, server-based products and custom-built applications are never used (12% and 13% respectively). Organizational units that do not work in server-based environments suggests that the organizations have not (yet) transitioned into an enterprise environment for geographic information but are still operating in a single-user file- and project-based environment. This is a concern for SDI implementations, which rely on distributed approaches to managing and sharing information.

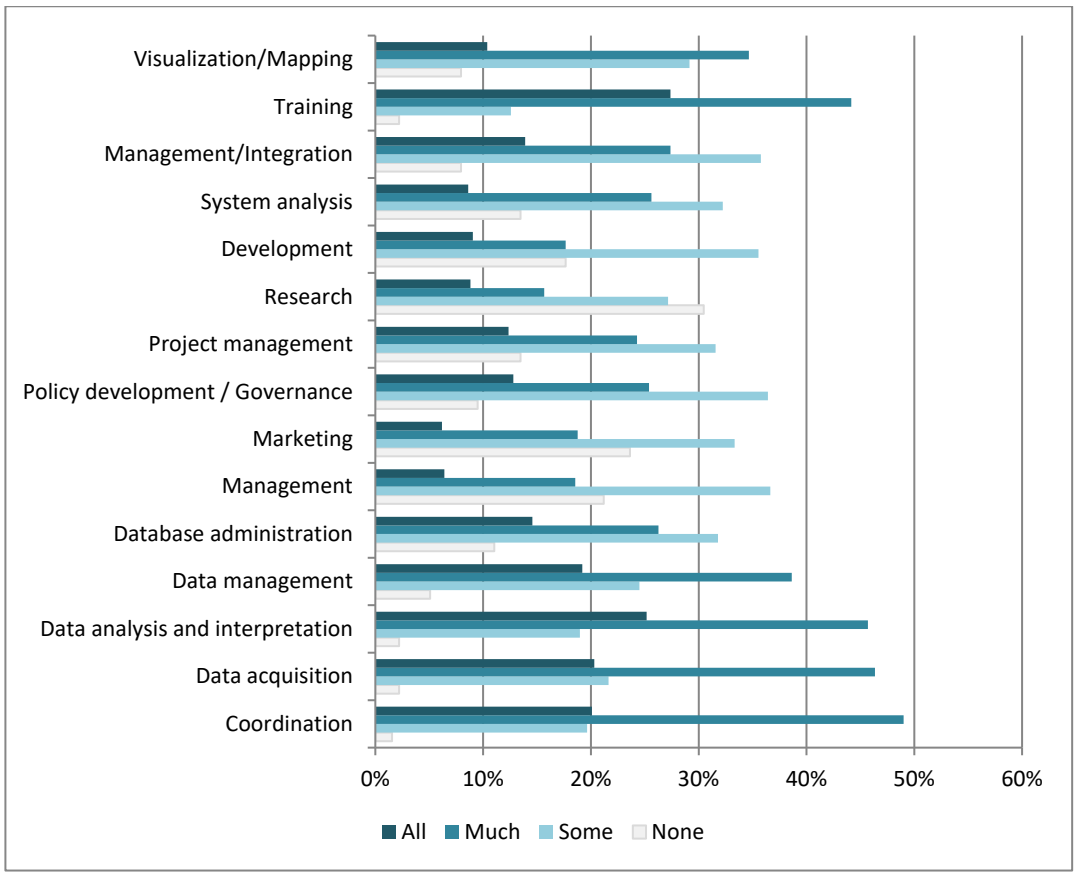


Figure 5. Different roles in which the GISc work is performed

A further question requested respondents to indicate in which roles the GISc work in their organizational unit was performed. See Figure 5. In 40% of the organizational units, much of the work performed is training, data analysis and interpretation, data acquisition, coordination. Next are data management (39%) and visualization/mapping (35%), followed by database administration, policy development/governance, project management, system analysis, and management/integration (each around 25%). Some of the organizational units indicated that the unit performed a single role. This was true for the roles of training, data analysis and interpretation, and data acquisition. The high prevalence of data acquisition and coordination reflects the respondents' involvement in SDI related activities. The data analysis and interpretation response shows that there is also use of data, while the high involvement in the role of training is encouraging for SDI capacity building.

In the final question of this section of the survey, respondents were asked to specify the relevance of different GISc knowledge and skills to the business or mandate of their organizational unit. The options that could be selected are a combination of knowledge areas from the Body of Knowledge (BoK) prepared by the University Consortium for Geographic Information Science (DiBiase *et al.*, 2006) and themes from the South African GISc academic model (du Plessis & Niekerk, 2014), in use at the time of the survey. Results are shown in Figure 6. Geospatial data, geospatial data acquisition, and cartography and visualization were regarded as relevant by at least 50% of the respondents. Data manipulation and analytical methods were considered to be relevant in the organizational units of at least 30% of the respondents. Geocomputation, mathematics, statistics and physics are considered to

be irrelevant by many of the respondents (between 20% and 40%). Similar to the previous question, responses suggest an emphasis on SDI-related mandates centered around data, while data use (analysis, visualization, etc.) also takes place. The low relevance of mathematics, physics, etc. should not be understood as an indication for removing the topics from any curriculum, as they provide the theoretical foundations for any GISc work.

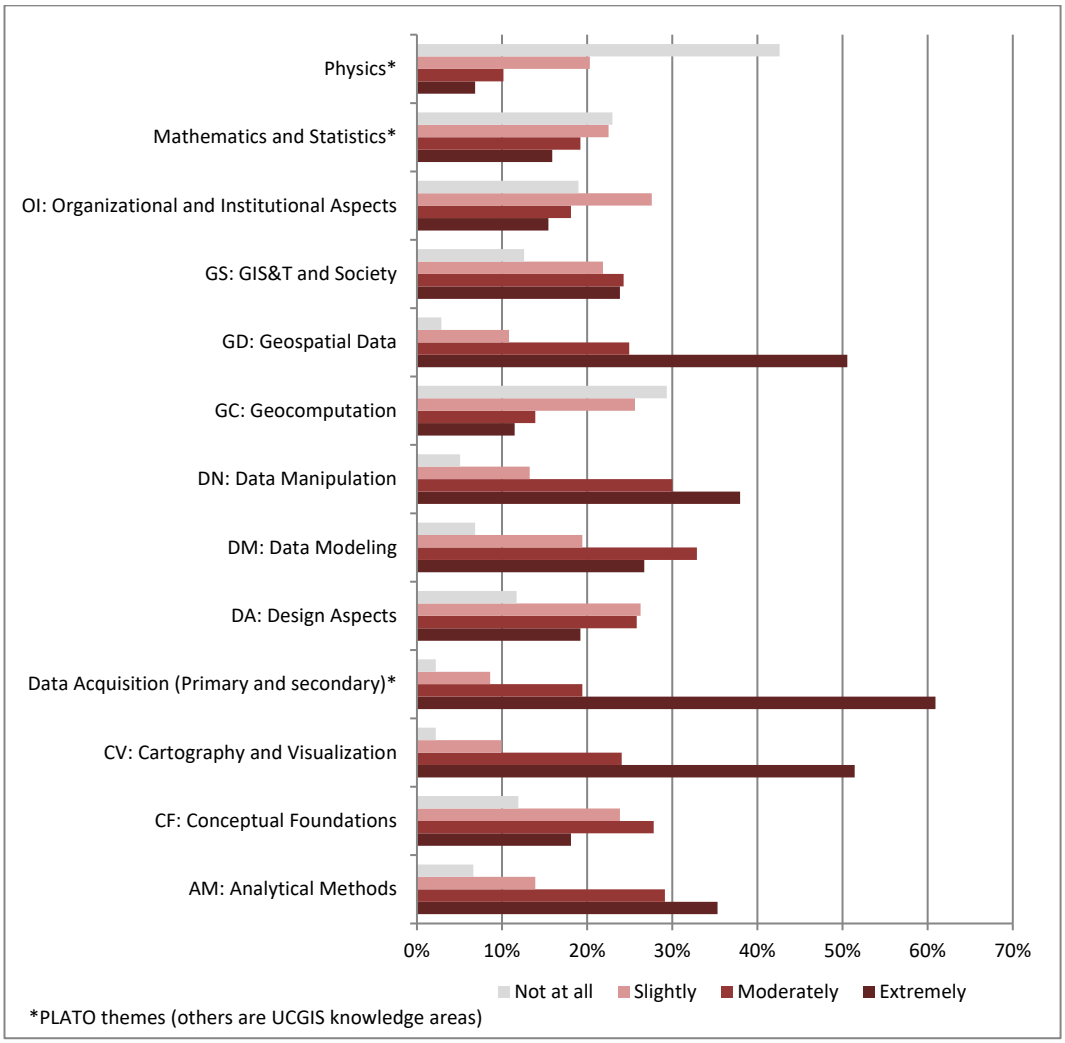


Figure 6. Relevance of GISc knowledge and skills to the business or mandate of the organizational unit

3.3 Perceived future demand for GISc knowledge and skills

This section presents an analysis of the responses to the question: Which GISc knowledge and skills do you think the employees of your organizational unit will require in the future (which they don't have now)? Respondents could type in any text as free format text.

In Figure 7a, the frequency of words in the (raw) responses is indicated. Figure 7b shows results after responses were categorized by keywords. This was done to remove noise words and also to harmonize keywords. The range of keywords is extensive: no single keyword appeared in more than 5% of the responses. ‘remote sensing’ (5%) and ‘programming’ (4%) were mentioned most; followed

by 'ArcGIS', 'data manipulation' and 'Web mapping' (3%). The most frequently occurring keywords were further categorized, revealing that most future demand is perceived to be in programming (19%), data (12%) and analysis (8%).

a) Raw text

b) Keywords

Figure 7. Responses about future demand for GISc knowledge and skills (prepared with www.wordle.net)

4. Discussion of the results

4.1 Supply vs demand

In this section, the results of the survey about the demand for GISc knowledge and skills are compared to the results of an earlier survey that determined the GISc workforce supply in South Africa. The comparison highlights differences between the current workforce and what will be required in future. The purpose of the workforce supply survey was 'to get a better understanding of who the members of the South African GISc community are and what they do on a day-to-day basis at work'. An online questionnaire was distributed and the 626 responses were mainly from GISSA members (Coetzee, Eksteen & Roos, 2014). A main difference between the two surveys is that the questions in the supply survey were directed at the individual, while the questions in this demand survey were directed at the organization and organizational unit.

The employment sector of respondents differed significantly between the two surveys. In the earlier supply survey, there was an equal distribution between respondents from the public sector

(35%) and the private sector (36%); the remaining respondents were from state-owned enterprises, academia, research and non-governmental organizations (NGO) (29%). In the demand survey the majority of respondents (62%) work in the public sector, followed by the private sector (17%) and state-owned enterprises (14%); the remaining respondents (7%) were from academia, research and NGOs. In both cases, the public sector proportion of respondents is higher than the estimated public sector proportion of total employment in the country, which is estimated at 22% (*Sowetan,* 2012). These figures suggest that there is a strong supply and demand for GISc knowledge and skills in the public sector. This is an encouraging sign, since the international panel of experts that documented future trends on behalf of the UN GGIM believes that governments will continue to play an important role in the provisioning of geospatial information (Carpenter & Snell, 2013).

Less than half of the respondents (40%) in the earlier supply survey are registered with a professional body and 57% of those who were registered, had done this because it was required for their jobs. This confirms the demand survey results where 59% of respondents indicated that GISc professional registration is compulsory for certain posts or jobs in their organizational units. Since SASDI will be implemented in the public sector, it is important that the education of professionals includes SDI-relevant topics.

In the earlier supply survey, 30% of correspondents had 5 years or less experience in GISc work and 70% of correspondents had more than 5 years of experience in GISc work. This is more or less the inverse of the demand survey results, which indicated a 40/60 demand at the organizations for more than five years and less than five years experience, respectively. The 40/60 distribution reflects the typical composition of a team or organization where fewer experienced employees oversee a larger number of less experienced employees.

Comparing the figures of the surveys seems to suggest that there is a mismatch in the supply and demand. However, the first survey evaluated the supply of *individuals*, while the second survey evaluated the demand at *organizations*. Therefore, further studies are required to better understand whether there is a mismatch in actual numbers.

The supply survey indicated that GISc practitioners mainly perform data analysis and interpretation (20%), followed by data acquisition (12%), visualization/mapping (12%) and data management (11%). A corresponding question in the demand survey revealed that in 40% of the organizational units, much of the work performed is in the role of training, data analysis and interpretation, data acquisition, coordination. Next are data management (39%) and visualization/mapping (35%). These results show that both the supply and demand for knowledge and skills in data acquisition, data analysis and interpretation, visualization/mapping and data management are high. Training and coordination roles featuring in organizational units only are interesting, but difficult to explain. This could be explained by the demand survey asking questions about organizations while the supply survey was directed at individuals. An alternative explanation could be that respondents to the supply survey were asked to select a subset of roles, while the demand survey respondents could indicate a value on a Likert scale for each role.

4.2 Future demand

The perceived future demand for programming, data and analysis reported in this study largely corresponds to studies in other parts of the world. According to respondents in a survey for a European GISc workforce demand assessment, mobile and web technologies would gain importance in future, as well as related topics, such as applications and development. Analysis, which could mean spatial analysis or data analysis, was expected to remain an important part of geographic information expertise (Hofer *et al.*, 2014).

The UN GGIM international panel of experts points to technology-driven trends in the geospatial industry, which will result in 'previously-unimaginable amounts of location-referenced information', an indication of the importance of data-related skills in future (Carpenter & Snell, 2013). Apart from skills required to manage and extract value from the data (i.e. data analysis), the panel also emphasized the importance of visualization skills. The respondents to the demand survey did not consider visualization to be a demand for the future workplace. This could indicate limited awareness of the importance of visualization to extract meaning and value out of large volumes of data.

4.3 Implications for GISc curricula

Figure 8 shows the demand for GISc knowledge areas in organizational units against the proportional content of the same GISc knowledge areas in the GISc Professional academic framework , according to which the South African Geomatics Council accredits programs for GISc professional registration at universities. The graph shows four discrepancies: the framework has proportionally less content relating to geospatial data (GD), cartography and visualization (CV) than in the perceived demand; and the framework has proportionally more content related to programming, mathematics and statistics than in the perceived demand. Does this imply that programs should include more content related to data, cartography and visualization? Probably not, because as it is, it is already difficult to fit the required content into four years of tertiary study. It could however point to specialization fields in the workforce. While demand for mathematics and statistics *per se* may be low in the GISc sector, its importance as foundational knowledge in any GISc education is not disputed.

A survey among European stakeholders in geographic information related education and training suggests a clear teaching gap regarding 'mobile' competencies, and a possible gap regarding 'Web' and 'programming' competencies. The study also found that there may be a need for more teaching in the UCGIS BOK knowledge areas of Organizational and Institutional Aspects, Design Aspects, Analysis Methods and Data Manipulation (Rip, Wallentin and Van Lammeren, 2014).

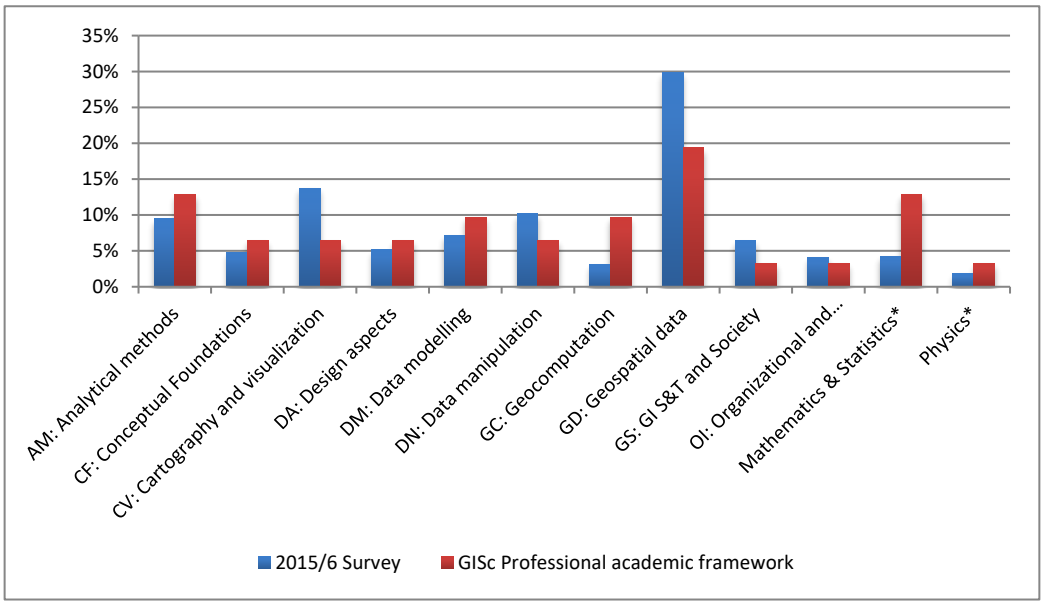


Figure 8. GISc knowledge areas: demand vs academic framework content

5. Summary and conclusion

Understanding the South Africa GISc community requirements is critical for the development of locally relevant education and training initiatives. This paper presented the results of questionnaires administered at a series of workshops held throughout South Africa and also distributed online by e-mail invitation to the broader GISc community. The results characterize the demand for GISc knowledge and skills at organizations involved in the implementation of SASDI.

The organizations are engaged in surveying; land administration and/or land information systems; environmental; public utilities; and urban and regional planning. These application areas are relevant to SDI implementations. Organizations are mainly involved in consulting, data acquisition and GISc implementations, which is to be expected among role players in the SDI environment.

The survey response shows a strong presence of GISc skills in national departments and a low representation of GISc skills in provincial departments. This needs to be considered when deciding on the role of provincial departments in the implementation of SASDI. Requirements for GISc professional registration at the organizations reflect the government's drive to professionalize the public service.

At least 10% of organizations in the survey have not (yet) transitioned to an enterprise environment for geographic information but are still operating in a single-user file- and desktop-based environment. This is a concern for SDI implementations, which rely on distributed approaches to managing and sharing information. A 'systems' view of geographic information among GISc practitioners and organizations is essential for realizing an SDI. The comparison with the earlier supply survey shows that both the supply and demand for knowledge and skills in data acquisition, data analysis and interpretation, visualization/mapping and data management are high.

The perceived future demand for GISc knowledge and skills is mainly in programming, data and analysis. This future demand is confirmed by other studies. The South African survey results seem to indicate limited awareness of the importance of visualization knowledge and skills for extracting meaning and value out of large volumes of data. In future, programming, data and analysis will remain at the top of the list of knowledge and skills required in GISc organizations.

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