GEOGRAPHY AND TOURISM, Vol. 7, No. 1 (2019), 63-76, Semi-Annual Journal
eISSN 2449-9706, ISSN 2353-4524, DOI: 10.36122/GAT20190706

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Geospatial Technology Competency Model – Geography Academic Competencies

Abstract: The main goal of this paper is to present a wider view of challenges and opportunities encountered by university teachers in terms of programs, including accountability, articulation, geography curriculum design and assessment, and general education itself. What is more, it also provides the reader with the role of university initiatives in completing and promoting the Geospatial Technology Competency Model with regard to the development of geography academic competencies. Said model identifies the foundational, industry-wide, and industry sector-specific expertise that distinguishes, and binds together, successful geospatial professionals. Another aspect raised in this article pertains to the contents of this very model, the process which prompted its development, its possible uses, along with evaluation of how geography-oriented higher education curricula are aligned with the current workforce needs.

Keywords: Geospatial Technology Competency Model, outcome-based education, OBE, geographic skills, spatial thinking

1. Introduction

Development of geospatial technology has opened the door to employment in diverse occupations, yet, unfortunately, the job opportunities emerging in this field outweigh the supply of a qualified workforce (Estaville, 2012). As such, it poses a challenge for geographical higher education institutions to develop curricula addressing the knowledge and abilities which prospective geographers will be expected to possess (Gotlib, 2008). Accordingly, this article aims to look into this issue. On another note, modern historical geographers and authorities in the field attempt to shed light on the relationship between geospatial technology and geography. Beyond all doubt, there are reasonable grounds for certain professionals to comment on the difficulties experienced by non-specialist users of geographical information when overcoming disciplinary boundaries even within the subdisciplines of geography itself.

This article highlights research potential within the field in question while exploring the areas of study that have yet to be examined for the sake of advancing the discipline. The Geospatial Technology Competency Model framework legitimises the activities and perspectives of various educational constituencies. Partly owing to these developments, the simple idea of geography as one of the geospatial technology components gave way to a new formulation: geography as a technical competency. This is, to be sure, a shift of emphasis rather than a fundamental transformation, yet it reflects and engenders an entirely new geographical, technical language and justification. Since geography has a powerful presence at all levels of education programs, there is a need for revision of school and university systems in order to both inculcate and align information and communications technology. According to Bodenhamer (2013), academic disciplines periodically undergo reorientation in the form of a core theme shift so as to redirect research and either focus on new issues or address the long-standing ones from a different perspective.

Geography in and of itself is integrated in the learning area of natural, human, and social sciences. Numerous educational institutions have already put forward broad guidelines as what was termed competence assessment criteria, range statements, and performance indicators. The majority of geography lecturers struggle with the changes and face a wide variety of challenges related to understanding outcome-based education (OBE)[1] and how it should be practised (Molin and Orbring, 2017). Therefore, for the sake of ensuring an effective learning process, the geographic community should utilise and create or redefine learning outcomes[2] and assessment standards[3]. Progression in geospatial skills is particularly needed in the field of geography. For one thing, the matter of implementing a technical learning outcome in geographical science poses an issue, yet for another it may lay the foundations for future learning processes and geography competency models.

This paper also seeks to delve deeper into the components of the Geospatial Technology Competency Model, which might be essential for geographers especially, and features a few of the many approaches to learning geography which should be taken into consideration. For this reason, the identification of technology competencies for geographers is closely associated with the identification of objectives in terms of intended technology outcomes. In order to plan suitable learning objectives, further geography technology objectives need to be set at an appropriate level as well. On account of the competency model, geographers now need a new skillset that encompasses basic geography and science, along with communication abilities, critical thinking, and problem solving.

2. Research aim, scope, and methods

This article takes the form of a research literature review that complements both the growing body of guidance on geospatial studies and the specialized process of performing a spatial analysis by fully qualified geographers. As a matter of fact, the literature search and review constitute a crucial element of the research process used herein. The literature refers to the sources that are relevant and effective in providing the in-depth knowledge pertaining to the current geospatial technology academic competencies with special reference to geography.

In the following sections, the reader will be introduced to a brief description of the Geospatial Technology Competency Model framework that specifies particular competencies, including the ones characterising the work of the majority of successful professionals in the geospatial industry, which are also of great relevance for geographers.

3. Essence of the Geospatial Technology Competency Model

In this part one may learn about the final framework on the geospatial programs at US community colleges from the late 1980s to the present.

By the late 1980s, a wide spectrum of said higher education institutions were allowed to participate in GIS projects and were granted funds by private and public organisations. Many community colleges have been thus better positioned to start teaching GIS and geospatial technology ever since. The National Aeronautics and Space Administration (NASA) with its headquarters located in the United States contributes greatly to this matter by dint of launch-

[1] Outcome-Based Education (OBE) – educational model in which curriculum, pedagogy, and assessment are all focused on student learning outcomes (Molin and Orbring, 2017).

[2] Learning outcomes – stated expectation of what someone will have learned (Molin and Orbring, 2017).

[3] Assessment Standards – trigger an image of rigid rubrics, behavioural objectives, tightly contained curricula, and reduction to quantitative measures (Molin and Orbring, 2017).

ing several programs to develop and identify key competences together with trained specialists, who can use geospatial technologies in their jobs (Gaudet et al., 2003). The final result was the first Geospatial Technology Competency Model (GTCM) and a matrix that associated 39 competencies, each of which comprised of 12 worker roles. The GTCM originally represented a process that was popularised by the late psychologist David McClelland in the early 1960s (Fig. 1). According to his words specifically, there was a need to conceive innovative methods that would help predict human performance (Gaudet et al., 2003), the theoretical base being the IABC competency model[4].

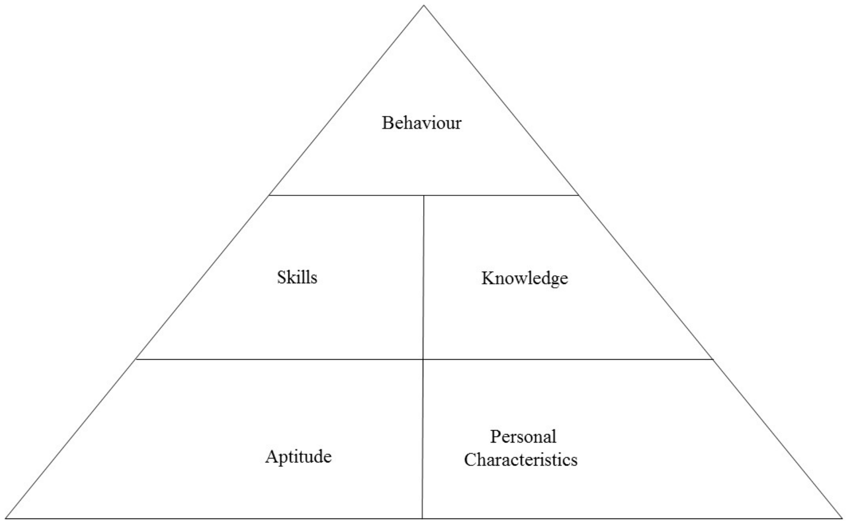

Figure 1. McClelland's Competency Pyramid Model (Source: McClelland, 1973)

In 2010, the US Department of Labour Employment and Training Administration (DOLETA) designed a new Geospatial Technology Competency Model (Fig. 1) based on its previous version. The aims included promoting the development of industry-driven competency models in high-growth, high-demand industries. Revised in 2014, this model attempts to identify specialised knowledge and abilities commonly used in the geospatial technology field. Tutors in the US and several other countries in the world may apply it to their teachings when formulating curricula that align with their respective workforce needs.

The Geospatial Technology Competency Model framework was established through a collaborative effort involving the Employment and Training Administration (ETA), the GeoTech Centre, and industry experts in general. Over the course of 2013–2014, the GeoTech Centre and industry subject matter experts updated the model with guidance from ETA to indicate the expertise needed by today's geospatial technology professionals.

Bearing that in mind, the US Department of Labour released a nine-tier geospatial technology competency model that specifies fundamental, industry-wide, industry sector-specific, and occupation-specific competencies (Fig. 1). It delineates 74 essential competencies and 18 competency areas that characterise the work of most successful professionals in the geospatial industry. As for its purpose, this model was devised to guide individual professional development.

[4] IABC competency model – a global accreditation program for business communicators built around major skillsets: communication, management, and a series of certain knowledge areas (Pompper, 2013).

Table 1. Tiers and blocks of DOLETA's Competency Model Framework (Source: DiBiase et al., 2010)

Tier 9: Management Competencies	
Tier 8: Occupation-Specific Requirements	
Tier 7: Occupation-Specific Technical Requirements	
Tier 6: Occupation-Specific Knowledge Areas	
Tier 5: Industry-Specific Technical Competencies	**Block:** Positioning and Data Acquisition; Analysis and Modeling; Software and Application Development
Tier 4: Industry-Wide Technical Competencies	
Tier 3: Workplace Competencies	**Block:** Teamwork; Creative Thinking; Planning & Organization; Problem Solving & Decision Making; Working with Tools & Technology; Checking, Examining, & Recording; Business Fundamentals
Tier 2: Academic Competencies	**Block:** Reading; Writing; Mathematics; **Geography;** Science & Engineering; Communication; Critical & Analytical Thinking; Basic Computer Skills
Tier 1: Personal Effectiveness Competencies	**Block:** Interpersonal Skills; Integrity; Professionalism; Initiative; Dependability; Lifelong Learning

The tiers of DOLETA's pyramid progress from general to specific (Fig. 2). Tiers 1 through 3, called foundation competencies, specify workplace behaviours and knowledge exhibited by successful employees in most industries. Tiers 4 and 5 include the distinctive technical competencies that characterise a given industry and its sectors. Tiers 6 to 8 cover occupation-specific competencies and requirements included in the occupation descriptions. Tier 9 represents management competencies associated with one or more occupations. The pyramid graphic (Fig. 2) shows that the majority of tiers consist of several building blocks, each of which represents a competency cluster. The complete model includes an official list of competencies associated with each block.

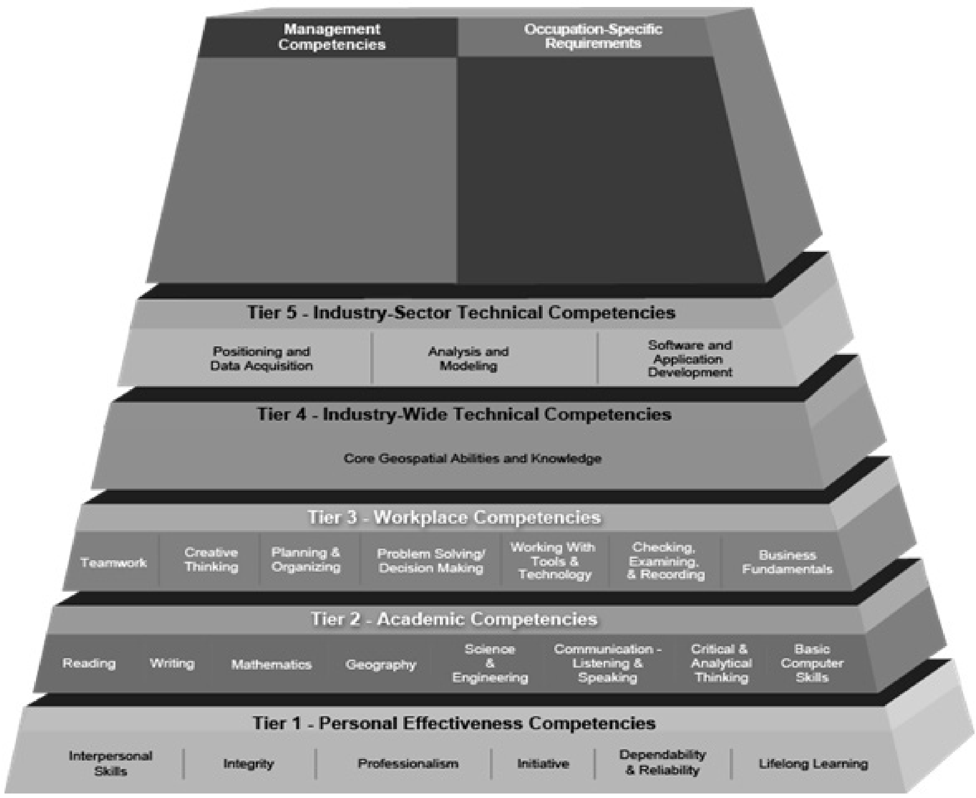

Figure 2. Geospatial Technology Competency Model (Source: DOLETA's Competency Model Clearinghouse, http://www.careeronestop.org/competencymodel)

The additional section pertains to the geography block which appears in the academic competency tier with its associated cluster (Table 1). The author believes that DOLETA's pyramid is designed to offer job seekers, including geography students an opportunity to learn the requirements for entering a chosen field. As far as this competency model is concerned, geography is defined as "Understanding the science of place and space. Knowing how to ask and discover where things are located on the surface of the earth, why they are located where they are, how places differ from one another, and how people interact with the environment" (National Research Council of the National Academics, 2010).

4. Geography Academic Competencies (Tier 2)

Before the matter of geography academic competencies is discussed directly, it is necessary to create a context for this part of the article, namely the vast image of academic competencies itself (Table 2).

As demonstrated, fundamental academic competency is built around eight major skillsets (e.g. science and technology, critical and analytical thinking, or computer skills) and a series of abilities important for the overall competency block (e.g. comprehension, application, or reasoning). The fact that most researchers have found the academic competencies necessary to deploy these terms as essential to geospatial competencies confirms their importance. They have taken additional steps to identify specific competences that are crucial to geography academic competencies. Thus, the utmost prominent objective of today's geography education is to provide individuals with all existing knowledge, methodology, technology, and otherwise so they will be able to produce new geographical information.

Table 2. Basic Academic Competencies (Source: Wrench, 2013)

Academic Competency							
Reading/ Comprehension	Writing	Mathematics/ Statistics	Science and Technology	Listening and Speaking	Critical and Analytical Thinking	Active Learning	Computer Skills
Comprehension; Attention to details; Integration; Application	Organization and development; Mechanics; Tone	Quantification Physical measurement and estimation; Psychological/ communication measurement and evaluation; Application	Comprehension Application	Speaking; Listening; Two-way communication; Persuasion/ influence	Reasoning; Mental agility	Learning strategy; Application	Comprehending the basics; Entering data; Preparing documents.

Geography is the science of the Earth's surface and its varied occupation, also known as understanding the science of place and space. It involves knowing how to request and discover the location of objects diverse in size and structure, the grounds of their location, differences between a variety of places, and interaction of people with the environment. As the new developments in geography are affecting every field (including the field of education itself), the need for qualified individuals equipped with certain abilities has emerged. Only recently one of the most essential aims of geography courses is to ensure that the people in question acquire basic skills[5] that will bring their perception of space and place to the next level (Degirmenci, 2018).

[5] Skill or geographical skill – basic element of knowledge; ability to consistently perform any activity at a certain level of competence; one of the targeted abilities to be acquired and developed by the student through the teaching process (Degirmenci, 2018).

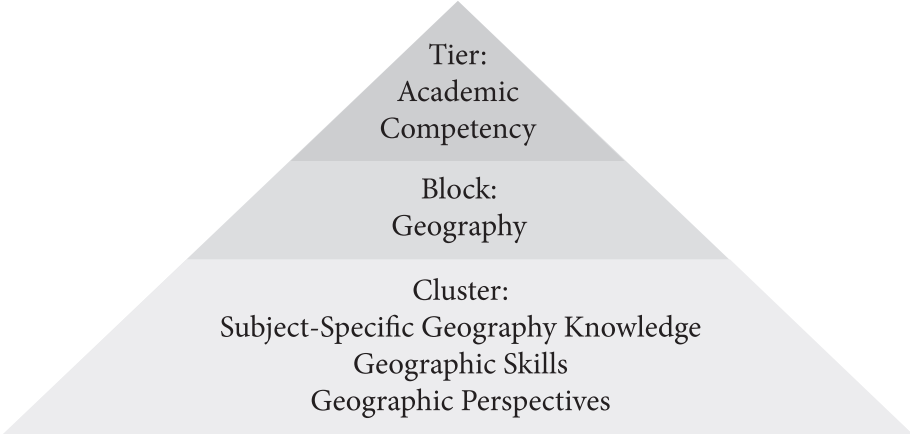

Figure 3. Geography Competency Model Structure (Source: after DiBiase et al., 2010, changed)

Figure 3 comprises a pyramid made up of structured blocks related to professional geographer competencies, which were identified among others by Solem et al. (2008). The researchers conducted a series of surveys intended to illuminate workforce needs in the field that employs individuals with a degree in geography. According to DiBiase et al. (2010), the topic that generated the most intense discussions was the definition of Geography Competencies in Tier 2. The Professional Geography Competency Model was the key resource for that block, while also playing an important role in validating the Foundation Competencies in Tiers 1 to 3.

Table 3. Example of Tier 2 Academic Competency Cluster (Source: DiBiase et al., 2010)

Key geographic skills as a basic element of geographical knowledge – necessary tools and techniques	
Geography-Environmental Interaction:	knowing and applying geographic information about relationships between human and non-human systems (certain physical, natural elements), interacting to alter environmental conditions (e.g. changes in biogeochemistry due to hydrological or geomorphological processes, biogeography, and water and atmospheric quality. In the social sciences, faculty interests incorporate analyses of natural resource allocation and policy, social and ethical issues of sustainability, environmental impact assessment, as well as local community development and resource use).
Regional Geography:	knowing and applying the knowledge of physical and human geography of a specific geographical space, country or region, apart from applying geographic information about relationships, external influence and linkage between regions.
Physical Geography:	knowing and applying geographic information about the processes that shape physical landscapes; weather, climate and atmospheric processes; ecosystems and ecological processes; natural hazards.
Human Geography:	knowing and applying geographic information about human inhabitation on Earth are regularly engaged in organising, reorganising, and interacting with other groups (e.g. culture and cultural processes, including religion, language, ethnicity, diffusion, meaning of landscapes, cultural significance of place).
Subject-specific geographic knowledge	
Geographic Information Systems (GIS), Land Information Systems (LIS), Urban Information Systems (UIS), Natural Resources Information Systems (NRIS):	a data processing system designed for map production or visualisation;
	a data analysis system for examining conflicts over plans or optimising the design of transport system;
	an information system to be used in responding to queries about land ownership or soil type;
	a management system to support the operations of a utility company, helping it to maintain its distribution network of pipes or cables;
	a planning system to aid the design of roads system, excavations, or forest harvest operations;
	an electronic navigation system for use in land or sea transport.

Cartography:	visualised and analysed geographical data;
	producing, creating, and designing either paper or digital maps.
Field Methods and Techniques:	use interviews, questionnaires, observations, photography, maps, GPS, GIS, and other techniques to measure geographic information in the field.
Spatial Statistics:	use quantitative methods to process spatial data for making calculations, models, and inferences about space, spatial patterns, and spatial relationships.
Environmental and Resources Management:	detects changes in the environment (e.g. erosion, particularly of productive agricultural soils; pollution of rivers, lakes and oceans; climate changes; urban related changes)
Geographic Perspectives	
Spatial Thinking:	identifying, explaining, and finding meaning in spatial patterns and relationships (e.g. site conditions, similarities and differences between various places, the influence of land features on its neighbours, the nature of transitions between places, linkage of different places at local, regional, and/or global levels).
Global Perspective:	possessing and applying knowledge of how people, places, and regions are linked by global networks and processes (e.g. globalisation, international trade, immigration, Internet technology, global climate system).
Interdisciplinary Perspective:	drawing on and synthesising the information, concepts, and methods of the natural and social sciences for geographic research and applications.

At the very bottom of the Geography Competency Model pyramid one can find general cluster sections, such as subject-specific geography knowledge, geographic skills, and geographic perspectives. As for the top part, however, it outlines the main geospatial academic competencies defined by the model owners.

Table 3 presents an example of Tier 2 Academic Competency Geography Cluster (DiBiase et al., 2010). The approach suggested by the researchers defines particular cluster elements. Unfortunately, the solutions they offered do not reflect the discipline-specific abilities to the full extent, which seems to have been confirmed even by the authors themselves. The given example thus clearly shows the lack of correlation between the needs of the geospatial industry and the geographic education knowledge requirements. For this reason, it is necessary to define geographical subject-specific skills, and identify what distinguishes geography from geospatial market needs when taking the nature of geographical knowledge into consideration.

At present, geography educationists debate about geographic perspectives, especially the nature of thinking geographically. In order to familiarise the reader with the very concept of said thinking, the authors provide them with several definitions. Most of them contain common concepts and aspects, e.g. space and place, scale and connection, proximity and distance, relational thinking, or the bridge between nature and society – space, place and environments, space and time (Haggett, 1965; Lambert and Jones, 2013; Jackson, 2016). Referring to the given example of Tier 2 Academic Competency Cluster (Table 3), the special thinking is not fully considered as the core of a specific geography ability. It also seems that geography-oriented skills are beyond the scope of the model. Then again, when it comes to specific elements of the spatial thinking abilities, they have been looked into more thoroughly. As an illustration, numerous geography researchers have developed and defined the following categories: spatial perception, mental rotation, and spatial visualisation. As such, spatial visualisation has been long used in geography research as a primary technique (Molin and Orbring, 2017; Orbring, 2017).

Furthermore, the Academic Competency Geography Cluster concept includes two more elements: Global Perspective and Interdisciplinary Perspective. Geography's relevance to science and society arises from a distinctive and integrating set of perspectives through which geographers view the world around them. The conventional structure of the geographical paradigm is summarised in Figure 4. Information about the Earth's surface is stored in terms of its spatial and temporal dimensions, and in terms of the intrinsic characteristics of interest (Haggett, 1965).

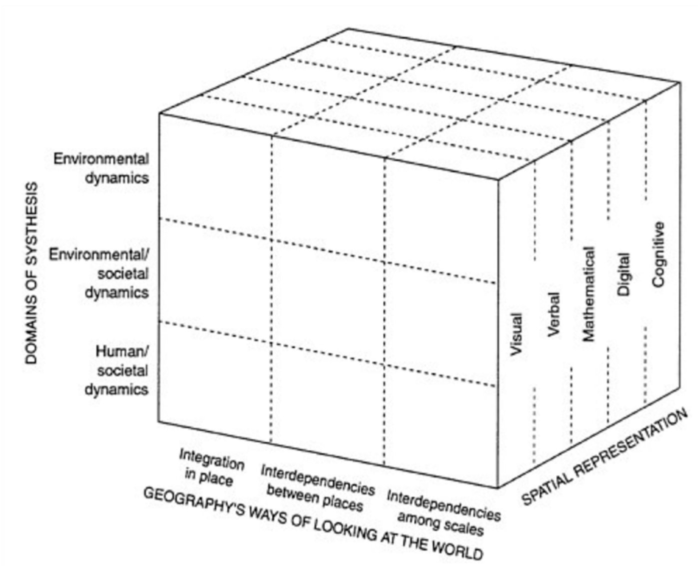

Figure 4. The matrix of geographic perspectives (Source: Haggett, 1965)

Like any other academic discipline, geography has a well-developed set of perspectives (Haggett, 1965):

– geography's manner of looking at the world through the lens of place, space, and scale;
– geography's domains of synthesis: environmental-societal dynamics relating to human impact on the physical environment, environmental dynamics linking physical systems, and human-societal dynamics linking economic, social, and political systems; and
– spatial representation using visual, verbal, mathematical, digital, and cognitive approaches.

The geography perspectives presented above cover a wider spectrum than the one proposed in the model. Spatial representation, the third dimension of the matrix, underpins and sometimes drives research in other branches of geography.

From a geographical point of view, one of the most important external contacts is spatial representation science. Since the early days of geography, the range of its techniques has widened considerably in order to cope with the difficult processes, as well as returns to scale and input substitution problems.

The Academic Competency Geography Cluster framework should be defined as the capability to apply or use a set of related knowledge, skills, and abilities required to successfully perform major work functions or tasks in a defined work setting (DiBiase et al., 2010; Wikle, 2010). It should be noted that in certain cases it may be difficult to assess whether the Academic Competency Geography Cluster framework will benefit industry sectors, academic community in the EU, and individual professionals at this point.

5. Aligning the academic competency geography cluster to the geography discipline

According to the researchers behind the Geospatial Competency Model, this model is being used by individual professionals, several public and private institutions, along with companies and educators worldwide. In addition, it highlights potential for assessing the alignment of academic program curricula with geospatial workforce needs. As for analysis of all information related to the comprehensive Geospatial Competency Model – especially the block and cluster concerning geography – a few common themes have emerged:

Geography and geospatial technology

At this stage of the discussion, the author believes that the theoretical basis for resolving dilemma about technology and geography is essential to understand the overall theme of this section. The following criteria, which are also of great importance to the geography discipline, were proposed as a point of departure for evaluating the topic: a) the changes brought about by technology in the field of geography, b) the influence of technology on the production and representation of geographic knowledge, c) the effect of technology on the structure of the geography curriculum.

The topic of technology is vast and rich, and geographers have not been and are not among the most prominent explorers in the studies of the history and philosophy of technology (Harvey and Chrisman, 2004). Geographical data is a key element of the dilemma regarding technology and geography for many researchers. It is thus no surprise that the conversion of existing geographical data from an analogue into a digital format was seen as a turning point in terms of geography research. In this regard, a large number of geography researchers and educators consider it a crucial point in the evaluation and development of analytical tools, scientific methods and techniques Walford (Walford, 2002).

It should also be noted that numerous supporters of the geospatial industry began to take a different perception of relations between technology and geography since then. To be more specific, the field of geography is part of geographical science in general. Such statement constitutes an undoubtedly other stream of geographical knowledge than the one presented in this article, but, as implied by Agnew and Livingstone (2011), this approach has often had little or no direct influence on the cultivation of geographical knowledge and practice. Both geography and technology deal with the structure and character of spatial information to a certain extent; for instance, new technologies, such as global positioning systems (GPS), geographical information systems (GIS), digital photography, and geospatial visualization have facilitated the processing, analysis, and representation of geographical data (Harvey and Chrisman, 2004).

As for geography itself, the didactics, fieldwork, direct observation, measurement, mapping and indicative inference have been lauded for a long time. It must be remembered, though, that these practices have always been influenced by technology development. Nevertheless, relatively little has been done to understand the relationship between science and technology, not to mention technical artefacts, which makes it difficult to see why geography researchers have neglected this matter to such degree. In fact, one of the common reasons mentioned by them is that they have hardly ever glanced at the devices which explore the employed with the purpose of obtaining geographic data. It so transpires that historians of geography still put focus on instrument types, markers, categories, etc. However, in this day and age greater emphasis should be placed on computerisation, automation, instrument configuration, capacity, error identification, maximum precision possible, as well as required tolerance thresholds. What is more, the Internet is being increasingly used as a means to find information necessary for research, and not only that, it may also serve the purpose of educational instruments. For example, virtually all of the traditional assumptions pertaining to geography research and education in geo-technological context boil down to the fact that GIS project-based learning is necessary to facilitate the use of geographical tools. In the same vein, the professionals in this field have more than GIS applications at their disposal when it comes to geographic information systems. There are geography-oriented tasks and adopted technical tasks performed by geographers, such as data creation, organisation, conversion, validation, evaluation, along with their import, export, and updates; other responsibilities include mapping, georeferencing, conducting geostatistical analyses, digitising data, conducting image analyses, etc. As such, those tasks are collectively called either geography specific or non-specific, and may most likely become predominant activities in geography labs within a decade or two.

Technological changes within the field cannot occur without clear support from national and worldwide geography organisations. Up to a few years ago, the debate on geography and technology was almost forgotten. For this reason, a certain number of geography researchers indicate a lack of control over technology or technological development in terms of geography. At present, this topic is substantially larger and includes more aspects and research concerns.

Geospatial industry and geography labour market

Very little is known about the interface between post-secondary education and the labour market in geography. For that matter, it cannot be ascertained precisely when students leave their universities and enter the work force. Geography education should essentially provide them with opportunities to work on their respective labour market, and include all geography degrees. As a matter of fact, the need to evaluate the occupation structure of geography degree recipients worldwide gave rise to a list of professions with which most geographers would identify. Thus, a multitude of university communities from around the world endeavoured to determine basic competences for specific geographic occupations. Incidentally, several of them used DOLETA's model as an example.

It should be mentioned that geography labour market often consists of various submarkets with different sets of knowledge, skills, and competencies necessary for productivity in multiple segments. The segmentation of said market challenges economic theories on the ground that workforces and professions are not perfectly tailored to the universal market mechanism. As an illustration, the geospatial competencies proposed in the Geospatial Technology Competency Model are part of already established criteria for geography-related occupations (Fig. 5).

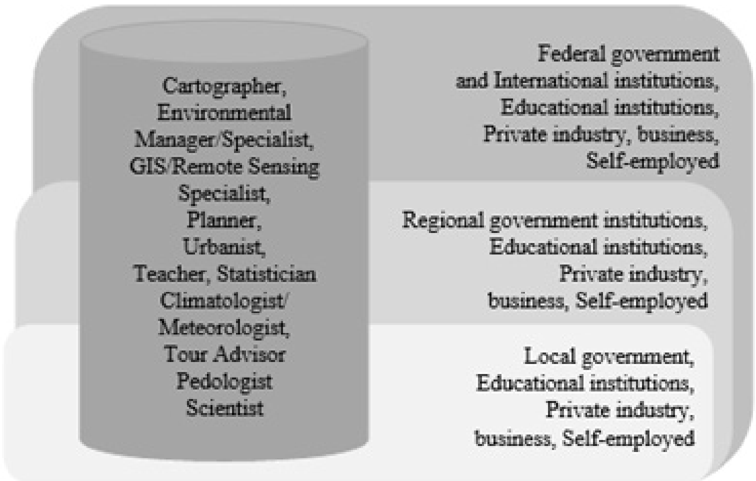

Figure 5. Geography graduates organized into Occupation and Employer (Source: after Rediscovering Geography Committee, 1997, changed)

The geospatial industry is strongly related to the geography labour market as well, so the Geospatial Competency Model supporters have attempted to propose a standard definition of it. In this case, most of the suggestions revolve around the term geospatial[6], which has been widely defined by historical geographers. However, in recent times, the new geospatial approach in geography is strongly associated with the main challenge faced by

[6] Geospatial – meaning of symbols, such as words, graphs, and other representations that are employed to describe real-world objects (Shekhar and Xiong, 2008).

educators who venture to implement geospatial assessment practices used for geospatial thinking in the geography discipline (Sharpe and Huynh, 2015).

Geospatial industry and geography higher education

This part of the paper focuses on the development of the geography education system as it relates to geospatial industry. Particular attention is paid to the curriculum structure and learning progression, geospatial assessment, spatial thinking, etc.

Recent years have seen a renewed interest among researchers when it comes to geography education. Multiple geographical topics are contentious to a certain extent, and the manner in which they are handled may send a misleading message to the geospatial market about the contribution made by professional geographers in the development of geospatial competencies. The question which arises here concerns the geography curriculum and how many efforts should be invested to understand the actual needs of the geospatial industry, which represents different abilities and interests. On the same note, the issue of geographic education knowledge requirements has been addressed as well. The number of opportunities for developing innovative approaches in both teaching and learning geography has been increasing rapidly nowadays, including the attention paid to designing a geography curriculum that is pertinent to the geospatial industry needs. Geography authorities have been particularly active in seeking the links between geography and other sectors of geographical labour market, e.g. the role of technology and the instruments of exploration in geography. In addition, there have indeed been transfers in content between geography education and geospatial industry. By virtue of a concern regarding geography curriculum design, syllabuses, and programmes of study, an attempt has been made to strike a balance between regional and thematic (spatial patterns) approaches (Standish, 2009; Zentai and Gercsák, 2009). In reference to the US university communities' experience, the geography departments that have not yet undertaken, for example, GIS teaching and research may encounter severe sustainability issues. Therefore, at present, the majority of these departments complement the discipline with GIS education and scholarships (Johanson and Sullivan, 2010; Estaville, 2012).

In the current educational environment, spatial thinking would play an important role in the educational standard for various geography fields, and as such should be implemented into it. At the same time, as observed by Turki (2010), a wide range of urban studies and forthcoming education programmes still pay no mind to GIS and spatial thinking in general. Consequently, over the past few years, several researchers have started conducting empirical studies on the competency assessment model in terms of geography competency system. In short, the research has been directly related to the spatial thinking process. Finally, geographical system competence (GSC) has been defined as cognitive achievement dispositions necessary to analyse and comprehend geographic systems in a specific context, as well as act adequately towards them (Viehrig et al., 2017. That being said, the GSC model consists of three separate dimensions: comprehend and analyse systems, act towards them, and spatial thinking.

In a general sense, a large number of geography researchers argue that spatial thinking is an amalgam that involves knowledge about three components: the nature of space, methods of representation of spatial information, and the process of spatial reasoning (Jo et al., 2012). As a result, the criticism of geospatial competency assessment among geographers contradicts their already growing interest in spatial thinking. Ultimately, spatial thinking is integral to the success of all geography students. Living organisms and their environments are situated in space, and when it comes to human-environment interactions, they must be understood in terms of locations, distances, directions, shapes, and patterns (Jo et al., 2012).

Geography education standards exhibit the potential of infusing spatial thinking into the discipline, and demonstrate the need for a coordinated approach to spatial thinking standards across the curriculum. Paradoxically, however, GIS as a support system for geographical thinking is said to have been unfairly relegated to an appendix instead of being integrated into the structure of geography standards, which illustrates a rapid change in geospatial technology as well. Other than that, there is a possibility of developing standards for spatial thinking across the curriculum.

Another crucial matter that should be noted refers to the owner of DOLETA's model, who is of the opinion that university teachers have been provided with all the requirements including standards, certification, accreditation, and licensure. Unfortunately, the lack of consensus in the academic community on GIS being a research subject (or even a profession) gave rise to the situation in which the majority of geography curricula cannot ensure proper education for the ones who may work in this field at a later date. On another front, geography and technical skills complement each other in various aspects, the shared characteristics being the focus on GIS specifically.

Since the early 1990s, geography departments have been utilising Geographic Information Systems-related geospatial technologies in an effort to enhance teaching and learning. Research reveals that GIS is in fact a particularly relevant educational tool, which facilitates inquiry learning in regards to problem solving, and can be combined with many innovative practices, which, again, may contribute to the development of students' spatial thinking skills. Owing to these advantages, GIS is proposed to be included in the geography curricula. In the same vein, it is a clear sign for geography teachers that a subject concerning said systems may be of use for the students who want to make sense of the world.

Table 4. Geographic skill areas and general skill areas in professional geography (Source: Solem et al., 2008)

Geographic skill areas
Geomorphology; Weather and climate; Biogeography; Natural hazards; Economic geography; Political geography; Cultural geography; Population geography; Human-environment interaction; Cartography; Geographic information systems; Photogrammetry; Remote sensing; Field methods; Spatial statistics; Regional geography; Interdisciplinary perspective; Spatial thinking; Global perspective; Diversity perspective
General skill areas
Entrepreneurial skills; Teamwork; Coaching and advising; Relationship building skills; Intercultural skills; Teaching; Computer and technology skills; Publishing; Information management; Grant proposals; Time management; Adaptability; Self-awareness; Ethical practice; Project management; Fiscal management

In response to the challenges presented by geospatial technology, the geography discipline has adapted a wide variety of skills. Several academic departments have confronted these issues by initiating professional master's or doctorate programs that integrate either management training or technical training and internship with scientific education. As a matter of fact, the changes that have been made answer most of the concerns related to geography and geospatial technology. Additionally, based on their empirical research, Solem et al. (2008) put forward a new set of geographical and general skill areas in professional geography (Table 4).

6. Conclusions

The geospatial industry exerts influence on the geography discipline and is growing by leaps and bounds. Continuous development of technologies, be they new or long-standing, not only confounds the educational system, but also affects the geography labour market. That being said, it is true that the current uncertainties related to the creation of pertinent geography curricula for selected countries or the world in general obstruct an efficient implementation and enforcement of geospatial industry standards. At the country level, a geography curriculum should prioritise integration and application of the rapidly growing geospatial technology. Apart from these two aspects, a geography curriculum must favour technological innovation projects in its respective field to meet the prospective professional geographers' expectations.

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