Spatial Intelligence and Toponyms

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Abstract. In the past toponyms were the main tool to make spatial relations and spatial reasoning. They are reflecting spatial relations in historical, cultural and other contexts. Toponyms as base of knowledge about spatial relations contain a lot of information. After theory of multiple intelligences proposed by Howard Gardner in 1983, spatial intelligence is one of the more recognized intelligences (bodily-kinesthetic, linguistic, logical-mathematical, musical, interpersonal, intrapersonal, naturalistic and spatial). The most common description of spatial intelligence is the ability to be able to recreate one's visual experience and reasoning about shape, measurement and orientation. In the conceptualization of the spatial relations using toponyms spatial intelligence is not based only on the visual experience. Spatial reasoning using toponyms is the ability to reason about spatial relations using toponyms as objects that are containing spatial information. It is the ability to extract position and orientation from toponym in everyday life. Toponyms are often not taken as the complete object that is built of information about geographical feature, noun and position in the space. Without any of the element toponym is not completely defined. For example, spatial reasoning using not completely defined toponym can lead to cardinal mistakes; noun Berlin can be connected to capital of Germany, but also settlement in Finland and region in France. Spatial intelligence is mostly connected to visual sense and visualization of space features. Because of that is sometimes term visual thinking used. But, blind persons also have spatial intelligence and spatial intelligence is not exclusively tied to the visual sense. Toponyms can be given in narrative way and not only in the written form. They are also not primarily connected to visual effects. Standardization of toponyms and development of Spatial Data Infrastructure (SDI) or spatial Information and Communication Technologies (ICT) systems is using toponyms in semantic approach that is leading to conceptual models. Ontology, as new trend is still not fully standardized. ISO is writing more standards on ontology to giving more possibilities in connecting different bases of knowledge and that is important for toponyms whose elements are defined in different disciplines. Definitions of toponyms made

by United Nations Group of Experts on Toponyms (UNGEGN) and EU INSPIRE have small differences that are defining different base of knowledge and can lead to different developments and practical solutions. That can lead to different spatial reasoning using toponyms. This work is indicating basic relations between toponyms and the spatial intelligence and spatial reasoning.

Keywords: spatial intelligence, spatial reasoning, toponym

1. Introduction

Toponyms are tools to define position and orientation. They are developed and used for centuries. They are assigned to features to articulate the space around us, but also to serve as tool in communication. The toponyms reflect historical and cultural development of area and they are defining not only features, but also individuals, groups and nations that are using them. Toponyms are one of the most widely used tools in recognition of the place and orientation in space.

Because of the importance of the toponyms, United Nations (UN) founded United Nations Group of Experts on Toponyms (UNGEGN) as a permanent expert body for standardization of the geographical names. European Union (EU) is developing Infrastructure for Spatial Information in the European Community (INSPIRE) (European Parliament 2007). Geographical names are one of the data themes among 34 other INSPIRE data themes. Toponyms are one of the main parts of global, regional and national Spatial Data Infrastructures (SDI).

Toponyms, maps, GIS and SDI can be interpreted as spatial thinking tools that are representing historical development steps. Toponyms have been used as spatial thinking tool before maps and GIS and SDI are next development steps. Each generation of tools is more developed and giving more possibilities. Spatial intelligence, that is relatively new approach, is opening huge area in research on the basis of studying development of spatial thinking tools.

2. Elements of the Toponym's Base of Knowledge

Toponyms have complex structure containing information about space, feature, language, time, group that is using it and other. Because of that they are researched in more scientific fields. More international institutions are influencing development of toponyms. But, already differences in defi-

nitions of the toponym can be articulated. They can lead to other interpretations and definitions of the base of knowledge.

Because inconsistency of toponyms on topographic maps, United Nations (UN) recognized importance of standardization of toponyms and United Nations Group of Experts on Geographical Names (UNGEGN) was founded (UNGEGN 2010). One of the main goals of the UNGEGN is to stimulate national and international standardization of toponyms, supporting and promotion of national standardization efforts and adoption of unique writing system (ECSEE 2013, Hećimović et al. 2009, Hećimović et al. 2011).

European Commission established in 2007 INSPIRE to harmonize and maintain pan-European spatial data (INSPIRE 2013). INSPIRE defined 34 data themes including geographical names classified as basic, annex I, data themes: coordinate reference systems, administrative units, transport networks, cadastral parcels, hydrographic and geographical names. Geographical names are defined in the context of EU regulations and ISO specification. To preserve characteristics of geographical names, INSPIRE permitted to duplicate toponyms, as well addresses (e.g. minority language or exonyms) and that is not permitted to other groups of data. Toponyms should not be translated, but used as exonyms (e.g. Dunav (hrv), Danube (eng, fre), Danubio (ita, spa), Tonava (fin), Danubi (cat), Δούναβης (gre)...). Based on INSPIRE, EU established EuroGeoNames pan-European system of geographical names (Zaccheddu and Afflerbach 2008). It is maintained by EuroGeographics as a part of INSPIRE development trough European Spatial Data Infrastructure (EuroGeographics 2013). EuroGeoNames is defining geographical names conceptual model on the level of UML object oriented semantics (EGN 2009, Ormeling 2009).

The International Council of Onomastic Sciences (ICOS) is the international organization with a special interest in the field of studying of proper names (place names, personal manes and other), founded in 1949. The main aims of ICOS are the advancement, representation and co-ordination of onomastic sciences on an international level and in an interdisciplinary context (ICOS 2013).

2.1. Definition of Toponym

The UNGEGN, INSPIRE and ICOS definitions of toponym are created in different epochs and different base of knowledge are in backgrounds of each definition. UNGEGN has standardization of geographical names as primary goal and it is connecting more branches. INSPIRE is strongly under influence of ISO geoinformation standardization with goal of building European SDI. ICOS is following onomastic, linguistics base of knowledge. UNGEGN, INSPIRE and ICOS are defining toponym as:

- UNGEGN: toponym - proper noun applied to a topographic feature (Kadmon 2002). (Topographic feature - a portion of the surface of Earth or of any other planet or satellite that has recognizable identity.)
- INSPIRE: geographical name (toponym of a feature on the Earth) - proper noun applied to a real world entity (INSPIRE 2010)
- ICOS: toponym - proper name of a place, both inhabited and uninhabited (Terminology Group ICOS 2010).

In all definitions, toponym is defined as proper noun. It should be applied to topographic feature, real world entities or place. Proper (noun) is indicating intention to uniquely identify feature. It is giving to toponym meaning of unique identifier of spatial feature. There are differences in definitions of what should be named. UNGEGN is defining named place as the portion of the surface of Earth that has recognizable identity, INSPIRE is defining named place as real world entity and ICOS is naming a place. These differences can cause different interpretations of formal representation of toponym in a universe of discourse and difference in realization of conceptual model. UNGEGN definition is giving possibility to give name to every portion of the surface of Earth that has recognizable identity. What feature is going to be recognized and named depend on needs of individuals, groups or nations. One of basic reasons why the names are applied to features is communication considering position and orientation in space. Already reason of giving names to some spatial feature is related to future spatial thinking.

2.2. Semantic and Ontological Approach to Toponyms

Toponym is interdisciplinary problem that is joining geography, surveying, cartography, linguistics and other branches. Toponym is complex object that includes more elements (see Figure 1).

Elements of toponyms on figure 1 are researched in more scientific fields. Semantics approach to geoinformation is classical approach. Semantics as the study of meanings is used as the background in establishing relationship between spatial data. ISO/TC 211 geographic information standards and INSPIRE are using UML schema as object oriented semantics in description of the data model (Jakir et al. 2011). ISO/TC211 geoinformation standardization of ontology approach is intended to provide General Feature Model (GFM) modular models that can be joined by ontologies (ISO 2010a and 2010b). Ontology is giving possibility to connect different views of the real or hypothetical world that includes everything of interest; e.g. universe of discourse. Because idealization of real world in to universe of discourse, in the information-communication technology (ICT) more ontol-

ogies about the same part of reality can be developed. Scalability of ontological models is allowing integration of new knowledge bases. Ontologies are allowing integration of heterogeneous data of different communities (Kovacs et al. 2006).

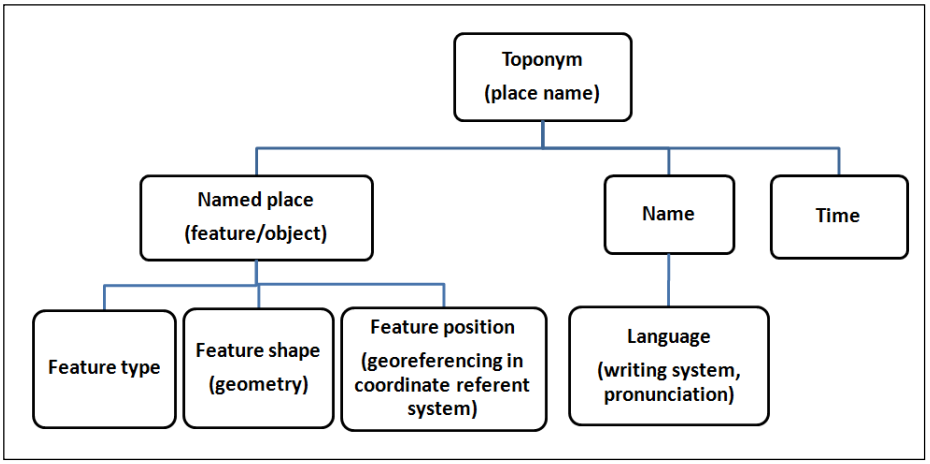

Figure 1. Essential elements of a toponym (Jakir at al. 2011).

Semantics and ontological approaches of toponyms and other spatial data are defining theoretical background of spatial thinking from geoinformation point of view.

3. Spatial Intelligence and Toponyms

Howard Gardner introduced in 1983 the theory of multiple intelligences. He defined intelligence to refer a biopsychological potential to process certain kinds of information in certain kinds of way. He introduced seven intelligences: linguistic, logical-mathematical, interpersonal, intrapersonal, spatial, musical and bodily-kinesthetic (Gardner 2007). In 1999 he added a naturalist intelligence as new intelligence that is relating information to one's natural surroundings, without claiming that this is a complete list of intelligences (Slavin 2009). Representations of real world and real worlds with elements of imaginations and subjective interpretations can give to intelligence other dimensions. Intelligence is most widely studied in humans, but also has been observed in animals and plants. Beside bio intelligences also artificial intelligence of machines can be articulated. Virtual technologies are giving possibility of development of unique spatial intelligence. Cartoons, fantasy, fairy-tale and imagination worlds and spatial relations contain special spatial relations and place names (Molitor 2013).

Brain activities can be interpreted as chemical and electrical activities; e.g. tots, sensations of feelings, decisions, emotions, memory and other activities. Spatial intelligence is the biological capacity that focuses on spatial judgment (Gregory at al. 2013, CDK007 Production 2009). There are many spatially related concepts in use: spatial ability, spatial reasoning, spatial cognition, spatial perception, environmental cognition, cognitive mapping and other.

3.1. Spatial Thinking

There are more forms of thinking: mathematical, verbal, logical, metaphorical, hypothetical, and other. Ability to use space as a framework for understanding, to define problems and give solutions is based on spatial thinking. Spatial thinking is an essential competence in a lot of branches like surveying, cartography, architecture and other. There are no standardized measure of essential knowledge and skills of spatial thinking (Committee on the Support for Thinking Spatially 2006). Tests and analyses of spatial thinking are mostly under influence of logical and mathematical approaches strongly influencing interpretations of tests and definitions of spatial thinking elements (Fibonicci 2013, Pattridge 2013).

There is no consensus about scientific definition of spatial thinking (Lee and Bednarz 2012). The main disagreements occur about the scale, dimensions, the nature of cognitive processes involved, the number of major components and the relationships. Spatial thinking is a combination of cognitive skills: concepts of space, tools of representation and processes of reasoning (Committee on Support for Thinking Spatially 2006). Space provides the conceptual framework. Representations provide the frame within which spatial information can be processed and reasoning processes provide the means of processing spatial information and making decisions. This ability can be observed in animals and humans (Zhan 2013).

3.2. Elements of Spatial Thinking and Toponyms

Spatial thinking is mostly approached from individual person point of view; e.g. psychological, educational, testing individual's approaches. Communicational aspects are in backgrounds. Toponyms are used as tool to define spatial relations for centuries. Much before maps, toponyms defined approaches to spatial thinking and reasoning. Spatial thinking using toponyms is giving us insight in spatial thinking development before maps. Toponyms can be given in written form (on maps, GIS, spatial DB...) or in narrative way (pronunciations and phonetic are becoming important). Toponyms are defining spatial relations. Using toponyms spatial thinking is not defined considering only visualization. Visual sense is very dominant sense used by humans, and usually treated as the most important in everyday life.

Toponyms are basic tools for spatial reasoning in communication. Analyzing spatial thinking using toponyms the past spatial thinking relations can be analyzed. Some of the problems in spatial reasoning using toponyms could be caused because:

- the same noun can be used for different features,
- the same feature has more names,
- toponym is not uniquely defined (at least: feature, georeferenced shape and noun),
- endonym/exonim problems (Dunav, Danube....),
- not unique writing system (toponyms in the writing system readable for all (Romanization system); if the map of Europe would be written in native national writing systems it would be readable only for very few people because variations of Latin alphabet with national diacritic characters, Greek alphabet, Cyrillic alphabet...),
- some countries have more official languages,
- minorities languages and toponyms (official on the local areas)
- dying of toponyms with dying of people and languages,
- and other.

3.3. Toponyms and Ambiguous Spatial Reasoning

Toponyms are mostly used as unique identifier of feature/objects. But, if all elements of toponyms are not defined, toponym can be ambiguous information. For, example, if somebody is saying: "I am going to Berlin." The most of people will connect Berlin with capital of Germany. But, there is Berlin settlement in Finland and region in France (see Figure 2), and spatial reasoning is going to be ambiguous.

To be uniquely defined toponyms should contain at least: defined feature (capital, region, settlement), georeferenced geometry of the feature (Germany, Finland, France) and name (Berlin). Because ambiguity toponyms can be seen as association about space. But, in the past before maps, toponyms were the only spatial reasoning tool and today they are still massively in use.

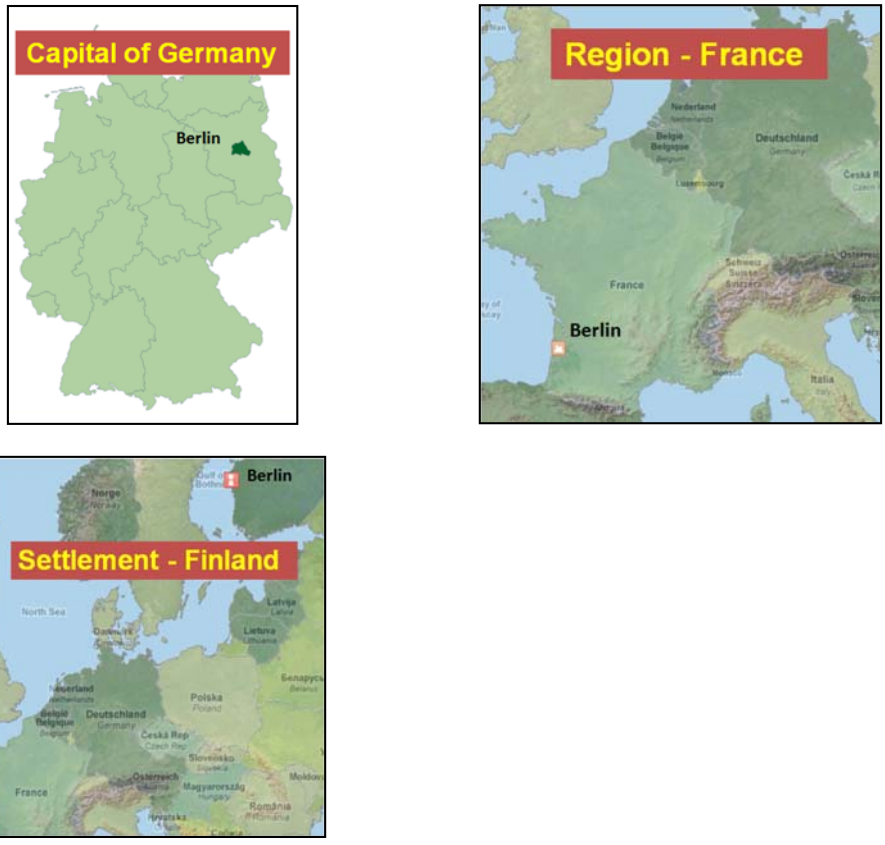

Figure 2. Toponyms Berlin.

Toponyms have the role of unique identifier. But, unique identifier should have defined domain of its definition. There is no unique opinion if “A 3”, “E 40”, "Route 66" are toponyms or only unique feature identifier (see Figure 3).

Figure 3. Toponyms or only unique identifiers of the roads.

Toponym, name of the street can be date "6th July". In this case proper noun of the street (feature) is date.

ICT technologies do not accept ambiguity relations. They do not have possibilities to make additional communication and collect more information and explanations. SDI is using unique identifier in massive scale and that community is accepting the identifiers as names.

Toponyms are complex objects that are defining:

- space (toponyms are defining rudimental definition of space, and defining spatial relations between features...),
- representation (toponyms are defined in verbal or written form and they are represented by language, writing system, pronunciation...),
- reasoning (toponyms are giving us possibility to find position and orientation in space...).

Toponyms have strong spatial information, but they can have special meaning for particular groups. For example, the toponym Alps, the mountain range in the Europe, has different meaning for:

- somebody who is living in Alps and Alps are part of his living surroundings,
- somebody who is living in the other parts of Europe; non Alpine area,
- somebody who is living on the other continent (Africa, Australia...),
- cartographer, geologist, surveyor or expert of other branches,
- poets using toponym Alps in poems,
- painters, photographers of Alps,
- and other.

3.4. Spatial Reasoning and Spatial Scaling

If in this very moment somebody is going to call you on mobile phone and ask you: "Where are you?" Consider three cases:

- 1 case: somebody is calling you, who you see every day (wife, husband, friend...),
- 2 case: somebody who is your friend or relatives that is living in other town and you see or hear from him/her few times a year,
- 3 case: somebody is calling you who you meet once in your life, you exchanged elementary information with that person.

The answers will contain our relative position considering the feature/object we suppose the caller know. Our spatial reasoning is assuming overlapping of our and caller knowledge about space and object in it. Our answers (spatial reasoning) are going to be spatially more detailed as we suppose caller know better our spatial, living area; e.g. possible answers

are: "In the office room." (case 1). "At the job." (case 2). "In home town." (case 3). These answers usually contain toponyms. During answering, our spatial reasoning is forming answers considering our assumptions the caller know about our living space.

3.5. Toponyms and Spatiotemporal Thinking

There is no point in universe that does not change in space with time. Spatial relations and spatial thinking without temporal relations do not exist. Space-time (spatial-temporal continuum) is one object. Most usually, spatial relations time scales are important from less than seconds (earthquakes, airplane or car movements...) to centuries (topography changes, geological processes...).

Toponyms are changing with time. New toponyms are created, some are forgotten or not in use any more and some are modified. Usually, changing of toponyms in one region represent one epoch of that region.

4. From Toponyms to SDI Spatial Thinking Tools

Toponyms are defined as a part of the global, regional and national SDI. That is defined by UN Resolutions (United Nations 2009a and 2009b), INSPIRE Directive (European Parliament 2007) and national SDI Laws. SDI will define new possibilities in the field of spatial analysis and spatial thinking.

Toponyms, maps, GIS and SDI are spatial thinking tools developed in different epochs. Toponyms have been used to define spatial relations before maps, and GIS and SDI are next steps in development of spatial thinking tools. Each of the development steps contains more developed spatial thinking tools and is influencing fundament of the spatial intelligence.

Spatial intelligence has possibility to open a huge area in research on the basis of studying development of spatial thinking tools.

5. Conclusion

Semantics and ontological approaches of toponyms and other spatial data are defining theoretical background of spatial intelligence from geoinformation point of view.

Toponym is a complex object that contains information about spatial relations. It contains not only spatial information, but also information about language, people that are using them, and it reflects temporal relations of

one epoch. There are differences in UNGEGN, INSPIRE and ICOS definitions of toponym. They are based on different bases of knowledge.

Toponyms have been recognized as the fundamental part of the global, regional and national spatial data infrastructures. Toponyms, maps, GIS and SDI are spatial thinking tools that are representing historical steps in development of spatial thinking tools. Toponyms have been used as spatial thinking tool before maps and GIS and SDI are next development steps. Each generation of tools is more developed. Spatial intelligence is opening huge area in research on the basis of studying development of spatial thinking tools.

References

CDK007 Production (2009) The Origin of Intelligence. http://www.youtube.com/watch?v=NEEXK3A57Hk. Accessed 22 January 2013

Committee on Support for Thinking Spatially (2006) Learning to Think Spatially. The National Academies Press. Washington, D.C.

ECSEE (2013) East Central and South-East Europe Division of the UNGEGN. http://ungegn.dgu.hr. Accessed 20 March 2013

EGN (2009) UML representation of the Conceptual schema & documentation, D4.2e EDINA, University of Edinburgh. Revised Final Edition March 2009. ECP 2005 GEO 038026 EGN

EuroGeographics (2013) EuroGeoNames. http://www.eurogeographics.org/eurogeonames. Accessed 10 February 2013

European Parliament (2007): Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). Official Journal of the European Union, L 108, Volume 50, ISSN 1725-2555, 25 April 2007, Brussels

Fibonicci (2013) Spatial Reasoning Aptitude Test. http://www.fibonicci.com/spatial-reasoning/test. Accessed 12 February 2013

Gardner H. (2007) Five Minds for the Future. Ross Institute Summer Academy 2007. http://www.youtube.com/watch?v=ZRUN1F4rWAE. Accessed 23 February 2013

Gregory P, Lubinski D, Camilla P. B. (2013) Recognizing Spatial Intelligence. Scientific American. http://www.scientificamerican.com/article.cfm?id=recognizing-spatial-intel. Accessed 28 February 2013

Hećimović Ž, Štefan Z, Jakir Ž (2009) Standardizacija geografskih imena. Prvo nacionalno znanstveno savjetovanje o geografskim imenima, 23. - 24. listopad 2009, Zadar

Hećimović Ž, Štefan Z, Jakir Ž (2011) Standardization of toponyms in Croatia. In Ruas A (Ed.) Advances in Cartography. Selection from ICC 2011, Paris, and

GIScience. Volume 1. Lecture Notes in Geoinformation and Cartography, Subseries: Publications of the International Cartographic Association (ICA), Springer Heidelberg Dordrecht London New York, 349-365

Jakir Ž, Hećimović Ž, Štefan Z. (2011) Place Names Ontologies. In Ruas A (Ed.) Advances in Cartography. Selection from ICC 2011, Paris, and GI Science. Volume 1. Lecture Notes in Geoinformation and Cartography, Subseries: Publications of the International Cartographic Association (ICA), Springer Heidelberg Dordrecht London New York, 331-349.

ICOS (2013) ICOS Statutes. http://www.icosweb.net. Accessed 10 February 2013

INSPIRE (2010) INSPIRE Data Specification on Geographical Names – Guidelines, v 3.0.1. INSPIRE Thematic Working Group Geographical Names

INSPIRE (2013) Welcome to INSPIRE. http://inspire.jrc.ec.europa.eu. Accessed 17 March 2013

ISO (2010a) Geographic information - Ontology - Part 1: Framework. ISO/TC 211 Geographic information/Geomatics, ISO/TS 19150-1

ISO (2010b) Geographic information - Ontology - Part 2: Rules for developing ontologies in the Web Ontology Language (OWL). ISO/TC 211 Geographic information/Geomatics, ISO/TS 19150-2

Kadmon N (ed) (2002) Glossary of Terms for the Standardization of Toponyms. United Nations Department of Economic and Social Affairs Statistical Division, United Nations Group of Experts on Toponyms, ST/ESA/STAT/SER.M/85, New York

Kovacs K, Dolbear C, Hart G, Goodwin J, Mizen H (2006) A Methodology for Building Conceptual Domain Ontologies. Ordnance Survey, Southampton

Lee J, Bednarz R (2012) Components of Spatial Thinking: Evidence from a Spatial Thinking Ability Test. Journal of Geography, 111:1, 15-26

Molitor L (2013) Spatial Intelligence. http://www.youtube.com/watch?v=ydOXWo6SijA. Accessed 27 February 2013

Ormeling F (2009) The EuroGeoNames Project, Results And Expectations. ICC 2009, Santiago Chile

Pattridge G (2013) The Visual Spatial Learner. http://www.youtube.com/watch?v=lIkhP7yIx3Y. Accessed 26 February 2013

Slavin RE (2009) Educational Psychology: Theory and Practice (9th Edition). Pearson/Allyn & Bacon, Boston

Terminology Group ICOS (2010) List of Key Onomastic Terms http://www.icosweb.net/index.php/terminology.html. Accessed 10 April 2013

UNGEGN (2010) UNGEGN Overview. http://unstats.un.org/unsd/geoinfo/about_us.htm. Accessed 10 September 2012

United Nations (2009a): Resolutions Adopted at the Nine United Nations Conferences on the Standardization of Toponyms 1967, 1972, 1977, 1982, 1987, 1992, 1998, 2002, 2007. Group of Experts on Toponyms, GEGN/25/8a, Nairobi

United Nations (2009b): Resolutions from the Ninth United Nations Conference on the Standardization of Toponyms, 2007, New York. Group of Experts on Toponyms, GEGN/25/9, Nairobi

Zaccheddu P-G, Afflerbach S (2008) 2nd Annual Report 16th August 2007 – 31st August 2008, ECP 2005 GEO 038026 EGN

Zhan C (2013) Picture Smart: Spatial Reasoning and Its Role in Cognition. http://serendip.brynmawr.edu/bb/neuro/neuro02/web3/czhan.html. Accessed 26 February 2013