Innovative Learning Geography in Europe

Innovative Learning Geography in Europe: New Challenges for the 21st Century

Edited by

Rafael de Miguel González and Karl Donert

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INTRODUCTION

Opportunities for developing innovative approaches in teaching and learning geography have been increasing very rapidly in recent years. This is in part because of the spread of new technologies that allow access to geographic information and geographic geo-media resources. Technological applications and user tools are readily available and this book examines aspects of their use in the classroom. These new tools that offer broad access to information and open data sources have revolutionised the way in which teachers of geography—in higher education, but also in primary and secondary education—can do their work with pupils and students. Education for Digital Earth, as conceived by Al Gore 20 years ago is now possible. The exclusive use of traditional approaches to the teaching of geography is no longer reasonable today.

The digital-earth.eu has identified many visualisation tools, Web sites, software developments, apps, didactic materials, Web-cartography and geographic geo-media. Many of these opportunities are already freely available on the Web accessed via Cloud-based services. The world of GIS, virtual globes and other forms of information representation and analysis offer immense pedagogical possibilities making the study of geography more attractive and effective for teachers and students. Geo-media allows the visualisation of information from different media sources and is concerned with digital content and its processing based on place, position and location. Cartographic communication has never been so easy to implement, thus twenty-first century school education needs to include geo-media into its daily workflow. Education for Digital Earth is critical if we are to make meaning of the world around us and learn how manage our environment and relate to others.

Innovative approaches to teaching and learning are needed to embrace study environments from local to global scales, for various reasons: empowerment in learning to excite and fascinate, technology providing potent tools and solutions to explain complex problems of the present world, enhancing learning processes, good classroom practice and building suitable training approaches. It is important to be aware that the media itself will not be the crucial factor for learning achievement, but the pedagogic approaches employed. The use of digital-earth tools can substantially enhance learning strategies and achievements when applied

according to suitable, relevant and meaningful learning and teaching methods, such as active, student centred learning. In the case of geo-media, the development of spatial thinking and spatial citizenship as educational concepts leads those concerned to holistic learning experiences.

The European Commission-funded network initiative, digital-earth.eu, has promoted innovation and best practices in the implementation of geo-media as a digital learning environment for school learning and teaching. The network encourages the sharing of innovative practices. Some of them are described in this book, whose production was intended as a follow up to the European Conference held in the University of Zaragoza in 2012 about teaching and learning geography, with the support of the same network (www.digital-earth.eu) and EUROGEO, the European Association of Geographers.

The book is divided into two parts. The first comprises several chapters that analyse the main challenges facing geographical education. After firstly describing general issues addressed by this book and the importance of geospatial information in European school education, chapters two to five specify four major areas of innovation in geography education: curriculum, methodology, teacher training and geospatial technologies. The inclusion of these four main factors of pedagogical renewal is not baseless as they match the Special Interest Groups of the Comenius network digital-earth.eu. The second part of the book describes some on-going practices and illustrates different examples of the use of geoinformation in geographical education in different European countries and in various educational systems and contexts.

The opening chapter sets the scene, by defining the concept and movement of Digital Earth. It comments on the significance of geospatial technologies as big business today with many advances fuelling economic development, growth and planning. Europe has lagged behind the United States in recognizing the significance of this and though industry, science and technology are forging new horizons, Europe has been much slower to respond. The text reports on the activities of the digital-earth.eu networking initiative to raise awareness of the need for Digital Earth education in Europe and support teachers and trainers in dealing with this at Centres of Excellence throughout Europe (www.digital-earth-edu.net).

Teaching geography in schools is regulated by different curricula for school education. The second chapter offers a comparative study of the geographical curriculum featured in five European countries. The analysis carries reflections on common elements of the teaching of geography in Europe, but also shows differences in the inclusion (or exclusion) of content related to geospatial learning.

Spatial thinking/literacy in education should be a fixed component of school curricula and treated in a similar fashion to linguistic and mathematical thinking. It is an important part of everyday life. One of the best subjects to introduce spatial thinking in education is through geography. But, nevertheless, the introduction and use of GIS and geo-media in education has not yet been broadly acknowledged in most countries. Researchers have identified many reasons for this, mentioning among others the lack of education standards on the use of GIS in the school curriculum. The third chapter explains how the digital-earth.eu network has created and endorsed a benchmark with learning outcomes to be used throughout the primary and secondary education curriculum. To make it more practical this chapter suggests that a learning line in using GIS should be developed, with learning outcomes and activities with an increasing level of complexity.

As Geographic Information Systems (GIS) become more and more important in modern society, geography teachers and teacher trainers are increasingly interested in the possibilities of using GIS for teaching and learning. Teachers often have the feeling that they do not have the required knowledge to design and coach viable and effective geographic inquiry projects with GIS. The fourth chapter offers further insights into the nature of this issue. It describes some of the outcomes of a design study about the possibilities of using GIS in enquiry-based secondary geography education. The content suggests that teachers not only need to have sufficient GIS knowledge, but they must also have geographic and geographic-didactic knowledge in order to integrate GIS successfully in Inquiry-based geography education.

Teachers' and students' attitudes towards information and communications technologies are very important. The successful use of geo-media and geospatial tools depends partly on infrastructure, pedagogical use and leadership. The fifth chapter describes some of the leading resources and geo-tools for teachers, including GIS, and develops two case studies, one in a secondary school and the other in a higher education degree.

One of the reasons for school success in Finland has been the open minded implementation of educational innovations: this is replicated in Finnish geographical education. Thus the second part of the book (Chapter Six) begins with a review of the Finnish targets of acquiring and using high quality geographical information. A particular goal has been to make diverse use of information technology to interpret processes and to present this information. These skills should be developed throughout geography education. In upper secondary school optional courses on regional studies

using GIS data and applications are also offered. Incorporating GIS in the Finnish school curriculum has had multiple benefits. It enhances spatial perception skills, improves understanding of the environment, and promotes sustainable way of living, as well as develops skills required in working life and enhances digital literacy skills. The text shows how a web-based GIS learning environment PaikkaOppi has resolved these issues and offered a high quality and easily accessible tool to support the learning of spatial information in Finnish schools. The study showed that Finnish teachers have a high appreciation for the free, web-based learning environment that allows them and their students to engage openly with GIS. They also think it is important to teach with GIS, not about GIS.

The seventh chapter describes a prototype course that uses GIS to teach Albanian middle school students about urban sustainability subjects. The course is based on free online and off-line data and software. The topics address both Albanian and global subjects, while the software includes the ArcGIS Online Map Services and Google Earth. The course, and related data and software, and the products created by the students are freely available online. Pedagogical principles that guided the design of the course include: teaching with GIS rather than about GIS, integration of technology across many media forms, integration of concepts across disciplines, connection of students' personal experience to the larger world, a mixed-age classroom rather than a single age classroom, balance of students' role as consumers of knowledge versus that as creators of it, and a networked classroom structure versus a hierarchical one.

The aim of Chapter Eight is to compare the GIS education in the geography curricula of two countries, Turkey and Portugal, how the approaches to GIS education vary, to what extent the curricula deal with GIS education and in what way. It examines the main similarities and differences. It is important to ask such questions within this research in order to understand how and why GIS has been placed in the curricula.

Chapter Nine explores an educational participatory approach built around a geo-referenced e-tool created to identify packages of integrated e-services for tourists. It asks whether digital cartography can help to synthesise feelings, ideas, values, and land-use projects. The project aimed to create a network of local actors and students by using a bottom-up approach and create direct connections with the landscape. The results are a map of the city of Genoa constructed in a cooperative/collaborative way that shows the efficiency of the geo-referenced website as a facilitation tool for the young people involved in the project.

Another national case is shown in Chapter Ten where the applications of GIS in Greek secondary education are described, as well as the research,

pedagogical materials and results of introducing GIS and geospatial technologies in school classrooms. Moreover, it suggests cartography can be utilised by students to approach concepts such as numeration, measurement, patterns, relationships, functions, data, probability etc. The map, however, as an absolute metric spatial tool, based on "syntactic" rules, illustrates space in an abstract form. As a result, a map in apprehending space requires two different, but simultaneous, approaches: the map as a cognitive object and the map as an object of spatial knowledge. Chapter Eleven thus presents a framework with examples of how to reinforce cognition in space, through instruction with maps, demonstrating that digital earth technologies and spatial thinking are integrative and cross-curricular with specific applications for other subjects of primary and secondary education.

The book concludes with two chapters (12 and 13) explaining different experiences of the use of geo-media tools and resources for the study of several issues about Spanish geography, such as landscapes, and Spanish Geographic Institute map resources.

Building the capability to introduce geospatial information, tools and technologies in education requires commitment from leading educators by challenging tradition, developing and building ideas and creating innovative materials for classroom use. It also requires that the geospatial industry encourages and supports these leaders, allowing them to sustain their actions and efforts. Decision makers also need to be made aware of the state-of-the-art and advised in terms of how geo-media should be incorporated in programmes and curricula. Civil society organisations and citizens must also become more involved. At this moment in time there is no forum to bring these actors together. The digital-earth.eu initiative has started to break down some of the barriers and focus on connecting these stakeholders.

Rafael de Miguel and Karl Donert, Editors

PART ONE:

GENERAL ISSUES

CHAPTER ONE

BUILDING CAPACITY FOR DIGITAL EARTH
EDUCATION IN EUROPE

KARL DONERT

Introduction

In 1992, former U.S. Vice President Al Gore presented a farsighted Digital Earth concept, whereby detailed geospatial information could be accessed from any place, at any time, by anyone (Gore, 1992). The subsequent scientific and technological movement has made this vision a reality today. Based on a US Department of Labor study, Gewin (2004), writing in the scientific publication Nature, proposed that geo-technology (with related spatial thinking skills) would become one of three most significant technological advances for economic development in the next decade. Since then, in the United States there has been a strong lobby for geospatial education, resulting in Congress's acknowledging the significance of the National Academies Press publication "Learning to Think Spatially" (National Research Council, 2006). This has transformed the US research and education technology agenda and, as a result, the National Science Foundation (2011) recently awarded significant grants to geospatial education research. In Europe most developments have been haphazard, small scale, and without backing from political stakeholders.

Digital Earth and European school education

The Digital Earth vision expressed by Al Gore linked groups of scientists interested in cooperative studies of the planet and its resources (Gore, 1998). The initiative directed technology and research actions towards solutions for sustainable development. Since then, advances in digital earth technologies have created a profound revolution in science

and technology. Strong societal connections have been established as a result the rise of the Geo-web and use of social media.

The acquisition and use of geospatial information, combined with developments in computing and communications has made near real-time information about the earth available to billions of people. The Digital Earth concept has become a reality and the results play an increasingly important role in addressing the social, economic, cultural, scientific, and technological challenges affecting the way we understand the earth. Digital Earth allows scientists to focus their attention on many of the important challenges faced by Europe today, such as economic efficiency, resource depletion, sustainable energy, natural hazards, food and water supplies, environmental degradation, population migration and smart cities. Politicians are beginning to realise the immense opportunities Digital Earth offers in everyday decision-making processes.

Access to information enables citizen participatory processes (Turnhout et al., 2012). Recent developments of geographic geo-media can be used to bridge the gap between citizens, Digital Earth technologies and real-world problems by socially connecting them through geographic location. Geo-media therefore has the capacity to create powerful learning opportunities that can empower students and result in flexible, individualised learning based on critical thinking and approaches that can explore complex interdisciplinary issues. Despite this potential, European education, for instance in science, history, geography, media studies and ICT, has so far, by and large ignored the opportunities afforded by these Digital Earth developments. This is despite the fact that geo-technology has become a significant employer and geoinformation and geo-media have become almost ubiquitous commodities accessible from mobile, tablet and laptop.

In school education, geo-media can help students to construct spatial concepts and promote a meaningful understanding of our world through problem solving, experimentation, project work and the communication of findings to others (Gryl, Jekel and Donert, 2010). The visual elements offered by geo-media are essential for enquiry, exploration and communication. However, here are only small pockets of intense activity (Kerski, 2008) and geo-media education in Europe has generally lagged behind (Donert, 2010), especially concerning its implementation in schools and teacher training.

Creating a digital-earth.eu European network

Research has confirmed that in Europe little or no attention has been paid to the significance of emerging geospatial technologies in schools (Milson et al., 2012; Donert, 2010; Gaudet and Annulis, 2003). A few pilot projects have been funded to create teaching resources in several languages. A number of face-to-face and online training courses have been successfully delivered to relatively small numbers of teachers and educators. It is apparent that large-scale, ministerial-initiated implementation in education has been generally lacking, indicating that European education has generally been unable to keep pace with technological and societal changes taking place. Awareness of the significance of these technologies among these stakeholder groups remains low, despite the recent initiatives on ICT, jobs and skills encouraged through the Digital Agenda for Europe (http://ec.europa.eu/digital-agenda/).

During 2009, in response to geospatial developments and the absence of centralised initiatives, an Austrian Centre for geo-media education (digital:earth:at) was created centred in Salzburg and linking a number of Austrian organisations who were working with schools and teachers. The goal was to share resources, tools and innovative ideas to increase the use of geo-media with Austrian pupils and teachers. Its successful launch and implementation resulted in the development of a proposal for a networking initiative, called digital-earth.eu, connecting stakeholders across Europe. The result was a proposal consisting of 49 partner organisations from more than 20 countries. Funding was obtained from the European Commission Lifelong Learning Programme (http://eacea.ec.europa.eu/llp/) for them to collaborate together for three years (2010-2013) under the Comenius Programme for schools and teacher education.

At the heart of this development was the creation of an infrastructure centred on a European Centre of Excellence, based at the Austrian Centre of Excellence (Lindner-Fally, 2009). The aim was to build a Community of Practice based on individuals and organisations that could support teachers and schools in different parts of Europe, connecting people working in national and regional contexts (Jekel et al., 2008). The digital-earth.eu Comenius network sought to raise awareness by educators of the many innovative 'geospatial' developments taking place and reflect on their implication and potential impact on school education systems. Another purpose of the networking project was to influence policy makers who had already begun to connect European issues involving social and environmental developments to citizens. A series of lobbying activities were undertaken, predominantly by the European Association of

Geographers (EUROGEO), through digital-earth.eu. This led to political engagement with the EC 'Digital Agenda for Europe', 'New Skills New Jobs' and 'EyeonEarth' initiatives. Dissemination activities promoted the incorporation of 'education for digital earth' into regional, national and European educational agenda. Politicians and decision makers at different scales were addressed and informed.

Digital-earth.eu would allow those involved in the network to connect with one another, share ideas and information, communicate future visions, and develop an informed Community of Practice (CoP) (Li et al., 2009). The CoP was to be based on a network of expert Centres for geo-media across Europe. An evaluation of proposed members was undertaken through a peer review process and accredited by the European Centre and the European Association of Geographers (EUROGEO). These expert Centres should form multipliers by working with many teachers and trainers in their own situations and contexts. They were also able to offer advice and guidance to Ministries of Education and decision makers at national, regional and local levels. This process offers increased visibility to organisations that are doing outstanding work; it encourages and supports innovation in learning and teaching approaches and rewards quality. At the time of writing this chapter, sixteen Centres in 14 European countries have been established, and two others are going through the review process.

The activities of the digital-earth.eu project address a broad range of issues. These include teacher training standards, professional development and geo-media competences. They consider issues of data availability following the results of the EU INSPIRE initiative and the tools available for educators to use.

At the core of the digital-earth.eu network have been four thematic special interest groups affording opportunities for collaboration in specialised areas. In the project proposal these were defined as:

1. Data, Tools and Technologies
2. Learning and teaching environments
3. Teacher Education and Training
4. Curriculum developments

A needs analysis of network partners confirmed the importance of these themes and confirmed that while technical advances have extended the Digital Earth vision in scientific terms (Gore, 1998; Foresman, 2008; Goodchild, 2008), in education their uses were still mostly restricted to a few users within schools and teacher training. There has been an explosion in the number of geospatial Web 2.0 tools available for teachers to use

with their students, yet digital earth technologies were not widely described in national curricula. Most European Ministries of Education and even the European Commissioners for Education and the Digital Agenda remained largely unaware of their existence.

These groups reviewed the state of the art and contributed to an online catalogue of materials, courses, publications, links and best practice scenarios as well as producing a series of research papers, publications and guidance materials. Dissemination through social media and a series of electronic newsletters sought to keep those involved up-to-date with developments and resources.

The digital-earth.eu project team recognised that it was almost impossible for most teachers to keep pace with the plethora of technologies at their disposal. The Data, Tools and Technologies group examined many of these new resources and opportunities and created a database and geo-services to promote their availability in school and teacher training contexts. These tools and technologies included social media, media content like RSS feeds, blogs and video clips, open apps freely available to download for mobile devices, mashup interfaces (Al-Khudhairy and Delilah, 2010) that allow interactive on-the-fly mapping, sophisticated visualisations and geo-collaborative activities developed via distributed Cloud-based, Web GIS (Alexander, 2006).

The group explored some educational perspectives of the outcomes of the European INSPIRE initiative and examined the possible impacts for teaching in schools and in teacher education. They then reviewed data availability, standards and interoperability and addressed property rights from a school perspective, producing publications to inform teachers and teacher educators. This resulted in a series of recommendations for action. A report was produced which explored issues related to freedom of information developments across Europe encouraged by the INSPIRE Directive and the Digital Agenda. It considered issues like copyright, Intellectual Property and quality issues concerning data and information in different European countries relating to schools and teachers. Volunteered geographic information (Goodchild 2007) and crowdsourcing (Howe, 2008) were examined as interesting alternatives to traditional information sources from mapping agencies and companies. An online searchable catalogue of resources was created which provides an infrastructure through which resources, data, information and teaching materials can be shared.

Digital earth technologies can be used in education as tools to encourage enquiry and problem-based learning and enhance critical thinking and geo-communication (Kriz et al., 2013), construct personalised teaching materials,

and assist students' self-expression (Beak et al., 2008). The second working group looked at learning and teaching concerns that were connected with the use of geo-media in schools. There are many different aspects that can play a determining role in successful learning. Their focus developed on learning environments created and used in schools and classrooms. They examined student-centred learning approaches, using geo-media in transmissive, dialogic, constructivist and co-constructive ways (Mishra & Koehler, 2006) where teachers are encouraged to create guided enquiry approaches in their classrooms (Powell, 1999). The role of digital storytelling opportunities was considered highly significant, encouraged by Web 2.0 tools and communications technologies (Levine, 2010).

The group reported on key competences in the use of geo-media, examining the concept of geo-media literacy and made recommendations for the inclusion of spatial competences as key competences for lifelong learning. They then undertook a review of learning and teaching approaches and provided practical guidance for teachers and teacher educators. A publication (in press) will introduce different learning and teaching approaches to teaching with geo-media and geoinformation by examining comparative approaches and including exemplars, highlighting best practice. This publication will be connected to a conference dealing with aspects of e-learning, geo-media and spatial citizenship in teacher education and schools.

It was confirmed that Digital Earth technologies offer opportunities for meaningful, deep learning experiences in and beyond schools. It contributes to teaching and learning by supporting exploration and experimentation; it improves motivation and learner engagement and offers the learners more responsibility and control through individual and group communication (Kolacny 1969). The research undertaken confirmed that European education must focus on spatial thinking, so that learners will understand spatial patterns, linkages, and relationships (Bednarz et al. 2008).

The third working group addressed the complexity of pre- and in-service teacher education. Kerski (2008) discussed the important role teacher's play in using key technologies to prepare students to be tomorrow's decision makers, where they are able to tackle local, regional, and global 21st century issues. The group recognised that teachers remain key components to an effective use of computers and geo-technologies in the educational system (Zhao et al., 2001). They established developing positive attitudes towards using technology in education is essential and confirmed research by Teo et al., (2007) that demonstrated how teacher attitudes towards new technologies are a major predictor of successful uses.

The report produced by the group reviewed the state of teacher training and geo-media and makes recommendations for benchmarking. It confirmed that support must be offered to help teachers develop positive attitudes toward computers (Kadijevich and Haapasalo, 2008). To achieve this, the group created the European Centre for teaching and training in geo-media and produced a business plan that would establish an infrastructure of Centres of Excellence across Europe to support teachers and trainers at grassroots level. The group also looked at quality enhancement issues in training and the formulation of an agreed terminology and a benchmark statement for geo-media. Research was undertaken to report on teacher accreditation across Europe (Lindner-Fally et al., 2012) and the opportunities for certification and accreditation in geoinformation. A booklet for teacher training will be produced to offer a checklist and guidance on incorporating geo-media/GI for those training teachers. It will deal with in-service training and continuing professional development of teachers.

Educational technology plays an important role in moving from teacher-centred learning activities to student-centred learning activities. It is therefore essential to have trained teachers competent in using and managing educational technology (Smarkola, 2008). The working group confirmed that the main remaining challenge was to convince education management stakeholders across Europe that the adoption of Digital Earth tools in their classrooms and training sessions both enhances the way they work as well as improves their effectiveness as teachers.

The final special interest group examined the curriculum opportunities for using geo-media and geoinformation in schools. This is concerned with the situation that, as most teachers have a strong sense of subject identity, they are predominantly influenced by disciplinary concerns. However, as Kerski (2008) suggests, today's main challenges lie with transforming the general structure of our educational systems to meet the needs of society. Geo-media applications tend to provide cross-curricular opportunities challenging traditional curriculum development. This group is developing a series of case studies of best practice, gathered through the Centres of Excellence and from earlier projects and initiatives to illustrate how to open access to the use of geo-media to all pupils. This publication will provide examples in main curriculum areas, including mathematics, languages, science, history, economics, business studies, marketing and geography. It will illustrate some techniques used to engage pupils and some of the outcomes from the classroom. The group also produced resources and guidance that target curriculum creators and programme developers, to advise and guide those involved in developing curricula,

creating courses and lessons using geo-media. It also examined professional connections and links between schools and enterprise.

The management of change in education will become very significant if we are to embrace the new geo-media environments that encourage personalised learning. Their adoption, adaptation and integration in education cannot currently keep pace with the rapid growth of Cloud-based apps and geo-browsers offering access to state-of-the-art geo-technologies. Projects like digital-earth.eu are essential for the future of the industry if education is to match the rapidly increasing demands for a geospatial workforce. In future, capacity building of a professional profile and school-to-career developments will be needed if geospatial industry development is to be continued and the increasing demand for geo-media professionals can be met. These aspects remain to be addressed in the future.

Widespread network dissemination has sought to reach as many relevant organisations as possible, including teacher associations, Ministries, academies and other relevant institutions in 'hard-to-reach' situations. The goal has been to raise the profile of learning with digital geo-media, encourage innovative practices and reward organisations and individuals displaying 'excellence'.

Conclusions

Originally education was fundamental to the original Digital Earth concept, as Joseph Kerski (2008) commented:

"The Beijing Declaration on the Digital Earth recommended that Digital Earth 'be promoted by scientific, educational and technological communities, industry, governments, as well as regional and international organisations' (Xu and Chen, 1999). The declaration emphasised 'understanding the oneness of the Earth and its relevant phenomena.' It called for "adequate investments and strong support in 'scientific research and development, education and training'". (Kerski J., 2008)

However, educational perspectives of Digital Earth have not received as much attention as other areas. The digital-earth.eu project is a direct extension of the original Digital Earth initiative. The European Centre was invited to become a member of the International Society for Digital Earth in 2013 (http:// www.digitalearth-isde.org/). The project has raised awareness of the importance of geo-technologies and geo-media and has stimulated further innovative developments in the uses of geo-media in schools and education across Europe, for example through the Spatial Citizenship project (http://www.spatialcitizenship.org). The digital-

earth.eu project has attracted considerable interest from researchers who are seeking to make advances in curriculum, learning and teaching approaches, teacher training and awareness of useful tools and technologies.

The digital-earth.eu network project was founded to raise awareness of geospatial education and inform politicians and Ministries of the significance of digital earth tools and technologies. It has been developed to connect organisations involved in geospatial education, so they can share practice, provide advice and guidance on the use of geographic (geo-media) to others and be a place for innovative future thinking and new initiatives.

The growing shortage of a geospatial workforce in Europe (Schultz et al., 2013), the significance of open data, freedom of information and the EU INSPIRE Directive suggests that Digital Earth education and training developments are urgently needed as part of educational structures like the European Qualifications Framework (European Commission, 2008). European policy makers have to be made much more aware of geospatial concepts (Marsh et al., 2007; Strobl, 2008) and then actively encouraged by stakeholders to respond to them in policy terms. This work is ongoing and needs to continue through the accredited Centres of Excellence and in developing a "Digital Earth education for all".

References

Donert K (Ed.) (2010), *Using Geoinformation in European Geography education*, Vol. IX, International Geographic Union-Home of Geography, Rome, 145pp

European Commission (2008), *The European Qualifications Framework for Lifelong Learning (EQF)*. Luxembourg: Office for Official Publications of the European Communities

Gaudet, C., & Annulis, H. (2003), Building the Geospatial Workforce, *URISA Journal*, 15 (1), 21-30

Gewin, V. (2004), Mapping opportunities. *Nature 427*: 376-377. 22 January

Gore, A., (1992), *Earth in the Balance: Ecology and the Human Spirit*. Boston: Houghton Mifflin.

Gryl I, Jekel T and Donert K (2010), Spatial Citizenship, In Jekel T, Donert K and Koller A (Eds.) *Learning with GeoInformation V*, Berlin, Wichman Verlag, p. 2-12.

Jekel, T., A. Koller, and K. Donert, Eds. (2011), Learning with *GeoInformation VI*. Heidelberg: Wichmann Verlag

Kerski, J. (2008), The role of GIS in Digital Earth education, *International Journal of Digital Earth*, 1(4): 326-346

Kriz, K., Cartwright, W., and Kinberger, M. (2013). *Understanding different geographies* (pp. 1-6). Springer Berlin Heidelberg.

Li, L. C., Grimshaw, J. M., Nielsen, C., Judd, M., Coyte, P. C., & Graham, I. D. (2009). Evolution of Wenger's concept of community of practice. *Implementation Science*, 4(1), 11, http://www.implementationscience.com/content/4/1/11, accessed 3/6/2013.

Lindner-Fally M (2009), Digital:earth:at – Centre for Teaching and Learning Geography and Geoinformatics, *Proc. HERODOT Conference*, Ayvalik, Turkey, http://www.herodot.net/conferences/Ayvalik/papers/geotech12.pdf, accessed 10/11/2012

Lindner-Fally M, Herlander Mira H, Silva DV, Carvoeiras LM, Lambrinos N, de Lazaro y Torres M-L, Schmeinck D, Zwartjes L and Donert K (2012), *Teacher Education and Training and geo-media in Europe* http://213.235.245.69/fileadmin/deeu_documents/4_1_report_teachere ducation_final.pdf, accessed 10/11/2012

Marsh, M., R. Golledge, and S.E. Battersby (2007), Geospatial Concept Understanding and Recognition in G6 College Students: A Preliminary argument for Minimal GIS, *Annals of the Association of American Geographers* 97(4): 696-712

Milson, A. Demirci, A, Kerski, J. (Eds.) (2012) *International Perspectives on Teaching and Learning with GIS in Secondary Schools*, New York, Springer

National Research Council (2006): *Learning to think spatially. GIS as a Decision-Support System in the K-12 curriculum*. National Academies Press, Washington DC

National Science Foundation (2011), *NSF Geography and Spatial Sciences (GSS) Program*, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503621, accessed 5/10/2012

Schulze, U., Kanwischer, D., and Reudenbach, C. (2013). Essential competences for GIS learning in higher education: a synthesis of international curricular documents in the GIS&T domain. *Journal of Geography in Higher Education*, 37(2), 257-275.

Strobl, J. (2008), Digital Earth Brainware, In J. Schiewe, and U. Michel. (Eds.) *Geoinformatics paves the Highway to Digital Earth* (gi-reports@igf) University of Osnabrück. Osnabrück, 134-138.

Turnhout, E., Van Bommel, S., and Aarts, N. (2010). How participation creates citizens: participatory governance as performative practice. *Ecology and Society*, 15(4), 26, http://dare.uva.nl/document/227945, accessed 2/7/2013.