Learning and Teaching with Digital Earth – Teacher Training and Education in Europe

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Abstract

This paper presents research in the field of geographic media in school education. After a short introduction to the spatial thinking concept and the digital-earth.eu project, results of a European survey on the use of geographic media in teacher training and education (2011) are giving insight into the current situation, offers and needs. Two drafts for geo-media learning lines in teacher training and education are presented. Finally, the conception of Centres of Excellence and Experts for learning with geo-media and their implementation at a European scale are discussed including a suggestion for criteria of excellence.

1 Introduction

Along with the digital revolution, the use of geographic media in school education is an indispensable necessity in the 21st century. Whereas technological developments and accessibility of information and communication services is steadily increasing, educational implementation of digital technologies lags far behind (MILSON et al. 2011, JEKEL et al. 2009-2011). Widely accessible, free-to-use web-services and -tools are not only penetrating citizens' lives and societies, they are increasingly changing navigation, information and communication behaviour. School education needs to include these techniques into its teaching and learning in order to A) enable students to properly use and B) raise awareness for chances and challenges caused by the use of digital and/or mobile technologies. After years of a technology-centred approach to learning with geo-media, recent publications and experiences show a trend towards a "spatial thinking" approach.

Spatial thinking is integral to everyday life. It is the concept of space that makes spatial thinking a distinct form of thinking. We live in a spatial world, we solve spatial problems. Thus it is a basic and essential skill that can and should be learned, besides other skills like language, mathematics and science. According to the National Research Council (2006) thinking spatially enables knowing about

- Space – e.g. different ways of calculating distance, coordinate system
- Representation – e.g. effect of projections, principles of graphic design (semiology)
- Reasoning – e.g. different ways of thinking about shortest distances, estimate the slope of a hill from a map of contour lines

Teacher education and, above all, teacher training need to include theoretical and practical courses on how to implement spatial thinking in education by using new technologies and teaching concepts. Based on the idea of Al Gore's Digital Earth vision (ISDE5 2007), a European network for geographic media in schools has been established in 2010. digital-

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earth.eu is a framework for collaborative research and development of geographic media for school education. This includes the conceptualisation of teaching approaches and learning lines for teachers and students. The network has established four Special Interest Groups (SIGs), dealing with 1) geodata and resources 2) Learning with geoinformation 3) Teacher training and education and 4) Curriculum development.

Within the network, a "digital-earth.eu Glossary" is cooperatively developed in order to define key expressions to a general audience. The glossary not only supports the network partners to clarify their language, it should above all address teacher trainers and teachers interested in the topic. Therefore, it is kept compact and simple rather than giving exhausting scientific definitions. The wording of this paper is taking account the digital-earth.eu glossary, which the authors recommend to disseminate, discuss and complete.(see Annex 1)

This paper reflects the work of "SIG 3 – Teacher training and education". Different aspects of geo-media in teacher training and education are discussed within the special interest group. However, dissemination and broad discussion beyond the SIG and the digital-earth.eu network are crucial for high quality results.

2 The Situation of Geo-media in Teacher Training and Education

"Geography educators have justified GIS's introduction using three competing and yet complementary rationales that correspond to GIS's strengths: (1) the educative rationale: GIScience and GIS support the teaching and learning of geography; 2) the place-based rationale: GIS is the ideal tool to use to study geographical problems at a range of scales; and 3) the workplace rationale: GIS is an essential tool for knowledge workers in the twenty-first century. These arguments have not appealed to large numbers of teachers however." (BEDNARZ & VAN DER SCHEE 2006). According to their research the main reasons for this lack of implementation were:

1) GIS is not a core item in teacher training (pre-service) and education (in-service)
2) Geography is increasingly taught by non-geographers
3) The curriculum doesn't include or impede adoption to include GIS
4) Lack of availability of free data and software
5) The attitude of teachers, "Innovations that are complex in form and function, hard to grasp and affect multiple aspects of the teaching–learning system are less likely to be implemented" (BEDNARZ & VAN DER SCHEE 2006). It seems difficult to persuade teachers to use new technologies, especially if they are highly technical demanding.

Bednarz & van der Schee recommended that GIS should be institutionalised into curricula, making sure that it is aligned with significant general learning goals like graphicacy[1], critical thinking and citizenship skills. The same recommendation was made by The National Academy of Science (2006). Furthermore they recommend that in order to successfully introduce GIS, attention should be given to teacher training and the availability of user friendly software and ICT equipment in schools. Also a "community of learners" approach should help (BEDNARZ & VAN DER SCHEE 2006).

1 Graphicacy: being able to understand and interprete graphics (comp. literacy, numeracy).

In recent years a lot of progress is made. There are a lot of free GIS viewers or open source full GIS software programs available. In order to research the present state-of-the-art, a survey has been conducted by digital-earth.eu. Teachers, teacher trainers and educators from all over Europe were invited to provide information on their countries' status-quo in 2011. Since 2006, licensed GIS have been widely replaced by free of charge online services and digital globe environments. Taking this fact into account, the digital-earth.eu survey was investigating a broader field of interest than BEDNARZ & VAN DER SCHEE: geo-media and geoinformation, including GIS and their implementation in teacher education and training.

The results show the current teacher training offers and accreditation opportunities in the different countries, as well as the needs in this field.[2] 65 responses from 20 countries give a clear idea about different aspects of teacher training and education.

The digital-earth.eu survey shows that teachers and teacher trainers are partially aware of this availability and already starting to integrate them into their teaching. Also, the availability of data has improved dramatically; Special Interest Group 1 of digital-earth.eu is as a matter of fact mapping this on European level (see geo-service at www.digital-earth.eu). The main limitation of the digital-earth.eu survey 2011 is that the sample is mainly based on people who were already engaged in the use of geo-media from the digital-earth.eu network itself. It must be assumed that a vast majority of European teachers has not reached this level of knowledge and reflection yet. To reach these must be one of the main goals of future initiatives.

2.1 Who is dealing with teacher training and education in Europe?

In-service teacher training is provided mostly by universities, colleges of education or other institutes or organisations[3]. Those in charge of delivering teacher education are mostly university personnel (94%) and specific trainers (52%), e.g. ICT trainers.

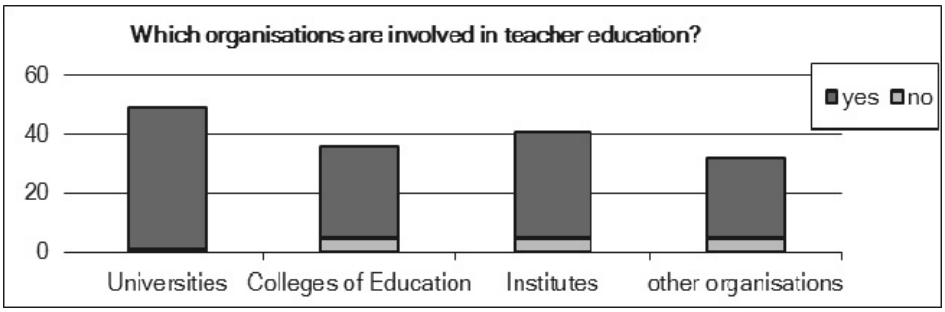

Fig. 1: Organisations involved in teacher education (digital-earth.eu survey 2011)

[2] The digital-earth.eu report „Teacher Education and Training and geo-media in Europe" is a main deliverable of SIG 3. It includes facts and figures from the digital-earth.eu survey 2011, a list of current courses and materials, country reports and a bibliography on the topic. It is available at www.digital-earth.eu.

[3] Multiple choice question.

Courses are usually provided *face to face* (93%). *E-learning* (53%) is another way to provide and/or consume teacher training – an increase of these offers may be expected in the next years.

2.2 Availability of teacher training and education including geoinformation

45% of the participants indicated that geoinformation/GIS is included in teacher education/training in their countries, 42% of the teachers don`t have the possibility to learn with and about geoinformation within their education. Including the 13% who do not know whether there is an offer, we are facing 55% of teachers that have to be provided with teacher education/training courses and information on available offers. Digital-earth.eu and upcoming centres of excellence are facing an important need at this respect.

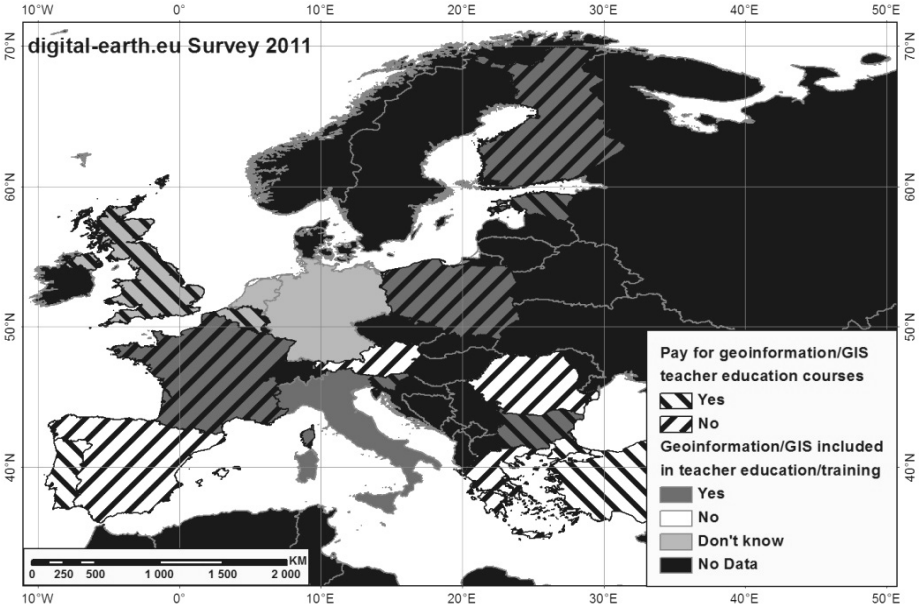

Fig. 2: Geoinformation in teacher training in Europe (digital-earth.eu survey 2011)

In several European countries, geoinformation is included in teacher education and training. France, Poland and Finland offer free courses to their teachers, whereas teachers in Estonia and Bulgaria they have to pay for GI-courses. Nevertheless, there remain several "white spots" on the map. Interestingly, survey participants who indicated that there was no geoinformation included in teacher education/training in their country gave answer to the financial aspect of such courses. This could be interpreted in a way that A) there are courses outside official teacher training/education that are attended by teachers or B) that if there were courses inside teacher training/education, they were free of charge (or not). However, Portugal, Spain, Austria, Romania, Greece and Turkey need to catch up with institutionalisation of geoinformation in teacher training and education, as teachers are not yet officially taught in geo-media use.

2.3 What kind of services/systems are used?

The fact that licenced GIS Systems score the highest percentage here, may be due to the fact that some of the participants had participated in a European GIS training course shortly before the survey. Those who did not yet have the possibility to participate in special courses, think that the kind of geoinformation/GIS tools that should be used are *Webmapping services* (85%), *Freeware Systems* (81%) and *Special geographic services designed and developed for educational use* (77%). Only 42% think that *Licenced GIS Systems* should be used. This attitude may be interpreted as a result of general lack of financial means and/or technical support within schools in Europe. Teachers thus show a realistic and practical approach towards applicable and feasible learning methods and technologies. Those who are introduced to GI/GIS have been using the following services/systems[4]:

Table 1: Services used in teacher training/education courses (digital-earth.eu survey 2011)

Digital Globes	60,9%
Webmapping services	56,5%
Special geographic services designed and developed for educational use	60,9%
Freeware GIS Systems	78,3%
Licenced GIS Systems	82,6%
Other digital cartography software	26,1%

Asked for their needs, teachers requested more training, teaching materials, good practices, assistance for technical support, teacher education programmes, data at a national level, and a comprehensive and well structured compilation of digital-earth tools. Also, the survey found documentation of a need to share experiences with colleagues in other institutions and countries.

2.4 Why do teachers attend special trainings/courses?

Financial benefits are the less motivating factor for teachers to do special courses. Almost 70% say that they will or would not benefit financially, whereas almost all teachers declare their own motivation as well as students/pupils motivation as the most important reasons to teach with geo-media. Given the percentage of teachers that have already done or are willing to do supplementary courses, the result could be interpreted in a way that teachers are very idealistic individuals. Competitive benefits (e.g. getting a better job in a better school) score 30% – this is presumed to depend on the school systems/policies in the different countries. Lobbying for engaged teachers would be a topic for those countries where neither competitive nor financial benefits may be expected by investing in better/advanced training/education.

Mapping financial and/or competitive benefits through innovative teacher training/education in Europe shows interesting details. Finland, for example, seems to push innovation through competitive advantages for engaged teachers much more than through finan-

[4] Multiple choice.

cial compensation, whereas Italian and Bulgarian respondents strongly agree that both factors are valid. Some countries don't give any benefits to innovative teachers, such as Portugal, Belgium and the Netherlands, whereas the majority of the survey participants feels competitive rather than financial advantages (Spain, France, Austria, Poland).

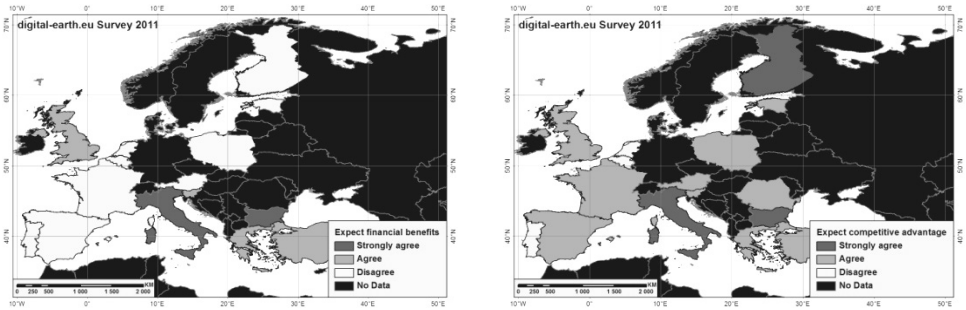

Fig. 3/4: Financial and competitive benefits through GI in teacher training and education in Europe. (digital-earth.eu survey 2011)

The results of the survey also document that accreditation of teacher training courses is developed essentially within the geography discipline (84%) and general ICT competencies (35%), providing the following benefits for teaching:

- motivational benefit for the teacher (e.g. being able to use geoinformation in teaching, being up-to-date, active learning methods...)
- motivational benefit for the students/pupils (e.g. more motivated by using geoinformation in an active learning environment)
- higher teaching and learning success in comparison to traditional geography teaching
- preparing students for daily social and workforce challenges of a geospatial society.

47% have already attended courses for the use of geo-media in school teaching in their countries or in Europe. Almost 80% of the participants are interested in European teacher training courses for the use of digital earth tools, which leads the authors to recommend the creation of such training opportunities either face-to-face or via e-learning/blended learning.

The results of the survey document that accreditation of teacher training courses plays an important role wherever career models for teachers are applied. In some countries, teachers do not (yet) have career models they can follow, so they do not feel the need for accreditation as strong as their colleagues in other places. In any case, geo-media training courses must be provided in order to meet the needs of teachers and modern society.

3 Successfully Introduce Geo-media in Education: An Attempt

Taking in account the different age groups and levels of complexity of learning with geoinformation, the best option is a "learning line" approach. A learning line is defined here as

the educational term that refers to the construction of knowledge and skills throughout the whole curriculum. This learning line reflects an increasing level of complexity, ranging from easy (more basic skills and knowledge) to difficult. As an example the Flemish geography curriculum (LEERPLANCOMMISSIE AARDRIJKSKUNDE (2010) defines these learning lines in the secondary geography curriculum:

Table 2: Learning lines in the Flemish geography curriculum for secondary education

Learning lines:	Fieldwork	Working with images	Working with maps	Working with statistics	Creation of knowledge
Level 1	**Perception**	– knowledge of facts			
Level 2	**Analysis**	– selection of relevant geographic information			
Level 3	**Structure**	– look for complex connections and relationships			
Level 4	**Application**	– thinking problem solving			

Five learning fields are structured into four levels of learning, at the same time geo-media are applicable in all fields and levels of learning. For example, the learning line maps:

- Level 1: Recognize and name the elements of the legend on the map. Distract the scale.
- Level 2: Retrieve the geographic elements that are relevant within a research context.
- Level 3: Classify and relate elements on the geographic map.
- Level 4: Interpret a map.

The authors think that a similar approach may be useful for teacher training and education. It gives a continuation of the achieved knowledge and skills to be implemented in higher levels of thinking throughout the curriculum. However, learning outcomes such as competences or abilities should be defined in order to make a learning line fit the learning. Therefore digital-earth.eu's Special Interest Group 3 (Teacher training and education) developed a benchmark statement for geo-media in teacher training and education, which intends to give rationale and recommendations on the implementation to teacher trainers, teachers and headmasters, but also to policy and decision makers. Benchmarks relate to the learning outcomes, and can therefore be seen as the standard by which the learning line can be measured or judged.

Table 3: Geo-media in teacher training and education – digital-earth.eu benchmark statement

Using geoinformation to participate in spatial decision making is an important skill for all active, responsible EU citizens in the 21st Century. Developing such spatial literacy assumes the availability of digital earth tools which allow students to interact with geoinformation, to answer questions and critically reflect using a geographic approach. They can also clearly communicate the results to a broader audience. Therefore, teachers must understand basic geographic concepts and be able to support students' learning needs. Taking in account the different levels of age and education, teachers must be enabled to apply different methods and tools in the respective learning environments. Appropriate evaluation and assessment methodology has to be developed and implemented by Europe's 21st century teachers, teacher educators and trainers.

Table 3 (continued)

Goals for teacher training and education in Europe

- Spatial literacy
- Create digital earth citizens that are aware of basic spatial concepts and able to use digital earth tools
- Increase active citizenship in spatial decision making
- Increase employability opportunities for teachers
- Encourage lifelong learning

Competencies:

- Spatial thinking:
  - to know concepts of spatial thinking (examples)
  - be able to use tools of spatial representation,
  - to apply processes of reasoning (Where is it? Why is it there? What if it was somewhere else? Making informed decisions and defend personal points of view)
- Pedagogic and didactical skills for the use of digital earth tools in school
- Ability to use spatial skills in real world problem-solving context
- Understanding complex and changing interrelationships
- Awareness for and understanding of the digital earth concept
- Ability to use digital earth tools (also technological skills)
- Lifelong learning competencies: ability to find training opportunities, time management, planning competency, communication competencies
- Being able to identify and evaluate resources
- Social learning:
  - being able to work with others – teamwork
  - use professional social networks (virtual and face-to-face)

In order to prepare teachers to effectively implement digital earth in their practice, teacher training and teacher education needs to appropriately prepare teachers for different levels of education:

Primary school teachers need to be able to enable students (year 1-6) to

- Open digital maps and virtual globes on a computer
- Indicate the different parts of digital maps/virtual globes (navigation bar, menu, scale, map window)
- Interpret symbols on digital maps
- Work with digital maps and 3D representations of the world:
  - find significant locations (their home, school or town) on a virtual globe
  - pan, zoom, orientate
  - make measurements
  - use the layers to focus on specific features
  - update maps
  - Interpret map content (basic)
- Be aware of generalisation levels applied in different zoom levels (e.g. road density)
- Access information efficiently and effectively, evaluate information critically and competently (see maps as manipulated representations created by people/organisations with a certain purpose, e.g. classification methods, colour schemes, map contents)
- Use digital maps and virtual globes for a variety of different purposes

Table 3 (continued)

Secondary school (year 7-12)

In addition to the learning outcomes of primary school, secondary school teachers need to enable their students to

- Know the digital earth concept and its tools
- Understand the basic purpose and application of digital earth to real world problems
- Be able to gather and evaluate information
- Use advanced digital earth tools for learning (starting with Web-GIS, GIS viewers to GIS software)
- Manipulate maps
  - display information on maps
  - create own maps
  - communicate cartographic information
- Understand the construction of digital maps as a representation of the real world
  - The power of maps (reliability of data, classification and colour schemes)
  - Topology: points, lines, polygons
  - Database
- Know about the professional use of GIS and other digital earth tools
- Gather information from data resources or through fieldwork activities (use GPS devices, mobile applications)
- Use digital earth tools for investigation/research
  - Interpret content (advanced)
  - Identify and ask significant questions that clarify various points of view and lead to sustainable solutions
  - Frame, analyze and synthesize information in order to solve problems and answer questions

This proposed benchmark is a first attempt that still needs to be discussed and precised. When finally approved, it will be used to give advice to academic teacher trainers and educators in Europe. A model of competencies for students/pupils is expected to be elaborated by SIG 2 (Learning and teaching with geo-media and geoinformation) in 2012/2013.

4 Creating a Network of Centres of Excellence

Besided the curriculum approach, Benardz & van der Schee (2006) advised that a community of learners is important. Digital-earth.eu intends to support this. Professional exchange on scientific and practical levels will be fostered by creating a sustainable network of Centres of Excellence for learning and teaching with geo-media.

The digital-earth.eu European Centre of Excellence (CoE) will link innovative centres around Europe where geo-media use in school education is well developed. These centres can be of regional or national scale and shall address more than one target groups within geo-media research and teaching contexts, e.g. researchers/teacher trainers/teachers/ students. Products, resources, experiences and ideas will be shared between the centres and opened to the public wherever possible.

The European Centre digital-earth.eu invites institutions to apply to become accredited "digital-earth Centre of Excellence". This is a measure for quality assurance and networking at the same time. The European Centre intends to support national/regional centres and those who want to become centres of excellence by sharing experiences and best practices, cooperation in projects and research.

For accreditation, multiple criteria will be scored by a team of experts. Any organisation (legal entity) will be eligible to apply for accreditation. Applications including several partner institutions will be appreciated, as teamwork is the fundamental way digital-earth.eu CoE's shall be working. Experts without institutional background are invited to apply for the "digital-earth Expert" certificate.

Evaluation criteria have been developed in order to be able to objectively decide on a centre's acceptance into the digital-earth.eu network of digital-earth CoEs and Experts. These include capacity or the applicant institution(s), organisational structure and strategy to run a CoE, the goals of the centre (focus, target groups, outcomes) as well as professional recognition and planned activities (outreach, courses etc).

Once accepted, holders of the digital-earth.eu Centre of Excellence/Expert brand will receive a series of benefits. They will be authorised to hold the "digital-earth Centre of Excellence/Expert" certificate and thus to make use of the digital-earth.eu brand, logo and identity. Support for website setup and free use of the digital-earth.eu communication platform are included as well as financial support for leaflets, launch events and grants for promotion (wherever digital-earth.eu resources permit). Attendance of digital-earth.eu meetings will be supported by the European centre, this will facilitate networking and opportunities for other initiatives and projects. Last but not least, advice for project application at a European level will be provided.

Being a digital-earth.eu CoE/Expert, institutions/individuals will of course have certain responsibilities, which are planned to be the following:

- To actively work as a digital-earth Centre of Excellence/Expert
- Promote the digital earth concept
- Share the work and brand of digital-earth.eu European Centre and Network
- Produce an annual report of activities
- Inform office@digital-earth.eu about changes within your CoE/Expert status
- The work of accredited Centres of Excellence and Experts will be reviewed based on annual reports and documentary evidence every year.

5 Conclusion and Outlook

The introduction of geo-media in education is not easy. There are many reasons why previous attempts didn't succeed. But there is a positive evolution. Generally, learning and teaching methodologies are a key issue to the introduction of geo-media in school education. Active, student-centred learning about and with real-life data, information and services has a great potential to transform school-learning into learning for life.

The conclusions of the digital-earth.eu survey show that there is a strong interest in using geo-media, and that number of teachers have already developed experience in using geo-

media at school. Still, a lack of suitable training and education opportunities, including accreditation and career models, can be attested. Future initiatives must seek to reach also those who have not yet got in contact with digital-earth developments.

In order to facilitate the use of geo-media in school education it must also be implemented in national curricula. The benchmark created by digital-arth.eu SIG 3 is a first step to explain the importance and learning line to decision makers. Further introduction will be facilitated by creating a network of "digital-earth Centres of Excellence" and "digital-earth Experts".

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