GeospatialLearning@PrimarySchool: A minimal GIS approach

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1. Introduction

With the advent of GI science and geographic information in general public (for example via virtual globes and navigation systems), education systems all over the world start integrating them in their curricula including competences like spatial orientation, spatial learning, and spatial thinking. The presented GeospatialLearning@PrimarySchool project takes up this movement, by introducing a simple GI application, a minimal GIS for children between 7-12 to foster these competences and being a support system for spatial thinking (Committee on Support for Thinking Spatially, 2006). In a case study a prototype for the XO-laptop of One Laptop Per Child (OLPC, 2010) is being implemented and tested for usability and its impact on spatial abilities in Primary Schools in Germany and Rwanda. This ongoing work tries to cover a variety of aspects in children's spatial learning with the help of Geospatial Technologies.

2. The Geo Activity

The Geo activity (application for the XO-Laptop) aims at providing a game activity for children at age 7-12 to support the progress of spatial cognition and competence. While a child of age 7 yet may not be aware of the spatial context it is living in, a child of age 12 already can differentiate consciously between different geometry types. Investigating this (quite general) target, we separate out three major groups of challenges to be considered, when doing the actual software design:

- Cognitive and educational aspects
- Usability aspects
- Technical aspects

We inquire, what educational aspects might be appropriate for the target group, and discuss how the activity can deal with increasing ambitions of elder children. This didactical approach is combined with the cognitive view of the development of spatial Also, we highlight usability issues to consider during the design process and point out technical aspects which come along when trying to transfer these aspects into the software.

2.1 Educational and cognitive aspects

Based on previous research and studies, we point out basic spatial concepts, the Geo activity shall provide. It is not intended to give an exhaustive list of possibilities, but rather to give a baseline to choose appropriate concepts.

OLPC aims on content and software design for pleasing and self-empowered learning, following the constructionism theory, based on Piaget's constructivism theory of childhood learning (Piaget, 1926/1930). Constructionism is a philosophy of education in which children learn by doing and making in a public, guided, collaborative process including feedback from peers, not just from teachers. They explore and discover instead of consuming prechewed knowledge (Papert 1991).

In contrast to the Constructionism, the Instructionism refers to all of the educational theories based on the idea of the teacher teaching, usually according to a predetermined schedule (curriculum), rather than on students learning from their own experiences at their own pace.

Our didactical approach can be found somewhere in between the constructionism and instructionism, as we are aware of the very important impact of "learning-by-doing", but also of the real situation in schools all over the world, where teachers mostly teach, following the subjects curricula.

In the spatial learning domain investigations of Piaget and Inhelder (1975) indicated, what kinds of spatial knowledge a child at age 7-12 already has developed. Descending from stage I (topological phase) of Piaget's model, wherein a child is using an object's concrete picture as a medium for its meaning, to stage II (projective phase), the child begins to axiomize space during the target age. This cognitive development includes grasping space as a continuum, rather than related pictures (symbolizing activities, once experienced). Finally, the child will enter stage III (Euclidean phase).
Montello and Freundschuh (2005) give an overview of spatial and environmental cognition, wherein, amongst others, they quote landmarks to play an important role to organize the environmental knowledge. Besides the cognitive organisation, Presson and Montello (1988) add another focus to the landmark concept: spatial orientation and wayfinding processes.

The construct of landmark makes possible several activities to gain spatial competence: orientation, navigation, measurements, etc.

To take into account Piaget's phases of the cognitive development of space (Piaget and Inhelder (1975)), the following concepts might cover all of them:

- Orientation within a spatial context (phase I and II)
- Locomotion within a spatial context (phase I and II)
- Concept of a coordinate and distances (phase III)

In a nutshell, this baseline of concepts can support/improve children's spatial thinking throughout the target age. In their study, Battersby et al. (2006) and Marsh et al. (2007) propose a minimal GIS for all grade levels at school, when particular spatial concepts were incidentally used. We believe, however, that such concepts are intrinsically used in human's environment, so a minimal GIS would make sense, anyway. The Geo activity can be used to provide spatial concepts in a gaming environment. No spatial analysis functionality is planned to be implemented, to reduce the educational content to the basic concepts, though, we think, the Geo activity could be considered as a minimum GIS, introducing simple spatial concepts to children.

The first concept to be applied in the Geo Activity is an adaption of the GPS-based game “Geocaching”, using a base map (from OpenStreetMap) and showing the laptops GPS position and the geocache position as support for the search.

The second concept is “Geotagging”, where children can map features in the neighborhood using photographs, symbols or text creating their own map of the environment.

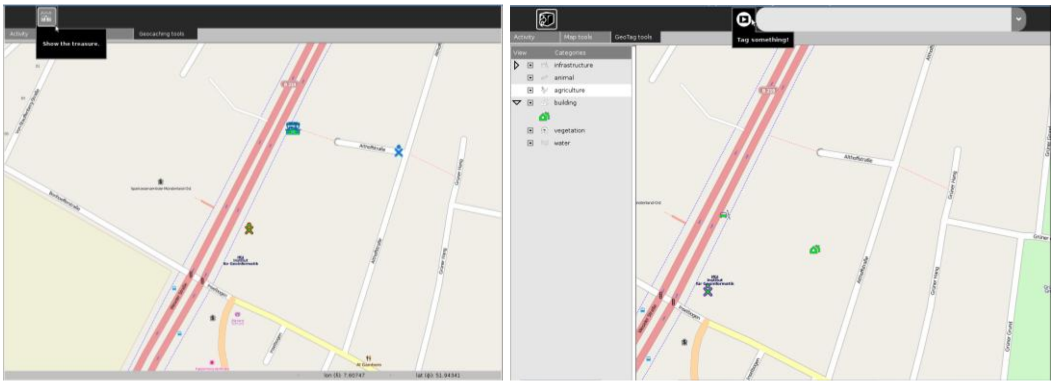

Figure 1. Geocaching and Geotagging games.

2.2 Usability Aspects

The fact, that the XO laptop is deployed as a learning environment in developing countries for children, raises three main usability aspects, which have great impact on the software's usability design:

- Cross-cultural appliance
- Age range of the target group
- Computer-based learning

Currently, cross-cultural aspects are discussed in research diversive. So far, several cultural models has been developed for HCI, to make mention of Hofstede's, Hall's, Victor's and Trompenaar's theories. However, Winschiers-Theophilus (2009) illustrates that these models and experiences delineated in research are not sufficient enough for doing a cross-cultural usability design process, without having understood and fully integrated the cultural flow.

Designing software for cultural-independent use requires either to adapt software to each culture actually using it, or designing and developing it free of culture specific attributes, a concept also known as Internationalization (I18N). A further step would then be making necessary changes to suit the software culturally and technically for the targeted culture (Yeo, 1996). The XO laptop does not target any specific culture, therefore, the Geo activity will provide the I18N concept.

Designing the Geo activity as a learning application is another usability challenge we are facing. In particular, Harms and Adams (2008) identify a usable, but also challenging game-like environment as appropriate when designing software for computer-based learning.

The age of the target group and the aspect of computer-based learning are interwoven heavily.

2.3 Technical Aspects

The Geo activity is designed as a framework to allow extensibility through a plugin mechanism, to provide more spatial learning games in the future. A key challenge was the implementation of collaboration functionality, where children can work together on maps or search for geocaches. The XO-Laptop provides the necessary hardware setup with integrated MESH-network.

Export of data to different platforms is possible via the KML format (OGC, 2007). Mappings can be displayed in Google Earth or other geo-visualization tools and be available for post-processing.

The GI workflow within the activity will remain in its original way: data collection and input, analysis and output (de Bakker and Toppen, 2009), but put onto a child's level. As data collection and output is provided through geospatial technologies like GPS and KML, the analysis happens in the cognitive processing of the relation between the child's displayed position and the spatial representations of the environment in the base map. For a teacher's preparation and post processing of lessons, the Geo activity will be connected to ESRI ArcGIS (i.e. for georeferencing of aerial imagery) and to provide a structured storage of user generated content. There will be a possibility for publishing content online to Geo activity users, so an exchange of data between international primary schools can be made possible.

3. Field Study and Results

Usability Tests are being realized throughout the software development to get an idea (and of course new inspirations) of a child's perspective using the software. Especially the collaborative aspects of wayfinding, searching and mapping will be inspected in detail.

Spatial Learning Tests will be performed with a test setting based on pre- and post tests on spatial abilities together with sketch maps of the schools environment. The spatial ability measures consist of children's paper and pencil versions of the Mental Rotation Test (Vandenberg & Kuse, 1978), Piaget's Water-Level-Task and a Spatial Orientation Test (Hegarty and Waller, 2004).

The tests are being performed in primary schools in Germany (March, s. Figure 2. and June 2010) and Rwanda (April, s. Figure 2. and May 2010), to take into account cultural aspects as well. The results will be made available after the tests.

Figure 2. Fourthgraders trying the Geo Activity in Germany and Rwanda.

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References

de Bakker, M., Toppen, F. (2009). Changes in the geospatial education landscape. A short overview of 20 years in the past and a forecast for the next years. Vision Paper EUGISES 2010.

Battersby, S. E., Golledge R. and Marsh, M. (2006). Incidental learning of geospatial concepts across grade levels: Map overlay. Journal of Geography. 102, 231-233.

Committee on Support for Thinking Spatially, 2006: The Incorporation of Geographic Information Science Across the K-12 Curriculum, N. R. C. Learning to think spatially. Washington, DC: National Academies Press.

Harms, M., Adams, J. (2008). Usability and Design Considerations for Computer-Based Learning and Assessment. Meeting of the American Educational research Association (AERA).

Hegarty, M., & Waller, D. (2004). A dissociation between mental rotation and perspective-taking spatial abilities. *Intelligence*, *32*, 175-191.

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

Montello, D. R., & Freundschuh, S. M. (2005). Cognition of geographic information. In: R. B. McMaster & E. L. Usery (Eds.), A research agenda for geographic information science (pp. 61-91). Boca Raton, FL: CRC Press.

OLPC 2010: The OLPC Wiki, online: http://wiki.laptop.org/go/The_OLPC_Wiki (last access 04/2010)

Open Geospatial Consortium Inc. (2007), KML 2.1 Reference – An OGC Best Practice. http://portal.opengeospatial.org/files/index.php?artifact_id=21469

Papert, S., 1991: Situating Constructionism. In: Papert, S. Harel I.: Constructionism (Ablex Publishing Corporation)

Piaget, J., 1926/1930, The child’s conception of the world, New York: Harcourt, Brace & World.

Piaget, J. and Inhelder, B. (1975). Die Entwicklung des räumlichen Denkens beim Kinde (3rd Edition), Gesammelte Werke 6 (Studienausgabe), Klett-Cotta/J. G. Cotta’sche Buchhandlung Nachfolger.

Presson, C. C., & Montello, D. R. (1988). Points of reference in spatial cognition: Stalking the elusive landmark. In British Journal of Developmental Psychology, 6, pp. 378-381.

Vandenberg, S. G., & Kuse, A. R. (1978). Mental rotations. A group test of three-dimensional spatial visualization. Perceptual and Motor Skills, 47, 599–604.

Winschiers-Theophilus, H. (2009). The Art of Cross-Cultural Design for Usability. In Proceedings of the 5th international Conference on Universal Access in Human-Computer interaction. Addressing Diversity. Part I: Held As Part of HCI international 2009 (San Diego, CA, July 19 - 24, 2009). C. Stephanidis, Ed. Lecture Notes In Computer Science, vol. 5614. Springer-Verlag, Berlin, Heidelberg, 665-671.