GIS@school – new didactical aspects of using GIS in geography education

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Geographical information systems are an integral though sometimes invisible part of daily life and are used in various fields such as research, planning and administration. Consequently, lesson materials and special GIS-programs have been developed for use in German schools. Moreover, using GIS in school has been made compulsory in a number of state curricula. Nevertheless, the GIS use as yet is only inadequately implemented in the school context, especially in non-grammar school and lower secondary education. Reasons for this are complex, but eventually lead to the question which added value the use of GIS can contribute to fostering spatial behaviour competence, which is the central goal of geography education in Germany. Until now however, studies have not dealt with that question, but rather focused on the contribution for GIS use for instance to computer literacy or how students are able to deal with GIS-techniques. Consequently, based on an overview of the current situation of GIS use in schools in Germany, new concepts for fostering spatial behaviour competence through the use of GIS and evaluating associated learning effects will be presented.

Key words
spatial behaviour competence, German geography education, GIS, curriculum, spatial education

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Geographic information systems (GIS) are used in a wide array of fields, such as researching malaria occurrence, planning cell phone networks or managing real estate. Consequently, being able to work with them has become an important skill in a variety of professions. As their penetration of the job market and daily life rises, their integration into high school geography education is increasingly demanded across Europe. In Germany, this process started more than ten years ago. However, the integration as well as the corresponding didactics have been described as still being at the outset, with only slow progress (De Lange, 2006; Falk and Hoppe, 2004; Falk and Schleicher, 2005; Schäfer, 2007b). This paper will give an overview about recent developments of GIS use in German schools. Then it will focus on an aspect which hitherto has been for the most part neglected, namely, the question of in how far the GIS use in school can contribute to reaching the guiding objective of German geography education.

The current situation of GIS at schools in Germany is characterized by a considerable variety with regard to at least six aspects, which in practice are all closely interrelated.

First of all, unlike to the clearly defined meaning of GIS within geoinformation science, the use of the term GIS in the educational discussion seems fuzzy (De Lange, 2007). The term seems to encompass both digital geoinformation and geographic information systems in the narrower sense. Thus users are confronted with applications so diverse as digital city maps (Reitz, 2005), navigation systems (Zürl, 2005), map-based online information systems which are provided for instance by government organizations (Schäfer, 2005a), Web- and Desktop-

GIS specifically developed for the use in schools (e.g. Falk and Nöthen, 2005; Heiken and Peyke, 2005; Püschel, 2005) and professional software such as ArcView (Falk and Nöthen, 2005). These types entail a wide range of differing possibilities of what can be done with the data (viewing only, manipulate, query,...) and whether only given or also own data can be used. In the academic discussion, consequently, there appears to be a trend towards speaking of "GI in schools". However, in accordance with the common use of the term GIS in curricula as well as for example internet services for teachers such as www.lehrer-online.de, the term GIS will be used in its 'fuzzy' sense in this paper.

The fuzziness of the term points to a great diversity of practices regarding which kind of GIS should – or can be – used in the school context. Several examples exist that a start directly with desktop-GIS is possible (e.g. Klein, 2005; Krause, 2004; Unterthurner, 2004), but there is also an increasing number of proponents for starting with WebGIS first (Joachim, 2006; Püschel, 2007). The layer structure of a GIS can even be learned without computer and software, however, using for instance transparencies (Siegmund, 2001). Seemingly, despite even a state wide licence in Baden-Württemberg (Engelhardt, 2004) and lesson examples (e.g. Schwab and Kussmaul, 2005; Vogler, 2007) ArcView use in schools is currently not as much a topic as in other countries (e.g. for New Zealand see www.gismaped.co.nz, for USA see Kerski, 2000). While comprehensive statistics are missing, it appears that Desktop-GIS programs developed specifically for schools (www.dierckegis.de, www.schulgis.de, Heyden, 2006; Krause, 2005; Schäfer, 2005b), free software like SpatialCommander (www.gdv-mapbuilder.de, Püschel, 2007) and a variety of WebGIS (e.g. www.sn.schule.de/~gis/, www.webgis-schule.de/127_ENG_HTML.php, Joachim, 2006; Püschel, 2005) are currently the most commonly mentioned for schools.

The discussion of which GIS should be used is closely connected to the question of which basic approach should be taken, that is, whether GIS should be content or tool. In this context, four terms are important: teaching about GIS, teaching with GIS, learning with GIS and researching with GIS. Teaching about GIS means that the teacher gives explanations as to what a GIS is, how it works and where it is used. Teaching with GIS refers to a still largely teacher centred lesson, but GIS, for instance with the help of a projector, is used as a tool to discuss a geographic topic. In contrast, learning with GIS means that the GIS is in the hands of the pupils who with its help work on a geographic topic, using given data sets. Finally, researching with GIS stands for the pupils creating own data sets and then working with them (Falk and Schleicher, 2005; Schleicher, 2007; USGS, 2005).

Various progressions of these four stages are in discussion, closely linked to the question of age group. One model proposes teaching about GIS from grade five, then teaching with GIS from grade six/ seven, learning with GIS from grade eight/ nine and researching with GIS from grade ten/ eleven (Falk and Schleicher, 2005; Schleicher, 2007). In contrast, others see the place of teaching about GIS in university level, of teaching with GIS in school education and of researching with GIS in higher education (USGS, 2005). Oftentimes, however, a clear allocation of models or examples to the terms or to specific age groups seems difficult (e.g. Püschel, 2007). Generally, it can be said that there is a range from those wanting to start with the beginning of *Sekundarstufe I*[1] (grade five) (e.g. Püschel, 2007), to those stating that pupils need a certain amount of pre-knowledge and hence GIS should be used only from the end of *Sekundarstufe I* on (e.g. Feyk, 2006), to finally, those asking whether GIS has a place in school education at all (Schallhorn, 2004).

This variety is also reflected in the recent curricula reforms. With regard to age group, GIS is for example made compulsory already from grade seven/ eight on in the federal state Baden-Württemberg, but not mentioned explicitly in the curriculum of the federal state of Bremen (Ministerium für Kultus Jugend und Sport Baden-Württemberg, 2004; Senator für Bildung und Wissenschaft, 2001; 2006). It appears that compulsory GIS use has been largely restricted to *Gymnasium*[2] so far. However, the standards for the Intermediate School Certificate, recently published by the German Association for Geography, include GIS explicitly (German Association for Geography, 2007). It remains to be seen in how far this will lead to an increased integration into non-*Gymnasium* federal curricula in the future. In any case, even though GIS is not included in the curriculum as compulsory, teachers could use it if they want, as curricula offer justifications such as that pupils should be able to gather information from a variety of sources (Senator für Bildung und Wissenschaft, 2006). With regard to the basic approach of GIS education, there is a broad range across different documents. The recommendations for the Intermediate School Certificate, achieved at the end of grade ten, state that pupils should be able to "describe the applications of GIS" (German Association for Geography, 2007:17). In contrast, the *Gymnasium*-curriculum of Baden-Württemberg states that at the end of grade ten pupils should be able to "employ geographic information systems

[1] In Germany, when the focus is on the age group and not on the type of school, the following terms are used: Primarstufe (usually grade one to four), *Sekundarstufe I* (usually grade five to ten) and *Sekundarstufe II* (grade eleven to twelve or thirteen).

[2] *Gymnasium* is a school type of secondary education. It encompasses grades five to twelve (or thirteen). It leads to the *Abitur*, i.e. the certificate which allows pupils to enter a university.

(GIS-presentations) for analysis" (Ministerium für Kultus Jugend und Sport Baden-Württemberg, 2004:242, transl. by authors).

Different opinions also exist with regard to the rationale for why GIS should be used in school. Often cited arguments are the high prevalence in everyday life and the increasing importance of GIS in the job market. Moreover, an "added value" is also seen in GIS being a tool to train the pupils' methodical competence, media competence and social competence. Furthermore, from the viewpoint of the practice an increase in effectiveness with regard to learning processes, getting up-to-date data and faster access to information once the basics of GIS have been mastered are underlined as well as the motivation factor of using this kind of new media. GIS is also seen as contributing to the pupils' overall computer literacy. Other arguments that have been put forward – in context of demands formulated in recent educational discourse - include opportunity for autonomous learning, changing teacher role or linking community and school (e.g. de Lange, 2006; Falk and Hoppe, 2004; Joachim, 2006; Schäfer, 2007a; Siegmund, 2002).

However, besides this colourful variety of arguments, already in 2002 it had been stated that "the guiding principle of GIS use in school is conceptual and systemic learning" as part of a process leading to "sustainable thinking and understanding in the system human – society – environment" (Schäfer, 2002, transl. by authors). It needs to be pointed out that these very subject specific aspects have not been sufficiently deliberated in the added value discussion yet.

With a look to the guiding objective of geography education as a whole, it is apparent that conceptual thinking, thinking in systems and sustainability are essential parts of what has been termed spatial behaviour competence (*Raumverhaltenskompetenz*) by Köck (e.g. Köck, 1989; 1993; 2005). Other guiding objective terms in discussion such as space-related action competence (*raumbezogene Handlungskompetenz*) or education for sustainable development (*Bildung für eine nachhaltige Entwicklung*) (Haubrich, 2006, Kultusministerkonferenz, 2005) incorporate these aspects as well.

Facing the high relevance of relating GIS use in geography lessons to the guiding objective of geography education, it is striking that only little empirical research has been done so far. One contribution to this research question originates from Kerski (2000). He conducted pre-/post-tests both with a standardized geography test and a fifteen minute 'spatial analysis-test', combined with case studies in the same classes. His study was carried out in grades nine

to twelve in three American High Schools, using ArcView. Little evidence arises out of the tests for significant differences between GIS and Non-GIS-groups, but some hints on positive effects of GIS use could be observed during the lessons (Kerski, 2000). In the German context, Klein (2005) used a questionnaire after a GIS training for thirteen *Sekundarstufe II* pupils in the state of Schleswig-Holstein to examine the added value of GIS with focus on the acceptance of GIS by the pupils and how they rate the value of individual GIS tools with regard to various aspects of spatial education. A majority of her respondents stated that GIS scores better than paper maps with regard to representation of spatial processes, easier search for structures, functions or processes and better being able to orient oneself in space. Moreover, one pupil commented that the layer principle simplifies spatial analysis (Klein, 2005). A project related evaluation in one class twelve in Berlin stated that in principle, GIS is a suitable tool to foster systemic thinking, for instance through pointing out complex interactions and global connections. However, it was conceded that the project could only provide a small contribution to fostering systemic thinking as pupils frequently lacked background knowledge to understand the individual systems (Falk and Nöthen, 2005).

Whereas the results of the aforesaid investigations can provide first hunches and valuable impulses for the integration of GIS into the classroom and its related research, it is obvious that they are by far neither sufficient to answer the question of the added value of GIS with regard to the fostering of spatial behaviour competence nor to impact policy decisions. Consequently, more fundamental research is needed to clarify the role GIS can – and maybe even should – play in high school geography education.

In order to investigate an effectiveness of GIS use on spatial behaviour competence development first of all adequate assessment instruments have to be developed and evaluated. For, despite the long standing history of the term no widely recognized means of assessment are available for spatial behaviour competence yet.

For the development of the assessment instruments first of all it has to be defined what exactly spatial behaviour competence does encompass. Thereby the different sub-qualifications of spatial behaviour competence as defined and described by Köck need to be taken into account (see Fig. 1).

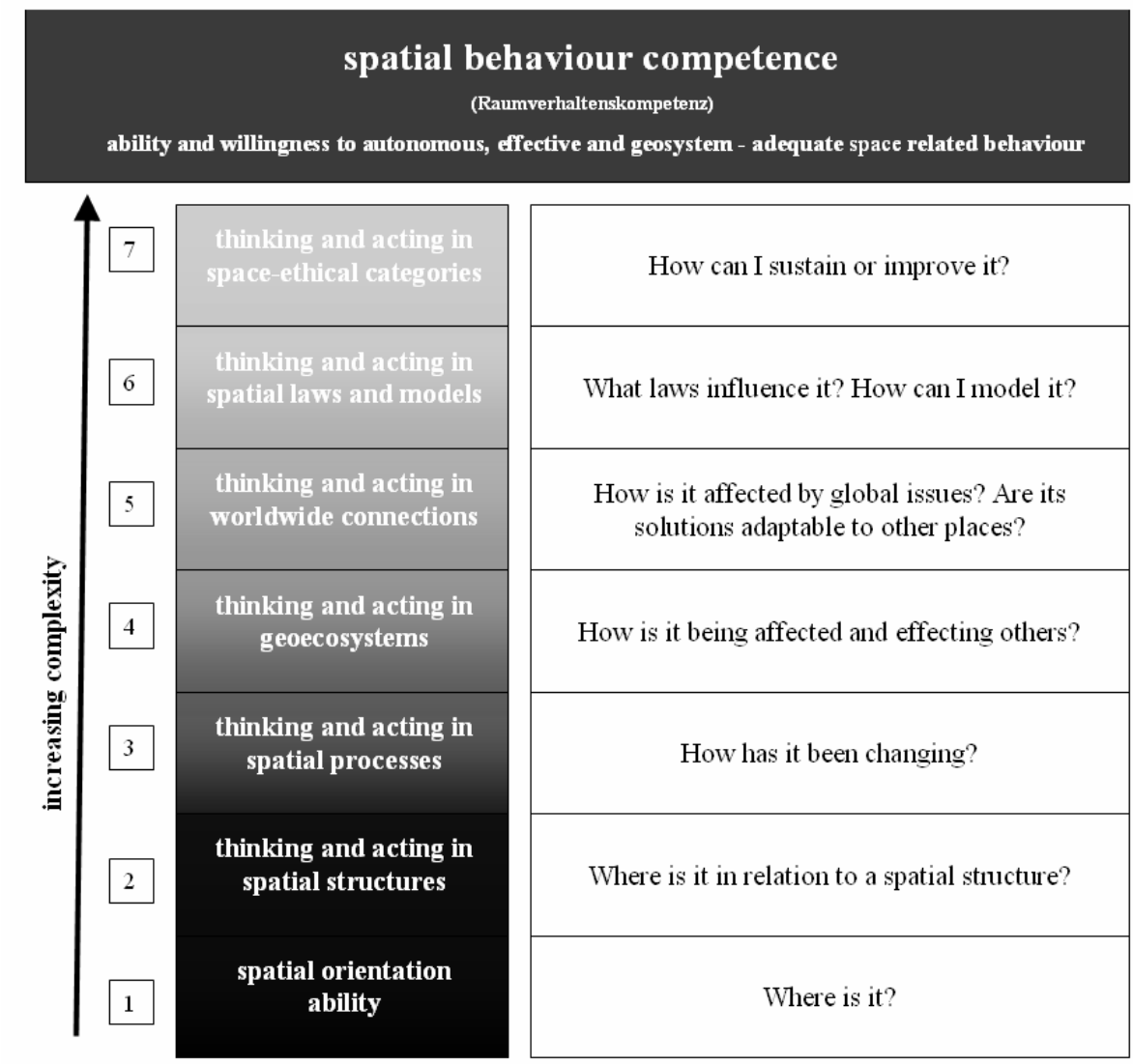

Fig. 1: spatial behaviour competence (based on Köck, 1993; 2005; Köck and Rempfler, 2004)

It is expected that the effect of GIS use differs for individual sub-qualifications. It can be assumed, for instance, that GIS use has an influence on spatial orientation but not on thinking in space-ethical categories. Therefore, it is necessary that the assessment instrument should allow a differentiation between sub-qualifications.

Moreover the instrument has to be age-adequate and linked to curriculum content. Since GIS use is the most controversially discussed and least covered with studies for the lower years of secondary education, the emphasis should be placed on that age group.

To sum it up, under the slogan “GIS at school” a great variety of what is named GIS and which learning objectives should be reached with the use of GIS in the classroom is subsumed. Moreover, the fuzzy term GIS is associated with the fostering of a multitude of competences. There are however only few empirical studies investigating this relationship.

Consequently, a project under way at the University of Education in Heidelberg aims at developing assessment tools and using them to explore the relationship between GIS use and competence development, focusing on spatial behaviour competence.

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