ASPECTS OF 3D MAP INTEGRATION IN INTERACTIVE SCHOOL ATLASES

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Abstract: *3D maps – thus computer-generated perspective views of three-dimensional geo-data models with cartographic content displayed on a two-dimensional media – are available for many different purposes and media. However, in modern digital school atlases they are still missing up to now. A new Web-based interactive edition of the Swiss School Atlas, the most widespread printed school atlas in Switzerland, should also include this attractive type of cartographic representation, aside from different kinds of classic topographic or thematic maps and cartograms. Starting from a poll with Swiss geographic teachers about the demands of a future digital atlas (carried out as a diploma thesis, co-supervised by the Institute of Cartography, ETH Zurich), we will continue our presentation with the need for 3D maps and their use in modern geography education at grammar schools. Based on these needs, didactical and concepttual aspects of the possible structure and technology of the planned Web atlas are discussed. From these considerations, the range of interactivity and functionality of interactive 3D maps will be derived. With an example of a 3D map showing the transversal gorge valley at Moutier in the mountainous Swiss Jura, the thematic aspects (geologic structure, land use, traffic network, and settlement structures) of this region are presented within a framework of visualization, thematic interaction and/or analysis and navigation.*

CURRENT STATE OF SCHOOL ATLASES AND 3D MAPS

School Atlases today

During schooldays, in geography, probably everybody met with school atlases printed on paper. Such atlases in general are a more or less comprehensive collection of maps depicting different locations, regions, or views of the world or celestial bodies (ORMELING 1996).

The maps present diverse thematic content, topographic generalization, scale and projection, especially for teaching purposes. The didactic approach is not only to systematically show the physical, socio-economic, or transitional phenomena on earth, but rather the depiction of typical showcases, which exist at different places. This showcase approach with the focus on a local and thematic scope has been introduced into nearly every school atlas.

Also, the Swiss School Atlas has been worked out with this approach in mind. It is among the most widespread printed school atlases in Switzerland (HURNI 2005, MARTY 2005) (figure 1). A large part of nearly fifty maps is dealing with thematic aspects about Switzerland. Another section of maps is dedicated to Europe or the other continents. The third group of maps gives a systematic overview on topography and land use of every continent of country groups. Still today, we suppose that printed school atlases are one of the most used teaching aids in geography education, especially in the German speaking part of Switzerland (KELLENBERGER 2005; MARTY 2005).

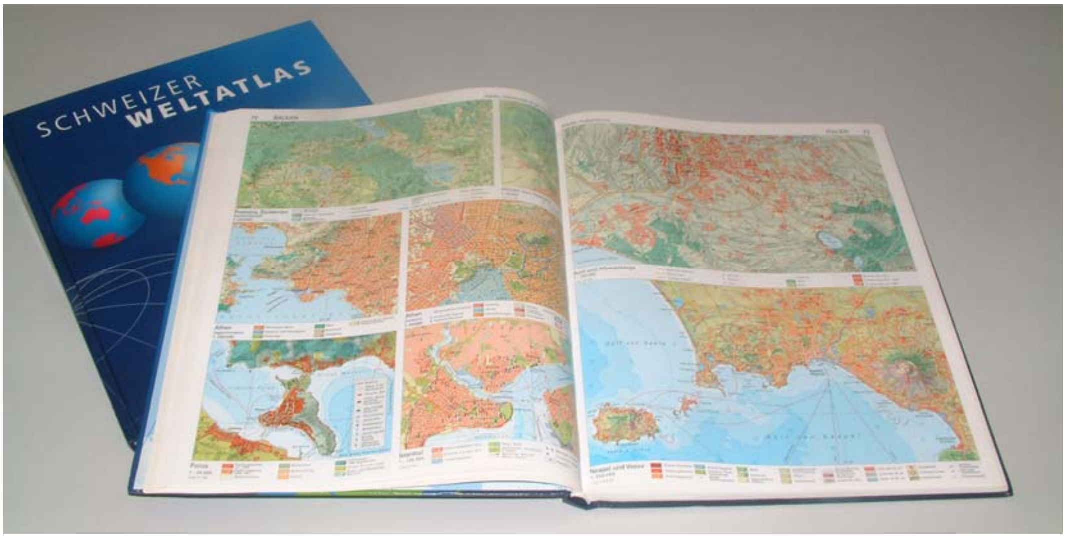

Figure 1: Swiss School Atlas ("Schweizer Weltatlas") with exemplary topographic and thematic maps (SCHWEIZER WELTATLAS 2004).

Digital School Atlases

Since the early nineties, numerous digital school atlases have been published. They evolved from experimental prototype atlases to supplementary or stand-alone information systems (HURNI 2004). Often, these types of atlases focus on national aspects, as for instance the *Atlas of Switzerland – version 2* (ATLAS OF SWITZERLAND 2004). Digital school atlases often contain rasterized maps of the printed edition (DIERCKE 2003). All thematic details, graphic styles, and even map labelling remain unchanged. Thus, the maps are mostly static and provide very limited interactivity (e.g. panning, zooming, and hot spots with hidden links).

The didactic approach consists of the supply of geographic information by maps and/or additional text. Guided school lessons or other e-learning tools are hardly realized. Occasionally, interactive quiz games are provided or available as a separate CD-ROM product (DIERCKE 2002). Current digital school atlases are mainly designed as stand-alone applications on CD-ROM. The advantages are undoubtedly the tailor-made software development as well as commercial aspects.

We do not know if today's digital school atlases are regularly used in geography. In Switzerland, only the above-mentioned *Atlas of Switzerland* has been established to some degree as teaching aid at secondary level of education (students aged from 12 to 19). It is occasionally utilized for complex analytical tasks, especially for accessing statistic data and generating terrain sections for different presentation purposes (MARTY 2005).

The didactic concept of digital school atlases, as well as other digital teaching aids and e-learning applications should be coordinated with the intended use in geography classes (IKA 2005). Digital atlases should not only serve as an information system but also as a pool of download resources and analytical tools for students and teachers. Consulting the above-mentioned poll with Swiss geographic teachers, future digital atlases should consider at least the following four guidelines (MARTY 2005):

- easy handling and concise navigation
- frequently updated atlas content
- heavy use of interactivity
- high cartographic quality

The variety of maps and depicted themes has to be large enough to follow the approved showcase approach of former printed school atlases. The broader the range of scales and themes is, the better the geography lessons can be served with maps and other cartographic representations.

3D Maps

The term "3D maps" is used as a computer-generated perspective view of a three-dimensional geo-data model with cartographic content presented on a two-dimensional media such as a computer display or a paper sheet (HAEBERLING 2005). Regarding the different aspects of such cartographic representations, the variety of thematic contents and interaction capabilities is unlimited. If we are considering the thematic spectrum, we can distinguish between 3D maps with pure topographic information (topographic 3D maps) and representations with additional thematic layers or objects (thematic 3D maps). In general, topography is always an integral part of thematic map type. As with 2D maps, 3D maps show the relationship between terrain and thematic phenomena very clearly - especially when the perspective view depicts a carefully chosen mountainous or hilly region (HAEBERLING 2004/2).
Therefore, 3D maps are also a preferred presentation type for teaching purposes. In printed school atlases, perspective views do rarely exist and if so, then only as schematic block diagrams, oblique aerial views, or thematic cartograms with perspective (point) symbols (DE GROTE BOSATLAS 2004; SCHWEIZER WELTATLAS 2004). If more advanced 3D representations are an issue, then they are still missing. Generally, only orthographic views of topographic or thematic maps are shown. In stand-alone digital atlas information systems, however (e.g. ATLAS OF SWITZERLAND 2004), numerous interactive tools for thematic layer selection, terrain analysis or thematic navigation can be implemented. At least, visualization variables for scene modelling (lighting and shading), environmental and atmospheric effects (sky, haze) and viewing variables (camera parameters) can be defined when rendering a 3D scene. But also fly-through variables and direct manipulation (camera path, speed, scene resolution) in virtual landscape applications (e.g. FLYTASTIC 2004) allow for animated representations on screen.
It is another vital issue how and with what techniques map content could be implemented in 3D maps. Currently, it is rarley possible to show specific phenomena and its complex relation to terrain within existing digital school atlases. Mostly, this happens by means of static perspective views in printed atlases (e.g. 3-DIMENSIONAL EARTH 2000; DE GROTE BOSATLAS 2004; SCHWEIZER WELTATLAS 2004). There is evidence that geography teachers could explain such phenomena even better by using 3D maps (MARTY 2005). Currently, only the *Atlas of Switzerland* (ATLAS OF SWITZERLAND 2004) – which is not specifically developed for schools – provides plenty of 3D functionality and interactivity. This is one of the main reasons why this stand-alone national atlas is in widespread use at Swiss secondary schools (MARTY 2005). Although the complexity of the application is high and the graphic user interface needs getting used to, the atlas is a powerful visualization and analysis tool within geographic education.
For high quality 3D visualizations, rather detailed data and terrain models are needed. Depending of the intended purpose (e.g. images, interactive models, animations), techniques for modelling, designing and rendering are inevitably complex and sophisticated. These requirements can currently only be achieved by stand-alone applications.

DIGITAL SWISS SCHOOL ATLAS WITH INTEGRATED 3D MAPS

Project for a Digital Swiss School Atlas

As a supplement to the printed Swiss School Atlas, a digital Swiss school atlas is planned, the so-called «Schweizer Weltatlas - interaktiv» (HURNI 2004; IKA 2005). This new didactic aid for geography at Swiss secondary education level classes is the answer to an old teacher's wish (IKA 2005; MARTY 2005).
At the beginning of this year, the responsible authorities approved the concept for a prototype implementation by the Institute of Cartography at ETH Zurich. The development will take place during the next two years. Among others, three important didactic guidelines will be followed explicitly:

- Knowledge about geographic and thematic information should be transferred exclusively by means of cartographic representations.
- Complex relations have to be taught by well structured and multifunctional maps.
- Cartographic aspects and skills (e.g. map design, map reading, analyzing) must also be taught by means of special map graphics or outline maps.

The target groups are not only students of secondary school level (12 to 20 years old) but also teachers and – at least – interested laities. The prototype of the digital Swiss School Atlas is planned as multimedia geographic teaching aid. This includes maps in different layer combinations for presentation in classrooms (as a replacement of wall maps), for analysis and for printing (e.g. base maps, outline maps or "silent maps"), but also interactive or guided cartographic e-learning courses for self-education could be integrated.

The development of the digital Swiss School Atlas is divided into five phases:

(1) During the first phase simple raster-based maps will be supplied for viewing on screen. Basic navigation tools allow for zooming or panning.
(2) Within the second phase the map content will be split into different thematic layers or layer groups. This allows a differentiated display on the screen and therefore a more analytic discussion in the class.
(3) Implementation of server-side functions such as on-line rasterization on demand and other Web services.
(4) Introduction of additional client-side functionality by the use of vector-based graphics.
(5) Providing special purpose software (such as a 3D viewer) and occasional CD-ROM/DVD production.

The thematic contents of the cartographic representations will be derived from the updated printed version. The map data – which exist only in digital form – will be adapted for screen display. The graphic appearance of the maps should be close to those in the printed edition. Map graphics in general must also satisfy high qualitative standards. But certainly, some adjustments must be made in symbolization because of different presentation media. Also, the interactive use and the navigation with and within the maps need appropriate graphics and labelling.

It is planned that the atlas will base on Web technology. For an easy use and handling, the atlas will basically require only common Web browsers. If additional functionality not covered so far is needed, plug-ins will have to be installed. Generally, most of the daily teaching should be mastered with standard Web browsers.

Concerning the demanded easy handling, the graphical user interface (GUI) must be designed in an intuitive, clear, and unmistakably way (MARTY 2005).It must not be too sophisticated with a lot of graphic gadgets floating around the different menus and input forms. A committed window technique and basic hierarchical text menus or search modes will satisfy the demands. Teachers as well as students should be able to browse the atlas without much effort for maps with the desired thematic content. The licensing policy of the atlas is also not definitively fixed at the time. Several possibilities are currently being discussed, ranging from a once paid license (e.g. provided with a printed atlas) to download or CPU fees.

Integration of 3D Maps

As mentioned before, 3D maps are greatly demanded (MARTY 2005). Besides aerial photographs and satellite images, users seem to be attracted by 3D maps of continents, regions or cities. Teachers hope to sensitize the students for the coherences between the dispersion of spatial phenomena and the terrain by means of perspective views.

We also have to consider the technical constraints of such an atlas, especially the Internet technology. This comprises maps and other documents, which are hosted on a remote server. Additionally, the way the users will access these documents must be considered. It might be necessary to know how they proceed to get the desired maps and representations. After the data has been transferred, the users should be able to manipulate the maps with an easy and familiar handling.

Regarding the integration of 3D maps in the digital Swiss School Atlas, some limitations are given:

- Cartographic 3D models cannot be provided, because they have to be modelled and visualized by special 3D software (which is not available locally). Thus, the atlas can only deal with pre-processed products such as images or animations.
- Currently 3D map models can only be visualized by additional plug-ins (VRML, 3D3). A correct installation is left to users. Unfortunately, 3D browser plug-ins do yet not run satisfactorily.
- 3D map interactivity and navigation has to rely on standard Web technology (e.g. hot spots links, image maps).

In the planned digital Swiss School Atlas a few examples of attractive 3D maps will certainly be included, although the different kinds of classic topographic or thematic maps and cartograms will constitute the main part of the atlas.
The amount of the provided interactivity and functionality depends on the thematic content, the availability of data as well as the limitations imposed by current Web technology. Additionally, the interactive 3D maps must account for the proceeding of the atlas development. Thus, at the two first steps, raster-based maps will dominate the atlas. Vector data will rarely be used during the initial phases.

3D MAP EXAMPLE "KLUS VON MOUTIER"

What kind of 3D maps and what functionality should be offered effectively within the planned atlas? The concept and possible interactions will be discussed and shown by the first 3D map example. The example reveals the geological structure of a transversal gorge valley in the Jura mountains next to the village of Moutier in Switzerland (figure 2). Because of the characteristic hilly shaped terrain, the different anthropogenic infrastructure and vegetation patterns, the so-called "Klus" is an ideal example to teach the impact of natural geomorphologic processes on human-made structures. The content of the 3D map shows the didactic concept. Different thematic layers like geology, vegetation or traffic networks can be superimposed on a section of the digital terrain model DHM25 (SWISSTOPO 2005/3).

Figure 2: Klus of Moutier in the Jura Mountains (Switzerland). Left: section of a topographic map 1:50 000 (SwissMap 50: © Swisstopo, Wabern; SWISSTOPO 2003); right: aerial perspective view (SCHWEIZER WELTATLAS 2004).

Due to the necessity of an easy handling and the preferred Internet technology the data model must be simple. The base data for the whole 3D map should correspond to the purpose and costs. A GIS-based geological data set at the scale 1 to 25 000 will be soon available (from the Federal geological survey at SWISSTOPO, Wabern). The surface mosaic with geological structures is not very detailed. As common to geology, the map is generously interpolated and roughly generalized.
For comparisons and combinations with the geological structure at the Klus of Moutier, other data sets about settlement, river and traffic networks or vegetation patterns must be available as raster or vector data. For this purpose, data from official digital topographic maps, landscape models or other GIS projects will be used (Swisstopo 2005/1 and 2005/2) (figure 3). And of course, the scale and the degree of generalization of these data sets should be adequate.
From all these basic data sets, raster textures will be derived for draping a section of the standard Swiss digital elevation model DHM25 (SWISSTOPO 2005/3). With a grid size of 25 meters, the underlying DHM25 is not very detailed. But for teaching purposes at schools, the accuracy of terrain shapes is quite sufficient. But in future, better models will be available. If possible, the different themes will be modelled in vector mode and split into different layers or object groups

(with ADOBE *Illustrator*). Then, the intended thematic layer combinations will be exported as raster images with a reasonable resolution. Alternatively, raster-based thematic data will be directly imported as layers into a raster file (e.g. in ADOBE *Photoshop*) in order to create composites. Finally, the prepared raster or vector- data will be converted to thematic. There may possibly result many different combinations.

Figure 3: Colour separated layers of the Pixel map PM25, the digital Swiss national topographic map 1:25 000, depicting the region of Moutier. Left above: situation (with buildings, traffic network, cartographic information, labelling); right above: river network; left bottom: forest boundaries and single trees; right bottom: forest areas (PM25: © Swisstopo, Wabern; SWISSTOPO 2005/1).

As a first attempt, it is intended to derive the following textures from the different sources:

- geological structures
- digital topographic map (including labelling)
- geological structures combined with digital topographic map (including labelling)
- geological structures combined with river network
- vegetation patterns
- geological structures combined with vegetation pattern
- orthophoto

Subsequently, the textures will be used as a "material" in a 3D landscape modelling software (e.g. *DAZ Bryce*), superimposed on a DTM section. The DTM section along with its textures constitutes a simple cartographic 3D model. Before visualization, the camera and the lighting model must be specified. We need to know what camera position and viewing inclination should be defined or how the light angle and direction must be chosen for an optimal presentation of the focused region and details. After having defined all the visualization parameters and input variables for atmospheric effects (e.g. sky structure, haze density) a single 3D map with the desired thematic texture can be rendered. In fact, we get only static map images (figure 4).

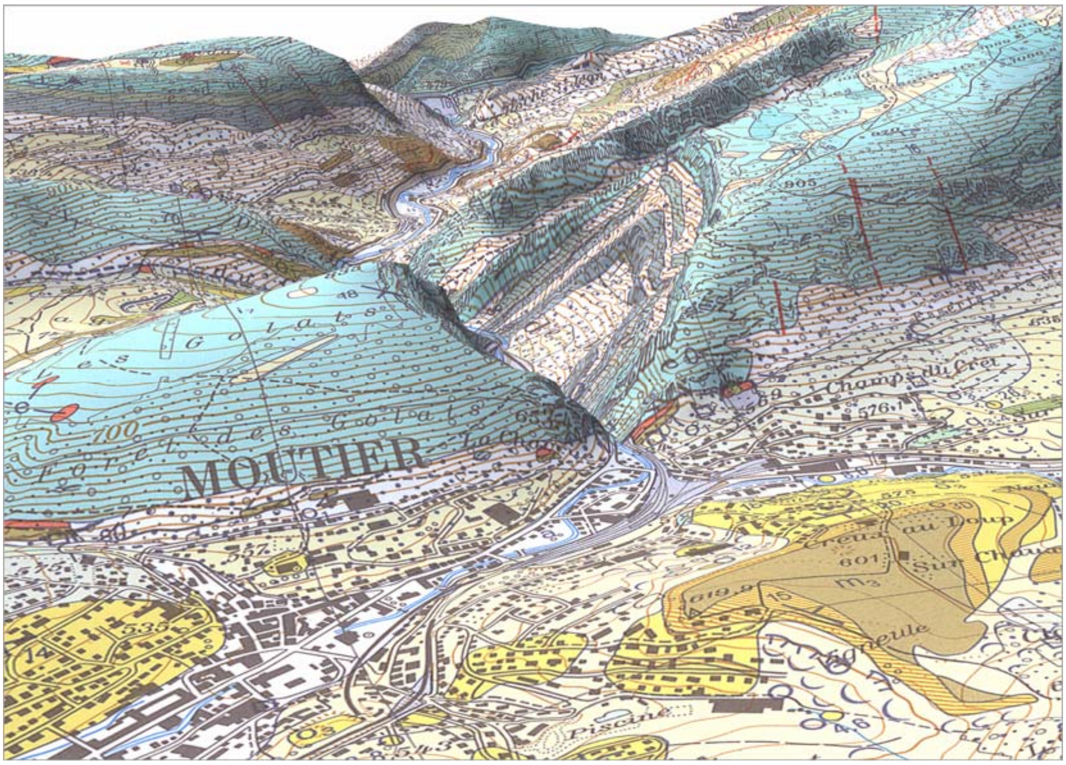

Figure 4: Geologic 3D map of the "Klus von Moutier". Section of the DHM25 textured with the equivalent section of the raster-based geologic map 1: 25 000 (Data: © Swisstopo, Wabern; SWISSTOPO 2005/3 and 2005/4).

The given set of textures enable to arrange sequences of images in two different ways:

(1) There is a fixed view from where all the diverse thematic layers (and combinations, possibly with semitransparent layers) can be compared.

(2) We get series of 3D maps with the same thematic texture, but from different observation points and variable zoom factors. This gives the impression of a proper exploration of the model. (A next step would be a semi-automatically produced frame-by-frame animation.)

The navigation between the different samples of the static 3D map images could be achieved by linked hot spots within the single images. Otherwise, a hierarchic menu will lead to the desired 3D map. For example, the simulation of switching on and off thematic layers will be achieved by placing different 3D maps on the screen. Such an Internet based image collection will be an efficient but technically simple tool to be used at schools.

CONCLUSIONS AND OUTLOOK

Due to the structures and properties of the atlas, the planned digital Swiss School Atlas will be implemented as a document orientated atlas type. The types of documents may differ, e.g. raster-based map images, vector-based SVG files, movie files and text files. The use of plug-ins, or special purpose applications for viewing or analysing should be avoided. In case of a fully functional Internet connection, this structure helps to keep the atlas simple and ready to be used at any time. Thus, interactive 3D maps must consider these technical restrictions and limitations. But concerning the small number of 3D maps in the first prototype phase, the limited technology should not be a big handicap.

Clear functionalities within the map and a concise user interface must be reached. Links and references to other documents can be placed on every static 3D map. So then, not the map objects will be selected. But for single 3D map examples, the links could be placed so sophisticatedly, that the flow of maps and further information documents works fluently. The interactivity is more based on a free browsing through the supplied documents.

The didactic concept behind every 3D map series is the most important motivation. At the first prototype steps, no e-learning application is intended. The focus lays on useful tools for demonstration and analysis in geography lessons. This means also, that the graphic appearance of the 3D maps is a vital attraction factor. The similarity in style and duct with the printed Swiss school atlas must also be retained in the digital version.

With the 3D map of the Klus of Moutier we would like to show a typical example of a map adaptation for the use at schools. Therefore, 3D maps must be optimized for screen display or paper output. Also, it should be equipped with the needed interactivity. And the chosen perspective views with different thematic layers must convince potential map readers by the use of high resolution images and attractive map design. After first attempts in modelling and visualization, we will test and evaluate the maps and the interactivity with teachers and students similarly. This evaluation will inform us whether the initial concept for an integration of such 3D maps in digital school atlases is successful or not.

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Hansruedi Bär, born 1955, received a MSc and PhD in geography from the University of Zurich. In his PhD thesis he developed a system for the interactive manipulation of digital terrain models. After the studies, he was engaged in a project for a visitor's information system for the Swiss National Parc. In 1995, he joined the Institute of Cartography at ETH Zurich, where he was in charge with the conception and programming of the interactive version of the "Atlas of Switzerland". He has been involved in TH projects "Interactive Multimedia Atlases", "Interactive Multimedia Atlas Information Systems", and, most recently, "Distributed Maps on Demand". Since 2001, he also collaborates with a EU project for a statistical Atlas of Europe (STATLAS).

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After his master degrees in Business Administration and Geography at the University of Zurich, Christian Haeberling, born 1961, started his cartographic career at the Institute of Cartography at ETH Zurich in 1995. His PhD dealt with his favourite subject of 3D maps, especially with the design and creation process of these attractive map representations. 2005 he became one of the project leader of a research project dealing with the interactive version of the Swiss school atlas, the "Atlas of Switzerland".