REMOTE SENSING IN SCHOOL – THEORETICAL CONCEPT AND PRACTICAL IMPLEMENTATION

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ABSTRACT:

Due to the importance and presence of remote sensing in science, industry and the public, the use of satellite imagery is now propagated for or even included in school curricula and the national educational standards for geography. Remote sensing data are characterized - in addition to their high clarity and timeliness - by having a great educational potential. This has been insufficiently tapped in school practice.

This paper presents a modern didactical concept and examples of practical implementation. It begins with the results of an international comparative study of the use of satellite images in schools as the basis for a didactical concept for using this medium in school. Furthermore, examples of implementing this theoretical model from different school types and grade levels will be shown. For the lower secondary level, interactive learning games concerning the basic functionality of remote sensing have been developed. Moreover, for both the lower and upper secondary level as well as for non-formal education, the creation of remote sensing tools on selected topics such as global change and urbanization is in progress. Another example is the development of web based software for the analysis of satellite images in school.

These examples of implementing remote sensing in education demonstrate the possibilities of a problem-and action-oriented use of remote sensing as a modern medium and tool of geography teaching. The materials foster different competencies of students and promote education for sustainable development.

1. INTRODUCTION

Working with remote sensing data in school is often reduced to analogue applications e.g. to examine different points of view for one area or to improve map reading skills. In times of GoogleEarth, geo-caching and navigation-systems children and teenagers are mostly conversant with using new techniques and new software. So why not use digital remote sensing data in class? Besides the teachers' personal misgivings, lack of suitable tools to work with satellite data for different class levels can be seen as impediments for application. Requirements regarding the tools' functionality and interface design differ considerably between younger and older students. Consequently, a concept has been developed to offer optimized tools for different age groups, proficiency levels and school types. The tools include interactive learning games, web based remote sensing applications and software to analyze satellite data.

2. INTERNATIONAL COMPARATIVE STUDY

At present, a geographical concept for remote sensing didactics is missing and therefore the different viewpoints of teachers and pupils about the extent and kind of satellite images that are used in lessons have been examined in an international online questionnaire. In addition to the personal and school surroundings, the technical ability of the pupils in handling satellite images has been examined. The participating countries were chosen based on the results of the 2003 PISA study in natural science competence. Countries above, at and below the OECD average have been selected. Target schools are secondary schools with pupils aged twelve to eighteen years.

The questionnaires for teachers and pupils are available in the respective languages (www.ph-heidelberg.de/satbild).

As the research project is not concluded yet, only preliminary results can be presented. Correlations and final analysis are forthcoming.

For example first results of selected countries show that in Germany, Poland and England more than 50% of the pupils have already worked with satellite images in school, in England more than 80%. In Turkey, South Korea and the US less than 50% of the pupils have worked with satellite images. First analyses also show that satellite images have a great potential when used in school. In all six countries more than 70% of the pupils answer with exactly/almost true when asked if the work with satellite images was interesting. In comparison, the motivation – as an important determinant for an effective learning process – is in almost all the countries significantly below the interest (see figure 1).
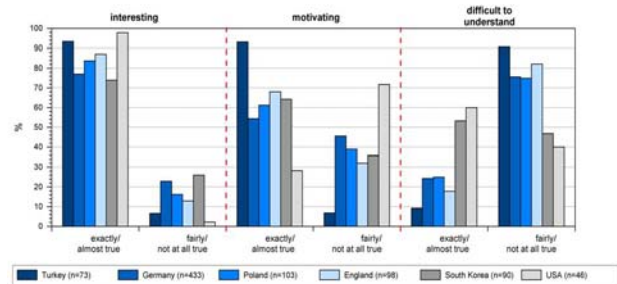

Figure 1: To work with satellite images in school was ... (Data base: own inquiry)

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Following steps must be the complete analysis of the empirical data and the correlations between different aspects. Altogether thirteen countries were involved so that a theoretical overall concept of remote sensing didactics for school could be developed.

3. "GLOKAL CHANGE" – COMBINING COMPUTER-BASED SATELLITE IMAGE ANALYSIS WITH FIELDWORK FOR AN EDUCATION FOR SUSTAINABLE DEVELOPMENT

By working with a web based learning management system (LMS), such as "Glokal Change", students can learn about the complex relations of non-sustainable human activities and their subsequent environmental as well as economic and social impacts. For students of lower secondary school levels at the age of 10 to 16 years, it is hardly possible to understand the human induced environmental changes in their full complexity, and to comprehend the far-reaching impacts of human activities on the relationship between environment and human society regarding the ecological, economical and social dimensions. Using satellite image analysis is an important key to solve this problem. The LMS embeds satellite image analysis into a framework of education for sustainable development, demonstrating the possibilities of a problem- and action-orientated usage of remote sensing media as a modern tool for learning geography and environmental science. Thematic modules using satellite data from different points in time and of different band composites, at least for the local scale, allow for a comprehensive didactical approach to apply satellite image analysis to the education for sustainable development (see figure 2).

3.1 The Learning Management System "Glokal Change"

The project "Glokal Change – Evaluating global environmental changes locally" offers a web based learning management system for lower secondary school students which can be used in curricular as well as extracurricular environmental education. With regard to contents, the LMS refers to the subjects of geography and environmental science. As educational learning software, the methodical and didactical approaches being used within these subjects, especially within geography, are applied in the LMS. In our view, a multimedia-based configuration of the LMS with free navigation opportunities is very useful to give the students a more or less realistic presentation of the complex connections between human activities and environmental changes.
The project focuses on current non-sustainable human activities in the fields of forest management, digging and mining of non-renewable resources, cultivation of biofuels in agriculture and conflicts in land use. Each is the focus of one thematic module, and the four modules are linked among each other. Generally, this modular structure is the core of the LMS. Each module is treated in a problem-orientated manner, starting with the non-sustainable environmental change itself, e.g., the clearing of forests, or the cultivation of biofuels while many people in developing countries suffer hunger. In the course of the modules the view shifts from the global perspective with some international examples at the beginning to examples from Germany, and finally to the local surroundings of the students. The modules are composed of a mix of text elements, graphics, photos, flash animations and, especially, satellite images.

3.1.1 Using satellite image analysis

On the global to regional scale, examples of non-sustainable developments are visualized by two satellite images of the same region, but of different temporal origin. Satellite data offer actual spatial information which are easily available via the internet and cover the whole world. In the age of globalization and dynamic sampling of processes, they give students the opportunity to get to know the reality from places far away. Besides, using satellite data increases the motivation of students to deal with environmental topics. They are very useful because the impressive visualization of a geographical issue on a satellite image permits a better understanding of the spatial processes and circumstances which have been mapped. Students do not only learn how to deal with this remote sensing data but they also get to know how to "read" their content of geospatial information. Within the LMS, students can improve their ability to analyze the information about spatial and temporal processes and developments in the respective regions depicted in the satellite images (Brucker, 2006). According to Brucker (2006), satellite images are generally keys to the understanding for students that the earth is a closed ecological system, and that human interferences lead to global implications. Both aspects are essential to the project "Glokal Change" as it tries to demonstrate the environmental, and to a lesser degree the economic and social, consequences of human activities including satellite image analysis.
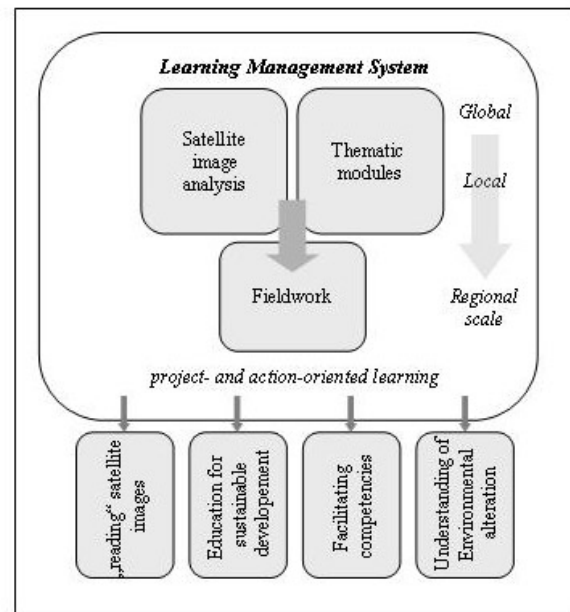

Figure 2: Structure and objectives of the learning management system "Glokal Change".

On the local scale, satellite data from three different points in time, 1985, 2000 and 2007, and of three different band composites, true color images, false color images and images showing the Normalized Difference Vegetation Index (NDVI), help to intensify the learning process. For this purpose a mapserver, as part of the LMS, contains satellite image mosaics of the whole area of Germany for each of the three points in time and band composites. For 1985 and 2007 LANDSAT 4-5 TM images are used, while LANDSAT 7 ETM+ are used for the 2000 images. The mapserver offers several tools to work with the satellite image mosaics, namely zoom in/out, pan, search by zip code or geographic coordinates and measure. Moreover, a given position on the mosaic, e.g., a special building or an important position in the field, can be marked.

Additionally, an interesting satellite image detail can be printed or saved as a *.geotif data for further analysis in established image processing programs.

3.1.2 Using advantages through combining satellite image analysis and fieldwork methods

The third component of the LMS is a manual for corresponding action-orientated fieldwork, containing for example mapping instructions and interview guidelines (see figure 2). From our understanding, it seems important to complement the knowledge students´ gained through working with the interactive learning modules and the mapserver with individual experiences in the field. This multi-perspective (global, regional to local) and multi-sensory ("head, heart and hand") approach aims at sensitizing students to the problems of current non-sustainable human-environment-interactions. Examining these relations is not only the basis for understanding the term sustainability but also for facilitating the individual cognitive competencies of each student. In the mainly geographically orientated context of the project "Glokal Change", the four modules are designed to meet the educational standards of the subject geography in German secondary schools introduced by the German Geographical Society (DGfG, 2008). The didactical concept of the project wants to activate and/or facilitate the following personal competencies as they have been denominated by the DGfG (2008):

- Spatial orientation: Students learn to orientate themselves virtually on a satellite image. During the fieldwork they learn how to orient themselves in real space. Combing both includes the ability to transfer the virtual orientation on the satellite image to the real conditions in the field.
- Knowledge gain/methods: Beside the satellite images other sources of information such as text elements or graphics activate and/or facilitate the student´s ability to gain and to analyze information for the handling of geographic/geoscientific questions.
- Communication: Students shall improve their ability to understand and to express geographic/geoscientific messages via teamwork. Moreover students shall improve their way to come to a well-founded opinion.
- Evaluation: Students learn to evaluate selected situations and circumstances in space by using their geographic/geoscientific knowledge. Furthermore they learn to integrate ethic/social values and standards into their evaluation of geographic/geoscientific circumstances and processes.
- Action: Showing non-sustainable behavioral patterns on the one hand and quoting options for alternative sustainable patterns on the other hand activates and/or facilitates the willingness to act in geographically/geoscientifically relevant situations; this includes the students' ability to reflect their own action regarding spatial implications.

3.1.3 Using a microdrone

One part of the fieldwork is using a low-cost mircodrone to map small local areas, e.g., razed forests or damages in cornfields (Thamm, 2005). The drone is equipped with a multispectral camera for high resolution aerial photos, which are usually used in forestry. Using the drone, pupils can find out the fundamental aspects of remote sensing like the high resolution of aerial photos, and this can yet be achieved in an action-orientated way enhancing the students´ motivation. Another didactical approach for understanding remote sensing is the demonstration of taking aerial photos in real-time as an example of the origin of satellite images. At the same time, students learn about the principles and difficulties of producing remote sensing data.

3.2 The contribution of remote sensing data to a more sustainable future

Overall, the intent of the project is to promote an active engagement of lower secondary school level students in non-sustainable environmental change and thereby increase their interest in questions of environmental protection. Students get to know personal and societal options for an alternative utilization of natural resources in order to make a more ecologically compatible, economically effective and socially righteous development in the 21st century possible (German UNESCO Commission, 2009). If we accomplish this task, the requirements of the present may be satisfied without cutting the needs of future generations. In this regard, satellite image analysis in combination with instructions for fieldwork is an important geographical/geoscientifical didactically´ helpful method to call lower secondary school level students´ attention to the problems of the present, and to inspire them for a more sustainable behavior in the future. At the same time, the students´ acquisition of individual competencies can be facilitated.

4. BLIF: A WEB- BASED REMOTE SENSING SOFTWARE FOR SCHOOLS

In the age of „Google Earth", nearly everyone is able to take a look on the earth from above. It is this kind of view of which Sokrates must have been dreaming when he stated: "We would understand the earth, if we could see her from aloft." More than 2000 years later, the use of satellite images is known as key-method to understand the earth and learn more about its geo-scientific correlations (Brucker, 2006). Real colour images, known from "Google Earth", contain interesting and valuable information (Albertz, 2007).

The development of this unused source of information for a contemporary education in school is one of the core concerns of the didactics of remote sensing (Brucker, 2006, Siegmund & Menz, 2005). The project „Blickpunkt Fernerkundung (BLIF)" offers a web based software to establish remote sensing more frequently in school as a digital kind of modern learning.

The international comparative study about the interest and the motivation in using satellite images in schools has shown the huge educational potential of working with remote sensing systems in school (see chapter 2). Most pupils are highly motivated and fascinated by working with satellite images (Wolf & Siegmund, 2007, Voß, 2007). However, no computer application suitable for students to process and analyse remote sensing data on their own is available. Appropriate software solutions, which enable pupils to work with satellite images independently, are necessary to improve the various geographical and methodological skills demanded by German curricula (Roseeu, 2004).

There are several computer applications for professional users, such as ENVI, ERDAS, Idrisi, or eCognition. This kind of software offers a lot of possibilities to advanced users, but due to their complexity and non-intuitive user interface they are not appropriate to be used in school. Moreover, most of the mentioned software is too expensive for the majority of schools. "BLIF" provides a web based software to be used in normal classroom settings. The software is going to be developed and integrated into a didactical main concept. In addition to the software a great number of teaching aids to use the application

purposefully and activity-based will be provided. The characteristic feature of this application will be its intuitive, age appropriate usability.

Figure 3: Screenshot of BLIF-assistant-mode ("expert- mode"; stage of development: 05/10/2009)

There will be two modes. The first mode is the assistant guided mode, which is developed to introduce students in menu navigation (see figure 3). There will be three levels, starting with *beginners*, then the *advanced learners* and finally the *professional user*. Going through all the levels, the students will get accustomed to program procedure and learn how to process satellite images efficiently.

BLIF is structured into three main parts. The first one is the chosen satellite image area in the centre of the user interface. The second one is the menu bar above the image.

Figure 4: BLIF menu bar (Icons source: http://www.visualpharm.com)

The menu bar contains general software functions, like the folder-icon to open the satellite image, the disk-icon for storing individual processing steps, icons for zoom-in, zoom out, the undo and the forward button, the toolbox which contains special software features, the compass-icon for georeferencing, the layout button to design the results individually and the print button (see figure 4). The info icon will open an info-box, from which the BLIF user can get further information about the satellite image and the help-box.

The third main parts of the BLIF user interface are the framed content elements. By following the assistant's instructions, the students are introduced to the navigation of BLIF. Before starting a processing step, the user always gets the necessary information from the assistant, named "Satellitus". His advices are short and comprehensible, all important terms are hyperlinked to popup windows providing further explanations. The frame of the respective current processing level is highlighted (see figure 5). For instance, in figure 3 and 5 the students have to create a suitable band composition; consequently, the frame "band composites" is highlighted in red. By clicking on the "next-button", the students finish this step and the next frame with a new instruction is activated. According to the user-level settings at the beginning, the students will find various processing options. The "beginner" for example will not be able to improve the satellite image by using the histogram. Furthermore the beginner will not be able to make a histogram comparison or generate a "Normalized Differenced Vegetation Index" (NDVI) (see figure 5).
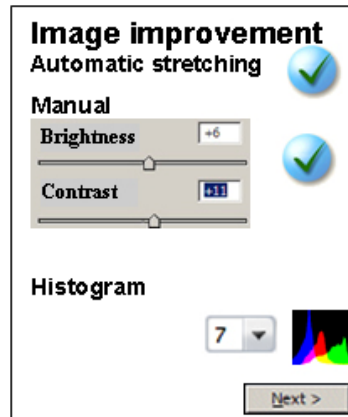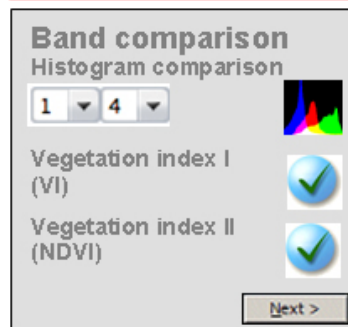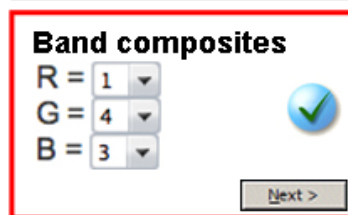

Figure 5: BLIF processing frame (cut out)

The second mode is the open form of using the software. The menu interface of both modes will be similar- but in the open mode it will be possible to have several special settings, depending on what kind of geographical question pupils want to explore and depending on their knowledge in using remote sensing systems. Because of these features, the software can be used by a wide range of user – ranging from beginners at the end of primary school to experienced users at the end of secondary school.

The technical features follow the most common utilities of remote sensing systems. Functionality will range from basic features (like importing and exporting files, zooming or the changing of vector files to image files and vice-versa), to different possibilities for image improvement (regulation of brightness, contrast settings or stretching) up to the possibility of georeferencing. Another group of features consists of treating the image as well as several forms of image classifications. Here, the pupils have the possibility to build different band composites (see figure 6). By combining the information of certain spectral bands, the pupils can get helpful information for an efficient interpretation of the classification results. The software also offers the young scientists the possibility to get different standard indices to explore the vitality of the vegetation, such as the NDVI. Moreover, it will be possible to evaluate the classified image and publish it with several standard layout elements, like title, scale and legend.

There are numerous situations in which it is useful to work with this software in school. It can obviously be used in a geographical context, but also in environmental science, mathematics, information technologies and in exercises which combine the mentioned or additional subjects.

There are lots of relevant themes, like desertification, the development of cities, the agricultural and industrial land use or the exploration of natural resources (Albertz, 2007, Jürgens, 2003, Hasenpflug, 1998). The main goal of working with satellite images is to encourage and motivate pupils to solve a geographical or environmental science problem on their own, while they are acting independently and feeling useful and important (Gudjons, 2008, Klafki, 2007).
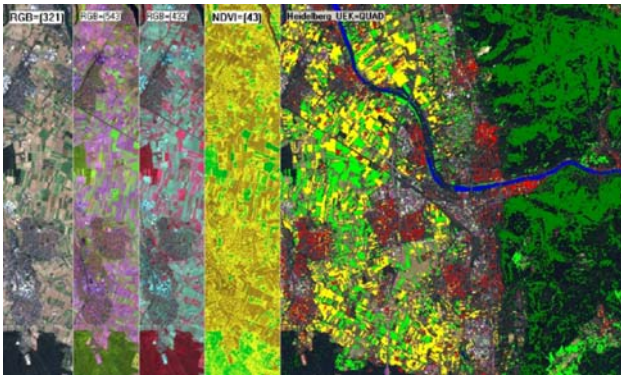
Figure 6: Choices of some technical features: True-colour-composition (RGB 321), false-colour-composition (RGB 543/432), NDVI (43) and supervised classification (based on Landsat images from Heidelberg/Germany)

To support the software, the teachers and pupils will find a tutorial and a selection of representative exercises which will give the students and teachers' helpful hints on using the software and interpreting the results. The development and testing of this web based software is still in progress. It will be available to all schools free of charge from summer 2010 on.

5. CONCLUSIONS

The implementation of remote sensing in class should become more regular and widespread – more than the actual situation where only some teachers are using satellite images or even software to analyze remote sensing data. As shown in this paper there are different ways to implement remote sensing in school, depending on the students´ age and knowledge. A first but main result of all the projects, which are still not finished, could be summarized in the cognition that remote sensing should be used as a geographical tool, like an atlas or a globe. The potentials of satellite images or aerial photos are immense, much more than a simple map of a region. So working with remote sensing data on a subject like the tropical rain forest includes a lot more information on e.g. the actual dimension and its vitality. To develop age-based content materials and software for different subjects using satellite data as tools seemed to be the important step in a concept to promote the implementation of remote sensing in school.

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