

## TEACHING MATERIALS, ENCYCLOPAEDIA, EASY-TO-USE IMAGE PROCESSING – THE FIS LEARNING PORTAL ON REMOTE SENSING

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### ABSTRACT

In this contribution we present a web-based learning portal on the subject of remote sensing for schools. The learning portal contains interactive material that is intended to give young students a new understanding of the value of natural sciences by connecting curriculum-oriented topics with specific exemplary applications from topics of remote sensing and digital image analysis. Above that, the portal contains comprehensive background information on remote sensing and specific analysis tools enabling individual exploration of satellite images. Both, the learning portal and the learning material are following a moderate constructivist approach encouraging students to discover the material independently. Here, we focus on the portal's learning management functions, giving teachers the opportunity to analyse their students' results. Furthermore, we present our first experiences with the portal after half a year of service.

### INTRODUCTION

The project FIS – Fernerkundung in Schulen (German abbreviation for 'Remote Sensing in Schools') – aims at a better integration of remote sensing in school lessons. Using satellite images in school has a number of advantages: the clearness and intrinsic motivating effect can contribute to foster natural science education (1) and the timeliness of the satellite data helps to demonstrate ways of problem-oriented working. For example, the comparison of recent satellite images with older ones makes changes on the land surface clearly visible (e.g., caused by natural disasters, pollution or climatic changes). Furthermore, working with satellite images can help to improve spatial orientation and methodological skills. Respectively, the overall objective of the project is to teach pupils the basics and applications of remote sensing. The project aims at age ranges from primary school up to high school graduation and therefore, the content and tools provided are graded relating to complexity. We developed a comprehensive and well-structured learning portal combining the aforementioned elements on the subject of remote sensing, which can be accessed by <http://www.fis.uni-bonn.de>.

In this paper we present the learning portal at work and the experiences we have had so far after 1.5 years of operation. The portal has initially been developed for use in schools in Germany and its content has been tailored to German curricula. Besides the very limited amount of learning material about remote sensing in German (2), we wanted to reduce barriers for its use in German schools and launched the portal initially only in German language. Recently, the portal has become available in English as well and can be used in schools in English-speaking countries or in bilingual classes.

There are several initiatives in the international (English-speaking) context having a similar aim, specifically on learning and teaching remote sensing image analysis skills, like Eduspace (ESA, [www.esa.int/SPECIALS/Eduspace\\_EN/](http://www.esa.int/SPECIALS/Eduspace_EN/)) (3), Bilko (UNESCO, <http://www.bilko.org/>) (4), Eurac Junior (EURAC, Bolzano/Italy, [junior.eurac.edu/](http://junior.eurac.edu/)) (5), or SEOS (EARSeL, [www.seos-project.eu/](http://www.seos-project.eu/)) (6), but they either focus on a different target group (Bilko) or are more "outreach-driven" (Eduspace, SEOS), which means that their focus is on the promotion of remote sensing knowledge on secondary/high school level. In our approach the focus is more on the needs of the pupils and the way they explore a curriculum-relevant topic. Remote sensing delivers the resources for that.

In this paper, we give a brief overview of the content and the functions of the FIS learning portal, describe the portal's learning management functionalities and show how E-learning can encourage pupils to work with satellite images in the context of natural science education.

## THE PORTAL'S CONTENT

With the FIS learning portal (7), information about the use of remote sensing in classrooms as well as the correspondent learning material is disseminated in a structured manner. The material is complemented by specific curriculum-related suggestions requiring teachers to prepare with relatively little effort.

The learning portal's underlying didactic principle is based on moderate constructivist approaches (8). Therefore, the learning portal focuses on the interactive analysis of remote sensing data for solving real-world issues or curriculum-specific tasks. An effective connection of theory and practice is achieved through individual working, creativity, and critical reflection. Accordingly, the provided learning material includes multi-media applications and allows for a high degree of interaction. Moreover, specific tools for research, analysis and exchange are integrated, thus independent working and discovery-based learning is encouraged in terms of a practice-oriented approach.

The learning portal is divided into six sections that can be accessed via the main menu. These sections are explained in the following sub-chapters. Additional learning management tools are explained in detail below.

### About FIS

'About FIS' provides general information on the project background, the motivation and the didactic concept of the project. Furthermore, links to project partners and publications can be found here.

### What is remote sensing?

In this section, users find a brief introduction to remote sensing. Two documents – one version for beginners and one for advanced users – describe the principles of remote sensing, the data that can be explored by digital image analysis and example applications of remote sensing methods. Additionally, an explorative and interactive environment offering information on satellites, their fields of application as well as basic background information is elaborated (Figure 1).

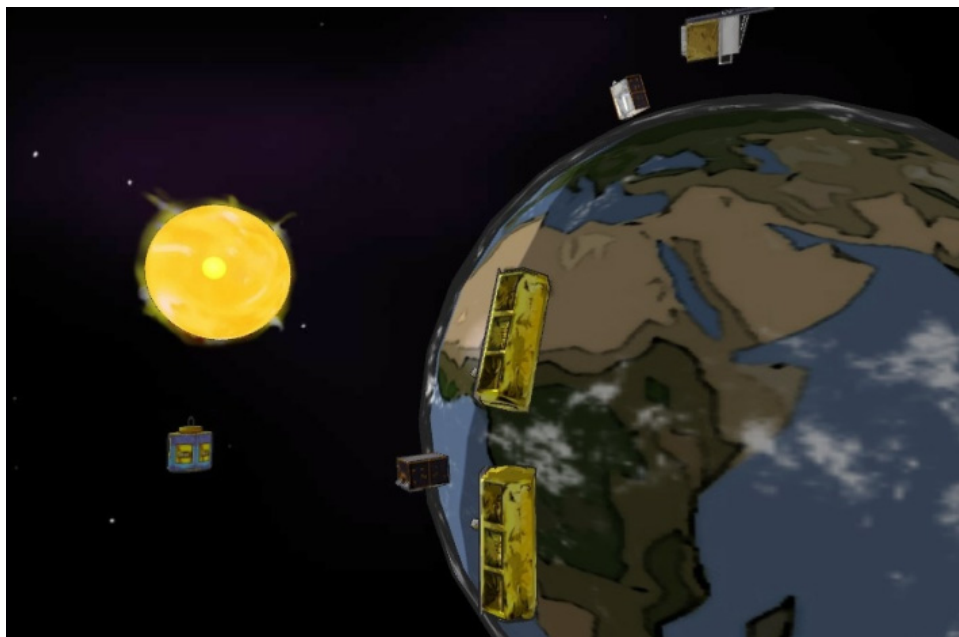


Figure 1: Explorative environment of FIS offering information on RapidEye, EnMap, Meteosat, TerraSAR-X, and TanDEM-X satellite systems.

## Teaching material

The core of the learning portal consists of digital and interactive learning modules that teach pupils remote sensing topics following the curriculum for specific school grades. To cover different aspects of remote sensing, learning modules for the subjects geography, biology, physics, maths and informatics have been developed. The learning modules' design enables users to apply remote sensing methods by using interactive tools. The complexity of the analysis is reduced to several core functions and, thus, the pupil's cognitive load is much lower compared to the use of conventional remote sensing software. The general concept of the FIS learning modules is described in Voss et al. (2009) (9).

All teaching material is available for download, including a didactic commentary and background information. Additionally, all interactive learning modules can be studied online.

## Research tools

To improve individual, discovery-based learning, the pupils find extensive background information on remote sensing in the 'research tools' section. Here, a digital glossary ('Info-Box'), an image gallery, and links to external information provide comprehensive background information for pupils as well as teachers. The Info-Box (Figure 2) is a digital encyclopaedia for terms and basics of remote sensing. In due consideration of the pupils' different previous knowledge, the Info-Box is presented in two versions, named 'beginner' and 'professional'. Additionally, pupils and teachers can search for supplementary visual material in the image gallery. Searching options in the gallery are given by a 'tag-cloud' matching specific keywords.

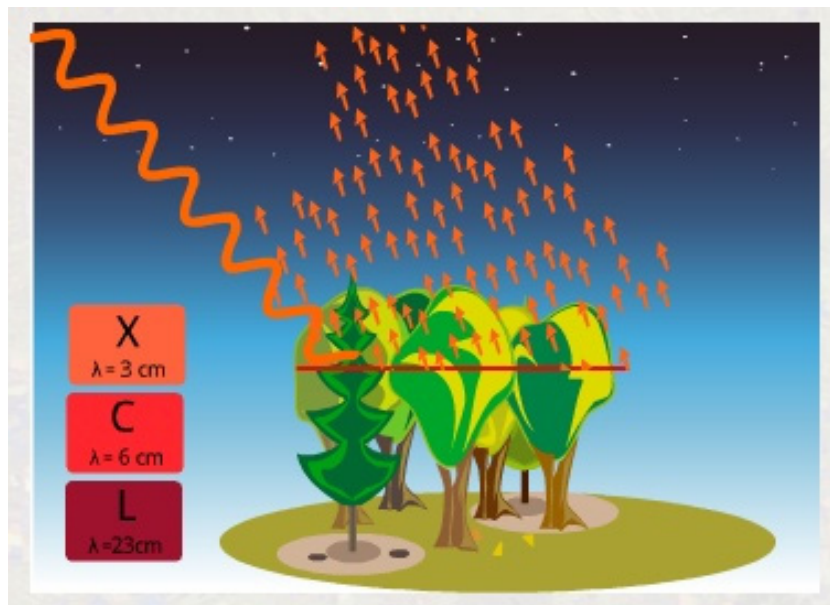


Figure 2: Interactive tool implemented in the Info-Box visualizing the penetration depth of the different microwave lengths.

## Analysis tools

Additionally, individual learning is put forward by different analysis tools. The tools offer means to analyse digital images directly irrespective of their embedment in a learning module.

An 'image calculator' enables users to perform simple arithmetic calculations with digital images, for example the vegetation index *NDVI* or simple image differencing. A tool for 'image classification' delivers the functions needed to derive a thematic map from a (true colour) satellite image. With a tool like this, pupils can experience the 'selective truth' of maps while creating a custom map from raw (satellite) data representing a snapshot of the reality (10). A third tool resembles the 'swipe' function in digital image analysis software and enables users to overlay two images in order to observe changes.

Beyond digital image analysis, some remote sensing products offer the possibility of observing current processes in a very high temporal resolution. To allow for that, a tool has been integrated into the learning portal that enables users to view current images of weather satellites – the 'MeteoViewer'. This tool shows images of the geostationary Meteosat-10 satellite (MSG-3), which are reloaded every 15 minutes automatically. Pupils can watch image loops for the full disk and for Europe to draw conclusions regarding present weather conditions. They can add and remove country borders and annotations and determine the speed of the loop interactively by dragging a controller. Besides near true colour images, a second version of the MeteoViewer provides images showing air masses in different colours (Figure 3). These images are particularly suitable to differentiate cold and warm air masses, identify the jet stream, and to observe cyclogenesis.

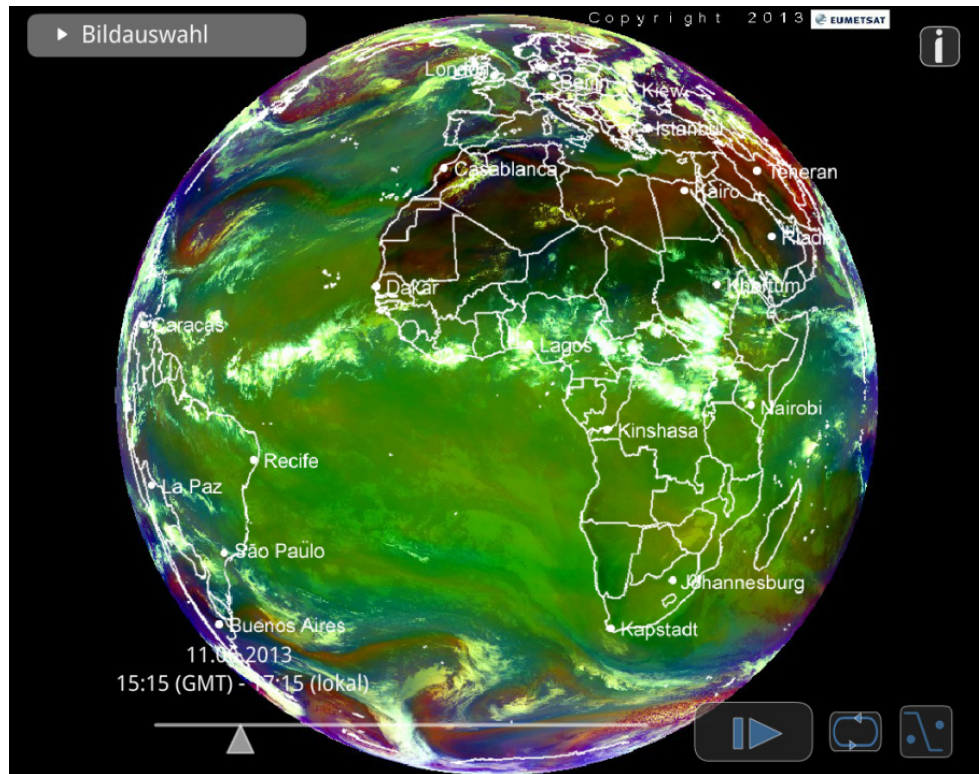


Figure 3: Second version of the MeteoViewer showing warm and cold air masses in different colours.

### Evaluation

To improve the learning material constantly, an evaluation section is implemented in the portal. Here, both teachers and students have the opportunity to evaluate the digital learning modules. At the end of each learning module, a link leads to the evaluation section immediately.

### LEARNING MANAGEMENT TOOLS

The content and all learning material described above is accessible to all visitors of the FIS learning portal. Additionally, we implemented some basic learning management functions that are available after registration. The advantage of those learning management tools takes effect when students work with the learning modules. The learning management functions affect the portal's handling for students as well as for teachers. For students, the advantage of registration is the automatic storage of the learning module's intermediate results. Usually, working with a learning module takes longer than one lesson. Without registration, users will have to start a module from the beginning when they are preparing for a new lesson or for homework. A registration in the learning portal allows users to save their progress and to proceed with their work at the point they have left the module before. The benefit of registering for teachers is the opportunity to see, analyse, and evaluate their students' intermediate and final results.

We decided to implement customised learning management functions into the learning portal instead of using a full Course Management System (CMS). Characteristics of a regular CMS are the following (for a detailed discussion about Learning Management Systems (LMS) and their distinction to CMS see Watson & Watson, 2007 (11)):

1. learning material is put online and delivered to learners in a way that ideally supports constructivist learning
2. the system offers instructors all tools needed to create and administer courses and learning material, store student submissions, track student performance, and to communicate with the learners
3. the interaction with the material and between learners and teachers takes place in a virtual classroom.

The first two characteristics were adopted for the FIS learning portal, but the third one has been dropped. We did not like the idea of pupils entering a 'classroom' that is decoupled from the rest of the content provided in the learning portal. In that classroom, the interaction with the material would take place, and after finishing the tasks given, the pupils would leave the classroom and close their (mental) doors behind them. Instead, we sympathized with the idea that learners move freely within the learning portal and can access, e.g., background information in the 'Info-Box' or the image gallery while working with a learning module. Registered users do not enter a 'new system' after logging in; they simply have access to additional functions. These new functions are accessible via an extra menu in the right margin column of the website.

Besides normal visitors, 'guests', we implemented two roles in the system: 'teachers' and 'pupils'. Every user can register in the portal with an email address and a self-chosen password. All users registered this way are assigned the teacher's role. Teachers can create new classes, manage and delete existing classes; they can create student accounts, assign students to classes, give working instructions, attach learning modules to classes, evaluate the progress of a class within a learning module, and see the students' answers to questions given in a learning module as well as their test results. This means, that we did not implement a barrier that selects if a teacher is a 'real' teacher in a real school. As a result the platform with its full functionality is open to everyone.

For organisational and data privacy reasons it was important to find a way that pupils do not need to register in the portal with their 'real' email addresses. Therefore we put the responsibility for the pupils' accounts in the teachers' hands. The first step in this procedure is to create an (empty) class by giving it a name, writing a brief working instruction for this class, and assigning one or more learning modules to that class (new modules can be added later on). Subsequently, the teacher can add students to the class by either typing in first name and family name in a form or by copying and pasting a list of names in a text box. After saving the names, the system generates login names and passwords for the students automatically. Teachers can save, email, or print this list and hand out the names with logins and passwords to the pupils. If pupils lose or forget their passwords, the teacher can create new ones individually.

The new name and password are used to log on to the learning portal as 'pupil'. The pupil is directed to the page 'my class' where the teacher's working instruction, a description of the assigned learning module, and a button to start the module appears. The main menu can be used to access the whole content of the learning portal outside the class. The pupil can return to his class by clicking on 'My Class' in the right marginal column menu.

When starting a learning module for the first time, a text box appears informing the user that intermediate results are saved from now on. If this is not desired, the user can log out before proceeding. Apart from saving the user's progress in the module, the quiz answers are saved. While working with tasks a pen symbol appears beneath the question, and the user is prompted to type in an answer (Figure 4). Having re-opened the module after stopping the work, the proceedings and given answers can be re-loaded into the module if desired.



Figure 4: Learning module within the portal and user interaction by typing in answers to a question.

## EXPERIENCES WITH THE LEARNING PORTAL

In the first months after the launch of the learning portal our main interest focused on solving technical issues and on spreading news about the portal in different circles, ranging from individual schools and local media to national and international networks, while our interest is shifting to quality assessment now. A very important aspect of developing and implementing a digital learning portal is a steady assessment of feedback, critics, problems as well as an evaluation of the general demand for the offered tools. For this purpose we have implemented an evaluation section, where teachers and pupils can evaluate the learning material separately (for the structure and the concept of the questionnaire see Voss et al., 2009 (9)). Additionally, the log-files of the learning portal are analysed monthly.

### Measurable feedback

The server log-files make it possible to estimate the demand for the FIS-learning material. We used the web analytics software Deep Log Analyzer<sup>®</sup> for the analysis. Hits caused by crawlers or IPs connected to the project itself are not taken into account.

Figure 5 shows the download numbers of all FIS learning modules. We can see a total amount of 15,066 downloads from the launch of the learning portal in June 2012 until October 2013 (941 downloads/month). The most demanded learning modules can be identified as those bearing names with curriculum-relevant topics in Germany. Among these are learning modules dealing with flood events (1,605), the atmospheric circulation (1396), oases (856), or brown coal (694) (German versions). It is gratifying to us that teaching units like 'Images to maps' (1,120) or 'Pixel off the right path' (478), which are highly relevant from a 'remote sensing perspective' are also downloaded constantly. Because FIS is a German project, the German versions (11,692) of the learning units are, of course, downloaded more often than the English (3,374). A deeper look into the log files indicates that the English teaching material is particularly downloaded by German schools leading to the suggestion that the material is implemented in bilingual teaching.

The demand for the currently nine modules that can be executed online without download is also shown in figure 5. The online versions of the learning modules have been executed 4,231 times in the period June 2012-October 2013. Interestingly, it is not a geographical learning module but a

Physics unit dealing with the processes of reflection and colour composition ('Tracing the invisible') (816) that is one of the most frequently executed modules.

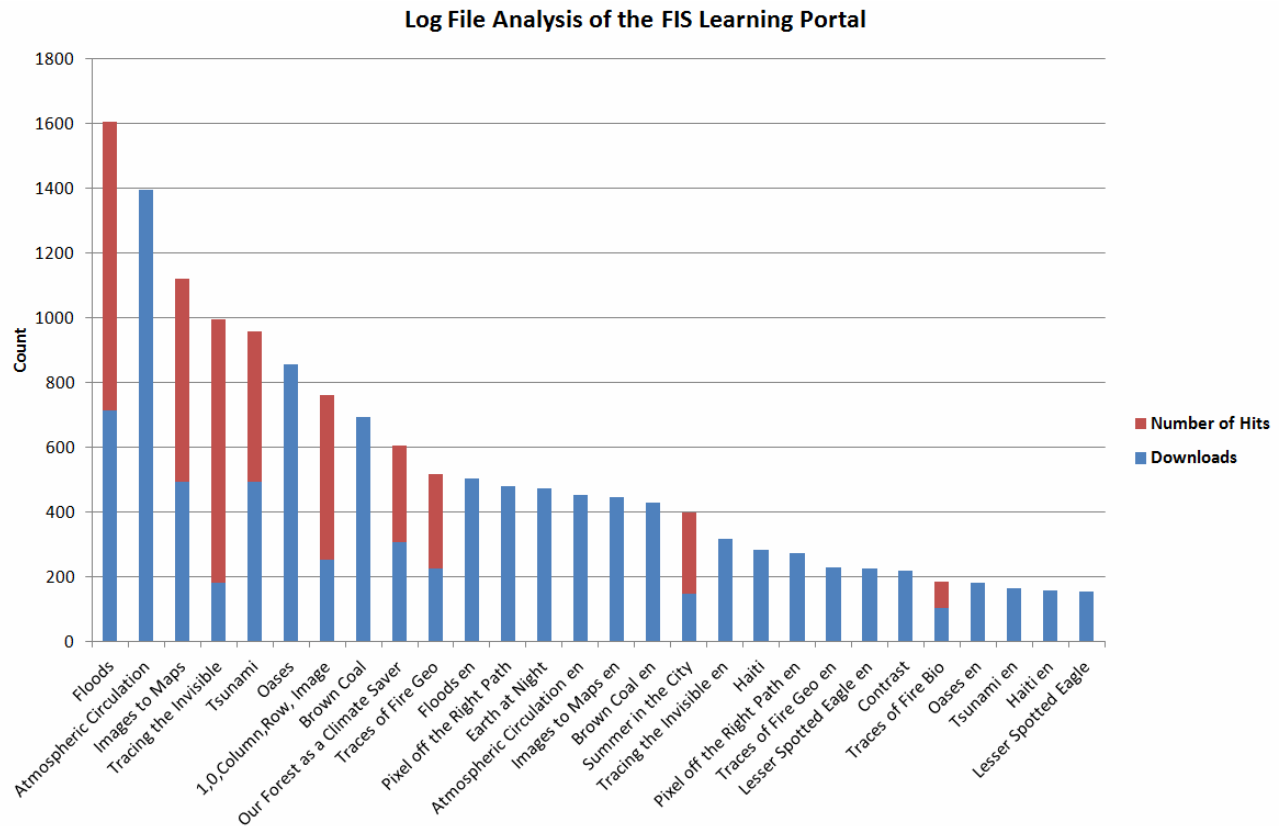


Figure 5: Download counts (full zip-file download) and number of hits (online version of modules) of the FIS learning modules (June 2012-October 2013).

### Qualitative feedback and stimuli

The analysis of the quantitative demand for the FIS learning material is only one way to estimate the usefulness of the FIS learning portal. Additionally, we asked teachers of collaborating schools and assessed the evaluation section of the learning portal. Since the launch of the portal in June 2013, 196 pupils and 19 teachers have assessed the interactive parts of the FIS learning environment (Figure 6). Because of the small response rate, we analyse the answers qualitatively only.

Using satellite data every day in a reflected way is not common for pupils. This coincides with recently published experiences (12). One out of four pupils has never worked with satellite images in school before and 55% have not used satellite images at home, either. With respect to the comprehensibility of the FIS material ( $n=215$ ) and the common use of the computer as work equipment ( $n=191$ , Figure 6), the results correspond to the experiences made earlier in the FIS project (13). Most of those polled classify the FIS teaching units as "not less than interesting", or answered "interesting or very interesting". The high degree of interest fits with a study carried out by Hemmer & Hemmer, 2006 (14). The exercises are marked comprehensible and the additional learning information is helpful for solving the exercises.

In bilateral discussions with teachers and pupils using the FIS material regularly, we can be satisfied about statements like "working with the FIS material and change detection analysis has been a totally new experience and a change to the school routine". Nevertheless, it is criticism which pushes educational projects forward. Here, we received very helpful suggestions related to different topics. For example, it was recommended to use question operators which are more open ended and relevant in A-level examination instead of simple questions like "what", "where" or "when". Additionally, it would be better to avoid a strict definition of the potential audience, e.g.,

address a whole educational level instead of a class level. Other suggestions were related to technical aspects like the speed of the FIS tutorials.

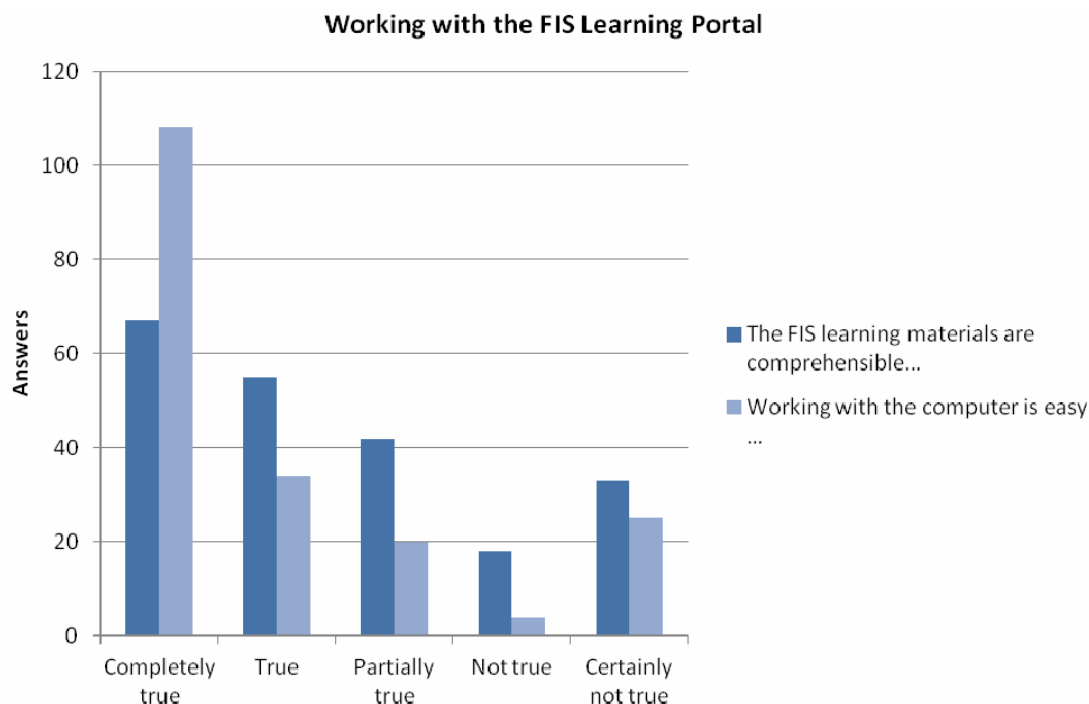


Figure 6: Comprehensibility and applicability of the FIS learning materials and the computer.

## CONCLUSIONS, DISCUSSION AND OUTLOOK

The FIS learning portal is intended to offer pupils as well as teachers an easy entrance point into the scientific method of remote sensing. Introducing learners to a more active role in combination with an intensive interaction with the learning material is one of the major aims of the portal. The core of the portal consists of learning modules which are accompanied by a digital glossary about remote sensing, and simple tools for digital image analysis.

In our approach we are addressing three target groups, what makes the learning portal different to other online resources on learning with remote sensing. The pupils are the main target group. Following a moderately constructivist approach they are enabled to work on specific research questions – either in a structured learning module or by self-studying using the ‘Info-Box’ or the analysis tools. The teachers are the second target group. By tailoring the learning material to the curricula of different subjects, by delivering comprehensive didactic commentary with the learning modules and by offering the possibility of managing classes and students’ results within the portal, teachers are explicitly addressed. This is a main difference as compared to other online resources, e.g. SEOS, where teachers were involved in the development of learning material, but where teachers do not find additional information on the use of the material in classrooms. The third target group is the remote sensing community. The FIS learning portal can be seen as a remote sensing outreach activity and is, hence, in the tradition of other approaches bringing young people the fascination of this topic, like, e.g., ESA Eduspace.

There is an opportunity for increasing the learners’ and lecturers’ motivation by combining two fascinating facets of remote sensing, (i) the use of modern technology and (ii) studying environmental interrelations and developments. This can offer new possibilities of transferring complex matters more easily, of initiating individual learning, fostering interdisciplinary thinking, and last but not least minimising the gap between the intensive use of geomedial in everyday life and the fact that there is generally little knowledge about geomedial.

Within the next months new learning material will be created and published in the learning portal, mainly short introductions to specific curriculum-relevant topics taking no longer than a school les-



son using satellite images from recent German satellite systems, like TerraSAR-X, TanDEM-X, RapidEye and the forthcoming EnMap.

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