

VISUALISATION OF HYDROLOGICAL PROCESSES WITH GEOVLEX: INTRODUCTION OF AN INTEGRATED METHODOLOGICAL-TECHNICAL ONLINE LEARNING APPROACH

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ABSTRACT:

Geosciences deal with complex, interdependent landscape processes, of which hydrological processes are an important example. Understanding such processes in time and space is crucial in geoscientific research and education. Addressing and communicating hydrological processes using traditional teaching methods (e.g. blackboards in lectures, printed study books) is rather limited though. Hence, within the framework of the geoscientific e-learning platform, novel online learning modules are being developed to allow a better understanding of the aforementioned processes.

The integration of new photo-realistic geovisualisation and web-based approaches are effective means to impart knowledge if designed accordingly, as the perception of a geovisualisation and its contents vary strongly depending on various factors. Therefore, to make use of all advantages of geovisualisation, their methods and characteristics have to be chosen carefully.

The departments of geosciences and computer science develop methods to visualise landscape processes based on precipitation-discharge-models that are directly integrated into e-learning environments. With the help of those online learning modules, users have the possibility to visualise the effects of dynamic variances in the landscape balance on discharge behaviour in small and medium catchment areas interactively and on-the-fly.

1. INTRODUCTION OF THE GEOSCIENTIFIC E-LEARNING PLATFORM GEOVLEX

The name of the online portal GEOVLEX (www.geovlex.de) – geovisualisation, virtual landscapes, and virtual excursions – represents the content of the elearning initiative of the department of remote sensing and cartography, which now exists since 8 years. The development of the learning portal is based upon two research projects. The learning portal WEBGEO (webbing of geo processes, www.webgeo.de) for the basic education “physical geography” was developed until 2004 in cooperation with eight German universities, being funded by the BMBF program “Neue Medien in der Hochschulausbildung” (“New media in university education”). This multiple price winning joint project served as the bases for subsequent, decentralized enhancements of the WEBGEO network by means of loan programs through the German states. This way, it was possible to lastingly stabilize the e-learning know how generated by WEBGEO. The financing of the project GEOVLEX was carried out in Saxony-Anhalt within the loan initiative “Multimedia in Lehre und Studium an den Hochschulen des Landes Sachsen-Anhalt” (“Multimedia in training and academic studies at the universities of Saxony-Anhalt”). The initiative ended in December 2006. Henceforth, GEOVLEX is continuously enhanced by the initiative of the authors and, if possible, with help of scientific assistants.

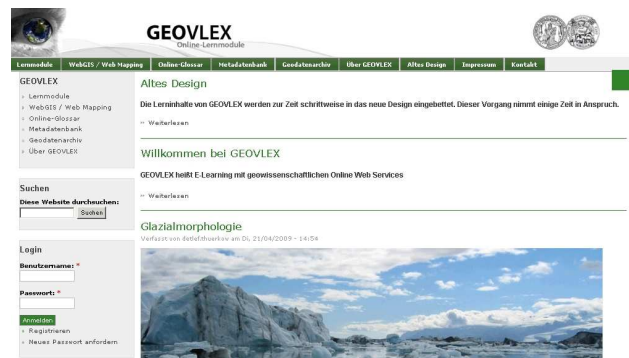


Figure 1: Portal of the geoscientific e-learning platform GEOVLEX (www.geovlex.de)

2. THE E-LEARNING CONCEPT OF GEOVLEX

The concept of blended learning (see Sauter et al. 2004) was consistently realized from the very beginning. Criteria for this decision resulted from different aspects:

- The Online portal aims to enrich traditional teaching and learning methods and should not replace them. Exchange and acquisition of knowledge are carried out in an open didactical and methodological field of activity and allow for different and individual learning types
- Multimedia-based applications allows for a huge diversity of new learning concepts
- Communication between teacher and learner is not to be replaced but completed
- Within the applications the scope is on interactivity and multiply usable 3D and 4D visualisation of geo-processes
- Numerous integrated interactive tests allow for immediate and autonomous control of the achievements

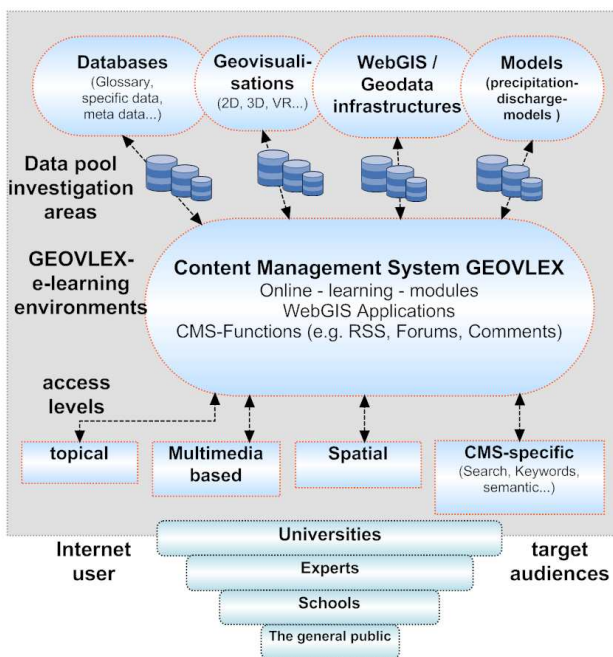


Figure 2: The scientific – technical approach of GEOVLEX

The chosen blended learning approach served as base for the conception of the learning platform. Figure 2 schematically shows the scientific–technical realisation of GEOVLEX. The use of learning management systems, that already existed, turned out to be inefficient due to the specifically geo-scientific requirements (spatial-relation of the learning application and visualisations). That is why the portal is based upon an ad hoc programmed and database supported learning environment, which is embedded into a content management system (CMS). The CMS is used for advancement in teacher – learner communication.

The GEOVLEX applications, i.e. online-learning-modules, virtual excursions (Gläßer & Thürkow, 2004; Thürkow et al. 2005), glossary- and subject databases, geovisualisation and WebGIS-applications combined with geodata-infrastructures, are typically cross-linked within the CMS. Numerous subject and geo-related data is integrated with the help of ontology-based frameworks. This procedure is described in detail in Scheuer et al., 2009.

Every module can be used freely and mutably by teachers and learners alike in connection with courses or for private study.

The different access possibilities to learning content by means of the service-based applications also account significantly for the academic achievements. The composition of GEOVLEX is thereby subject to severe regulations and standards.

Multiple choice, drag & drop and cloze texts are primarily used within the tests and exercises. For more demanding exercise environments, independent use of formula and drawing of data into learning objects is requested. The integration of data-based tests and exams is planned. However, at this point further research and development is needed, which asks for an advanced cooperation with didactics and computer science.

3. GEO-VISUALISATION SUPPORTS ACADEMIC ACHIEVEMENTS – EXAMPLES FROM HYDRO SCIENCE

Interactivity is one of the main properties of the multimedia-based applications of GEOVLEX. The triplet investigation area – topic – time is decisive for the visualisation of hydrological processes. The multidimensionality, which today mostly occurs in a 3D version, is labelled as 4D in combination with the time constituent, which is of high relevance for the geo-science. The time-level vary thereby within extremely different scales.

First example:

The GEOVLEX Online learning-module (GOLM) “Dynamik von Bergbaufolgelandschaften” (“dynamic of post mining landscapes”) dealt with the genesis of the post mining Bitterfeld- Goitzsche region. The period of examination of geo-processes covers several decades (see figure 3, URL 1). The anthropogenic interference with the nature by means of brown coal mining is illustrated with the support of interactive maps and animations. Effects on the hydrological cycle through different processes can be deduced through learning by doing. Today, the Goitzsche serves as an important recreation area in the region of Central Germany. The water body of the lake “Großer Goitzschesee” covers more than 12 km² and has a capacity of approximately 208 million m³. The former environmental disasters of the region by means of interference with the landscape through the opencast mining is due to the recreation no longer traceable. Therefore, the learning module not only contributes to a better understanding of hydrological processes but also accounts for environmental education in situ.



Figure 3: In learning module integrated geo-visualisations, which explain the change of environment in a certain region

Second example:

In contrast to the first example, GOLF “Entstehung und Ausprägung von Hochwassern” (“Origin and development of flooding”) deals with hydrological processes which elapse in a short period of time (see figure 4, URL 2). Processes within flood events are highly complex. The comprehension is often demanding for students. Realistic virtual landscape models and geovisualisations were developed in order to efficiently encourage the academic achievements. Those allow for an interactive and illustrative exploration of flood values. Moreover, within this learning module, certain factors of the origin of flooding, flood types, and flood damages are conveyed. The comprehension of the impact of global warming on the frequency of flooding is encouraged with the help of an interactive drag & drop exercise.

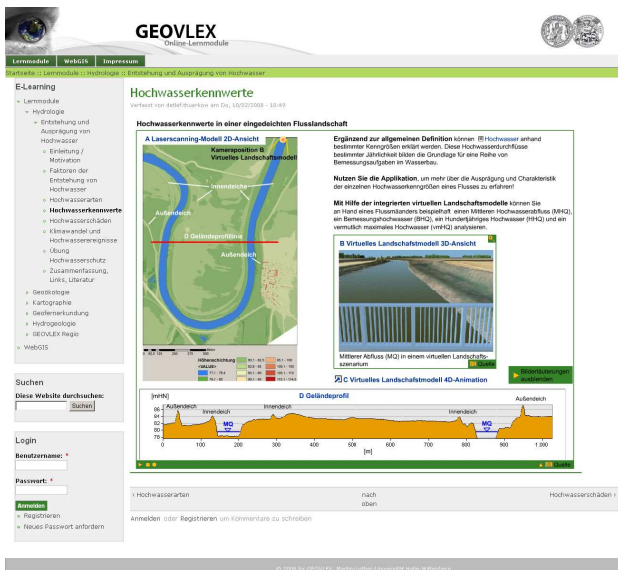


Figure 4: Screenshot virtual scenery of occurrence of flood values in an embanked fluvial topography

The academic achievements shall be increased by means of the integration of specific data and metadata from research projects, which are available for analysis and presentation through WebGIS and database supported web applications. Figure 5 exemplarily illustrates applications from a flood information system of the opencast mining Goitzsche. Spatial – time components are ontologically crossed-linked and serve to document the opencast mine flooding within the scope of reconstruction. Hence, in addition to the common presentation of knowledge, users are able to analyse and visualize values of different processes.

To get more information about the integrated approach to geographic data processing and geo-visualisation in the open, modular system from GEOVLEX, see Gläßer et al. 2009.

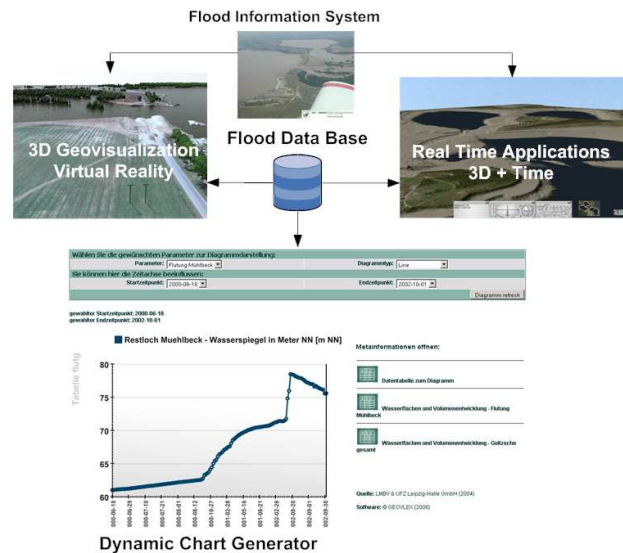


Figure 5: cross-linking of GEOVLEX components to illustrate processes

4. INTEGRATION OF PRECIPITATION-DISCHARGE-MODELS INTO E-LEARNING ENVIRONMENTS

The enhancement of the methodological-technical approach is in progress at the moment. A learning-module on hydrology linked with a model is under construction in cooperation with the Institute of Computer Sciences. In this module, users have the opportunity to model scenarios of precipitation runoff models for smaller and medium watersheds. The calculation of components of the water balance equation can be modularly implemented:

- precipitation (Thiessen Polygons)
- calculation of potential and effective evapotranspiration (Haude), (DVWK, 1996; Dommermuth & Trampf, 1991; Großmann 1996)
- calculation of immediate runoff of precipitation events on the basis of the SCS-method by the US SOIL CONSERVATION SERVICE (see Maniak, 1997)
- calculation of surface runoff of with the help of the rational method (USDA 1986)
- calculation of soil water balance including infiltration

Based on the linking of models, the user shall be able to interactively explore the different values of particular area parameters, such as climate, soil, vegetation and land use, and their effect on the runoff formation. Input data for three differently structured landscapes (central German arid environment, the Ore Mountains, the alps) is provided for the learning module.

Moreover, the user shall be able to use data from their own investigation areas. Therefore, predefined data types and data structures have to be used.

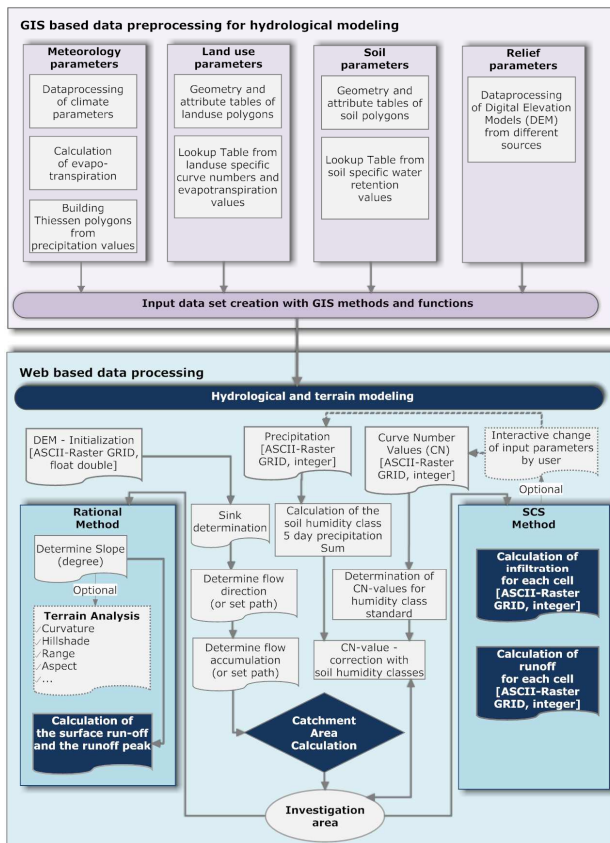


Figure 6: Process flowchart of the underlying data processing and hydrological modelling of the GOLF to the water balance of different catchment areas

All calculations shall be analysed and visualised in a WebGIS-framework (Scheuer et al., 2009) after completion. Furthermore, users should have the possibility to save the calculated geo-datasets on their local systems.

On the part of the Institute of Computer Sciences, efficient algorithms, which are needed for a web-based realisation of a learning module, are implemented within the framework of a degree dissertation. Parallelisation is traced within this context. The aspects that are traced within this context include for example:

- aspects of data exchange
- integrity of real parallel data structures
- prevention of redundancies, as well as deadlocks
- utilisation of cache-effects

The aim is to considerably accelerate calculations within the learning module. Accordingly, the parameters that are related to catchment areas shall be calculable within an arguable time range. For this purpose, many-core architectures are the core of researches of strategies for parallelisation. Main properties are therefore the reduction of computing and response time. The realisation shall be carried out with the help of parallel threads, whereas calculations and accesses on the required data are to be superimposed as far as possible.

Figure 6 illustrates a flow scheme on the intended methodological realisation of the linking of models from a geo-scientific point of view.

5. CONCLUSION

The e-learning methods developed in GEOVLEX do not only apply to hydrological topics. Modules on cartography, remote sensing, geo-ecology, geomorphology, geology and so forth are also realised. Thus, parts of the already described methods have already been successfully transferred to other fields of applications, as well as other user groups. The tools were nationally and internationally meet with vivid response. Users of the developed modules in the German-speaking region are students and lecturers of universities, alongside with numerous grammar school teachers. At the moment, there are more than 60.000 accesses on the web based services of GEOVLEX monthly, with an upward trend.

The quality of knowledge conveyance within the geo-sciences is selectively increased by the integration of geovisualisations and interconnection of models in online learning modules of various problems. The huge costs which result from the implementation phase are only reasonable if there is an increase in academic achievements for the users accordingly. The choice of the methods therefore needs to be exactly measured in regard to costs and benefits.

The modules of GEOVLEX are partly applicable for adoption outside university training. Already in demand are tools for environmental education and public sectors. Trendsetting prospects, which derive from geo-multimedia, not only for geosciences but also for other fields which are engaged with geo-data, such as agriculture, phytogeography, history or archaeology, are not yet in every extant identified. At this point, numerous varying possibilities result, which lead to future multidisciplinary cooperation within the e-learning sector. The question of finance remains open at this point.

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URL 2: <http://mars.geographie.uni-halle.de/geovlexcms/golm/hydrologie/hwentstehung>