Spatial Data Management
– Development of e-Learning Modules –

Antje Krüger and Thomas Brinkhoff
Institute for Applied Photogrammetry and Geoinformatics (IAPG)
FH Oldenburg/Ostfriesland/Wilhelmshaven (University of Applied Sciences)
Ofener Straße 16/19, D-26121 Oldenburg, Germany
Antje.Krueger@FH-Oldenburg.de, Thomas.Brinkhoff@FH-Oldenburg.de

SUMMARY

E-learning is gaining more and more importance in GI science. One key subject of GI education is spatial data management. The development and employment of courses about spatial data management are one of the central topics of the new e-learning project "FerGI". In this paper, we present the conceptional design and the didactical methods for developing such modules. One important objective is the tight connection between theory lessons on the one hand and exercises on the other hand. This requires the development of suitable instruments: A spatial SQL tool is presented as an example that visualizes the results of spatial queries formulated by the students.

KEYWORDS: *GIS, Education, e-Learning, Spatial Database Systems, GIS Standards*

INTRODUCTION

The technical advance of information technology, concerning mainly the internet, has not only influenced the economic development and the private life of many people, but has also an impact on training and further education to a high degree. GI science, which is very strongly connected to technology and engineering, is characterized by an increasing volume of information and a decreasing validity of knowledge at the same time. This trend requires new learning methods. In that context, buzzwords like e-learning, blended learning, lifelong learning or multimedia has appeared and since these terms would not be existent without computers, they can be associated with computer-aided or internet-aided learning.

In the last few years, many projects have started providing a large variety of e-learning courses. Chr. Brox (2003) gives a good overview of such initiatives. *FerGI* ("Fernstudienmaterialien Geoinformatik") is one of the newer projects. It started in October 2003. The development of e-learning modules about spatial data management is one of FerGI's aims. The management of spatial data has gained more and more importance. Emerging object-oriented spatial database systems and servers, new OGC and ISO standards and different types of web services are indicators of this trend. Therefore, spatial data management is an important part of any GI curriculum and of most GI e-learning initiatives.

The following sections deal with the development of e-learning modules about spatial data management. Conceptional issues as well as technical issues are discussed. In order to motivate learners over longer periods and to consolidate knowledge, it is important that the modules are particularly connected with exercises. This requires adequate contents and tools.

THE FerGI PROJECT

The FerGI project ("Fernstudienmaterialien Geoinformatik") started in October 2003. The aim of the three years lasting project will be to produce and evaluate 18 e-learning modules. These modules will not reflect the whole GI curriculum, but concentrates on special GI topics. Dividing the whole content into small compact modules (with ECTS points from 0.5 to 3) guarantees a better content exchange and a greater acceptance amongst GI lecturers (Schiewe, 2004). The contents of the modules will be given in German and / or English.

Module topics

Each of the 18 FerGI modules belongs to one of the five following topics:

- capturing of spatial data,
- spatial analysis,
- presentation of spatial data,
- GI applications, and
- management of spatial data.

FerGI is a cooperative project of the Center of Excellence in Geoinformatics in Lower Saxony (GiN) and the e-learning network VIA Online. The GiN partners – five institutes from the University of Hanover, the University of Osnabrück and the University of Applied Sciences in Oldenburg, will develop the contents whereas VIA Online, represented by the University of Hildesheim, provides the learning management system and gives didactic support. More information about FerGI can be found under: http://www.gin-online.de.

Learning Management System

Currently, FerGI is using the learning management system "Lotus LearningSpace". This platform allows importing several types of *multimedia elements* such as images, flash animations and videos. It supports *communication* between lecturers, tutors and students via e-mail, chat and forum. Such communication facilities are important for minimizing the anonymity of self-study modules. A *test manager* helps creating and maintaining tests for the evaluation of students' success. These tests are automatically evaluated by Lotus LearningSpace if the chosen question type allows such an evaluation. Furthermore, the presentation of *profiles* of students and tutors is supported (Grendus & Zander, 2004). Some screenshots depict these components in Figure 1.

A module in Lotus LearningSpace is organized by a *schedule* that contains the complete learning material divided into chapters. The tests are integrated into this schedule. All course databases are stored on a central server and can be downloaded by the participants as replicas. A *synchronization mechanism* allows the update of downloaded material as well as the upload of additional information like the answers to tests and personal annotations. Therefore, Lotus LearningSpace allows an efficient offline usage of the module (Schiewe et al., 2004).

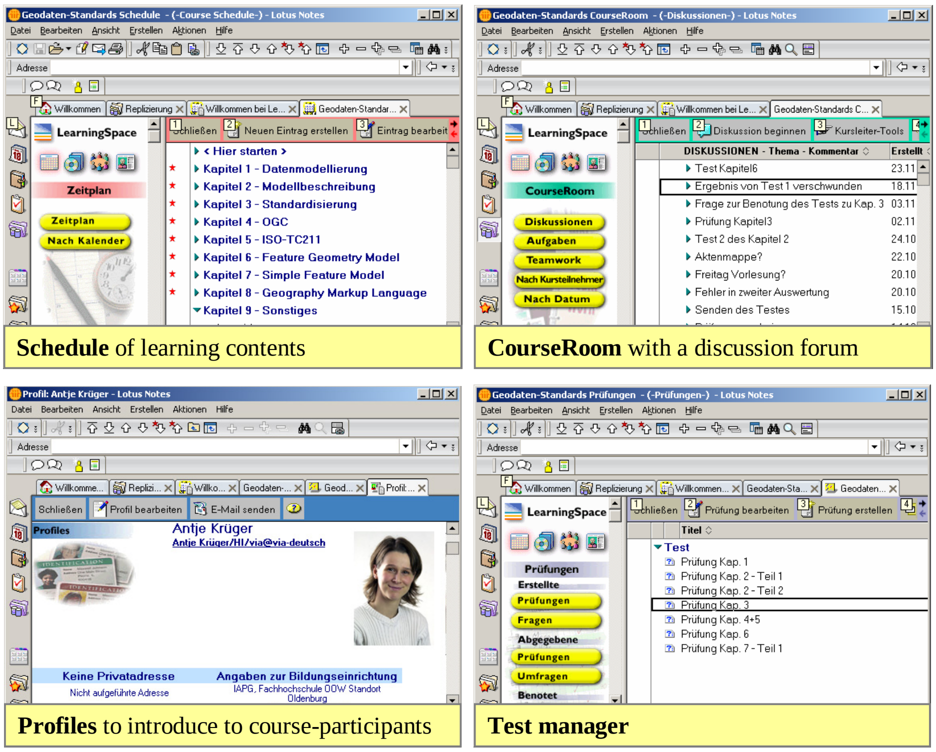

Figure 1: Screenshots of Lotus LearningSpace.

SPATIAL DATA MANAGEMENT – CONCEPTIONAL ISSUES

The FerGI modules on spatial data management are mainly provided by the Institute for Applied Photogrammetry and Geoinformatics (IAPG) in Oldenburg. Altogether, five modules about spatial data management are intended. Figure 2 depicts an overview of these modules and the connections between them. The size of the modules ranges between 1 and 3 ECTS points. Three of the modules are building the foundation of the other two, more application-oriented modules. Especially, the module "Standard for Spatial Data" is required or at least useful in many other GI modules.

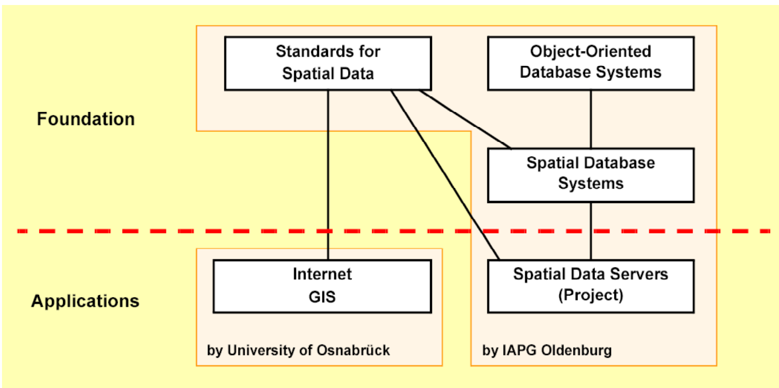

Figure 2: Modules about spatial data management.

Target Group and Practical Exercises

In order to produce a sustainable solution with high effectiveness, e-learning projects have to consider several aspects. An early definition of the target group and of the project aims is essential in order to avoid conceptional changes, which can be extremely costly. The module of the topic "spatial data management" will be used for teaching students of geoinformatics, geodesy, geography and environmental sciences. Blended learning at universities, i.e. a combination of long-distance learning and face-to-face learning, is the main application case of the modules. In a second phase, it is intended to expand the target group to participants of further education programs.

In order to motivate learners over a longer period of time and to consolidate knowledge, the modules are particularly connected with practice. Studying with the modules should enable the student to develop competence on cooperation, self control and multimedia usage, which is essential with web-based learning methods.

Modules in Use

Two of the modules developed by the IAPG Oldenburg, "Standards for Spatial Data" and "Spatial Database Systems" are completed and have already been integrated into lectures since September 2004. They are described in detail in the following paragraph.

The course "Standards for Spatial Data" consists of ten chapters starting with an introduction to data modelling. Afterwards, the basics of describing data models will be explored; in that context plenty definitions of terms like objects, classes and relations between objects are given in order to explain object-oriented modelling concepts. In addition, UML class diagrams are introduced in that section. Then, the course provides an overview of organisations for standardization of spatial data such as ISO/TC 211 and OGC. Three chapters present information about the Feature Geometry Model (Geometry and Topology package) and the Simple Feature Model. Both models are the foundation of the Geography Markup Language. The chapter on GML includes a short introduction to the basics of XML. Finally, the ISO standard 19115 "Geographic Information: Metadata" is topic of the last chapter.

The second course "Spatial Database Systems" focuses on the management of spatial data in databases. The introduction consists of a presentation and discussion of different techniques to store spatial data and of the concept of object-relational spatial database systems like the Informix Spatial DataBlade and Oracle Spatial. Then, the course provides an overview of standards for representing spatial data in databases including a short repetition of the Simple Feature Model and an introduction of the ISO standard SQL/MM Spatial. Oracle Spatial is presented as an implementation of such models. In this part, students can exercise spatial data modelling by using a special spatial SQL tool (see also next section). The last part of the module treats spatial query processing. Several techniques are introduced including approximations, quad trees, and r-trees. Again, students can exercise with Oracle Spatial and the spatial SQL tool.

SPATIAL DATA MANAGEMENT – TECHNICAL ISSUES

All FerGI courses present themselves in a unified layout using the same icons, font sizes and colors in order to give students a familiar setup. The design is based on an HTML template using a central Cascading Style Sheet (CSS). Figure 3 shows the layout by an example.

Figure 3: Layout of FerGI courses.

Animations

Animations are very helpful for explaining complex learning contents. They are especially suitable for illustrating the course of events. Figure 4 shows the insertion into r-trees as a typical example. By using animations deliberately, the time of learning can be shortened and the comprehension can be increased. Since it is fairly time-consuming and costly to produce them, it is advisable to analyse deeply the effectiveness of using animations. Sometimes a single picture can express the same content as good as an animation, but producing it is much faster and cheaper.

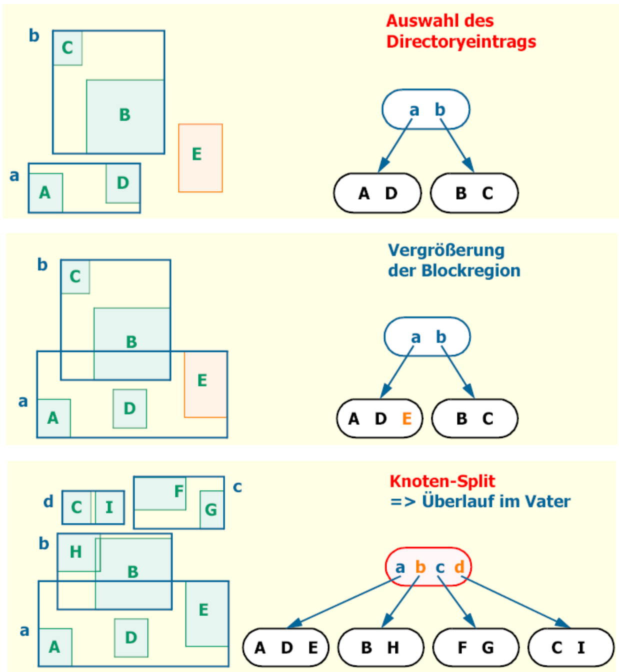

Figure 4: Animated insertion into r-trees.

Spatial SQL Tool

As mentioned before, theory lessons should be tightly connected with exercises. In case of standard database lectures, this is typically achieved by (web-based) SQL interfaces; examples can be found in (Kudraß 2003). Using such an interface, the user can enter an SQL statement. After that, he gets an alphanumerical result – typically the query result (i.e. a relation) or an error message. In case of spatial database systems, such an approach is insufficient because the contents of tables as well as the results of queries may include spatial attributes. A textual or numerical representation of spatial data is difficult to interpret. In consequence, students would have difficulties to decide whether the SQL command or query computes the right result or not. In order to solve such problems, a spatial SQL Tool – the so-called "Spatial Database Viewer" – has been developed. This tool allows the formulation of SQL statements. In addition to standard database tools, it

- supports the visualization of the (complex) structure of system- or user-defined objects,
- visualizes the content of tables with spatial attributes by displaying a map,
- visualizes the results of spatial queries (i.e. spatial attributes as well as the results of spatial operators) by a map, and
- depicts metadata of spatial attributes.

The visualization of tables and maps will be updated if a database update is performed using the Spatial Database Viewer. Spatial attributes of selected objects are highlighted in the corresponding map. The tool supports a German as well as an English user interface. Currently, it works for Oracle Spatial (Oracle, 2003a), release 9 and 10. Figure 5 illustrates the visualization of a spatial table, of a complex spatial attribute and of spatial metadata. The visualization of the spatial buffer operator is depicted in Figure 6.

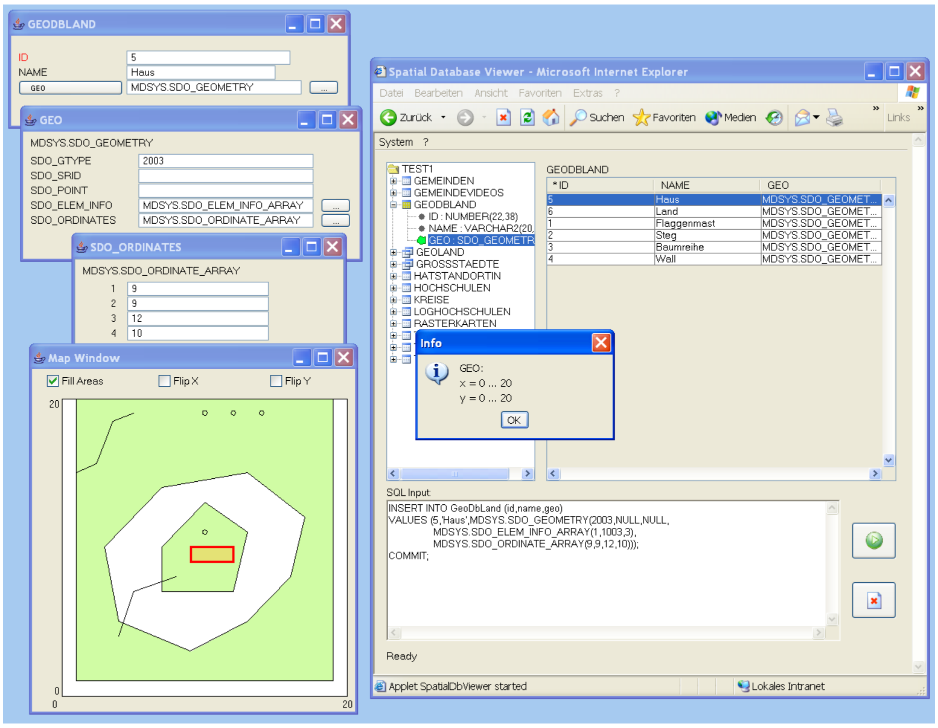

Figure 5: Visualization of spatial tables, complex attributes and metadata by the spatial SQL tool.

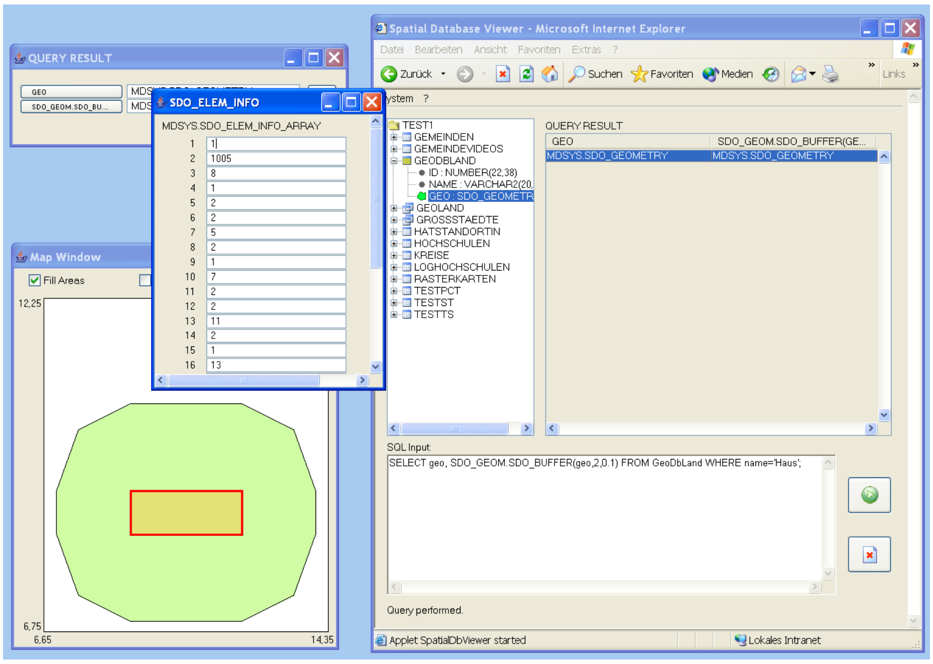

Figure 6: Visualization of the spatial buffer operator by the spatial SQL tool.

The Spatial Database Viewer is implemented in Java 2 Standard Edition, v1.4. It runs as a standalone application as well as a Java applet. Oracle's JDBC library (Oracle, 2003b) and SDOAPI library, the Java Topology Suite (JTS 1.4) (Vivid Solutions, 2003) and the Oracle Spatial library of (Geotools, 2004) are used. The principle steps for performing a spatial query are depicted in Figure 7.

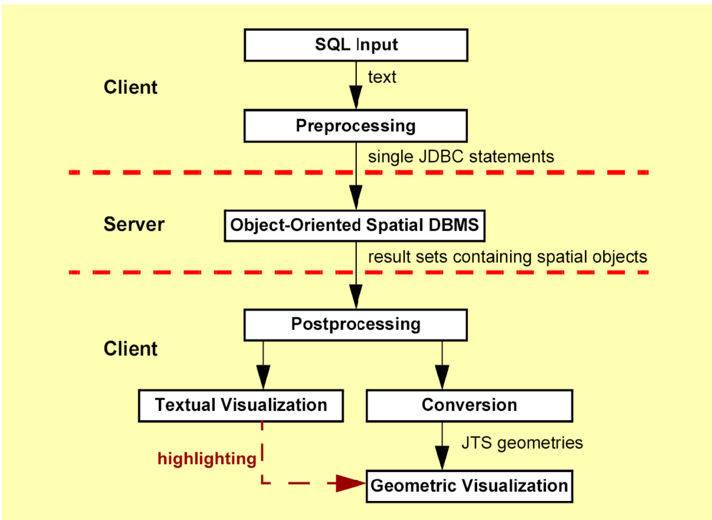

Figure 7: Processing of spatial queries by the spatial SQL tool.

EXPERIENCES OF APPLYING THE MODULES

The module “Standards for Spatial Data” has been evaluated in December 2004 by students who attended the course. Although these students had not yet worked with e-learning-content, they found the module intuitionally accessible and most of them were convinced that the presented media was more motivating compared to a traditional lecture. Furthermore, most students liked the idea to use such modules to support face-to-face-lectures, but not to substitute those. Concerning flexibility in time and place and the effectiveness of learning, there was a definite positive tendency. Viewing it through the eyes of a lecturer, it would be desirable to force students' usage of communication like chat and forum more intensively, so that they discuss not only technical and general problems, but also problems with the course contents.

CONCLUSIONS

In this paper, we presented the conceptional design and technical issues for developing e-learning modules about spatial data management. Up to now, two modules have been integrated into lectures. The current feedback of students in the discussion forum and the results of their tests were positive and show a broad acceptance of the courses. A first formal evaluation will be performed in January 2005. Finally, it will be important for the success of FerGI to develop a business model for the time after the end of governmental funding in September 2006. To finance further e-learning activities, a co-operation of FerGI with other GI e-learning initiatives in Germany and Europe would be necessary.

ACKNOWLEDGEMENTS

The FerGI project is funded by the German Federal Ministry for education and research and the Ministry for Science and Culture of Lower Saxony. This support is gratefully acknowledged.

BIBLIOGRAPHY

Brox C. (2003): Discussion Paper: Exchange of Internet-Based GI Teaching Modules, Proceeding 6th AGILE Conference on Geographic Information Science, Lyon, 2003, pp.243-48.

Geotools (2004): An open source / free java GIS toolkit, http://geotools.codehaus.org/

Grendus, B., Zander, M. (2004): Entwicklung von eLearning-Modulen unter LotusNotes-LearningSpace. Proceedings Workshop „eLearning in Geoinformatik und Fernerkundung – Stand und Perspektiven“, Vechta, Febr. 2004.

Kudras T. (2003) (ed.): BTW-Workshop Datenbanken and E-Learning, Leipzig, 2003.

Oracle Corp. (2003a): Oracle Spatial JDBC User's Guide and Reference 10g Release 1 (10.1), Dec. 2003.

Oracle Corp. (2003b): Oracle Database JDBC Developer's Guide and Reference 10g Release 1 (10.1), Dec. 2003.

Schiewe, J. (2004): Fernstudienmaterialien Geoinformatik (FerGI)-Konzeption und erste Erfahrungen. In: Schiewe, J. (Hrsg.): E-Learning in Geoinformatik und Fernerkundung, Wichmann Verlag, Heidelberg, pp. 41-51.

Schiewe, J., Ehlers, M., Grendus, B. (2004): Fernstudienmaterialien Geoinformatik (FerGI)-Konzeption und erste Implementierungsbeispiele. In: Plümer, L., / Asche, H. (Hrsg.): Geoinformation – Neue Medien für eine neue Disziplin, Wichmann Verlag, Heidelberg, pp. 143-153.

Vivid Solutions Inc. (2003): JTS Topology Suite, http://www.vividsolutions.com/JTS/ jts_frame.htm