

LINKED CONTENTS OF TEACHING

Wolfgang Huhnt, Philipp Baumann

Technische Universität Berlin, Department of Process Modelling in Civil Engineering, Germany

ABSTRACT: A curriculum of a study course covers courses that are focused on different topics. These courses are presented by experts from different special fields. However, the contents of the courses are dependent of each others: Some topics are based on the same fundamentals, and other topics are closely related to each other, because they are dealing with equivalent contents in different circumstances.

The explanation of these inter-dependencies is necessary and helpful for students. Recognitions and cross-references between courses help to understand and to learn.

To present cross-links between teaching documents, the project "Linked contents of teaching" was implemented. An Internet-based learning-teaching-system is developed. This server application presents links between documents. The format of the provided documents is PDF. Binary relations are used to describe inter-dependencies between contents that are presented in different documents and courses. The inter-dependencies are worked out as part of the project "Linked contents of teaching". The mathematical background of relational algebra is used to handle the relations.

The Internet-based system is planned to run over several years. Aspects of maintaining such a system of linked contents are addressed in the project "Linked contents of teaching". This paper describes an overview on the project and the implemented Internet-based system.

KEYWORDS: civil engineering, learning-teaching-system, internet-based system, linked contents.

1 INITIAL SITUATION

In general, a curriculum of a program of study contains a specific number of courses, which are presented by different professors and lecturers of different special fields. These courses are worked out individually, but they are not independent of each other. Some topics are based on the same fundamentals, specific fundamentals are applied to different problems, and other topics are closely related to each other, because they are dealing with equivalent contents in different circumstances. This applies to the study course in civil engineering at Technische Universität Berlin as well. The bachelor study course in civil engineering at Technische Universität Berlin contains 24 modules with 26 different courses and 26 different contents of teaching. The courses are presented as lectures, exercises, colloquies and tutorials. All these courses deal with different views on civil engineering and with different topics. This is why the contents of teaching are linked to each other. Because of the importance of this cross-linking between the contents of teaching, the project "Linked contents of teaching" was created. At present time, bachelor courses are the focus of the project.

The project prepares and presents the cross-linking between the contents of teaching on the basis of existing teaching documents. An Internet-based system is developed to present and to utilize the cross-linking to students and teachers. Students are advised to use cross-linking. Dependencies between teaching contents are shown, so

that effects of recognition can support the learning processes in a positive way. For teachers cross-linking is shown in an explicit way. Thus the importance of the cross-linking is distinguished.

Today, teaching documents of each course in civil engineering at Technische Universität Berlin are already provided digitally on the servers of the single departments. The implementation of the system "Linked contents of teaching" makes use of these digital documents. This means, the project doesn't create new documents or changes the content of existing documents, only Internet links are added to these documents.

In autumn 2006 the diploma study course in civil engineering at Technische Universität Berlin was changed to bachelor and master study courses in civil engineering. In addition the program of studies was unitized. This was an excellent point in time to reflect the traditional way of presenting teaching materials. The development of the system "Linked contents of teaching" started in summer 2006, the first online appearance is scheduled for autumn 2007.

A lot of Internet-based e-learning systems are available to present teaching material or to support course work like "moodle" [5] or "WebCT" [12]. The system "Linked contents of teaching" belongs to the field of e-learning. E-learning comprises many different aspects. The project "Linked contents of teaching" only focuses on the cross-linking between the contents of teaching documents.

There are no modifications in the content of the documents, and there are no multimedia files added to the documents. The system is flexible enough to allow such a multimedia expansion, but its focus is inter-dependencies.

At current time, Technische Universität Berlin works on a coordinated IT-infrastructure. This includes the selection of coordinated Internet-based systems. All these activities are in progress. The implementation of an own system for “Linked contents of teaching” is the most practicable way at present time. The amount of implementation work is not extensive. In future the online presentation of Technische Universität Berlin is planned to be implemented in PHP [8]. Therefore, for a later integration the implementation of the system “Linked contents of teaching” is made in PHP, too.

2 CROSS-LINKING OF TEACHING DOCUMENTS

2.1 Link-types

Contents of teaching are linked in different ways. Some topics are based on the same fundamentals. Other topics are dealing with equivalent contents in different circumstances. To satisfy these issues, different types of links are established. These types of links have different semantics. The following types were identified during the project:

1. Fundamentals: The content of the start point has the content of the end point as its basics.
2. Cross-reference: Start and end point are dealing with equivalent topics in different circumstances.
3. Application: The content of the start point is basic for the content of the end point where the basics are applied (transposed of the first type).

Each link consists of a start and an end point; mathematically they are a binary-relation. The relational algebra [7] defines different operations that can be applied to relations, e.g.:

- Complement

$$R := \{(x, y) \in M \times M \mid (x, y) \notin R\}$$

- Transposed

$$R^T := \{(y, x) \in M \times M \mid (x, y) \in R\}$$

- Intersection

$$R \cap S := \{(x, y) \mid (x, y) \in R \wedge (x, y) \in S\}$$

- Union

$$R \cup S := \{(x, y) \mid (x, y) \in R \vee (x, y) \in S\}$$

- Product

$$R \circ S := \{(x, y) \mid \bigvee_z ((x, z) \in R \wedge (z, y) \in S)\}$$

For instance, the operation transposed can be applied to links which are from the first link-type. Links of the third link-type are the transposed of links of the first type.

$$R_{Fundamental}^T = R_{Application}$$

2.2 Topics

Beside link-types and links, topics are introduced. These topics are assigned to start and end point of a relation. For the introduction and the denotation of the topics, a holistic view onto the complete curriculum is necessary. In this

case the level of detail is an important aspect. A high level of detail leads to a small amount of points to a specific topic. A low level of detail will return a huge unsorted amount of points. To assign points from different teaching documents from different courses to the same topic, the names of the topics have to be universally valid.

This assignment allows a direct query on a special topic which leads to a list of existing start and end points which already exist in other teaching documents. This list is generated automatically. It supports the creation of links to a new document.

2.3 Adding a new teaching document

The most important process of the project “Linked contents of teaching” is to add and cross-link new teaching documents to the system. Adding a new teaching document to the system requires the work of two persons. This work takes place in the following order:

1. The new teaching document is read by a first person and a topic list to this document is manually generated by this person (document topic list).
2. This topic list is the input data to a Java-program that generates automatically a second list which contains existing points in other teaching documents (system topic list).
3. With the document topic list and the system topic list a new list with new cross-links are created manually by the first person.
4. This new cross-link list is checked by a second person.
5. Points, topics and relations are stored in the system and Internet-links are added to the new document by the second person.
6. The results, the links are checked by the first person.

3 SYSTEM DESCRIPTION

3.1 System structure

The presentation of the “Linked contents of teaching” is provided by an Internet based system. The main elements are open source products:

1. A web server, that provides HTML pages and interprets PHP
2. A database management system, that uses SQL
3. A maintenance tool to administrate the database

The web server provides the necessary pages for the Internet presentation. The present implementation makes use of an Apache web-server [3]. The presentation consists of a static and a dynamic part.

The static part was implemented in HTML and consists of the homepage, login, an overview and the access to the download area.

The dynamic part was implemented in PHP [8]. During the usage of the system, PHP-requests [13] are sent to the server. Each request generates a SQL-query [13] which is sent to the database. By using the result of the query, an Internet-page is generated dynamically and returned to the user. The server software and the required PHP plug-in are free ware. In addition a Java-tool was implemented to

administrate the database. This tool also supports the operator by generating lists with points and relations.

It is an advantage that the system is independent of a certain platform. There are free versions of MySQL® [6], PHP, Java™ [11], Acrobat Reader® [1] and Apache [3] for GNU/Linux and for Windows® available in the Internet.

3.2 Document-type

One aspect of the project was to find a stable combination of browser, plug-in and document-type, so that documents can be opened at a certain position. Furthermore, adding Internet-links to the document must be possible.

The document-type PDF covers these requirements. Parameter passing [2] enables documents to be opened at a certain position and a tool enables Internet-links to be added to the document. Today nearly every modern personal computer provides an Internet-browser and an Acrobat Reader® [1] plug-in. In this context, only the version number of the plug-in is important because some versions don't support parameter passing.

At the Institute of Civil Engineering at Technische Universität Berlin, the authors already present their documents on their own homepages as PDF documents. This simplifies the introduction of the "Linked contents of teaching".

With minor modifications of the actual implementation, other document-types can be supported. A precondition to support other document-types is the availability of hyperlinks and anchors or open-parameters.

3.3 Amount of implementation work

The server provides HTML web pages to manage the access, the overview, and the download structure. The implementation of these HTML pages took a single day.

The dynamic part was implemented in PHP. It consists of a few files which generate Internet pages based on user input. An experienced developer of PHP and SQL implements these files during a few days.

A normalized database-design was created to ensure consistent data.

3.4 Instructions for authors

For authors modifications in preparing teaching materials, brought by the system, should be marginal. Some modifications are necessary, but they do not affect the preparation of teaching material directly. The format of the documents was chosen to be PDF. The focus of the project is to identify and present cross-links. Identified cross-links are presented to the authors. Each author has to agree to links from and to his document. For the authors of teaching documents, a manual and process models for core processes are provided [10]. The manual covers a general description of the "Linked contents of teaching". Core processes for the authors are:

1. A new teaching document is written and should be added to the system.
2. An existing teaching document in the system was modified.
3. An existing document in the system is obsolete.

4 USAGE OF THE "LINKED CONTENTS OF TEACHING"

4.1 Access to the system

Access to the system is restricted to the Intranet of Technische Universität Berlin. The restricted access reduces security problems. Technically an operation upon the Internet is possible. An advantage of the restriction to the Intranet of the university is that fast downloads can be guaranteed even for large files.

Access to the system requires a username and a password. With matriculation to the bachelor study course in civil engineering at Technische Universität Berlin, students get the possibility to establish a user account to use the university's computers. This account also enables them to use the system "Linked contents of teaching".

4.2 Presentation

In this chapter, the usage of the system is illustrated. After the login to the system, the user gets an overview (figure 1) upon the modules of the curriculum in civil engineering at Technische Universität Berlin. The program of study is divided into 6 semesters. The modules are shown in different colours.

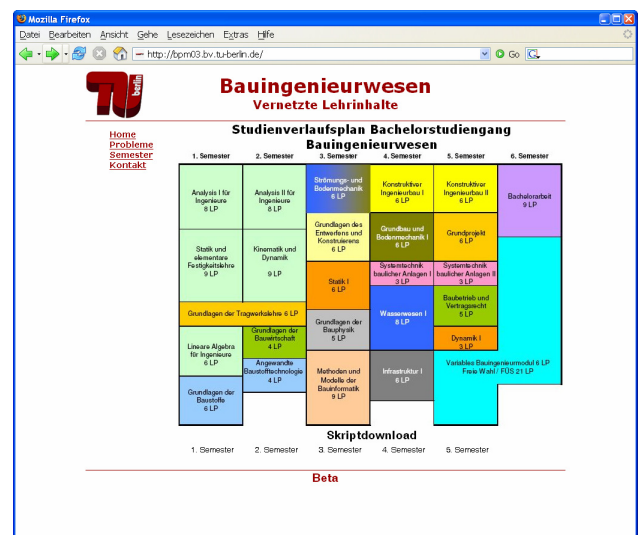


Figure 1. Overview of the curriculum of the Bachelor in civil engineering at Technische Universität Berlin.

The download area is situated beneath the overview. The user may choose a single semester and gets an overview of the modules of the chosen semester (figure 2).

Now the user may choose the module and gets a description of the module and a list of the teaching documents of the courses (figure 3).

The teaching documents in this list are stored in PDF-format and Internet-links are added to these documents. The document chosen by the user is opened in a new browser window.

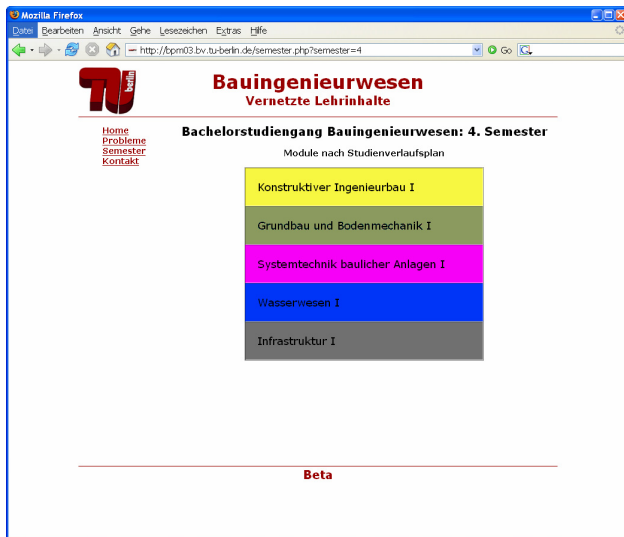


Figure 2. Overview of the 4th semester.

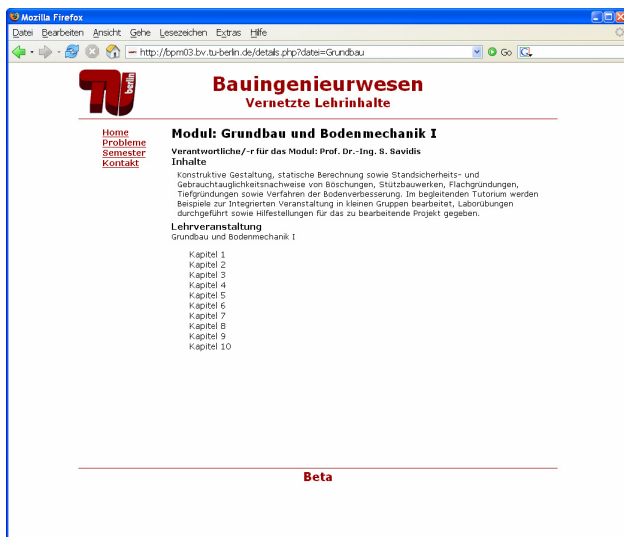


Figure 3. Description of the first module in geotechnical engineering.

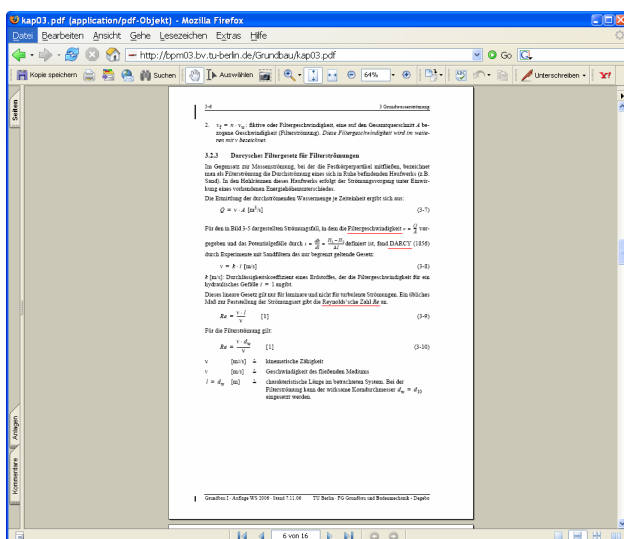


Figure 4. Example with Internet links, geotechnical engineering [9].

The present implementation marks Internet-links by red underlines (figure 4). It's possible to present them in another way. If the user clicks on an Internet-link, the system generates a new website based on his request. On this new site, an overview of teaching documents from other courses which are cross-linked with this document is shown.

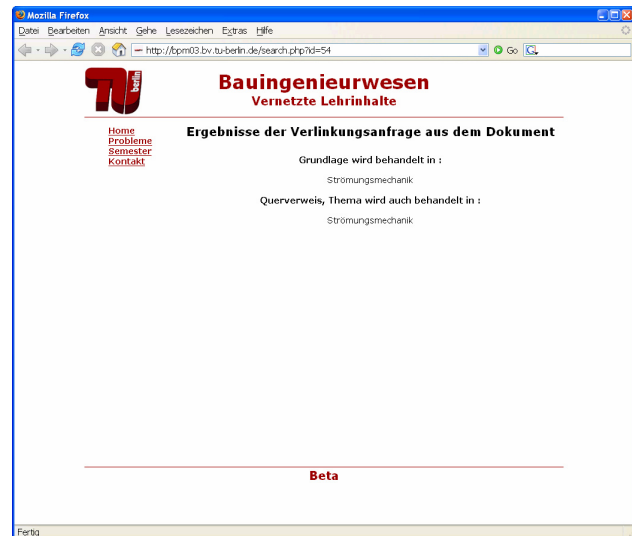


Figure 5. Search result.

Depending on the semantic of the Internet-links, the result presents basics, cross-reference and further application to the chosen start point (figure 5). If the user chooses one of these documents, the system opens this document at the page where the topic is handled. In this example there are cross-links to fluid mechanics [4].

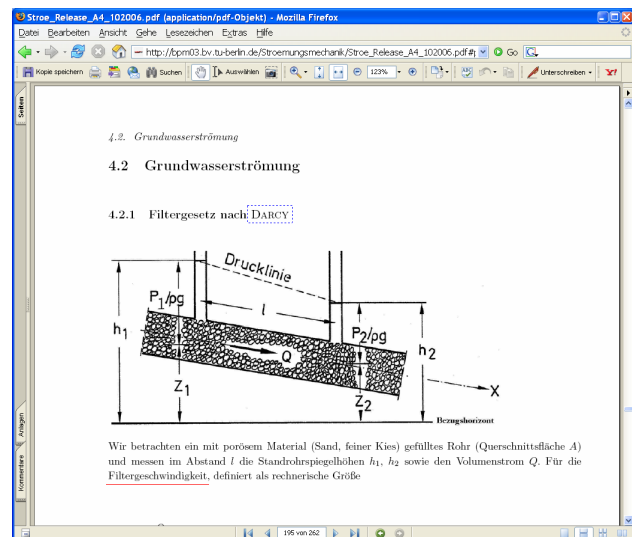


Figure 6. Example, fluid mechanics [4].

5 CONCLUSION

The actual state of the project "Linked contents of teaching" can be divided into techniques and content. The technical part contains the complete installation of server software including the database management system. It contains a project specific database design, a server software and a tool for database administration. The content

part of the project contains at present time the cross-linking between two courses. Additional courses are in progress.

The system will be available for students of civil engineering at Technische Universität Berlin in autumn 2007. In autumn 2007, cross-linking between selected courses will be available.

In March 2008, compulsory courses will be cross-linked and available online. The next project stage from April 2008 to March 2009 is focused on elective courses.

Many options exist to expand the present implementation. For instance, a full-text search might be helpful. However, the project itself is consciously restricted. The main focus is the presentation of links between the contents of teaching. Therefore, the implementations are restricted to core functionalities. The project addresses a core problem of e-learning systems: the inter-dependencies between the content. It tries to find a solution for this problem in the restricted area of teaching documents for courses in civil engineering.

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