

Concept of a cross-university question exchange platform with Moodle LMS

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ABSTRACT

In the European Social Fund (ESF) project "Profilgebundene-Wissenschecks 2.0", seven Brandenburg Universities and Colleges are working together on the implementation and further development of online tools for study orientation, study preparation and support. The work packages include the development of online subject quizzes (online self-assessments), in order to support prospective students to compare their individual knowledge levels with the knowledge required at the beginning of their studies. Depending on the results achieved, e-learning units are provided with the necessary subject-related knowledge. These units can be refreshed independently and the attendance of preliminary courses is recommended. The basis for the online assessments is a cross-university question exchange platform on which the affiliated universities share the developed questions and thereby establish a nationwide quality standard for self-assessments. The project partners at Brandenburg University of Technology Cottbus - Senftenberg (BTU) are responsible for developing the question exchange platform and for making the platform available to all partner universities. For this purpose, a concept was developed, wherein Moodle Learning Management Systems (LMS) is used as a basis and expanded to include functions for storing questions with associated metadata and search functions to search for questions with specific metadata. The concept of the cross-university question exchange platform is presented in this paper.

Keywords: higher education, databases, metadata, Moodle, platforms, plugins, self-assessments, question-bank

1. INTRODUCTION

LMS have become an integral part of everyday life at higher education institutions and increasingly also at schools. In the current phase of digitalization, learning platforms have become established for facilitating the access to learning materials, communication, quizzes (online self-assessments) and examinations independent of time or location. The pandemic caused by COVID 19 in 2020, especially in the lockdown phase, demonstrated both, the potentials and the flaws of digitization [1]. The LMS system Moodle is characterized by its modularity and freely available source code and can be adapted to almost any need [2]. Numerous question types and interfaces to other LMS systems are available and expandable [3]. In addition to the basic question types such as multiple choice or the possibility to fill in the blank, there are also special question types for mathematics and computer science, which have been developed in the Moodle Community especially for higher education [4].

The project described here provides an opportunity for saving staff and financial resources, because by establishing the cross-university question exchange platform, questions do not have to be created over and over again. Only one author develops a question once (with his metadata) and these are then exchanged between the universities, can be combined into new quizzes and thus minimize the workload.

Moodle's existing question bank [5] is used to organize all questions (quizzes) in the system (creation, import, editing, search and export). We take advantage of this and extend the question bank with functions to save metadata

corresponding to each question, searching for metadata, importing and exporting questions to other systems such as Question Mark Perception (QMP) [6].

2. REQUIREMENTS FOR THE PLATFORM

Important requirements for the implementation of the software are set out below, whereby these requirements are to be understood as minimum. The requirements are divided into the following groups:

1. Architecture of the solution/platform

General criteria for the design of the software and its implementation

- Creation of a web application for the question database with a browser-based client
- Use of a relational database system, securing the connection via Hyper Text Transfer Protocol Secure (HTTPS) or alternative mechanisms
- Extensibility to a web-based portal solution
- Possibility of integration into e-learning environments, to backup and restore the contents

2. User administration

Description of users, rights and groups of the solution

- Registration by LoginID and password
- Authentication against directories Lightweight Directory Access Protocol (LDAP)
- Creation, display, modification and deletion of user and profile data
- Implementation of a role concept, user groups

3. Question database

Structure of the database and function for using the database

- Creating, editing and deleting a question in the database
- Preview (display) of questions and composition of questions directly in the question database without export
- Creation, editing and display of metadata on the questions
- Search of questions

4. Conversion of questions (import/export)

Requirements for the exchange of questions between the Moodle and QMP systems

- Import/Export of individual questions or collections of questions for Moodle question types
- Conversion between Moodle and QMP with external resources for interchangeable question types
- Development of a generally valid and expandable relational data model for the agreed question types
- Summary of individual questions to form a collection of questions
- Import and export of questions and question collections

The database stores and manages all question types according to the current Moodle version. In addition, questions from the quiz software QMP are transferred to the database as far as possible. However, the question types to be stored in the database differ in several aspects: the software systems used (Moodle, QMP), the scope of the displayed components of the question, the structure and construction of the formats provided. When transferring a question from another system to the question database, a conversion tailored to the respective system must always be implemented. An example of the conversion can be found at the end of 3rd paragraph.

3. PLATFORM CONCEPT

To implement the formulated requirements during the project, a web application based on the LMS Moodle and a separate option for converting questions between Moodle and QMP is developed in a first step. In a second step, its integration into the platform is planned. This frequently used approach offers the usual advantages and disadvantages of multi-tier applications and is essentially based on the Moodle system used by the project partners, too. The questions concerning the integration of the solution into a future (web) portal can easily be implemented and offer a significant advantage over the desktop application of the prototype requirements for the platform.

By using Moodle as the core system, the effort for the development of the solution can be reduced, because different components of the system (user administration, import/export interface, question administration, quizzes) can be used for

the implementation of the question database. In principle, question exchange with other systems is possible via import/export interface. However, currently only the transfer of questions from other Moodle systems is well developed. Since all but one university use Moodle in the project, this existing interface to the question database for question import and export can be used by almost all project partners. In order to import questions from other systems (like QMP), a tool was implemented in the previous project [7] that is to be further developed into the Moodle-based database system by using a plugin. One approach is to use a plugin already available in the Moodle community [8] and to extend the functionality of the conversion of all possible question types. Therefore, it will be necessary to implement a semantic data source mapping to translate the respective question from Question Mark Perception format (QML) to Moodle Extensible Markup Language format (Moodle XML) and vice versa. [9] Following this approach, the import and export could be accomplished via the Moodle interface.

Moodle has been operated and continuously updated at BTU for many years in several instances (learning platform BTU, college, projects, test and development systems) and is currently used in version 3.5. In eLearning projects, extensions (Moodle plugins) for the learning platform have also been developed at BTU, some have been published in the Moodle community [10]. Most of the project partners also run live or Moodle test instances on which questions and quizzes are created. An exception is the Technical University of Applied Sciences Wildau, which operates the QMP system for quizzes in addition to Moodle.

Structure of the Platform

The structure of the solution is shown schematically in the following figure:

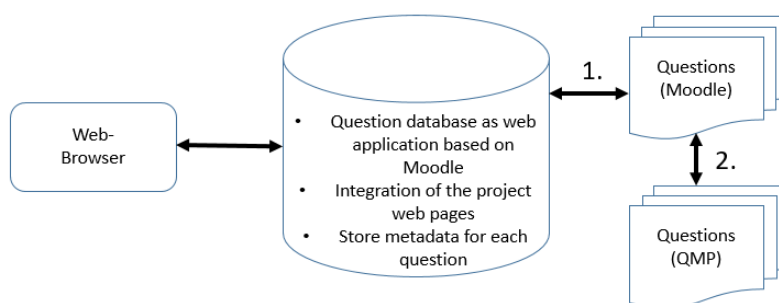


Figure 1. Basic structure of the question database platform

1. The interface for import/export of the question to/from the database is implemented on the basis of the Moodle interface. The use of additional metadata and categories for the management of the data requires an extension of the Moodle functions, in particular

- New implementation of a Moodle plugin for data management input/output and editing of metadata;
- Extension of the search function for questions by the function of searching for metadata in Moodle.

2. Questions from external systems (in this case QMP) are converted into the Moodle (XML) format with an external tool before import. When exporting, the question is converted from Moodle format to QMP (QTI) format. For this purpose, this tool is to be integrated directly into Moodle with the help of a plugin in the future.

- New Implementation of a Moodle plugin for QMP (QTI) import/export to/from Moodle (XML)

Features of the platform

Moodle was developed on the basis of the open source framework LAMP, which consists of Linux (operating system), Apache (web server), MySQL (database) and PHP (programming language). Due to the portability of these components and the modularity of Moodle itself (what the M stands for), it can support a variety of operating systems, database systems and web servers. The following graphic shows a simplified overview of the overall architecture:

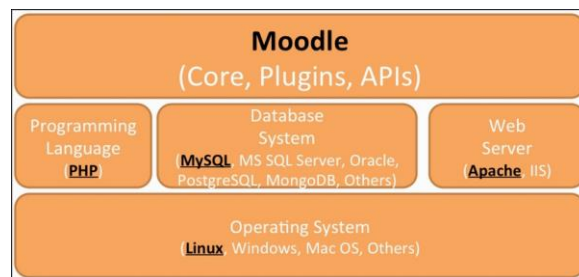


Figure 2. LAMP Architecture Moodle [1]

The modularity of Moodle enables us to implement our own extensions (Moodle modules) to expand the functionality and, thus, to better adapt the platform to our own needs. This allows us to implement the necessary adjustments for the question exchange platform. In our conception, Moodle is intended to be extended by the following main functionalities listed here and described in more detail in the next paragraphs:

- Platform design
- Authentication and Role management
- Question bank

Platform design

The design of Moodle is also fully customizable. By default, Moodle comes with three designs: Boost (Moodle 3.2 and above), Clean - a responsive design based on Bootstrap 4, and More - a design that can be customized by the Moodle administrator directly within Moodle [11]. The community provides a variety of other designs (so-called “themes”), some of which are free, others can be used and configured for a fee. In addition, own themes can be created and integrated, such as themes derived from Boost, so-called ‘child themes’. For the question exchange portal, the connection of database and website as a portal solution with a corresponding design of the start page is planned.

Our proposal for the platform design is based on a theme derived from Boost which we will adapt accordingly. The aim is to connect the existing project website and database to the platform. To integrate the website into the platform, the logo and all important information with links to the relevant topics of the project will be visible and selectable in the header. There will be an input field for the login to the platform. Colors and images will be adapted and integrated according to the project design and target group. Figure 3 shows a corresponding design draft for the platform landing page.

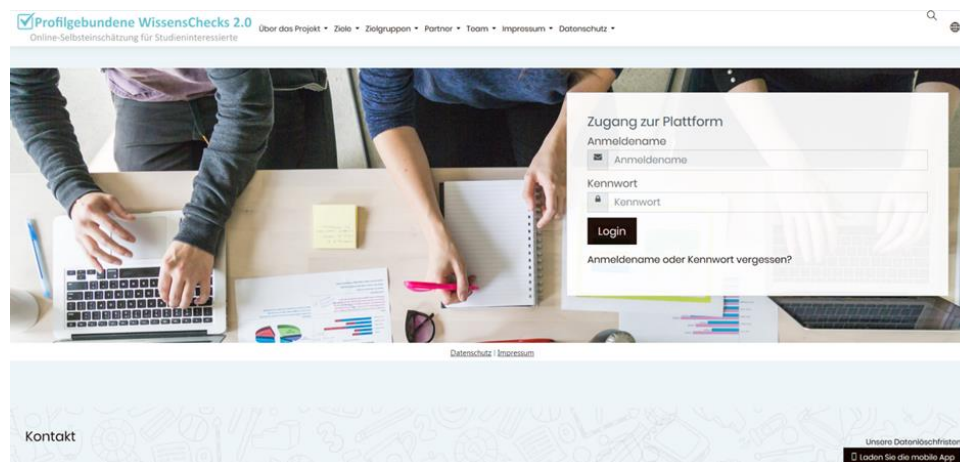


Figure 3. Design suggestion structure of the landing page

Authentication and role management

Roles define what users can or cannot see and do in your Moodle system. Moodle contains a number of pre-defined roles such as lecturers and students, but it also allows us to create our own roles, for example for users who can view, import and export questions. Each role has a specific area (called context) which is defined by a set of permissions (expressed as functions). For example, a teacher can grade an assignment, a student cannot. Or a student may submit an assignment, but a teacher may not. This is based on the authorization concept, describing which access rules apply to individual users or user groups. Only necessary access rights for the performance of each role tasks should be granted ('need-to-know principle').

In order to meet the specific requirements of the portal, the following four additional roles will be created and configured:

- **Administrator or Manager+:** Server/VM Administration (Administrator), Platform Administration (Manager+ interface between BTU computer administration center and project)
- **Portal Manager:** Set up, delete, block user accounts, as well as course areas, courses and sub-categories for questions
- **Portal Editor:** Import, export, search and edit questions, metadata
- **Portal User:** View and solve questions with metadata (in course)

Question bank

The basis of the implementations is the Moodle Question bank with the categories and metadata. After successful authentication, the user with specific role (portal roles) is immediately directed to the Question bank, where all questions are visible, sorted by category and with the corresponding metadata. The authorized user is able to select the corresponding top and sub category and thus to get a list of all questions contained in this category (Figure 4).

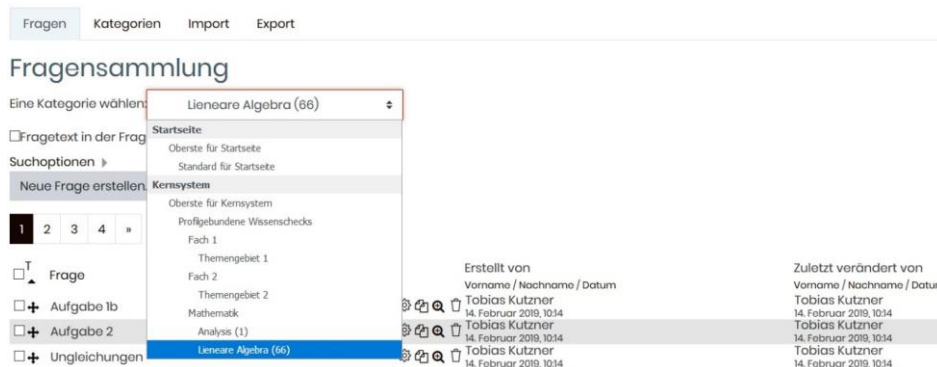


Figure 4 Moodle Question bank

Authorized users (see role management) have the possibility to create, edit, move or delete new super and sub categories. The import and export of questions is also performed via the functions available in the Question bank. The import function has to be extended for the import of questions by the input of metadata and the export function, which is used to export entire categories with the contained questions.

The import and export of questions is also performed via the functions available in the Question bank. Figure 5 shows the import function which has to be extended for the import of questions by the input of metadata. For the import, an existing - yet outdated - plugin in the Moodle community will be revised to allow the transfer of QMP (QTI) questions into Moodle (XML) questions, since it currently only works for a few question types. Figure 6 shows the export function, which is used to export entire categories with the contained questions. Here too, the corresponding extensions for the export of individual questions have to be implemented so that not only entire categories or individual questions of a certain category can be exported, but also collections of questions across categories. This can be done by implementing a "basket" for a collection of questions to be exported across categories.

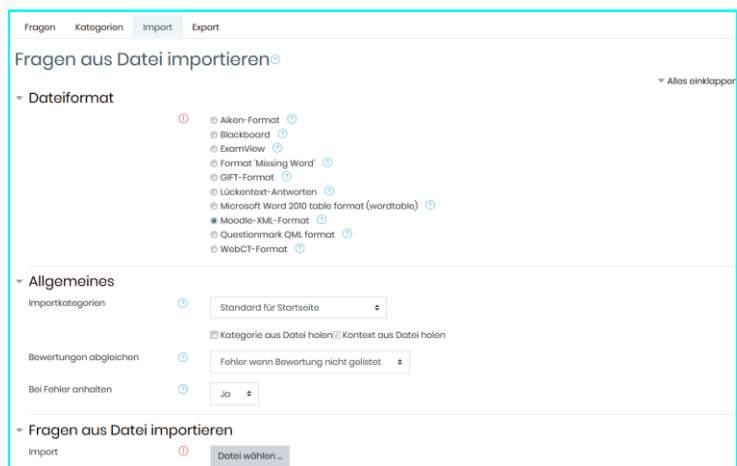


Figure 5 Moodle Question import XML and QTI

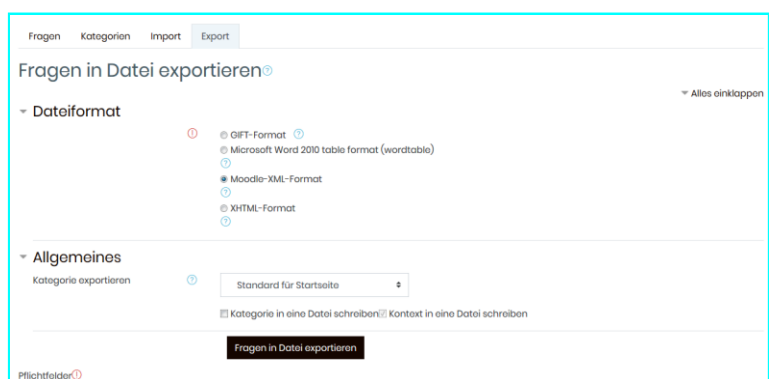


Figure 6 Moodle Question export XML

The basis for the collection of metadata is the extension of the Moodle database with corresponding table(s) for storing the metadata (see Figure 7). As Moodle already contains some metadata that can be used after successful verification categories and subcategories, a transfer of the metadata into the table to be implemented for the metadata plugin must be carried out.

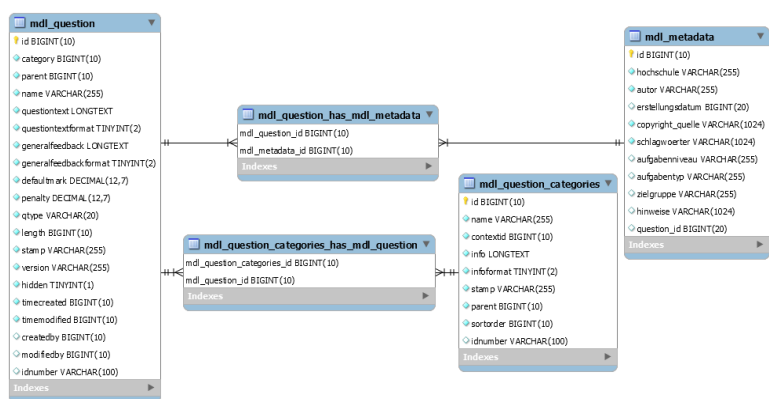


Figure 7 Extract required tables with relationships

In addition to the implementation of the new table structure for the storage of metadata, the Question bank has to be extended by the corresponding inputs and outputs for the acquisition of metadata, the functions for importing, searching,

and exporting questions. As not all functions available and usable for implementation in Moodle (Moodle-compliant implementation) are known at this stage, the final implementation may differ from this first draft.

It is planned to enter the metadata for both, questions to be imported in their entirety (directly during import) and for each single question after import, whereby the mandatory fields must be completed in all cases. Incomplete questions (mandatory fields Metadata not filled in) will be deleted for reasons of database consistency. The questions may then have to be re-imported.

There are two options for metadata entry:

1. When importing questions, it should be possible to enter the metadata for all questions at once in the import form. This means that the same mandatory metadata is saved for each question during import, thus enabling a quick import of many questions. Figure 8 shows a draft for entering the metadata for questions to be imported in the import form. This is followed by the input of metadata for each individual question. Metadata can be checked and adjusted for each question and further metadata can be entered.

The screenshot shows the 'Import' tab of the Moodle question bank interface. The main heading is 'Fragen aus Datei importieren' with a help icon and a link to 'Alles aufklappen'. Below this, there are several sections:

- Dateiformat**: A section header.
- Allgemeines**: A section header containing:
 - Importkategorien**: A dropdown menu set to 'Lineare Algebra (66)'. Below it are checkboxes for 'Kategorie aus Datei holen' and 'Kontext aus Datei holen'.
 - Bewertungen abgleichen**: A dropdown menu set to 'Fehler wenn Bewertung nicht gelistet'.
 - Bei Fehler anhalten**: A dropdown menu set to 'Ja'.
- [[metadata]]**: A section header with four input fields for: '[[Autor]]', '[[Hochschule]]', '[[Copyright/Quelle]]', and '[[Tags]]'.
- Fragen aus Datei importieren**: A section header with a sub-section 'Import' containing a 'Datei wählen ...' button and a dashed box for file selection.

Figure 8 Question bank draft import metadata all questions

2. After the import has been carried out without specifying the mandatory metadata in the import form, it is required to enter the mandatory metadata for each single question. Specifically, the metadata for each single question should be displayed, entered and edited. For this purpose, a dialogue box opens after having selected a corresponding icon assigned to the question (see Figure 9), in which the metadata can be entered or the metadata already entered can be checked and adapted.

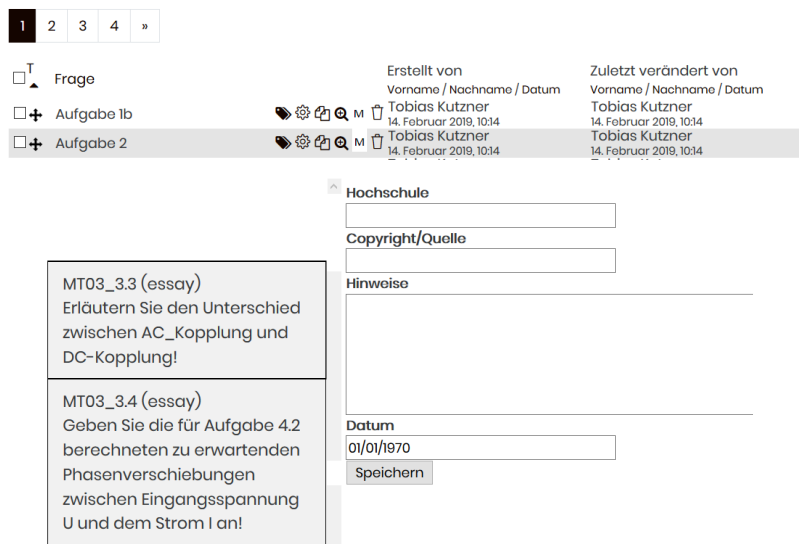


Figure 9 Draft icon action button, edit metadata and add metadata to individual questions

For the transformation of QMP tasks to Moodle and vice versa it is necessary to perform a data mapping. To be able to perform a successful data mapping, the basic requirement is to relate the different parameters of the question types of both systems. Figure 10 shows an example of how the different parameters are connected. This process must be implemented for all necessary question types and implemented in the Moodle plugin for QML import and export.

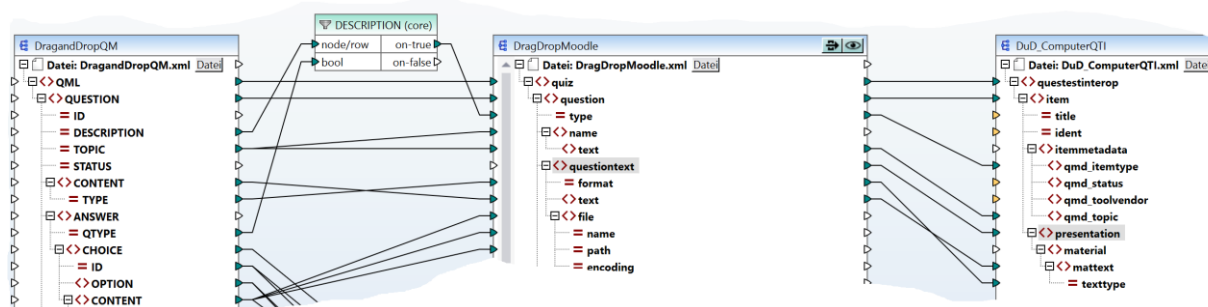


Figure 10 Mapping example (Moodle, QTI, QML) [7]

4. SUMMARY

In this paper, we presented a concept for building a question exchange database based on Moodle. The proposed solution merges the existing project website with the database into a database platform, ensures the collection of metadata for each question and offers the possibility to import questions from other systems. Due to the modularity of Moodle and with the help of plugins that can be newly developed and enhanced, Moodle offers the possibility to adapt the concept to the project's needs. Beyond that, the existing role management offers a regulated safe access to the questions depending on the user group. This makes it possible to give each partner university the necessary access to the questions. Furthermore, questions can be combined into quizzes and exported from the database to the universities' systems. Thus, the proposed system allows the questions for all partners involved in the project to be stored in a secure database, thus reducing time and effort required to create new questions.

5. OUTLOOK

In the future, the developed platform is deemed to be part of a "Brandenburg-wide online portal for study orientation and preparation"¹. For this purpose, it is necessary to consider the prospective integration into a portal or the expandability of the solution to a portal already during the development of the question database. Similarly, aspects of implementing the current regulations on data protection and data backup, transferring the software into a productive version, and increasing the number of users must also be taken into account in the development process.

6. ACKNOWLEDGEMENT

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¹ Source: Application "Profilgebundene WissensChecks 2.0", p. 7

