WebSIS – a web based portal with an integrated e-assessment environment

Heinrich Christian Dippel, Volker Neundorf, Vera Yakimchuk

Technische Universität Ilmenau

Key words: *e-learning, e-assessment, online-tests, self-assessment*

Abstract:

WebSIS, a web based portal, is being developed at the Technical University of Ilmenau as a central information source and contact point for students, prospective students, interested pupils, and students who have to repeat an examination at the TU Ilmenau.
One of the integral parts of WebSIS is the e-assessment environment TestWeb. Dynamic generation of tests based on parameterized tasks with different solution forms (currently: numeric value input, multiple choice, matching tasks, conversion of units), simulation of test conditions, the automated verification and rating of tests, and customized statistical summaries are some specific features of TestWeb.

1 Introduction

At the german universities exists a considerable deficit in engineering sciences students. The reasons for this deficit are on the one hand the insufficient number of first-year students and on the other hand the high failure rates, especially in the basic courses. A study published by The Association of German Engineers (VDI) [1] says that the number of alumni remains at about 40.000, while the demand for engineers increases. As VDI states, for three years there have been more engineers aged 50 or older then young engineers aged less than 35 years.
In conclusion, there is a demand to interest pupils in studying engineering sciences and to support the students, plus to make an optimal preparation for examinations possible.
To reach these goals, WebSIS is currently being developed at the TU Ilmenau.
An integral part of WebSIS is TestWeb, an e-assessment environment that is being developed especially for the demands of content in engineering sciences.
Main intentions of developing such a web based e-assessment environment are not only to use multiple choice exercises for tasks with mathematical content [2, 3] but to use enhanced types of exercises and a parameterized exercise pool to use randomized values in exercises [4].
After a short introduction into the WebSIS, we present the most important part of it – the TestWeb. We discuss some didactical aspects, the technological principals and prospective use of the environment.

2 Student Portal WebSIS

WebSIS stands for a web based Student Information System and is planned to be used as a central source and contact point for prospective students, pupils who start studying before their university-entrance diploma (so called “Frühstudium”), first-year students, those who changed university and students who have to repeat an examination at the TU Ilmenau.

One aim of WebSIS is to establish an e-Learning process flow from school to university. The content contained in WebSIS includes for example the course catalogues, arguments for a Bachelors- or Masters degree or a „Frühstudium" at the TU Ilmenau, career opportunities or alumni portraits. The important focus of WebSIS is a learning environment with e-assessment for engineering fields.
Further important features and content in WebSIS for the mentioned target groups are:

- lectures as video streams
- different types of self assessment units
- interactive animations
- interactive experiments
- e-assessment solution TestWeb
- access to the university's learning platform
- online-tutoring

All information for courses of studies is adapted to the target audiences and offered on WebSIS.
One of the core functions of the system is the integrated e-assessment environment TestWeb which allows the users to test themselves with individualized online tests. E. g. someone who is interested in studying may check his or her own suitability for a course of studies or a student may prepare him- or herself for an examination. Additionally, students who have to repeat an examination can prepare themselves with online-tests simulating the pending examination.

3 Integrated e-assessment environment TestWeb

TestWeb is a web based e-assessment application [1].
Our students have to pass some written examination every semester, but unfortunately the failure rate is high. Because of the large number of student who have to pass the same examination in the first three semester (e.g. for electrical engineering it is ca. 650 students) our department has not enough man-power to carry out any written tests during the semester to show the students their knowledge deficits. On the other side, we have implemented and tested a special short online tests for labor exercises [5] and the feedback from student was very positive, they liked to know how good or bad their knowledge state is. Based on this experience, we begun the implementation of the more complicated and universal environment – the TestWeb. The main challenges were (and stay for any extension) to analyze, specify and classify the tasks, to analyze and formalize the ideas used for generating the different variants of the same examination and to invent the appropriate data formats for these tasks and generation rules. In part we could use the experience from our preliminary work on knowledge-based exercise environment mileET [6, 7].
As first application field we took our subject "Basics of Electrical Engineering"[1]. The possibilities to use the TestWeb for other similar subjects are being discussed at every design phase. Some typical tasks and (already implemented) answers forms are presented in further parts of this paper.
The next challenge is to make the system easy to use, easy to manage, and easy to modify. The only requirements for usage are a PC with internet access and an up-to-date internet browser. TestWeb is developed in PHP and uses a MySQL-Database for storage of contents. TestWeb is based on a user administration with the role concept. To use TestWeb, the student has to apply for registration with his/her e-mail address and a password. The registration can

[1] Our task collection (in German) ist avilable under
http://getsoft.net/taskweb/new/aufgaben/index.html

be restricted to a specified domain. For example only users with an e-mail address ending with *@tu-ilmenau.de* could be able to register on our version of TestWeb. To complete the registration the user receives an E-mail containing a link that has to be used to confirm the identity.
Different rights can be assigned to the users, e.g. to create and edit contents, access to statistics or the usage of tests. Typical combinations of the rights result in the roles administrator, tutor and student. Creating of tests is available in the backend of TestWeb, which is accessible only for administrators and tutors.
TestWeb can be used for rated online-tests as well as for individual self-assessments. The generated tests are created from a pool with parameterized exercises, so the given values are nearly unique in every test. After completing a test, TestWeb automatically compares the answers of the user with the correct answers and rates the test. Correct Answers are generated by TestWeb as an invisible part of the generated test according to formulas prepared by author.
The information of every completed test is saved in the database. Based on this data, TestWeb generates detailed statistics. Consequential, every user can find out, which topics and exercise is above-average problematic for him. The tutors get an aggregated statistic of the performance of all users, broken down into e.g. topics, subtopics or exercises.
In the following, some core functions of TestWeb are described in detail.

3.1 Test Modes

TestWeb offers two modes of generating online tests: the *test-mode* and the *practice-mode*.
The *test-mode* generates tests which are comparable to an authentic examination. The user has to answer the test in a given time period and the difficulty and composition of exercises according with a preadjustment.
This mode is interesting e. g. for students who have to repeat an examination; they can check themselves under conditions which are close to reality.
The *practice-mode* allows the user to choose the thematic focus of a test. So he or she is able to prepare him- or herself individually and without time pressure.
The differences between test- and practice-mode are shown in table 1.

	test-mode	**practice-mode**
number of exercises	given	user-definable
content	given	user-definable
rating	points and resulting rating	points
time	given	not given

Table 1. Differences between test- and practice-mode

3.2 Presentation of mathematical content

TestWeb should be workable in any actual web browser. In the field of engineering sciences the problem of presenting mathematical content is one of the most important. On the one hand when using HTML, the available character sets are insufficient for displaying complex formulas and equations. On the other hand, the user should not be forced to install third-party software like browser-plugins for the representation of e.g. MathML.
So graphics are used for the representation of mathematical content in TestWeb, and LaTeX is used for the intern storage of mathematical formulas. The LaTeX code is rendered into a bitmap graphic while a test is being generated.
TestWeb provides the opportunity to enter mathematical content like e.g. formulas with a graphical formula editor like f.e. MathType.

The editor-GUI is developed in JavaScript and enables to enter even complex content. The mathematical symbols can be chosen via a menu and the mathematical expression is displayed as an image to the user. This image can be transferred from the editor into the user's test.

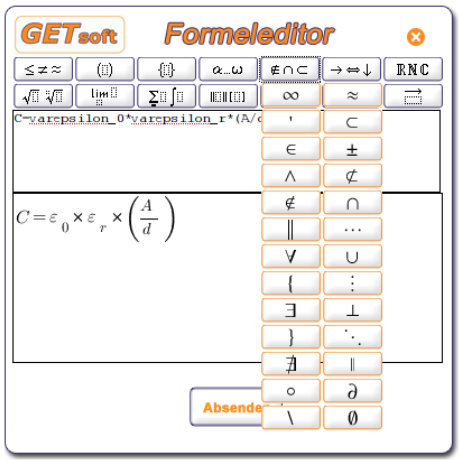

Figure 1. Formula editor

3.3 Tasks Structure and Parameterization

The content in TestWeb is structured hierarchically as shown in Figure 2.

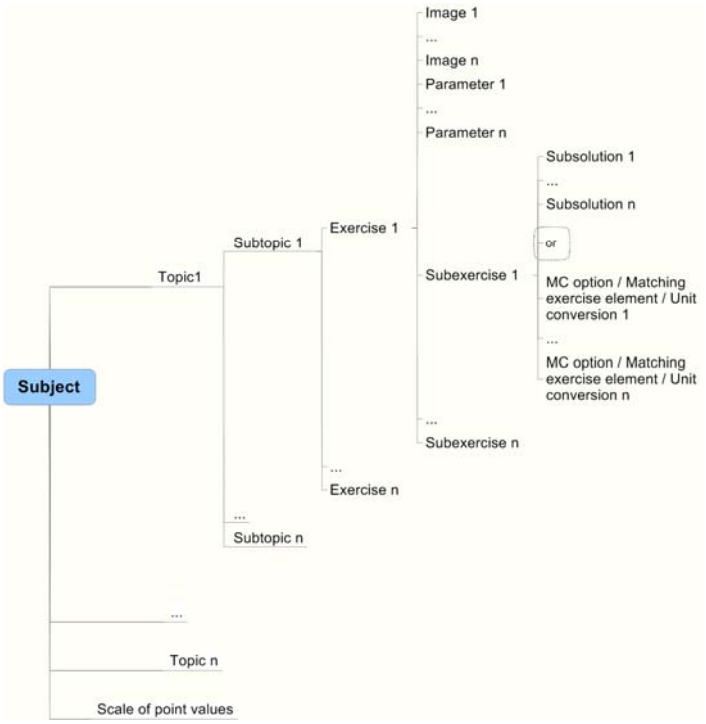

Figure 2. Structure of contents in TestWeb

When creating the definition for a test, a subject with at least one topic, one subtopic and one exercise must be defined. Every element has certain attributes, e.g. a subject needs the attributes name, available time for a test in test mode, numbers of exercises per test in test mode and a difficulty interval. For topics and subtopics a probability of occurrence has to be defined, so that the combination of exercises in test mode can be approximated to the combination in an examination.

Every exercise needs a value for its difficulty, a probability of occurrence and the amount of points that can be maximally assigned for the correct answers. These Date have to be set by an author of the task topic.
Subexercises can be composed of the different exercise types: numeric value input, multiple choice, matching exercises or unit conversions.
These exercises types and their main attributes are described in 3.5.
A core feature of TestWeb is the possibility to store exercises in a parameterized form. This allows generating unique tests with a randomized set of values. Every exercise has to be implemented just one time into the system; the effort for entering different alternatives of an exercise with different values can be omitted. Another advantage of such a parameterization is that the chance to get twice the same exercise or test is marginal. This makes it difficult for the users to share the results of exercises, or to use them for the next test without solving it again.
For every parameter that an exercise contains, the following attributes have to be defined:

- The **placeholder** as reference to a value in an exercise or to another dependent parameter. Every placeholder has to be unique in an exercise.
- The **unit** e.g. V for Voltage.
- The **type** of parameter defines which values the parameter can fulfill. Possible types are lists and intervals. A list consists of a finite number of possible values. For an interval a lower limit, an upper limit and the step size is needed. When a test is generated, one of all possible value of the list or the interval is randomized. Parameters can be referenced in every part of an exercise.

A trivial example exercise (covering Ohm's law) shall explain the concept of parameterization. When using Parameters during the creation of exercisse, the Parameters are written inside of curly braces, e.g. {U} for a voltage. These parameters are replaced by concrete values when displaying the exercise in a test to a user.

Placeholder	Unit	Type	Area	Optionally step size
U	V	List	[2;4;6]	
I	A	Interval	1-10	0.5

Table 2. Examples of parameters.

Exercise description: *Through a resistance R a current {I} flows and a voltage of {U} is applied. Calculate the resistance R.*

Placeholder	Algorithm	Unit
R	{U}/{I}	Ω

Table 3. Example of a solution.

If this exercise is picked randomized for a test, the defined parameters *U* and *I* are filled with values. In this case the voltage *U* could represent 2V, 4V or 6V. For the current *I* there would be 19 possible values: 1A; 1, 5A; 2A; ... 9, 5A; 10A.
In this case, we assume the following values were generated: I = 2A, U = 9V.
Now the exercise is searched for the appearance of the defined parameters and those are replaced by the generated values. Afterwards, TestWeb calculates the correct solution with the algorithm and saves the solution in the database (4.5 Ω).
For the user the concrete exercise is displayed: *Through a resistance R a current 2A flows and a voltage of 9V is applied. Calculate the resistance R.*
The calculated solution *R* is now made available as a new parameter to the system and can be

used in the following subexercises like the parameters *U* and *I*.
Parameters also can be dependent of each other.

3.5. Answer types

Currently TestWeb features four different answer types.

Numeric value input

Mathematical calculation is the elementary exercise form in the field of engineering sciences. TestWeb supports the request for numeric values. The correct solution is calculated with a defined algorithm, as described above.
It is possible to ask the related unit from the user, as well as the unit can be given by the system. When the user enters the unit, the system recognizes different prefixes and units, by example the input „4V“ is equivalent to „4000mV“.
When checking the user's solution, a defined precision of the internal decimal places and a tolerance interval is considered.

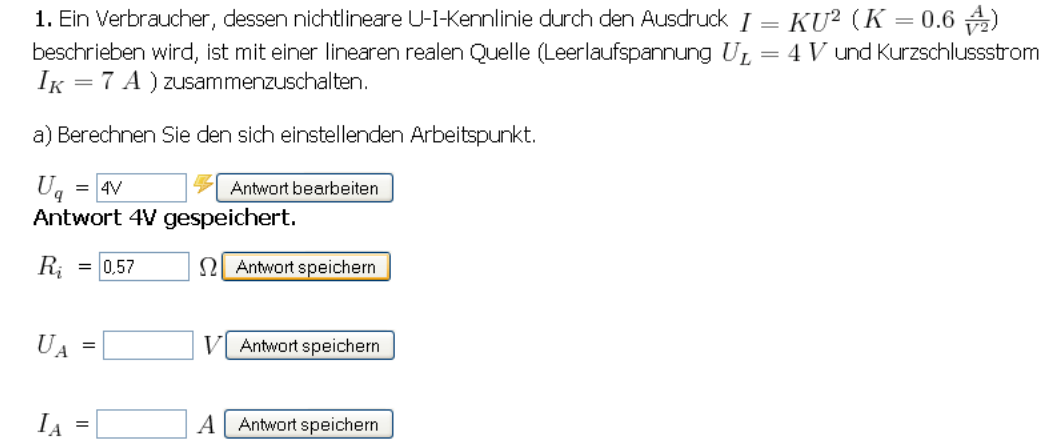

Figure 3. Numeric value input with and without given units

Multiple choice

Also multiple choice exercises can be created in TestWeb. It is arbitrary how many answer options one exercise consists. It is possible to create more options than the shown number in the exercise. Also the number of correct and wrong answers is variable. All options could be correct, all could be wrong or any mixture of both. When generating a task, the order of the options is randomized, so the probability of identical tasks is minimized. The probability gets lower, the more options are defined. If just one correct option is created, the result is a single choice exercise.
Posible answers can consist of text, images or flash movies.

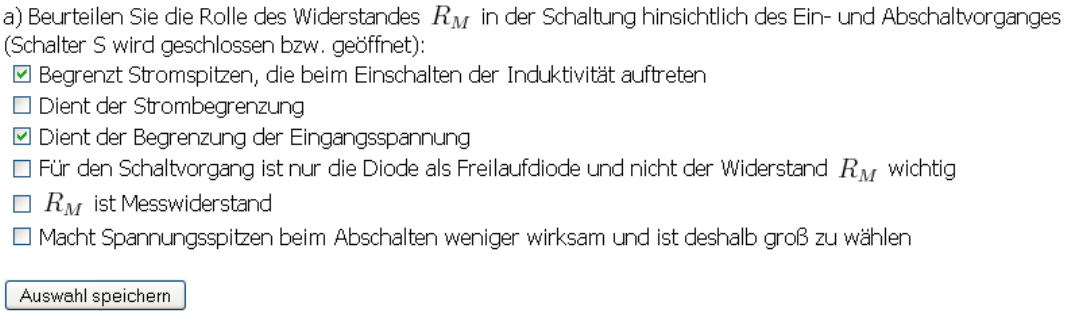

Figure 4. Multiple choice exercise

Matching exercises
Matching exercises consist of a list of elements that have to be assigned to a matching part. The user has to drag an element and drop it on or beside the matching part. An element can be assigned to one or none matching parts, the matching parts can belong to none, one or more elements.
Elements can contain text, images or flash movies.

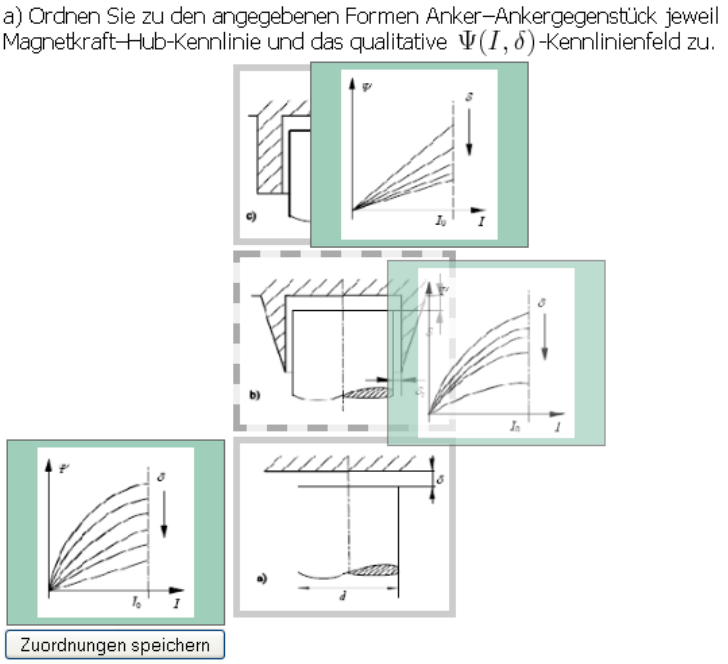

Figure 5. Matching exercise

Conversion of units
Another elementary type of tasks in the field of engineering sciences is the conversion of units. To create such an exercise, the multiplier for a conversion of a unit into one another is needed and some parameters for the randomized generation of a value to convert (interval of possible values, internal decimal places, tolerance for correct converted values).
When a test is generated and a conversion exercise is chosen, a value for the unit to be converted is randomized.

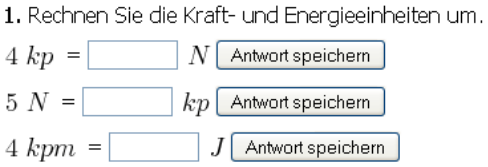

Figure 6. Unit conversion exercise

4 Perspective

WebSIS is currently under development; it has been implemented as a working prototype and will be tested in productive use at the TU Ilmenau during the next semester. At the same time further functions of the Test Web are being implemented. Currently we are working on a user friendly handling of the backend, so that content can be added easily. Then, the answer types will be enhanced - e.g. the checking of formulas can actually just be done by using multiple choice exercises

The integration of TestWeb into WebSIS is the next step. WebSIS is provided by means of the Content Management Systems TYPO3, so TestWeb have to be refined as a TYPO3-Extension. That means that TestWeb could be easily integrated in any website using TYPO3. In near future, an integration of TestWeb as a plugin into the LCMS Moodle[2] is planned.

References:

[1] Sheperd, E., Godwin, J., Assessments through the Learning Process, Whitepaper. http://www.questionmark.com/go/us020601.htm, 2004
[2] Jerzy Rutkowski, Katarzyna Moscinska, Piotr Jantos, Web-Based Assessment And Examination System – From Experiment To Practice, in Proceedings of the 10th IASTED International Conference Computers and Advanced Technology in Education, 8.10.-10.10.2008, Beijing/China, ISBN 978-0-88986-700-0
[3] Henke, K., Web-Based Test, Examination And Assessment System, in Advanced Technology for Learning, Vol. 4, No. 3, 2007
[4] Zorica Nedic, Jan Machotka and Andrew Nafalski: Effective on-line self-assessment in engineering education, in Interactive Computer Aided Learning ICL2006, 27.9.-29.9.2006, Villach/Austria, ISBN 3-89958-195-4
[5] Neundorf, V., Yakimchuk, V., Seidel, H.-U., GETsoft/LabWeb - a virtual electrical engineering laboratory for first-year students, in Interactive Computer Aided Learning ICL2006, 27.9.-29.9.2006, Villach/Austria, ISBN 3-89958-195-4
[6] Yakimchuk, V., Garbe, H., Thole, H.-J., Mobus, C., Wagner, E., "mileET: Problemorientiertes Lernen in einer wissensbasierten und adaptiven Lernumgebung fur die Grundlagen der Elektrotechnik", 2. Workshop GML2 2004, Alcatel SEL Stiftung fur Kommunikationsforschung, Norderstedt: Books on Demand, 2004, ISBN 3-8334-1573-8
[7] Yakimchuk, V., Garbe, H., Möbus, C., Thole, H.-J., Wagner, E., An Intelligent Problem Solving Environment in the Domain of Electrical Engineering, on AIED 2004, 11th International Conference on Artificial Intelligence in Education: Shaping the Future of Learning through Intelligent Technologies, Editors: Ulrich Hoppe, Felisa Verdejo and Judy Kay, IOS Press Ohmsha: Amsterdam, Berlin, Oxford, Tokyo, Washington DC, 2003, ISSN 0922-6389

Author(s):

Dippel, Heinrich Christian, Dipl.-Ing.
TU Ilmenau, KeLD (Competence Centre for E-Learning Services)
98684 Ilmenau, Germany
PF 100565
heinrich-christian.dippel@tu-ilmenau.de

Neundorf, Volker, Dipl.-Ing.
TU Ilmenau, Fachgebiet Grundlagen der Elektrotechnik
98684 Ilmenau, Germany
PF 100565
volker.neundorf@tu-ilmenau.de

Yakimchuk, Vera, Dr.-Ing.
TU Ilmenau, Fachgebiet Grundlagen der Elektrotechnik
98684 Ilmenau, Germany
PF 100565
vera.yakimchuk@tu-ilmenau.de

[2] http://moodle.org/