Reusable Assessment Modules

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***Abstract*—This paper describes a Web-based Test, Examination and Assessment system that can be used via the Internet. It is therefore suitable for both local and remote examination preparation as well as examination within a lab course (entry test). This solution is also intended for the use in lectures dealing with the design of complex digital control systems within the newly created European Master Degree Program "Remote Engineering". Actual Learning Management Systems (LMS) include mainly tools for authoring multiple choice or cloze questions and the like and use very simple assessment mechanisms. We also describe Web-based scenarios to assess higher levels of knowledge.**

***Index Terms*—Computer-assisted Learning and Instruction, Reusable Learning Objects, Interactive Learning Environments, Remote Engineering.**

I. Introduction

The main objective of the newly created *Joint European Master Degree Program "Remote Engineering"* (MARE) - which is being implemented by partners from CTI Villach (A), TU Ilmenau (DE), Univ. of Limerick (IE), Univ. of Brasov (SI) and Univ. of Brasov (RO) - is to elaborate a complete new joint curriculum in the field of "Remote Engineering". The program is planned as a Joint Master Degree program.

The general objective of the curriculum is to mediate fundamentals, applications and experiences in the field of remote engineering by an interdisciplinary approach in combination with "learning by doing" phases. In this way, we create a unique possibility to study "Remote Engineering" in Europe [1].

The use of virtual and remote laboratories and workplaces is one of the future directions for advanced teleworking/e-working environments especially in engineering and science but also in many other fields of the society. This would also benefit people with special needs and people working from their home.

That's why it is increasingly necessary to allow and organize a shared use of equipment but also specialized software components. A user at his workplace can access design tools and labs without travelling. This flexibility is important for teleworking, education and life long learning.

The Department of "Integrated Hardware and Software Systems" at the Technical University of Ilmenau is involved in this *Joint European Master Degree Program "Remote Engineering"* with lectures dealing with the design of complex digital control systems [2].

Starting from the basics of Boolean algebra, combinational logic and simple sequential circuits over various minimization techniques for logical expressions, dynamic effects in combinational and sequential circuits and the design of digital control systems based on Finite State Machine (FSM) descriptions, students in upper semesters learn different methods and tool concepts to create, implement and validate Embedded Systems, allowing them to solve complex design tasks. Examples for such design tasks are e.g. controls for technical facilities like elevator, vending machine and traffic light controller [3].

During the semester students have to carry out different labs for various courses via the Internet. Therefore it is necessary to check

- the *qualification of the lab users* (students)
  This will be done in the form of a Web-based entry test.
- the *quality of the prepared solution.*
  Since no direct support is possible locally, the security of the models to be controlled is the centre of attention. For detailed examples see [2, 4, 5].

In the following we would like to present a concept for a Web-based and database supported e-Learning *Test, Examination and Assessment System* which is - among other things - suitable for the mentioned entry test to the remote lab. It is at present developed at the Department for Integrated Hardware and Software Systems at the Technical University of Ilmenau.

II. Curriculum and Learning Objects

A. Modularisation of the curriculum

The complete curriculum is divided into *modules* (see Figure 1). Each module consists of several *courses*, which harmonize with each other and complete each other. The completion of a module will be done either one single examination concerning the content of all courses or the modules can be split into several sub-modules which can be examined separately. Courses are split into several *sessions*, e.g. lectures, seminars, exercises, laboratory work, project work and self-studies. Basically different sessions will lead to the aimed qualification. While lectures shall give an overview of the thematic, exercises are for practicing the content of the lectures. Seminars are rather for scientific consolidations.

In a module particular learning and teaching modes are to be described (lectures, exercises, seminars, practical work, project work, self-studies). Which courses would be important for a concrete case is a less important question. A session is divided into *Learning Objects*.

Because the production of high quality, media supported learning objects is a very cost and time-consuming process, universities and companies are searching for strategies and policies to reuse such valuable content in different scenarios and to get so called *Reusable Learning Objects* (RLO).

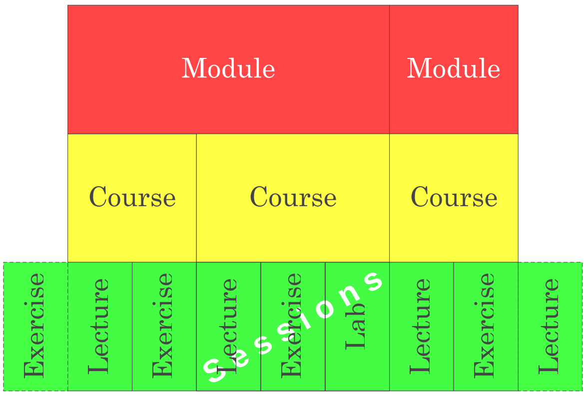

Figure 1. Modularisation of the Curriculum

B. *Reusable Learning Objects*

The following definition, taken from [6], gives a practicable description of a RLO:

"A reusable learning object (RLO) is based on a single learning objective, comprising a stand-alone collection of three components:

1. ***Content:** a description of the concept, fact, process, principle or procedure to be understood by the learner in order to support the learning objective*
2. ***Interaction:** something the learner must do to engage with the content to achieve a better understanding*
3. ***Assessment:** a way in which the learners can apply their understanding and test their mastery of the content".*

This definition fits with CISCO®s RLO-definition, shown in Figure 2, as well as with a refined model made by Uskov in [7]. The components of a RLO are called Reusable Information Objects (RIO) or Reusable Information Atoms (RIA).

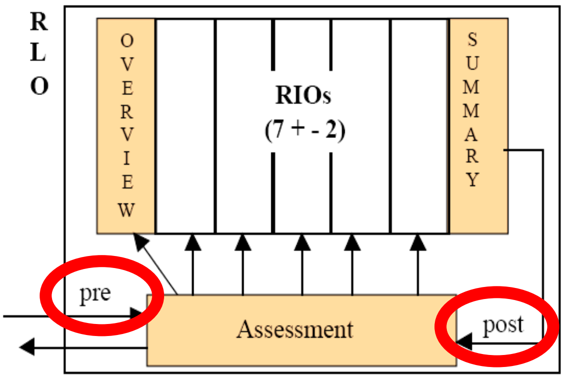

Figure 2. RLO - Defined by CISCO® [8]

Additional to this classification we would like to introduce a *pre-* and *post-test* for each RLO. The pre-test should give the user an impression if he should pass this learning object or not. It also should test if the learner has the required pre-knowledge to pass the learning object without the use of further materials. The post-test should assess the learning outcomes and give user a feeling about the level of knowledge he/she has reached [9].

For such kind of pre- and post-tests, we have developed a Web-based and database supported e-Learning *Test, Examination and Assessment System*, which will be described in the next section.

III. TEST, EXAMINATION AND ASSESSMENT SYSTEM

A. *Requirements*

During the development of the *Test, Examination and Assessment System* priority was given to platform independence. The system should be usable from any place at any time by different users with different system properties. Beyond that there should be the possibility to integrate this system into Learning Management Systems (LMS). At various universities there have been established diverse LMS. While planning the *Test, Examination and Assessment System* we choose not to implement mechanisms for a special LMS. Therefore a realization as Java-applets was selected as common platform offering the chance to use the system stand-alone without Internet connectivity in addition.

The *Test, Examination and Assessment System* is generally to be used for examinations (e.g. entry test for online labs). Furthermore it should allow exercising learning content anonymously (which means without any login procedure and grading). Tasks and working modes should be managed by database support.

An assessment happens either by displaying the correct results (during *exercise* mode) or by calculating a mark (during *examination* mode).

During the implementation of the *Test, Examination and Assessment System* great importance was attached to the

- reuse of the applied methods and tools for similar problems,
- reuse of the developed software modules,

what finally leads to synergy effects in the production process of different test and assessment tools.

B. *Architecture*

The *Test, Examination and Assessment System* essentially consists of the following components (Figure 3):

the test system *AWiP*[1] itself,

a database supported *Collection of Tasks*,

the *Task Assembler* and

an *Administrator* Tool.

For a detailed description of the whole system, see [10,11].

AWiP is realized as a Java-applet using PHP scripts for file handling. The core is an interpreter module for the segments of the task collection. All task segments consist of a label to specify the type followed by the content (text, image, applet etc.). All tasks follow a simple syntax and are completely text file based. That's why it is possible to process these files by any editor (offline as well). This is

[1] AWiP stands for „**A**pplet zur **W**issensüberprüfung **i**m **P**raktikum" - in English: an applet for knowledge testing in laboratory courses.

an important advantage compared to integrated QTE[2] editors of Learning Management Systems (LMS) [12]. Required attributes and metadata were determined by performing an analysis of demands and use cases [13].

Another feature is the possibility to modify the system for different requirements (e.g. different courses of study, lectures and labs) without any change of code.

For the administration of all data the data bank MySQL 5.0 was chosen. The complete system is implemented multilingual.

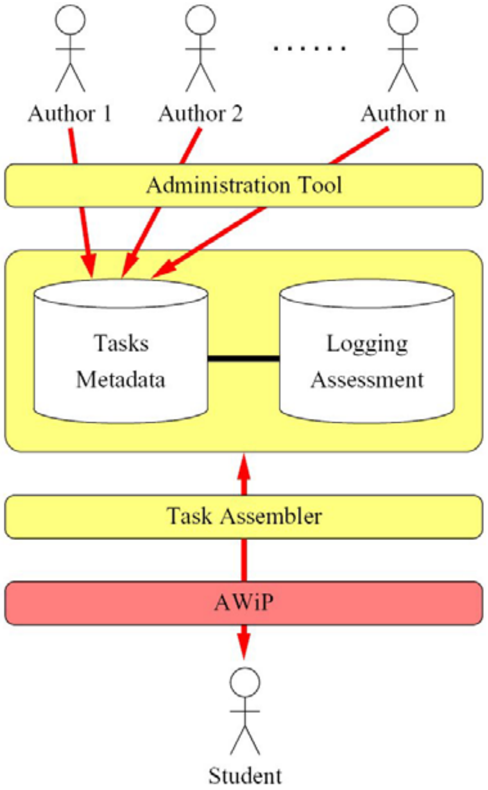

Figure 3. Components of the Web-Based Test, Examination and Assessment System [7]

C. *Supported types of tasks*

The *AWiP* system provides tasks from a (randomly selectable) task collection and performs an evaluation of the student's result. The student can solve these tasks in any order and is able to interrupt his work for a certain time.

At present the following types of tasks are implemented:

- Multiple Choice tasks (see Figure 4)
- Cloze tasks (see Figure 5)
- Applet tasks (see Figure 6).

The concept for the whole system is built in a way that new types of tasks can be implemented in perspective by using simple and common available text editors. It is also possible to place additional graphics in between the text of the tasks (see Figure 4).

Every task collection of the *Web-based Test, Examination and Assessment System* consists of a simple text file separated in one or more segments. Each segment begins with a type identifier in square brackets. A single task collection can contain any task of different types.

The multiple choice task, shown in Figure 4, is derived from the following source code segment:

```
# Example for a Multiple Choice Task
[text]
Given is the following schematic:
[image]
mc_analyse_08.gif
[choice]
Which of the following expressions
represent this circuit network?
- (/(x1&x0)+ /(/x2&x1&/x0) +
(/x2&/x1&/x0))&x3
+ x3
+ x3&/x1 + /(x2&x1) + /x2&/x0
- (/(/x1&x0) + /(/x2&/x1&/x0) +
/(x2&/x1&/x0))&/x3
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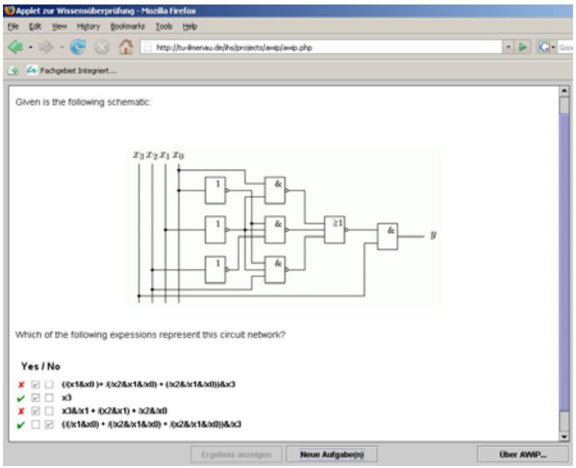

Figure 4. AWiP Example for Multiple Choice (with Check)

and the cloze task in Figure 5 is generated by:

```
# Example for a Cloze Task
[cloze]
A $$combinational$$ circuit is
designed using $$logic gates$$ in
which application of inputs generates
the outputs anytime.
A $$sequential$$ circuit is designed
using $$logic gates$$ and $$memory
elements$$ known as $$flip-flops.
```

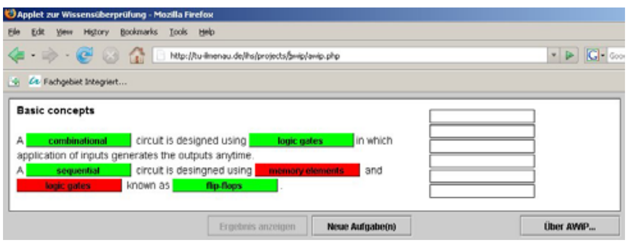

Figure 5. AWiP Example for Cloze Tasks (with Check)

Actual Learning Management Systems (LMS) include mainly tools for authoring multiple choice or cloze

[2] **Q**uestion and **T**ask **E**ditor

questions and the like. Those questions base on yes/no decisions and cover only the lower levels of learning objectives. Concerning to the RLO structure shown in Figure 2, in the following we want to give an example of a learning object tailored to special purposes of the educational process. Core of the learning object is an applet that we have discussed in former publications (see e.g. [9]). This applet follows the concept of “Living Pictures” where the big picture (a summary of a lesson) leads to the highly inter-active user interface of the learning object [14]. Based on such an applet we have derived a number of interactive tasks the students can use for an initial, intermediate or final assessment of their knowledge. These kind of interactive tasks give the students a greater variety of answers as the multiple choice and cloze tasks (discussed above) and thus a deeper understanding of the learning subject.

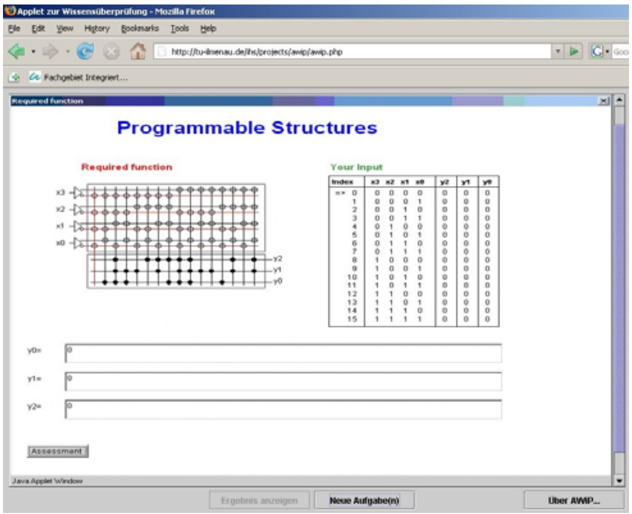

Figure 6. AWiP Example for Applet Tasks

To derive such interactive tasks the simulation component of the “Living Picture” was modified by a programmer. This kind of reuse requires special knowledge about the program code as well as appropriate programming skills and tools. The applet was modified to write the simulation results in a separate data structure instead of displaying results of experiments immediately. In this way, most of the code of the applet could be reused. Only components for task generation and assessment have to be added.

Figure 6 gives an example where the function[3] is generated in the form of a programmed ROM structure (“Required function”). Thus the students’ job is to analyze the programmed structure and to find out which values in the truth table have to be set to the value “1”. For this task the truth table is clickable and the values of the output functions y2 … y0 can be changed by simple mouse clicks (“Your Input”).

If the student has found a solution he/she can get an assessment of the solution by clicking the appropriate button. The program counts the faulty output values and gives a feedback, showing the differences between the required function and the students’ solution in the required view.

D. *Supported working modes*

The following working modes are supported at the present time:

- **Offline Test**

  Here the student can generate a collection of tasks suited for his requirements by using the *Task Assembler*. Later he is able to solve the given tasks and get an assessment of the results without Web support by using only the *AWiP* test system.

- **Online Test**

  In this case the student gets a collection of tasks either randomly or suited for his requirements but automatically generated by the *Task Assembler*. He can process this task collection online and gets an assessment for by the *AWiP* system corresponding to his answers.

- **Examination**

  During examination mode a log file will be generated automatically in the background that will record the actual state of the student's work. That's why a login procedure (with name and student ID) is required at the beginning of the examination. After that the student is given his task collection to be processed in a given time in any order. When all tasks are solved (or the time limit is over) the resulting mark will be calculated (via a comparison with an existing list of marks) and displayed. As a proof the student will get a certificate with relevant data (course, name, student ID, mark, date).

  While the *AWiP* system is in examination mode it can only be closed by a tutor (the supervisor in the examination room) using his admin password. During this closing procedure the created log file will be removed. If there is an unexpected break (without admin password) the exact state before the termination will be restored during an *AWiP* restart.

IV. Conclusion

A universal *Web-based Test, Examination and Assessment System* has been discussed which can be used for examination preparation as well as for examination within a lab course including the ability for both local and Web-based remote access. Within the *Joint European Master Degree Program “Remote Engineering”* it is increasingly necessary to allow and organize a shared use of equipment. Therefore, main focus is a Web-wide usage of the discussed system.

Using both, online tool support and laboratories, has the potential of removing the obstacles of cost, time-inefficient utilization of facilities, inadequate technical support and limited access to design and laboratory resources. This also would benefit students and researchers with special needs and students/researchers working from home. Even students/researchers working at their university's facilities can use specialized remote equipment at another university without travelling [15]. Students will learn more about the possibilities and limits

[3] For this example: 2^16 possible functions combined with 3 output variables and 3 different views

of remote control and observation dealing with practical examples via Internet. The student - besides achieving a knowledge consolidation by design and practical experiments using these new Internet technologies - is forced to estimate the technologies critically.

The kinds of assessment possibilities described in section 3 differ in the variety of possible answers as well as in the effort to produce new tasks. Inside the domain "Programmable Structures" the described method is very comfortable because a very big amount of tasks (2^16 possible functions combined with 3 output variables and 3 different views) can be generated automatically. To generate such an amount of multiple choice questions in the way described in section 3 all variants have to be written in extra text files, a very boring job!

But if we leave the domain of "Programmable Structures" another "Living Picture" has to be varied in the way described in section 3 by a skilled programmer. Thus booth ways have their own advantages and disadvantages and at least the available capacities for the development of reusable learning objects decide, which way can be gone.

Actual Learning Management Systems (LMS) include mainly tools for authoring multiple choice or cloze questions and the like. Those questions base on yes/no decisions and cover only the lower levels of assessment. The mentioned design tasks in high-level courses (see section 1) themselves require advanced knowledge up to the synthesis level. Assessing such a level of knowledge in a Web-based learning scenario is very difficult and not supported in usual LMS.

That's why, we plan to combine interactive learning objects with hands-on experiments - a solution of a Remote Lab that is connected to a LMS and is able to proof the students design. Stepwise the students get feedback about errors in their design. The principle is as follows: The students download a design to the Remote Lab Server and while the students' solution is running, each step of the control algorithm is compared with a prototype-solution. In case of an error, the LMS gets an input. This input can be used to inform the student and asses the students' solution.

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REFERENCES

[1] MARE: Joint European Master Degree Program "Remote Engineering", http://mare-project-org.server13031.isdg.de

[2] K. Henke and H.-D. Wuttke: *Network based Educational Design Tool*, International Conference on Information Technology Based Higher Education and Training - ITHET03, APRIMt Press, July 7-9, Marrakech, Morocco

[3] Digital Logic Design - Case Studies - http://www-ihs.theoinf.tu-ilmenau.de/projekte/gift/case_study, Technical University of Ilmenau, 2006

[4] K. Henke and H.-D. Wuttke: *Web-based design and training tools*, World Congress on Engineering and Technology Education, Guaruja/Santos, Brazil, 14.-17. March

[5] K. Henke and H.-D. Wuttke: *Web-based educational tool access*, Computers and Advanced Technology in Education, ACTA Press, June 30 - July 02, 2003, Rhodes, Greece

[6] D. Leeder, T. Davies and A. Hall: *Reusable learning objects for medical education: evolving a multi-institutional collaboration*, Retrieved January 23, 2005, from http://www.ucel.ac.uk/documents/docs/068.pdf

[7] V. Uskov: Design, development and teaching of innovative Web-based introductory "Computer Information Systems" course, Frontiers in Education, 2002. FIE 2002. 32nd Annual Conference Volume 3, 6-9 Nov. 2002 pp. S1E-13 - S1E-18

[8] CISCO, Reusable Learning Object Strategy - Definition, Creation Process, and Guidelines for Building, http://www.reusablelearning.org/Docs/Cisco_rlo_roi_v3-1.pdf

[9] H.-D. Wuttke and K. Henke: *Pre- and Post-Tests for Reusable Learning Objects*, e-Learning Conference, Coimbra, Portugal, 7.-8. September, 2006

[10] K. Henke.: *Web-based test, examination and assessment system.* International Conference: Computers and Advanced Technology in Education. ACTA Press, Lima, Peru, October 4-6 2006.

[11] Wagner, N.: *Computer Aided Test*, Study Thesis, Technical University of Ilmenau, 2006

[12] E. Gouli, H. Kornilakis, K.A. Papanikolaou and M. Grigoriadou: *Adaptive Assessment Improving Interaction in an Educational Hypermedia System*, Human Computers Interaction 2001, Panhellenic Conference with International Participation, Patras, Grece

[13] N. Ludwig: *Learning Environments for Remote Labs - Concept und Realization*, Master's Thesis, Technical University of Ilmenau, 2005

[14] H.-D. Wuttke and K. Henke: *Living Pictures – tool-oriented learning modules and laboratory for teaching digital via internet*, International Conference on Engineering Education UMIST, Manchester, Great Britain, August 18-22 2002

[15] K. Henke and H.-D. Wuttke: *Technologies for virtual and remote labs in the educational process*. Computers and Advanced Technology in Education, ACTA Press, Kauai, Hawaii, USA, 16.-18. August

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