THE EXPERIENCE WITH UNCONVENTIONAL AUTOMATED KNOWLEDGE ASSESSMENT IN MOODLE ENVIRONMENT

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Abstract

This contribution presents a knowledge assessment approach developed for support of Specification and description languages course. The main goals of this course include the skills in digital systems modelling using HDL (Hardware Description Languages), namely VHDL and SystemC. Similarly to the courses devoted to programming languages, the course assessment in this case should concentrate not only on testing the theoretical knowledge but also the practical skills the students gained. Obviously the previously used written form of exam using pen and paper is not very convenient when evaluating students' practical skills. So does the traditional on-line test. The assessment approach presented here enables to create unconventional on-line tests supporting various HDL and programming languages. It was designed as an extension to Moodle Learning Content Management System and was already used to prepare the midterm tests in VHDL, SystemC and Assembly language. The results of these tests were evaluated in comparison to other types of test and also the series of inquires among student concerning the test types were organized to see the problem from other point of view. The results and experience of these evaluations are presented too.

Keywords: knowledge assessment, VHDL, SystemC, assembly language, Moodle, Drag&Drop technique.

1 INTRODUCTION

In 2007, Faculty of Informatics and Information Technologies, Slovak University of Technology received a grant in Hewlett-Packard Philanthropy grant initiative, 'HP Technology for Teaching'. The purpose of this initiative was to support leading university educators in their efforts to redesign core courses in a way that positively impacts student learning through the innovative use of HP mobile technology. The project, supported by this grant was called Mobile Education Center [1]. Application of modern technologies became a new possibility to change teaching and learning process. The established Mobile Education Centre permitted using the novel HP mobile technology to introduce new ways of giving the lectures, practicing, as well as to improve the course assessment methods. Among the main project goals was the course redesign of Specification and description languages course. The aim of this course is to give the students knowledge and skills in the fields of formal specification and modelling of digital systems. The student should gain knowledge and practical skills in using HDLs (Hardware Description Languages) – VHDL, SystemC, and Handel-C as well as Petri nets to design digital systems models. The course assessment was divided into 3 parts: lab assignments (40 %), midterm test (20 %), and final exam (40 %). During the term the students elaborate individually four lab assignments that are checked and evaluated by lab teachers. Despite of the fact that the assignments evaluation is very demanding and time consuming work there are also several reasons why it is not always possible to ensure the lab work assessment objectivity (plagiarism, attitudinal / subjective assessment by different teachers, etc.). As a result, some students do not reach the required knowledge and practical skills, even though they gain the highest grades for lab assignments. The midterm test and final exam used to be done in written form using pen and paper (further pen&paper test). We believe the pen&paper test gives the minimum chance for cheating and therefore provides objective and fair assessment. On the other hand there are number of disadvantages concerning this type of exam, especially when students' practical skills were to be evaluated:
• The students have no chance to prove (check) their designs before sending them for evaluation.

• This type of exam does not allow verification of student’s ability to debug the created model, which is substantial part of student’s practical skills.

• What is more, pen and paper works require a lot of time and effort to read and correct. As a result students have to await the exam results for relatively long time (depending on the number of examined students).

Obviously the previously used written form of exam is not very convenient when evaluating students’ practical skills. However, the on-line tests based on the traditional types of questions are also difficult to use for this purpose. The specially designed computer based applications/tools suitable to examine student’s designing and programming skills can bring more objectivity into the course assessment at the time saving the teacher’s work and time. Ideally the applications should allow automated, real, and fair evaluation of student’s work.

2 RELATED WORK

Although hardware description languages are not actually programming languages there are similar issues concerning the process of learning skills or getting knowledge. To acquire programming or modelling language it is no use to memorize language constructs or exact syntax without writing any program. On the contrary the students should solve as many problems as possible using the language [2]. This is usually the task of lab exercises were students get sets of assignments to solve at school or at home. To make students work individually on the assignments they should be allocated more or less individually to the students. Sometime it is almost impossible to prepare unique assignments packet for each student, especially in big courses. What is more, to prevent plagiarism, the assignments packets should not be used repeatedly at least in the adjacent school years which is also difficult to comply with. Another issue is the programming assignments assessment. To assess them manually is quite a challenge for lab teacher who should determine to what extent the requirements were met by the solution, to evaluate programming style, as well as to consider the originality of the solution. Systems that automatically assess student programming assignments have been designed and used for over forty years [3–7].

There is other possible viewpoint: to give the students possibility to master the language by means of solving some assignments and to measure their knowledge and skills progress by means of skills-based tests. However the programming knowledge and skills assessment, whether it is assembly or higher level programming language, is another issue that have been simultaneously researched and developed for many years [8–13]. Most of the developed software Infrastructure is language dependent and can not easily be adapted to different language. What is more, HDLs are not as widespread as programming languages e.g. C or C++ therefore the list of available supporting tools is very limited.

This was the main motivation, why we concentrated our work primarily on using HP technology to enhance course assessment. In order to make the course assessment process more objective, fair and effective, there was an urgent need for assessment redesign. One of the solutions assumes that the substantial part of the course assessment will be shifted from the assignments to the skills based midterm tests. At the same time, new testing and assessment applications will be developed to perform the exam and midterm tests. The new applications, specially designed for this purpose, will enable to evaluate not only the knowledge, but also the skills, all in an automated manner.

Nowadays there is a common practice to use LCMS-type (Learning Content Management Systems) e-learning tools for course management, study materials creation, presentation, and management, as well as assignments and tests management. Most of the LCMS support only traditional types of test questions like multi-choice, True/False, gap filling, matching etc. for on-line tests development. These types of test questions are difficult to use when for example programming skills are to be evaluated. The LCMS Moodle [14], one of the most widespread and favourite environments, belongs to this number. Moodle is open source system, so it offers the possibility to implement specialized question types for example in the form of new modules or activities. The modules should support the effective way of writing or composing the source code and should also make the evaluation of these practical tests easier.

Several unconventional assessment applications were developed for this purpose [15–19] and incorporated into the assessment process at the Faculty of Informatics and Information Technologies,
Slovak University of Technology Bratislava. The tools published in [18,19] were devoted to SystemC modelling language. TabletPC testing system [20, 21] is client-server application that was primarily developed for VHDL and up till now was used only with this language. However, after some changes it should be applicable to other HDL or programming languages as well. The special VHDL testing module, presented in [22], is one of the latest solutions, suitable for online skills based examination. The module is integrated into the Moodle LCMS and was already used in course assessment process. Petri Net Educating Tool [23] was specially developed for assessing knowledge and skills in Petri net modelling. The tool we are going to focus upon in this paper is called Drag&Drop activity [24] and was also integrated into the Moodle LCMS. This is the only tool that is not bound to a specific language but can be used with any programming or modelling language.

3 DRAG&DROP MOODLE ACTIVITY

This testing system is the web application that was designed as an extension of an existing application Moodle Content Management System [14], improving thus the Moodle assessment capabilities. The application is based on Drag&Drop technique. The Drag&Drop activity is suitable for testing knowledge and programming skills not only in the area of HDL languages, but is fully functioning with any other (programming) language.

3.1 Activity creation

The assignment creation starts from the working design or program, prepared by teacher outside the system in a development environment, specific to selected language. This ensures the correctness of the solution. The teacher then decides and marks in the source code, which rows will be excluded from the code and replaced by the gaps. The tags <droper> and </droper> are used for this purpose. This program code is the main input of Drag&Drop activity. An example of source code in assembly language prepared for activity creation form is given in Fig.1. Only the whole rows can be

```
MAXLENGTH DB 10,13,'Zadaj retazec'
ULOHA_D:
mov dl,[di]
cmp dl,znak
jnz ULOHA_NENASIEL
inc bx
ULOHA_NENASIEL:
<droper> inc di</droper>
loop ULOHA_D
<droper> cmp bx,0</droper>
jz KONIEC_ULOHA_CHYBA
vypis vysledok1
mov dx,bx
<droper> add dl, 30h</droper>

Fig. 1 An example of source code in assembly language prepared for activity creation
```
chosen for exclusion, part of the line exclusion is not supported. However, any number of rows can be excluded from the code. This gives the teacher the possibility to prepare the test on various levels of difficulty.

The Drag&Drop activity is created in the same way any other activity can be created in Moodle LCMS. After importing the source code into the Drag&Drop activity, the excluded rows will appear on the right hand side of the teacher’s screen (Fig. 2), in the part marked [[codebox]]. These rows are also highlighted in the original code, displayed in left hand side window. By default each row has the weight 1. There is the possibility to change the weight to any positive integer number to make some of the excluded rows more important. In case the same statement was excluded from the source code for several times it will appear in the codebox only ones but the multichoice checkbox next to the statement will be checked. However, the teacher can check any number of checkboxes to make the statement stay on the place after being used to replace a gap.

![Fig. 2 Teacher's screen example: Activity editing screen](image)
The correct possibilities in the [[codebox]] can then be enriched by any number of incorrect/confusing statements, displayed in the part marked [[fake_codebox]]. This allows to make the test even more demanding. The correct and incorrect statements are then mixed together and presented in one pool, were students will pick out the rows to replace the gaps in the code.

### 3.2 Activity solution

The student interface used to solve the activity can be seen on Fig. 3. On the right hand side there is the pool of statements. The student should choose the correct statement from the pool, drag it from the pool and drop it above the gap (green rectangles) in the code on the left hand side. The selected statement will replace the gap.

![Student interface example](image)

**Fig. 3**  Student interface example: Solving the activity screen

### 3.3 Activity activation, closing and finishing

Unlike other testing activities in Moodle, the Drag&Drop activity can not be planned for automated activation on specific day and time but a teacher has to activate it manually. The activity can be in one of four states: scheduled, active, closed and finished, as illustrated on Fig.4. When created the activity
is automatically in the state scheduled and visible to students, although they can not solve it yet but to see the assignment leading text. To start the test a teacher must activate the scheduled activity. While it is active the students can repeatedly send the solution for grading and continue solving it. Of course, just like other activities in Moodle a teacher can hide it at any time making thus the activity not visible for students. When hiding an active activity the students will be able to finish their solutions and send them for grading but the activity will not be available for solution any more. To grade the solutions the activity must be closed. After finishing the activity the corrected code can be made available to students through revealing the hidden finished activity.

3.4 **Viewing the results**

After closing the activity the teacher can see the list or students' grades that is illustrated on Fig. 5. The test attainment is given in the form of number of gained points and also achievement in percentage.

![Fig. 4 Activities in different states](image)

After clicking on the assignment name below the student's name the teacher can review the corrected solution of the specific student. The form is similar to that given in Fig. 6 that is available for student. The correctly placed statements are displayed in green rectangles and the incorrect one in red rectangle.

![Fig. 5 List of students’ results available to teacher.](image)
4 ASSESSMENT RESULTS

The testing applications were designed and implemented in the frame of course Team Project. The development of these applications still continues, but at the same time we started to use the applications in the course Specification and Description Languages to evaluate students’ practical skills during the midterm tests, as well as exam.

4.1 Testing the skills in VHDL

The course assessment redesign in the frame of HP Technology for Teaching project implementation started in academic year 2007/2008. In the first period, the pen and paper tests were partially replaced by online tests. This was especially due to the fact, that traditional pen and paper tests require a lot of time to correct and evaluate.

This change resulted in a big increase in number of students that were successful in the course from 53.41% in school year 2006/2007 to 92.59% in 2007/2008 – that means about 40 % increase.
Unfortunately this did not reflect the increase in students' knowledge. It has just proved, that in spite of various types of questions (including multiple choice single and multi answer, true-false questions, cloze questions, missing words questions etc.), used to make the test more demanding, the online exam was much easier then the pen and paper one. The course attainment is illustrated by the diagram given in Figure 6.

In the second phase, the two new assessment applications were involved in the examination process - testing system called TabletPC and Drag&Drop Moodle activity. As we can see, the number of successful students in the course was reduced to about 70 %, giving thus the more realistic image about the students’ knowledge. We can say, that the first results have proved, that these kinds of online tests are more suitable for skills based examination in the area of digital systems modelling, when compared to the commonly used online tests.

If we compare the distribution of students' results (Figure 7) in the 3 academic years, we can see that

- In academic year 2006/2007, when only pen and paper tests were used in assessment process, there were very few students with the result A, B and C – about 5.5%. Most of the successful students – 30% reached only the result E.
- In academic year 2007/2008, when the pen and paper tests were mostly replaced by traditional on-line tests, most of the successful students reached average results C or D – about 65%. This is quite nice distribution, although not horizontally symmetric, but the overall number of successful students, over 92 %, is too big to reflect the students’ skills and knowledge realistically.
- In academic year 2008/2009, after replacing part of the traditional on-line tests by improved on-line tests, most of the successful students reached the result D – about 28%. In this case the distribution is slightly shifted to the right, but represent almost ideal Gaussian curve.

In academic year 2008/2009 the two new assessment applications were involved in the examination process - TabletPC testing system and Drag&Drop activity.

There were 3 midterm tests, forming together 30 % of overall course assessment.

The final exam formed 40 % of overall course assessment and was divided into 2 parts: traditional on-line test – 30 %, and practical exam – 10 %.

The rest of the overall course assessment – 30 % falls on individual Lab work of students, evaluated by lab instructors.

During the 3 midterm tests and practical exam the students were divided into groups in such a way, that each of the students was doing 1 Pen&Paper test, 1 TabletPC test and 2 Drag&Drop tests. In each test there was one assignment presented in 2 or 3 different ways. So theoretically, the severity of each version of the same test should be similar.

In the chart, given in Figure 8, we can see the average attainment of the tests. The attainment of Drag&Drop test and TabletPC test are similar to each other. When compared to Pen&Paper test the results are not quite distinctive. The reason is probably the fact, that the groups were not quite balanced. For example the group #3 that started with TabletPC test, did Test2 in Pen&Paper version and Test3 in Drag&Drop version. The results of this group are similar in all 3 versions.

The group #1, that started with Drag&Drop test, did Test3 in Pen&Paper, but during the Test2 they were combined with part of group #2 (Pen&Paper group) to perform Test2 on TabletPC.

In general, the exam tests have lower attainment then the midterm tests. This was given by the fact, that most of the students needed just a few points to finish the course successfully, so they did not worry much about the exam attainment.

4.2 Testing the skills in SystemC

4.3 Testing the skills in Assembly language

The course assessment redesign in the frame of HP Technology for Teaching project implementation started in academic year 2007/2008. In the first period, the pen and paper tests were partially replaced by online tests. This was especially due to the fact, that traditional pen and paper tests require a lot of time to correct and evaluate.
5 STUDENTS RESPONSE

During the term the students attended each type of test. After the final exam, the series of inquiries among students have been done. The valuable data have been collected and based on students’ feedback we are trying to incorporate some important enhancements into the applications. Here are some of the obtained data and resulting conclusions.

For inquiry question “Which type of testing approach was the most suitable?”, most of the students designated the traditional on-line test as being the most convenient. This type of test was oriented mainly to theoretical knowledge and therefore was the easiest one for students. On the other hand among systems oriented practical knowledge testing, they selected the TabletPC testing system as the most suitable one. This was due to possibility of compiling and simulating source code before the test submission. Moreover, in this application the syntax highlighting editor is incorporated that makes the model development easier.

After the test students were asked several key questions. The answers to these questions are shown in Fig. 6. As we can see, most of the students think that the Drag&Drop test, composing a model from given statements, is the best way of testing practical skills.

![Survey results](image)

6 CONCLUSIONS

The presented results prove, that this kind of course assessment provide more realistic image about the students’ knowledge in the area of digital systems modelling, compared to the commonly used in online tests. The results of TabletPC tests as well as Drag&Drop tests activity are comparable to previously used pen and paper tests. What is more, these testing applications bring number of other advantages compared to pen and paper tests. Firstly, there was the substantial reduction of time spent teacher to evaluate the tests. Secondly, the presented testing methods enable to evaluate not only the knowledge of students but also designing skills, the ability to debug their design, and even the student’s creativity, which was previously not possible. Finally, the students can profit from the possibility to verify their designs before submission.

The first results prove that the kind of online test described previously provides more realistic image of student knowledge of digital systems modelling, compared to tests based on the types of questions commonly used in online tests. Because the VHDL Moodle test requires creativity by students, the test results are worse compared to the Drag&Drop test.

The presented testing solution brings number of advantages. First, there is a substantial reduction in the demanding and time consuming work of the teacher, relative to paper exams correction. At the same time, the level of difficulty of the exam is preserved. Second, it enables the teacher to check the skill of students in the area of model debugging, which was previously not possible. All participants in the examination have at their disposal a source code editor with syntax highlighting, a VHDL language compiler, and simulator outputs. The application gives the teacher a means to comfortably manage the testing system. Finally, the students have the opportunity to verify their designs before sending them for evaluation.
ACKNOWLEDGEMENT

This work was partially supported by Slovak Science Grant Agency (VEGA 1/0649/09 “Security and reliability in distributed computer systems and mobile computer networks”) and HP Technology for Teaching grant 2007 “Mobile Education Center”.

REFERENCES


