Reusability and Adaptivity of a Web-based Boolean Axioms Application

Vladimir Mateev, Heinz-Dietrich Wuttke

Abstract: *A Web-based application, called Virtual Instrument, concerning Boolean axioms, is presented in the article. The instrument can be used for self-education and for self-testing, both in three languages: Bulgarian, German and English. In the self-education mode it possesses adaptivity – the process of self-education last shorter, when the user knows more and learns quickly and last longer, if the user hasn't got enough knowledge or learns slowly. A measurable Learning Ability Coefficient has been discussed.*

Key words: *Web-based education, Reusable Learning Objects, Adaptivity, Boolean Axioms, Applets, Learning Ability.*

INTRODUCTION

The process of virtual educational areas development is accompanied with the creation of expensive and labour-consuming high-quality software educational modules and it is very important to make it possible to reuse this modules many times in different educational scenarios and for different users. Resources, usually digital and web-based, that can be used and reused to support learning, are called learning objects. The creation of reusable learning objects will reduce teachers' efforts in the organization and conducting the educational process.

The qualitative preparation of the future engineers in the area of digital electronics requires them to know very well and to use firmly the Boolean axioms. Thus an application that can help them to learn axioms will be pretty useful.

The subject of the presented work is a Web-based application, called virtual instrument, for learning and testing Boolean axioms that can be used with different languages (Bulgarian, German and English) in different educational scenarios (learning and testing) and that has a kind of adaptivity concerning the duration of education according to the students' knowledge. The instrument is realized like a Java applet and has graphical user interface. One of the purposes of the instrument is its integration in a Digital Logic Design Virtual Laboratory (DLDVL), which is under construction and usage at Rousse University "A. Kanchev" [2, 3].

LEARNING OBJECTS AND REUSABILITY

In the last decade there have been considerable efforts in the computer mediated learning field towards standardization of metadata elements to facilitate a common method for identifying, searching and retrieving *Learning Objects*. The term *Learning Object*, first popularized by Wayne Hodgins in 1994, has become of great importance in the area of content creation and aggregation in the computer-mediated learning field [4]. The terms *Learning Objects* (LOs) and *Reusable Learning Objects* (RLOs) are frequently employed in uncritical ways because of a serious lack of conceptual clarity. That leads to the existence of a number of definitions and uses of LOs:

Wiley defines a learning object as "any digital resource that can be reused to support learning" [6].

A more precise definition of reusable learning objects can be found in [1], which is the following: "A reusable learning object (RLO) is based on a single learning objective, comprising a stand-alone collection of content, interaction and assessment".

The next definition is given by CISCO: RLO is a larger structure produced by a combination of individual reusable information objects (RIOs). Reusable information objects are self-contained chunks of information built around a single learning objective.

According to Uskov [5] "RLO is a collection of reusable learning atoms that are grouped together to teach a common task based on a single learning objective". A Reusable Learning Atom (RLA) is an elementary non-dividable piece of learning that is built upon a single learning objective.

A new way to classify RLOs is proposed in [7] according to 3 different levels of reusability:

1. Hard-RLO is a learning object that can be reused by means of using it "as it is". Hard-RLOs are executable and tested and guarantee a well-defined functionality.

2. Soft-RLO is a learning object that is offered as source code and can be adapted to the requirements of a user.

3. Firm-RLO is a learning object that is characterized by the following properties: • The source code is not available. • Their properties can be changed in relation to some predefined properties. • All changes affect only new features but they do not influence the previous defined functionality and behavior of the RLO. • If users make changes, they are fully responsible for the result of their changes but all other features of the RLO are still guaranteed.

Pre- and post-tasks as reusable learning objects are discussed in [8].

BOOLEAN AXIOMS

In a Boolean algebra there are defined 2 constants, 0 and 1 (FALSE and TRUE) and 3 operations – conjunction (“.”), disjunction (“V”) and complement or negation (“’”). The results of these operations over Boolean constants are given by the Boolean axioms:

0 . 0 = 0; 0 . 1 = 0; 1 . 0 = 0; 1 . 1 = 1; 0 V 0 = 0; 0 V 1 = 1; 1 V 0 = 1; 1 V 1 = 1; 0’ =1; 1’=0

They are something simple, but very important and must be known firmly.

INSTRUMENT’S ARCHITECTURE

There are 3 main entities involved in the process of education – an expert, an educator or teacher and a student. The expert keeps the knowledge, the educator organizes the process of education and the student learns. Following this approach, the instrument has the corresponding 3 modules: 1) an expert module with tasks and their decisions or ability for decision; 2) an educational module that prepares task for the student, appreciates student’s decisions and organizes the educational process; and 3) a student module that contains student’s information about student’s knowledge and presentation.

How these three modules are involved in the Model-View-Controller architecture of the virtual instrument can be seen in Fig. 1.

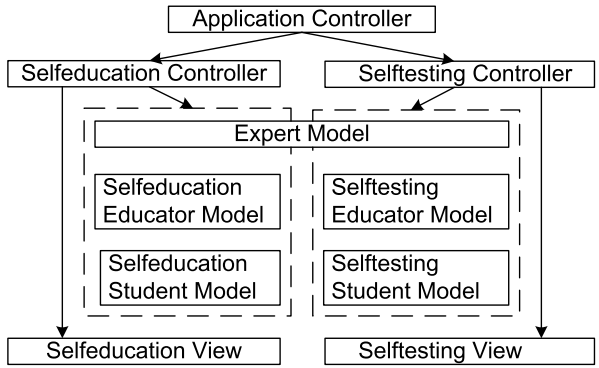


Fig.1. Model-View-Controller architecture of the virtual instrument

INSTRUMENT'S REUSABILITY AND ITS ACHIEVEMENT

The instrument can be used as tool for self-education or self-testing both in Bulgarian, German and English languages. The default language can be defined in advance, when the web-developer incorporates the instrument, realized as an applet, in an appropriate web-page and can be changed by the user during a session. The instrument can be integrated in a page in a way, giving the user the possibility to choose the language or the mode of the instrument (for self-education or self-testing) or both. All this possibilities are achieved by means of two applet's parameters – type, which values are "self-education" and "self-testing" and language with values "Bulgarian", "German" and "English". According to [7] the application can be considered a Firm-RLO.

ADAPTIVITY OF THE INSTRUMENT IN SELF-EDUCATION MODE

The control of the self-educational process, realized by the instrument, can be presented as a directed graph, shown in Fig.2. The tasks are classified in 4 categories - declared, additional, control and additional control tasks. The education starts with a number of declared tasks, desired by the user.

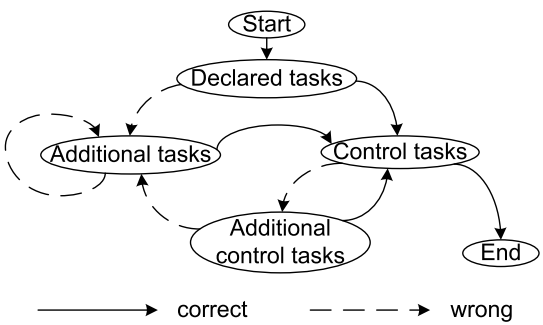


Fig.2. Self-educational process

The number of control tasks is always 10 and the user must decide all of them with no mistake in order to finish the education. Solid-line arrows show the way in case that all corresponding tasks are decided correctly. If there is even one Wrong decided task transitions are shown with dashed-line arrows. For every wrong decided declared task the user has to decide one additional task. For every first wrong decided additional task the user has to decide the same task again and if the decision is wrong again, the user must decide the wrong task again, but two times. At a mistake, again the same task must be decided 3 times and so on. When a task is decided wrong, the user gets as feedback the correct decision and can learn it.

LEARNING ABILITY COEFFICIENT

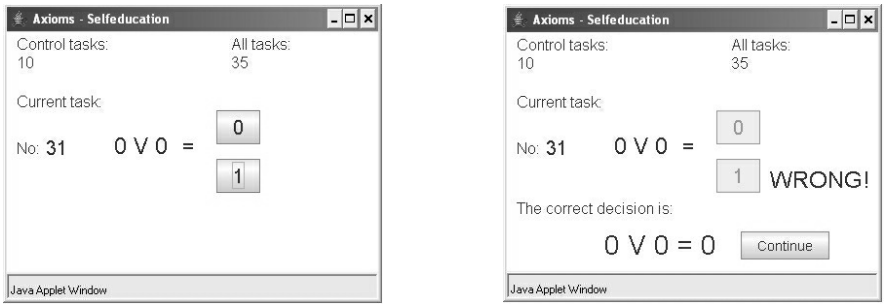
The "learning ability of a person" evaluates the person's ability to do an action with no mistakes, once he/she has learned it.

The coefficient is defined for a person who has to make the same action at least 2 times. If a person does an action only one time and does it correct, maybe he/she knows it. If a person is doing an action many times and every time correct we suppose that the person knows it. If a person does an action for the first time wrong, learns the correct way of doing it and when he/she has to do the same action again and again and does it correct we suppose that the person has learned the action firmly, i.e. has a big learning ability. If it is supposed, a person has learned something, but a bit later he/she has made the same mistake and must learn the same thing again he/she has got low learning ability.

The value of the Learning Ability (LA) Coefficient can be calculated by means of the formula: LA = ((A - B) / A).100 , where A is the sum of all actions, made after every action, and B stands for the sum of all incorrect actions, made after every action (actions that are identical, are made at least two times). The Learning Ability (LA) Coefficient lies between 0 and 100 %.

INSTRUMENT IN ACTION BY SCREENSHOTS

In Fig. 3a is shown the instrument's interface in the self-education mode. The user has to decide 10 control tasks. The total number of tasks (decided correctly or incorrectly or yet not decided) at the moment is 35 . The user has to decide in the next step the 31-st task. The decision is made by simply a click at the button "0" or "1". In Fig. 3b the user has chosen the wrong answer by clicking the button "1". A warning message "WRONG" – is given as feedback near the clicked button and the correct answer is given below. The user must click the "Continue" button in order to get the next task.



a b

Fig.3. Interface of the instrument in the self-education mode

The results can be seen in different views. One of them is shown in Fig. 4 as a table of all decided tasks during the process of education. In the "Decision" column the user can see if the given decision was wrong or correct. "Time for decision" is the duration of time from the moment the current task appears in the instruments window to the moment when the user clicks one of the buttons "0" or "1". "Time for education" starts at the moment when the user has clicked the wrong button until he/she presses the "Continue" button. The last column displays the task category.

All tasks

No	Definition	Correct answer	Decision	Time for decision, ms	Time for education, ms	Category
30	1 V 1	1	Correct	1641	0	Control
31	0 V 0	0	Wrong	169813	84062	Control
32	1'	0	Correct	7063	0	Control
33	0 . 1	0	Correct	1296	0	Control
34	1 V 0	1	Correct	1063	0	Control
35	0'	1	Correct	1172	0	Control
36	1 . 1	1	Correct	1390	0	Additional Control
37	0 V 0	0	Correct	1250	0	Additional Control
38	0 V 1	1	Correct	8244	0	Control

Java Applet Window

Fig.4. Table with all tasks, decided by the user in self-education mode

There are 2 other views for the results, "Statistic" which is not shown here and "Learning Ability" shown in Fig. 5. The number of tasks the user has to learn is 10. He/she has decided every task at least once. In this case the user has decided every task for more than two times. For the tasks 0.0, 0.1, 0V1, 0' and 1' every time the user has given the correct decision. For the tasks 1.0 and 1V0 the first answer was wrong but all subsequent answers were correct. The learning ability of the user in this case is 100 %. For the other tasks the user has made mistakes after he/she has given at least one correct answer.

The instrument can be seen at http://dldvl.hit.bg/axioms.html.

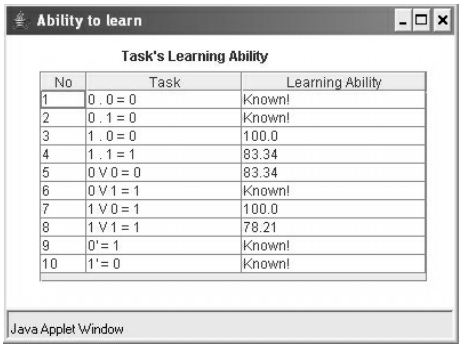


Fig.5. Learning ability

CONCLUSIONS AND FUTURE WORK

A Web-based application that can be considered a Firm RLO is presented in the article. It can be used as Boolean axioms self-learning and self-testing tool in Bulgarian, English and German languages. The self-educational operation mode of the instrument possesses adaptively a shorter duration of self-education, when the user knows more or learns quickly and longer duration, if the user hasn't got enough knowledge or learns slowly.

The tasks decided with this instrument are simple but the instrument demonstrates the architecture for a reusable and adaptable instrument for students' education and knowledge test and the same architecture can be used in instruments for more complicated tasks.

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The paper has been reviewed.

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