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KNOWLEDGE ASSESSMENT USING CAUSE-EFFECT GRAPHING METHODS

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Abstract: *This paper presents a test of the learning process that aims to check students' knowledge. Through additional activities in the learning process it's possible to check knowledge of the student, and in this paper are used activity questions and answers and multiple choice activities. It has been created a learning process that consists of a series of questions with possible answers true and false and multiple choice questions that support marking multiple correct answers. Testing will be performed with cause-effect method and the result will be shown by Cause-effect graph with defining test cases based on the obtained results.*

Keywords: *E-Learning, Distance learning, Personalized learning, Cause-effect graphing, testing software*

1. INTRODUCTION

Personalized learning allows customization of teaching material to the needs of students, participants in the learning process, depending of the shown knowledge. Applying the personalization, students are getting interactive learning process with additional activities that enables the check of student in accordance with the level of knowledge after specified domain. [4]. Student can independently check their knowledge through the activities in the learning process and on the basis of the obtained results determinate own level of knowledge. If necessary, it is possible to go through the process of re-learning and re-examination until the student is not satisfied with the results that obtained. Learning processes with additional activities affect the final outcome of learning (student's level of knowledge) and as such they must be reliable and consequently tested. In this work, the learning process with additional activities (questions and answers, multiple choices) will be tested by the method Cause-effect [3]. It will be shown well-known inputs (causes) and the expected outputs (effect, in this case the number of points of a student) from the learning process. After analyzing the obtained result will be shown corresponding Cause-effect graph with defining of test cases for different types of inputs and expected outputs of the learning process.

2. PERSONALIZED LEARNING

Learning materials used in personalized learning processes must be in the form of learning objects (small clear continent) containing characteristic metadata. Tendency towards dividing teaching materials as small learning objects makes available its reuse in various learning processes. Defining characteristic metadata for each object allows the further search of objects within the system. Professor, author of the course, when creating personalized learning process searches for learning objects where search is based on metadata (usually the level of knowledge) and puts them in the learning process.

During the learning process within the system is necessary to conduct: filtering, personalization and evaluation. Filtering involves defining the level of knowledge of the student and determining the further course of the learning process. The „Cause-Effect" technique in testing e-learning application is applied, because it is suitable for automation, as well as the fact that the test cases are extracted from the software specifications given in natural language. [2]

2.1 SYSTEMS FOR THE PERSONALIZATION OF THE LEARNING PROCESS

Students differ in their abilities, needs and profiles. The stated deviations should be taken into account when designing an intelligent learning process. In addition to the eventual evaluation given by the professor (the author of the course) it is necessary to review in detail the information available to the student after passing through the learning process. In the analysis of the student in the learning process it is also involved the context. Context represents any information obtained by the system, which characterizes the state of the entity. An entity represents a student, a place in the process of learning, object or any activity that may be relevant and as such can provide a description of the interaction between the user and the system. The information that can assist in the personalization of learning are related to the devices from which students approach to learning systems, the time required to interact with the system (number of clicks during the learning process) and the habits of students (at which time accesses to the system and goes through the learning process). During the learning process within the system is necessary to conduct: filtering, personalization

and evaluation. Filtering implies defining level of knowledge of student and defining of further course through learning process. In part of personalization specific teaching materials through the system of interface are being displayed to the student based on the level of knowledge. The last part, evaluation, implies the evaluation of students through a clearly defined task or test adjusted to the level of learning in which the student is and also to the shown knowledge. [1]

The concept of filters (filtering) is used as a modifier that can be applied to the space in which is developed a personalized learning process. In addition to defining the level of knowledge of the student it is possible to determine in which way is necessary to set up and to organize the learning process and to adapt it to the needs of the student. The concept of space represents a complete learning process. In any personalized learning process is possible to set nodes. The term nodes in a personalized learning is the formulation of the theme of the learning process, different aspects, groups of aspects and levels of abstraction. Every aspect of the context node is a sub-theme of personalized learning process. With the introduction of aspects it is enabled the formulation of themes and sub-themes within a personalized learning process with support for different characteristics of students, the manner and style of learning. [5]

Level of aspect is the importance of one aspect of the learning process. By using the level aspect it is made available the setting up of various student workload in certain parts of the learning process. In this way, by using of levels, it is possible to make the learning process so that one part is the theory of teaching theme, while the second part is based on exercises and tasks according to the theory. [6]

The system through the analysis of information about students (student model), the time spent on performing tasks, can define a group to which it shall assign the aspect with exercises and tasks. In that way, if the system evaluates that a group of students devote more time for performing of the tasks of teaching themes with the analysis, the accuracy of performed tasks, to this group of students will be assigned an aspect that will include exercises and tasks for independent work.

Interactive process. Starting from the predefined hierarchy of the course through the LMS system it is possible to create an interactive process in which students will participate (users). Interactive process enables the system to maintain student activities through the teaching process (answers to questions, most frequently opened teaching material, time spent on teaching materials) and consequently determine the manner of student learning and its activity in the teaching process. If the student spends most of his time doing tasks on the system, the system and the author of the course will have the information that it is necessary in continuation of the process to enable as many practical examples. Student has a profile in which data on the teaching process are stored, the process activities that student accesses etc. [7]

The user interface system adapted for personalized learning process communicates with the student and takes the characteristics of students (time interaction with the learning process, general information about the student, a device used for learning), and the connection between the student and the adaptive part of the system that deals with personalization.

The core of the system for support to personalized learning process deals with the creation of personalized learning process on the basis of information obtained by the students stored in a single student model. The core of the system combines teaching material and creates a learning process according to information obtained from the student model. Also, in addition to the original definition of personalized learning process based on knowledge, the core of the system continues the evaluation of the student's knowledge and the learning process that is assigned. If the system assesses that students spend too much time on the resulting learning process it shall be repeated the analysis of model student and it shall be redistributed the teaching materials and the re-creation of the learning process. In personalized learning processes the most commonly are found activities for testing of knowledge (questions and answers, tests, assignments for independent work) in order the system can assess at what level of knowledge the student is. By regular tests in the learning process is conducted an assessment of performance of learning of student within a certain theme. Automatic updating of the model student enables gathering information in the system on student activity within the learning process. Updating the student model after each access to the learning process is obliged in order of holding the right information in the system. If the student demonstrates a higher level of knowledge of the learning process in which there is a necessary to redistribute system of teaching materials and to be displayed to a student a different learning process according to the present level of knowledge.

3. CASE STUDIED - EVALUATION OF STUDENTS IN THE FRAMEWORK OF PERSONALIZED E-LEARNING SYSTEM

Students are offered with several questions in different forms. In order to adapt next learning activities on the e-learning system, each student is offered a series of questions of different types, such as: question with two response options (True / False), questions with multiple choice answers that are scored as a result of student performance are offered additional questions that allow him to earn extra (bonus) points, and the combination of interdepended questions to avoid cases of accidental correct response.

Ensuring the correctness of this complex combined system of questions and answers require very detailed and intelligent testing. As an effective way of testing it's suggested a combination of two techniques of functional software testing - "Cause-Effect" analysis and combinatorial testing known as orthogonal vector robust testing (OART - Orthogonal Array Robust Testing) on a concrete case of complex scenarios of questions and answers. In this paper, due to limited space, it will be

described only application techniques "Cause-Effect" analysis [2,3].

Before we go deeper into the very testing techniques that will be applied, we must first carry out an analysis of software for student assessment, so that we know precisely what is tested.

3.1 TESTING METHOD "CAUSE-EFFECT" graphs

Cause-Effect (C-E) graph is essentially a technique that is used to test hardware, and is adapted to software testing, and then such as is developed [3]. This is the technique of testing method of "black box", therefore, it observes at the functional behavior of the system, without the need to analyze the internal structure of the system design. Also, it is the only technique black box test design, which takes into regard a combination of causes of system behavior that is applicable in both the analysis and development of design specifications.

When C-E analysis should first identified in the specification and readily available, the initial documentation of software:

- Causes
- Side effects
- Limitations

Then, construct the "Cause-Effect" graph, as well as combinatorial logic network whose nodes are the elements, which are called "causes" and "effects", and if necessary intermediate node, representing the Boolean operations: AND, OR , NOT. Finally, search the graph builds the table of decision-making that will be converted directly into specific cases of using the software, and then the test cases.

Cause-Effect graphs also describe the functional model depending on certain components and software used in the design software. C-E analysis focuses on showing relationship of dependency between inputs (causes) and output (result) of the software. These links are presented visually using C-E graph. Graf is a visual representation of the logical relationships between inputs and outputs that can be represented Boolean algebra. C-E graph allows you to select various combinations of input values to be made a test. The explosion of the number of test cases is avoided by applying heuristics and logical rules during the time graph.

The cause is any condition set out in the claims which could affect the result of the work program. The result is a reaction to the program given combination of inputs.

Here we describe a generic procedure for test generation using C-E graph through the following activities:

- Identify the causes and consequences of re-reading required
- Every cause and effect to assign a unique identifier
- Show the relationship of cause and effect by using the "Cause-Effect" graph
- Transform C-E graph in limited decision-making table
- Generate test cases from the decision-making table

In evaluating the student performance progression through the lessons path, a series of questions are asked which are causes, in our case, that we will mark with the C1, C2, ... C8. The effect is the result of the response that is expressed in points designated as E.

3.2 DESCRIPTION OF PERFORMANCE ASSESSMENT solving by combining several types of questions

As part of the lesson, which deals with the application design patterns of software the questions are:

C1 - true / false question is: Sample State separates behavior that depends on the state of the object of the original object.

Correct answer: True. Any processing of questions and answers, in the application is observed as a transformation, so that the question C1 (the cause of) student earns an appropriate amount of points (E1) on the basis of this transformation we will mark it with a t1 (Figure 1).

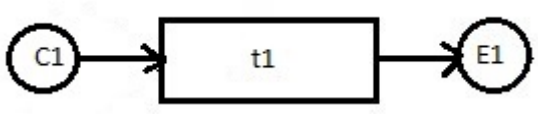

Figure 1: Relation t1, which is the result of responses to the question C1

C2 - true / false question: Software patterns that have as a purpose the description of behavior solving the problems which occur in the allocation of responsibilities classes and designing algorithms.
Correct answer: True.

C3 - true / false question: Software patterns to describe the behavior can be that when the behavior of a class should be transferred to the subclasses, use the structure of inheritance.

Correct answer: True.
Questions C2 and C3 both brings a student certain number of points E11 (t23 transformation within the application) if both correct answers (C2 and C3 are in the Boolean AND route i.e. Transformation of t23 is the AND operation that is shown in Figure 2).

Thus, C2 and C3 in the transformation result t23 give E11.

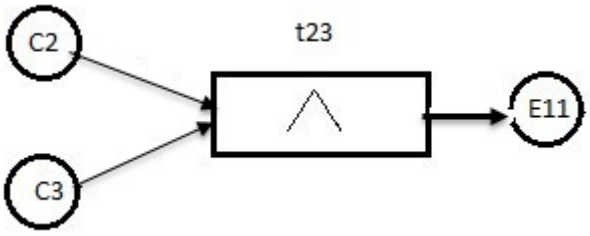

Figure 2: Relations t23 is Bull AND operation between C2 and C3

C4 - true / false question: Behavioral patterns do not suggest a static relationship between objects or classes but it describes the way objects communicate.

Correct answer: True.

The questions C3 and C4 together brings the student a number of points, i.e. E12. If answers are true to any of question points are added (C3 and C4 are in Bull OR operation.

Thus, C2 and C3 provide the result in the transformation of E11.

C5 - true / false question: The software pattern state does not belong to describe patterns of behavior.

Correct answer: false. If the answer on question C5 (cause) is correct (determined false), student earns a corresponding amount of points (E1) on the basis of this transformation we marked with t2.

C6 - multiple choice question: Pattern state is used when:

- behavior of the object depends on its condition - O6-1;
- behavior of the object does not depend on his condition. O6-2;
- behavior of the program changes the behavior of the object - O6-3;
- behavior change at the time of performance depending on the state - O6-4;

O - is a possible answer to the condition: signed or not signed (1 point or 0 points, respectively), incorrect marked offered answer is penalized -1 point.

Correct answer:
-> Behavior of the object depends on its condition, i.e. O6-1
-> Behavior change at the time of performance depending on the state, i.e. O6-4.

Transformation t3 - Results of the marked responses to C6 question

Students answer to the question number 6 is the effect of E6 (earned points) as a transformation t3 i.e. E6 = ΣO6-i (true) -ΣO6-i (false), O6-i = 1, 2, 3, 4 E6 may be a value of 0 (if the result of the transformation is negative Is set to 0) to 2 (the maximum possible number of correct marked response i.e. 100%).

C7 - multiple choice question: Pattern State:

- separates behavior that depends on the state of the object of the Original object - O7-1;
- behavior assigns a series of other objects - O7-2;
- assign a one object for each condition - O7-3;

O - is a possible answer with the condition: signed or not signed (1 point or 0 points, respectively), and incorrectly mark offered answer is penalized -1 point.

Correct answer:
- *separates behavior that depends on the condition of the object of the Original object i.e. O7-1;*
- *behavior assigns a series of other facilities i.e. O7-2;*
- *assign one object for each state i.e. O7-3;*

Transformation t4 - Results marked responses to C7 question

Students answers to the question number 7 is the effect of E7 (earned points) as a transformation t4 i.e. E7 = ΣO7-i (correctly) -ΣO7-i (false), i= 1, 2, 3 E7 may be a value of 0 (if the result of the transformation is negative Is set to 0) to 3 (maximum possible number of correct marked response i.e. 100%).

Furthermore:
C8 - multiple choice question: Role models are used:

- when we want a dynamic alteration functionality of the program - O8-1;
- when it is necessary to achieve the flexibility of Class - O8-2;
- when is need to reduce the complexity of Sistema - O8-3;

O - is a possible answer to the state: signed or not signed (1 point or 0 points, respectively), and incorrectly mark offered answer is penalized -1 point.

Correct answer:
-> When you want a dynamic alteration functionality of the program i.e. O8-1;
-> When it is necessary to achieve the flexibility of classes, i.e. O8-2;
-> When it is necessary to reduce the complexity of the system i.e. O8-3;

Transformation T5- result of marked answers to the question C8

Students answers to the question C8 is the effect E8 (points earned) as a transformation that is t5. E8 = ΣO8-i (correctly) -ΣO8-i (false), i= 1, 2, 3 E8 can be a value of 0 (if the result of the transformation is negative is set to 0) to 3 (maximum possible number of correct marked responses,. 100%).

To summarize:
C1 is the first type of question where the correct answer (true) student passes and receives a score of E1.

C2 is the second true / false type of question where with the combination of question C3 which is also true / false and correct answer receives a score E11.

C3 is a true / false type of questions and in the combination with C4 (fourth true / false questions) shows student scores E12.

C5 is a true / false type questions, which in transformation with a correct answer gives students a result of E1.

C6 is a multiple choice type questions, where 100% (if the E6 = 2 has a true state in all other cases, the answer is false marking) in combination with C7 100% (if the E7 = 3 status is true in all other cases mark the answer is false) and in combination with 8 additional sub-question multiple choice (if E8 = 3 status is true in all other cases mark the answer is false) guides student to additional points for commitment (additional 50%) and obtaining the results of E13 with additional knowledge test.

Through multiple choice student may incorrectly answer the question 6 (in Figure 3 marked the symbol of negation ~) or that score can fix in the question C7, which comes after questions C6. Additional points of commitment can be achieved on the queswtion C8, which in the total score and result of E13 brings the points. In that way, the student has the opportunity to correct his mistake in the process of learning offered through an additional set of questions. The final-Cause Effect graph is shown in Figure 3.

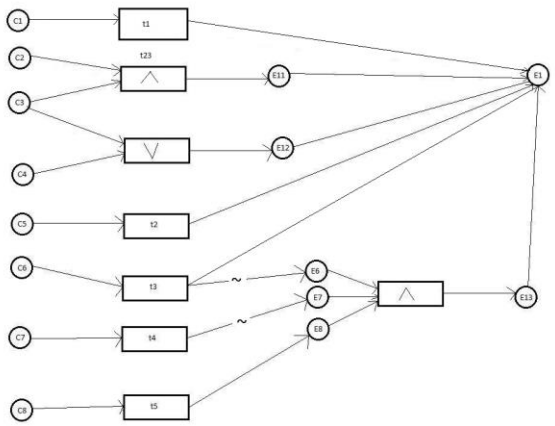

Figure 3: Final Cause-Effect graph for the described scenario of testing personalized learning process

3.3 TESTS FOR CHECKING implementation in e-learning applications - TEST CASE DESIGN

The easiest way to test is to create one test case for each combination of input parameters C which is obtained by the formula $2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 = 2^8 = 256$ test cases. This testing is obtained for n causes 2^n test cases. However, in the papers [2, 3] it is shown that the more efficient method is Passing back through the graph (Backward graph traversal) that we used.

Passing back through the graph is a technique that can optimize the selection of tests [2].

The method consists of the following:

- We consider the graph as a set of trees, through the branches of leaves to the roots, where every tree begins a consequence of (root), and ends with the causes (leaves)
- Following each of these trees the leaves (causes) in every possible way
- When you get to the leaves, those causes that we could not achieve in this passage we set the value of the unavailable (NO) or status is irrelevant to the cause, and one that we have put the check value (YES).

In our case, this procedure provides a set of six (6) test cases. Cause-Effect graph of our example would be the process of passage given back the next decision table:

We will create 6 test cases (table 1), define each C and E with the values true or false, and create a table. Note that the student answers questions one after the other C1 then C2 etc. It is necessary to determine the condition at each transition from the roots to the leaves i.e. that value (True or False) give proper effect to this path for which there is value YES. For example, in the case of TS1 to the question C1 be that the student answered correctly i.e. True, while the TS2 to the question C2 and C3 should respond correctly to both, and TS3 any correct answer to C3 or C4, or both leads to E12, and E1 as to the final result of passing back through the graph, and so on.

Table 1: Relevant test cases

	TS1	TS2	TS3	TS4	TS5	TS6
C1	**YES**	*No*	*No*	*No*	*No*	*No*
C2	*No*	**YES**	*No*	*No*	*No*	*No*
C3	*No*	**YES**	**YES**	*No*	*No*	*No*
C4	*No*	*No*	**YES**	*No*	*No*	*No*
C5	*No*	*No*	*No*	**YES**	*No*	*No*
C6	*No*	*No*	*No*	*No*	**YES**	**YES**
C7	*No*	*No*	*No*	*No*	*No*	**YES**
C8	*No*	*No*	*No*	*No*	*No*	**YES**
E1	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
E6	*No*	*No*	*No*	*No*	*No*	**YES**
E7	*No*	*No*	*No*	*No*	*No*	**YES**
E8	*No*	*No*	*No*	*No*	*No*	**YES**
E11	*No*	**YES**	*No*	*No*	*No*	*No*
E12	*No*	*No*	**YES**	*No*	*No*	*No*
E13	*No*	*No*	*No*	*No*	*No*	**YES**

4. CONCLUSION

Creating a learning process provides more interactivity with the students and improving of the quality of teaching materials. Personalization of the learning process presents an opportunity that each student based on the level of knowledge obtained teaching materials and check the acquired knowledge. Through personalized learning processes benefit both students and authors of teaching materials. Obtaining feedbacks from the learning process, by the activity within which is checked students' knowledge, the authors of teaching materials have an insight into the possibilities of each student and therefore

they can plan and develop other parts of the learning process.

The process of software testing can be very problematic due to imposed limitations in resources and time. Thoughtful planning of a testing strategy is crucial to the quality managing of the process development and software testing. It must be taken into consideration both economic and technical aspects, particularly the risks of non-disclosure of defects.

Benefits of "Cause-Effect" technique, which was used in testing e-learning applications, as its susceptibility to automate and the fact that the test cases are extracted from the software specifications given in natural language. On the other hand, the same technique is very problematic because a relatively small force in reducing the number of test cases. Therefore, in future studies it should be experimentd with more complex case scenarios of questions and answers, using combinatorial testing known as orthogonal vector robust testing (Oarta - Orthogonal Array Testing Robust).

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