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Automated systems and processes visual modelling skills control in training engineering specialists with simulator complex

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Abstract. The article presents the prototype of the computer simulator complex (CSC) developed for automated control of visual modelling skills of systems and processes in the training of engineering specialists in the field of food production. With the use of CSC, it is possible for teachers to create and students to perform exercises on analysing and building diagrams in various standards (in particular, UML). The key functionalities of CSC are: setting up exercises on analysis and construction of visual models by the instructor; formation of individual variants of exercises in accordance with the instructor's settings; execution of exercises by the student in a special interface, including the use of a graphical editor for building diagrams; automatic formation of a reference solution of the exercise and evaluation of the students' solution in accordance with the reference. The CSC prototype, implemented in the form of a web-based system, is used in Russian Biotechnological University when training students in the field of development of automated control systems for food production. The application of CSC simplifies the processes of knowledge control, collection and analysis of data on knowledge control, which contributes to the improvement of learning outcomes of specialists.

1 Introduction

An important task for modern food production, in conditions of wide application of automation, informatisation, robotisation, is the training of qualified personnel of engineering profile, in particular, technologists and specialists in the development of automated systems of control (ASC).

To improve the efficiency of the educational process in the training of these specialists, various computer technologies are widely used. In particular, scientific works and developments in the field of e-learning [1-3], computer simulators for training operators of production processes [4-6], virtual laboratories [7-9], and intellectual technologies in the educational process [10-12] should be highlighted. However, the main functional capabilities

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of these systems are mainly limited to automated knowledge control (testing), involving the compilation of a large database of test tasks, as well as to the teacher's verification of completed practical tasks in a remote format. Accordingly, there is a high labour intensity of the teacher's work when controlling knowledge and skills. The existing systems do not take into account the specifics of the food industry.

To improve the quality of training results of the above specialists, to reduce the time for routine tasks during the control of knowledge and skills, to simplify the document flow in the educational process, the actual task is to develop a computer simulator complex (CSC) to control the skills of practical tasks in the training of engineering specialists in the field of food production. The main advantages of CSC are the possibility to form an individual variant of an exercise for each student on the basis of knowledge about the subject area, to evaluate it automatically, to form advice to the student about mistakes made and ways of their elimination, to store and process data on the learning process.

Specialists in the development of ASC (and related profiles) in the field of food production should have skills in applying various graphical notations (in particular, UML, IDEF0, DFD, ARIS) for modelling business processes, developing models of the structure and process of functioning of ASC software (software), which contributes to the introduction of information technology in production processes in order to improve their efficiency. Let us consider the distinctive features of the developed CSC on the example of exercises for these types of modelling, representing typical examples of tasks, the performance and evaluation of which in CSC can be automated to the best extent.

2 Visual models of systems and processes analysis exercises

The simplest types of exercises in the developed CSC, used to test knowledge and initial skills, are devoted to the analysis of models made in a certain graphical notation.

In particular, the CSC has the functionality to set up by the instructor and the student exercises on the analysis of UML diagrams as one of the most common visual modelling languages [13]. Such exercises allow testing the knowledge of the learner on the graphical notations of the main elements of the model, the purpose of each of the elements and the model as a whole. Unlike many computer-based knowledge control tools, in which questions are selected from a database of questions created in advance by the instructor, in CSC the formation of individual variants of the test for each student is done automatically based on the settings of exercise parameters, in particular, the parameters of UML diagrams to which the exercise is devoted.

Let's consider an example of an exercise on analysing Use Case UML diagrams. Fig. 1 shows the web interface for setting up the exercise, where the instructor sets the properties of the diagram to which the test questions are dedicated, as well as the properties of the questions themselves.

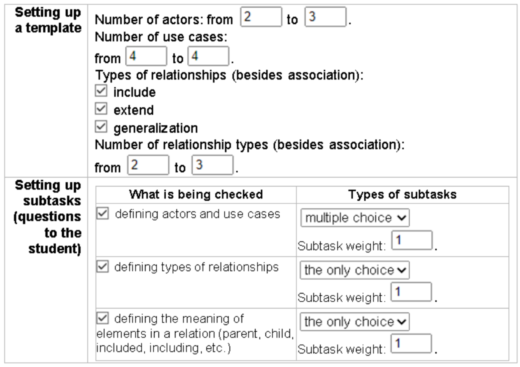

Fig. 1. Setting up Exercise 1 by analysing the Use Case diagram (instructor's web-interface)

In addition to those shown in Fig. 1, additional parameters affecting the structure, execution and evaluation processes of the exercise are allowed.

The web interface of the student's individual variant of the Use Case diagram analysis exercise is shown in Fig. 2.

To assign a final grade for the exercise for each test question, the system automatically determines the correct answers based on knowledge about the structure of these diagrams, the purpose of its main elements. As can be seen in Fig. 2, the names of actors and use cases are labelled automatically in the form of X_i, since such exercises are not tied to a specific subject area. Names of actors and use cases in this format exclude hints in questions on the meaning of graphical elements of diagrams.

In the exercises above, a single Use Case diagram is generated for all test questions. CSC also implements a subspecies of diagram analysis exercises Use Case, where a new diagram or diagram fragment is provided in each question statement or answer choice. Accordingly, the set of settings set by the instructor to generate the exercise changes (Fig. 3).

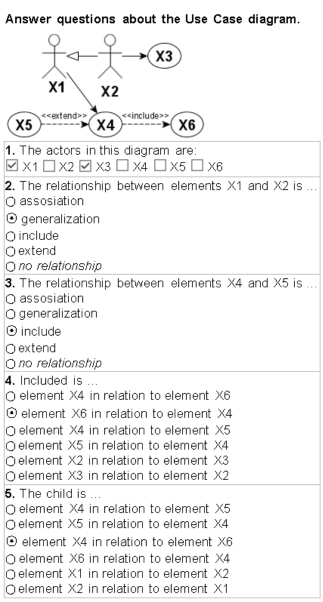

Fig. 2. Exercise 1 on analysing the Use Case diagram (student's web-interface)

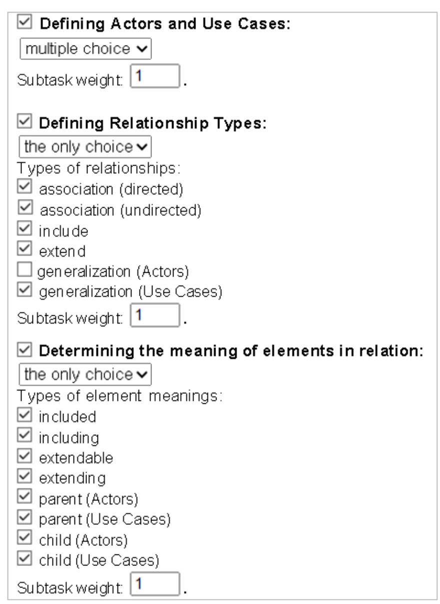

Fig. 3. Setting up Exercise 2 on analysing the Use Case diagram (instructor's web-interface)

The web interface with an example of a customised exercise variant generated according to the settings in Fig. 4 in the web-interface with an example of an individual variant of the exercise is formed according to the settings in Fig. 3, the content of the test questions changes compared to the example in Fig. 2.

The settings of such tasks may take into account the relationships between the diagram elements to prevent the situation of actual duplication of questions. For example, if there is a generalisation relationship between actors X1 and X2 in the presented test task, either a question can be asked which of these actors is the parent, or a question can be asked which of the actors is the descendant.

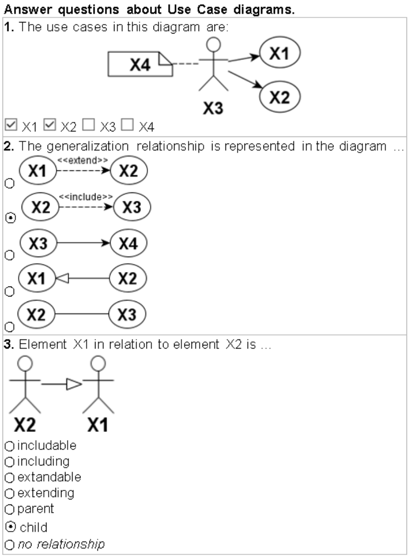

Fig. 4. Exercise 2 on analysing the Use Case diagram (student's web-interface)

3 Exercises to develop visual models of systems and processes

More complex exercises consist in building visual models of systems and processes in the field of food production. Based on the problem statement and the available palette of elements, the student builds a diagram in a specific graphical notation.

Fig. 5 demonstrates an example of the web-interface for setting up the exercise to develop a Use Case UML diagram for the textual description of software requirements defined in the problem statement in accordance with the subject area.

According to the settings in Fig. 5, the instructor sets the necessary number of variants of the exercise, differing in the description of the requirements to the software being developed. In a special interface, the instructor can set the software requirements (for setting the task to the trainee) using the text area, as well as set the reference Use Case diagram corresponding to these software requirements using a small graphical rector.

Also, according to Fig. 5, the setting of the task evaluation process, which determines the features of comparing the student's diagram and the reference diagram (the evaluation settings determine the consideration of partially correct solution of the task), and the setting of the palette of elements for building the diagram (the palette settings affect the level of difficulty of building the diagram, increase/decrease the number of elements available to the student for building the diagram).

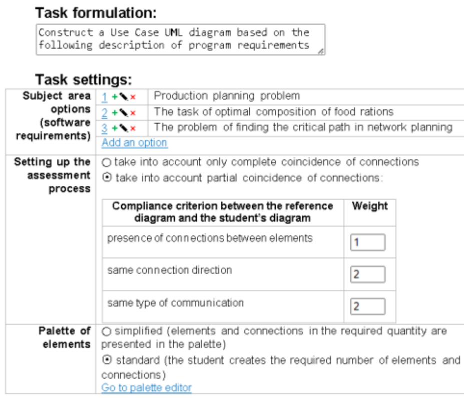

Fig. 5. Setting up a Use Case diagramming exercise (instructor's web interface)

An alternative to the presented exercise of developing a Use Case diagram based on a specific food-related subject area is the automatic generation of a diagram for each student [14] based on additional settings of the diagram template by the instructor (similar to Fig. 1). Such settings save the instructor from the need to manually generate variants of subject areas to control the initial skills of the learner.

In addition to the settings shown in Fig. 5, there may be additional settings, such as a time limit for the exercise that affects the evaluation process and/or the exercise itself.

The web interface of the learner's exercise of developing a Use Case UML diagram is shown in Fig. 6. The exercise takes into account the instructor's customisations set in the interface in Fig. 5. As the subject area in the example in Fig. 6 is the functional requirements for a programme that implements the optimal diet task (as one of the variants of the exercise set up by the instructor earlier).

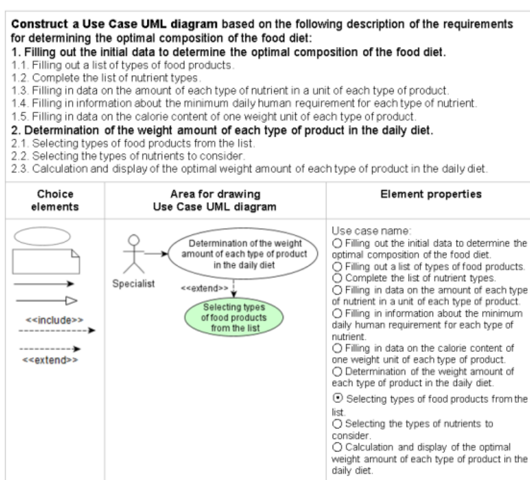

Fig. 6. Execution of the Use Case diagram development exercise (student web-interface)

The student constructs the Use Case diagram (Fig. 6) in a small graphic editor. The student selects the necessary elements of the diagram, names of actors and use cases. In Fig. 6, the current diagram element (use case) for which a name must be selected from the list of answer choices is highlighted in colour for clarity. Exercises such as the one shown in Fig. 6, represent simplified versions of real problems in the field of food production for the educational process.

It is allowed to generate advisory actions to the trainee in the process or by the results of the exercise, if the advisory actions are provided by the instructor in the settings.

4 Conclusion

1. A computer simulator complex prototype (CSC) has been developed for automated control of visual modelling skills of systems and processes in the training of engineering specialists in the field of food production. With the use of CSC, it is possible for teachers to create and students to perform exercises on analysis and construction of diagrams in various standards (in particular, UML).
2. The key functionalities of CSC are: setting up exercises by the instructor for analysing and building visual models; forming individual variants of exercises in accordance with the instructor's settings; performing exercises by the student in a special interface, including the use of a graphical editor for building diagrams; automatic formation of a reference solution of the exercise, and evaluation of the students' solution in accordance with the reference.
3. The prototype of the web-system is applied in Russian Biotechnological University when training students in the field of ASC development by food production. Application of the web-based system allows us to simplify the processes of knowledge control, collection and analysis of data on knowledge control, which contributes to the improvement of learning outcomes of specialists.

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References

1. Chan Jung Park, Jung Suk Hyun, Life Science Journal **11(7),** 700-705 (2014)
2. Dan Bouhnik, Golan Carmi, Journal of Information Technology Education: Research **11,** 201-219 (2012)
3. A. E. Tshibalo, South African Journal of Higher Education **21(6),** 684-693 (2007)
4. A.A. Krivonosov, et.al, Labour safety in industry **3,** 86-92 (2020)
5. E.A. Boyko, I.V. Zagorodny, Energobezopasnost' i energosberezhenie **4,** 49-55 (2020)
6. R.A. Faizrakhmanov, et.al, Russian Electrical Engineering **88(11),** 725-727 (2017)
7. M. Alkhedher, O. Mohamad, M. Alavi, Global Journal of Engineering Education **23(1),** 55-61 (2021)
8. Yi-Han Liu, Yu-Tong He, Di Tian, Run-Long Fan, Li Yao, Computer Applications in Engineering Education **26(5)** (2018)
9. Milo D. Koretsky, Computer Applications in Engineering Education **28(1)** (2020)
10. A.P. Grigoriev, V.Ya. Mamaev, Scientific Instrumentation **26(4),** 77-84 (2016)
11. V.V. Zhuikov, Vector of Science of Togliatti State University **2(28),** 162-165 (2014)
12. M.V. Guner, O.I. Pyatkovsky, Izvestia Altai State University **1-1(77),** 94-99 (2013)
13. A.P. Gagarin, E.V. Ivanov, Modern information technologies and IT-education 13(3), 61-71 (2017)
14. M.M. Blagoveshchenskaya, et.al, AIP Conference Proceedings **2627,** 070001 (2023) https://doi.org/10.1063/5.0135984