USE OF AT-TECHNOLOGY WORKBENCH FOR CONSTRUCTION OF TUTORING INTEGRATED EXPERT SYSTEMS

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Abstract: *Analyzes the experience of development and use in the educational process MEPhI tutoring integrated expert systems created on the basis of problem-oriented methodology and programming intelligent environment of AT-TECHNOLOGY workbench. The emphasis is on the peculiarities of the implementation of certain tasks of intellectual training, related to the identification of knowledge and skills of students to solve the problem unformalized.*

Keywords: *artificial intelligence, integrated expert systems, problem-oriented methodology, AT-TECHNOLOGY workbench, intelligent software environment, automated planning, tutoring integrated expert systems, intelligent training.*

ITHEA Keywords*: Applications and Expert Systems*

Introduction

Interest in intelligent tutoring systems (ITS) arose at the turn of the XX and XXI centuries, and now they occupy a significant place in a wide scope of intelligent systems issues. . Educational sphere is a good "ground" for the application of artificial intelligence methods and tools, giving rise to a considerable number of approaches and system architectural solutions for intellectualization, individualization and web orientation of learning and training processes . Now, there is an "information explosion" of publications both in Russia and abroad on the subject of ITS. Without claiming to be exhaustive in our review of works in the field of ITS, we will mention only a few papers [Rybina et al, 2016; Smirnova, 2012; Nye, 2015; Rybina, 2011; Bonner et al, 2015], reflecting the results of researches that were conducted in MEPhI and other universities. "Intelligent Systems and Technologies" laboratory at MEPhI's department of Cybernetics has accumulated a lot of experience in the development and use of tutoring integrated expert systems (IES) based on problem-oriented methodology [Rybina, 2008; Rybina, 2014] and powerful modern tools such as AT-TECHNOLOGY workbench [Rybina, 2014; Rybina, 2011; Rybina, 2008] is accumulated in the laboratory "Intelligent Systems and Technologies" department "Cybernetics" MEPhI.

Tutoring IES and web-IES are fully functional, new generation ITS that implement all the basic ITS model (student model, tutoring model, problem domain model, ontology of courses and disciplines, etc.). As well, IES allows solving wide scope of intellectual training tasks, the main ones are [Rybina, 2011; Rybina, 2014; Rybina, 2008]: individual planning of a course / discipline study methodologies; mining solution of educational problems, and intelligent support of decision-making. Process of measuring knowledge level (declarative knowledge of a course/discipline) and detection of skills (procedural knowledge, which shows how this declarative knowledge could be applied in practice) is the basis for all mentioned above tasks. A number of methods for this purpose is proposed. To implement these processes there is a significant number of different methods, according to which the control tests and tasks are developed. For example, in tutoring IES network orientated model of student is formed dynamically on the analysis of answers to questions from special web-tests that are generated with the help of genetic algorithms and the method of estimation is based on calculating the final grade for the whole test. After that the current model of a student knowledge is compared with an ontology of a course/discipline. As a result, one can determine so called "problem areas" in students' knowledge. There are other approaches to identify the level of student's knowledge, as described, in particular, in [Kehayova et al, 2016; Bonner et al, 2015; Durlach, 2012; Conati, 2012], however, with methodical, algorithmic and technological points of view the implementation of these processes is not particularly difficult. Speaking of ITS with possibility to automatically detect students' abilities to solve problems, there can be difficulties connected with the specifics of a particular course/discipline.

For example, teaching special courses within educational programs like "Applied mathematics and Informatics" and "Software engineering" ("Introduction to intelligent systems", "Expert systems", "Intelligent Information Systems", "Intelligent interactive systems" etc.) is connected with students to do such tasks as [Rybina, 2014]: the ability to build models of the simplest situations in a problem domain based on frames and semantic networks, modeling strategies of forward/backward inference in the ES, construction of linguistic model of business sublanguage and other.

Therefore, to support the construction of tutoring IES on the basis of problem-oriented methodology (AT-TECHNOLOGY workbench) was created and tested in practice in the educational process of MEPhI and other universities special funds that implement "manual" methods of solution of various Non-formalised problems, in particular, is presented in [Gavrilova et al, 2016].

Another important aspect of research and development in the field of ITS is connected with development of tools and technologies for automated support of ITS development. Currently there is no big diversity and innovation of tools and researchers are focused the focus is on reengineering and development of the existing tools [Galeev et al, 2004]. It should be noted that currently there is no standard technology of ITS development, so workbench of general purpose is often used for ITS . For example, [Gribova et al, 2015; Gribova, 2016] The focus of this work is the further development of methods and tools for automated construction of tutoring IES with use of intelligent software environment components.

General characteristics of the components of an intelligent software environment of the AT-TECHNOLOGY workbench

The AT-TECHNOLOGY workbench is a modern tool that supports intelligent software technology for automated construction of IES of different types and levels of difficulty. The conceptual base for the integration of methods of knowledge engineering, ontological engineering, intelligent planning and traditional programming is the concept of "intelligent environments" first introduced in [Rybina, 2008] and studied experimentally in the process of developing a number of applied IES, including tutoring IES [Rybina, 2014; Rybina, 2008; Rybina, 2014; Rybina and Blokhin,2015]. The basic role in the intellectual software environment belongs to the intelligent scheduler, which manages IES and web-IES development projects. Different versions of the scheduler are described in detail in [Rybina, 2008; Rybina, 2014; Rybina and Blokhin,2015] and other works.

Therefore, this work is focused on questions related to the methods of implementation of the above-mentioned tasks of intelligent training with the help of other, equally important components of an intelligent software environment of the AT-TECHNOLOGY workbench. As shown in [Rybina, 2008], the main components of an intelligent software environment used for building and execution of plans for the development of prototypes of applied IES include standard design procedures (SDP) and reusable components (RUC). In accordance with [Rybina, 2008], SDP model for tutoring IES is represented as

$$SDP_T = \langle C_T, L_T, T_T \rangle \tag{1}$$

where C_T is a set of conditions, which ensure SDP invocation; L_T - an execution scenario described with internal SDP actions description language; T_T - a set of parameters initialized by the intelligent planner when SDP is included into an IES prototype development plan. Every RUC, involved in IES prototype development is defined as

$$RUC = \langle N, Arg, F, PINT, FN \rangle \tag{2}$$

N in this model is the name of the component, by which it is registered in the workbench. $Arg = \{Arg_i\}, i = 1...l$ - set of arguments containing current project database subtree serving as input parameters for the functions from the set. $F = \{F_i\}, i = 1...s$ - a variety of methods (RUC interfaces) for this component at the implementation level. $PINT$ - a set of other kinds of RUC interfaces, used by the methods of the RUC. $FN = \{FNi\}, i = 1...v$ - set of functions names performed by this RUC. The main algorithm element used during development plan generation process of the IES prototype is SDP. By SDP we mean a set of elementary instructions (steps) which are traditionally executed by a knowledge engineer at every development lifecycle stage. The intelligent planner of the AT-TECHNOLOGY workbench has knowledge about all available SDPs, and based on this knowledge it forms a set of tasks for any IES prototype development (accordingly to a current lifecycle stage). Then, basing on special requirements specified at the system requirements analysis stage, the planner decomposes the plan into smaller tasks (subtasks). All the workbench SDPs are classified in the following manner: task type independent SDPs

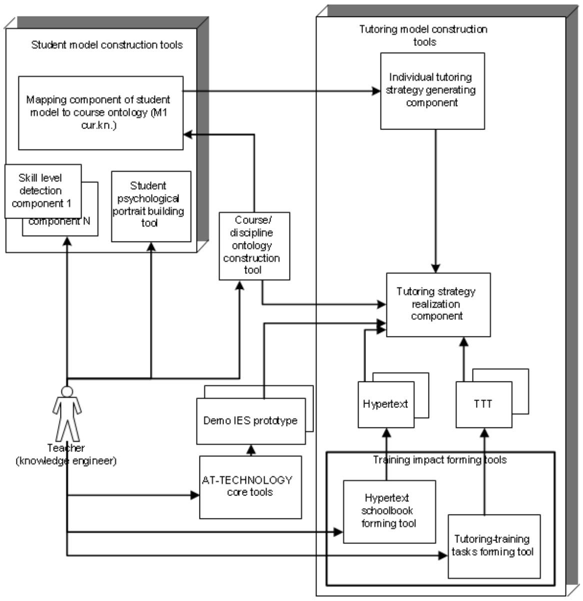

Figure 1: Execution scheme of the SDP "Tutoring web-IES construction" in DesignTime mode for a teacher (or a knowledge engineer)

(for example, "knowledge acquisition from database"), task type dependent SDPs (for example forming tutoring IES components), SDPs related with RUC, i.e. procedures, that contain knowledge about RUC lifecycle from its configuring up to including it into the IES prototype model. SDPs of the last type also contain knowledge about problems solved with this RUC and its necessary configurations. The general architecture of the AT-TECHNOLOGY workbench is built in such manner, that all functionality is distributed between the components registered in the workbench and acting under intelligent development environment. In other words, these components are reusable components of the workbench, and they are developed in accordance with some workbench rules [Rybina, 2008].

There are two different types of RUC used in the current basic AT-TECHNOLOGY workbench version - procedural and informational components. In the first one the components provide capabilities for execution either actions with non-typical results, i.e. results that are not stored in some special storage (repository) as the results of previous developments, or actions, that require user interaction (for example, editing the ER-scheme or viewing the expert interviewing protocol). In the second one the components provide capabilities for executing actions which result in the information that has been collected earlier and is stored in the repository (knowledge, data, schemes, structures etc.) with further copying of this information into the current project and preprocessing if needed (i.e. copying of created earlier ER-diagram or typical diagram analysis). Special storages (repositories) are used for RUC of the second type. They collect different types of data which is used in further development processes.

In the basic AT-TECHNOLOGY workbench many SDPs of the first and second types are implemented and used, in particular: the SDP for combined knowledge acquisition, the SDP for database designing, the SDP for configuring IES prototype components, the SDP for creating hyper-text tutorials etc. There are SDPs related to distributed knowledge acquisition from different knowledge sources, dynamic IES development SDP and the most complicated

SDP for tutoring IES construction [Rybina, 2008] in the experimental stage. The difficulties of the tutoring IES development technology are caused by supporting two different work modes - DesignTime, oriented to work with teachers (course/discipline ontology creating processes, different typed training impacts creating, etc.) and Runtime, for working with students (current student model building processes, including psychological model, etc.). The execution scheme of SDP "Tutoring web-IES construction" in the DesignTime mode is presented in Fig. 1, and in the RunTime mode - in Fig.2.

As shown in Fig. 2., in the RunTime mode the following AT-TECHNOLOGY workbench instruments are used: training impact building tools (hypertext schoolbook, tutoring-training tasks), basic core workbench tools for IES prototype construction, student psychological model builder tool, tools for course/discipline ontology building, individual tutoring strategy former, tutoring strategy realization component, different skills level detection components, component for mapping a current student model to course/discipline ontology. As shown in the scheme of Fig.2. the student

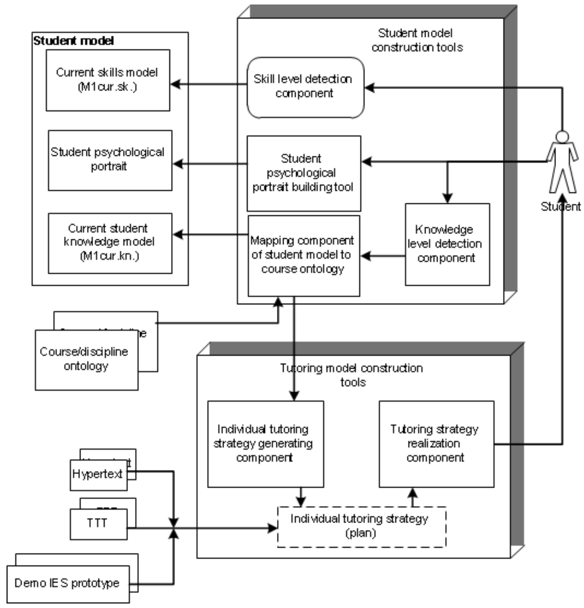

Figure 2: Execution scheme of the SDP "Tutoring web-IES construction" in the RunTime mode for students

model construction (student model current knowledge, student model current skills, psychological model components) is directly connected to the tools for construction and realization of the tutoring model, as well as to the component for mapping a current student model to course/discipline ontology. The mapping component is also connected to the individual tutoring strategy forming component. The peculiarity of a tutoring web-IES developed with AT-TECHNOLOGY workbench is a presence of some components of skill level detection and of the component for building a student's psychological model (as an aggregate of personal characteristics which are collected as a results of psychological testing).

Consider this SDP in context of topicality of intelligent development technology usage for tutoring IES. The schemes of the SDP "Tutoring web-IES construction" shown in Fig.1. and Fig.2. clearly show a big amount of repeating routine operations which must be performed by a knowledge engineer during the designing lifecycle stage (DesignTime mode) and maintenance (RunTime mode) of the tutoring web-IES for certain courses/disciplines.

The most difficult and complicated stage is the construction of the "Training with IES" training impact, which includes a comprehensive problem of the applied IES development for a certain problem. This IES is developed using AT-TECHNOLOGY workbench core. For example, almost all the courses of the "Intelligent systems and technologies" specialization require some knowledge of engineering methods. These methods are presented as non-formalized tasks and non-formalized methods such as "System analysis of the problem domain about applicability of the ES technology", "Choosing knowledge representation formalism", "Choosing development tools" and other tasks requiring expert knowledge [Rybina, 2008]. The aggregate of the listed non-formalized tasks and their logical relations are the base for the problem domain construction. The problem domain is constructed with the knowledge representation language used in the AT-TECHNOLOGY workbench.

Features of realization of some intelligent training tasks based on the use of operational and informational RUC

In accordance with problem-oriented methodology for constructing IES [Rybina, 2011], one of the important components of a generalized model of a typical tutoring problem is the network student model, the construction and renovation of which is carried out dynamically by implementing control measures, provided by the curriculum of each course / discipline. For these purposes, as a part of the subsystem of construction of tutoring IES / web-IES, which works in both (basic and web version) of AT-TECHNOLOGY workbench, there are special tools for building student model.

As described above, the set of SDP and RUC are components of intellectual technological knowledge base [Rybina, 2011; Rybina, 2008] providing the intellectualization of the creation and operation of a wide class of IES, including tutoring IES. Detailed description of the intelligent software environment model and the means of its implementation are given in [Rybina, 2014; Rybina and Blokhin,2015]. Specifications of operational and informational RUC's that copes with major issues of intellectual tutoring are presented in this work. Brief description of these RUC's is given below.

01 Individual planning of studying methods of a course

Main operational RUCs for this task are the means of building the ontology of a course/discipline [Rybina et al, 2012]. Also it uses about ten informational RUC's, associated with fragments of hypertext electronic textbooks (HT-books) for specific courses / disciplines, and several informational RUC's for building a generalized ontology "Intelligent systems and technologies" and ontology "Automation of physical installations and scientific research" (Department of Automation [Rybin, 2011]). In general, the current RUC's for construction of a student model are the following:

1. Operational RUC "Component that identifies a student's level of knowledge" (and several informational RUC's that describes test problems for various fragments of a course/discipline ontology);
2. Four operating RUC's associated with evaluating the level of skills of a student include: component of detection of student's skills to simulate the forward / backward inference, component of detection of skills to build components of a linguistic model of business prose sublanguage, component of detection of skills to simulate the simplest situation in problem domain using frames and components of detection of skills to simulate the simplest situation in problem domain using semantic networks;
3. For ontology's, "Automation of physical installations and of scientific research" [Rybin, 2011] is used the operational RUC associated with the detection of learners' abilities to develop automatic control systems (ACS) over physical units ("Physical Component ACS units").
4. Two operational RUC's - "Psychological test generator" and "Component for student personal characteristics detection". The process of generation of psychological tests is carried out using informational RUC's containing fragments copyright psychological tests aimed at identifying the set of personal characteristics of students.

It should be noted that the component for displaying current student model, compared with ontology of a course / discipline, and designed as an operational RUC. It allows to reveal "problem areas" of a student. That helps to construct the individual plan (strategy) of tutoring. Figure 2 shows the architecture of tools for building a learning model and for automatic generation of an individual learning plan, that uses operational RUC "Component of forming tutoring plans (strategies)", and a special RUC "Component of managing the application of tutoring impact ".

Each training strategy includes a specific sequence of tutoring impacts such as: reading of a hypertext book; solution of several types of training problems ("Building relationships between elements of the graphical representation," "Organizing graphics", "Enter a numeric value for the interval", "graphic analysis", "The mapping and sequencing of the blocks", "Formation of the answer by selecting its components from the proposed list "," Marking the correction of the text"," Filling the gaps in the text ","Setting correspondences between blocks "," Enter the answer to the open question"); implementation of tutoring impact "Training with IES"; explanation of the obtained results; tips; localization of errors made; control of the correct solutions, etc. Any tutoring strategy is characterized by a specific set of procedures and application of tutoring impacts, the content of which is determined by the degree of destabilization of the problem, depending on the level of knowledge and skills of a student and his or her psychological portrait. The process of formation and implementation of all relevant tutoring impacts is supported by special operational and informational RUC's.

02 Intelligent analysis of tutoring problems solutions

To identify the skills and abilities of students to solve tutoring non-formalized problems from six courses/disciplines represented in a generalized ontology "Intelligent Systems and Technologies" [Rybina, 2014] a simulation of student's reasoning for solving four types of learning tasks was used: modeling strategies of forward / backward inference, simulation of simple situations of problem domain using frames and semantic networks, building the components of a linguistic model of business prose sublanguage. Let's briefly comment on operational RUC's that support the above tasks.

1. Operational RUC "Component of detection of student's skills to simulate the forward / backward inference" and several informational RUC's (fragments of knowledge bases) are designed to identify the learner's skills to simulate the forward / backward inference (courses "Introduction to Intelligent Systems", "Expert System", "Intelligent information Systems" etc.). Students go through the following steps: create DBs, consisting of production rules; input initial facts for direct inference; model a strategy of forward inference; input facts and goals for backward inference; model strategy of backward inference. Students skills are evaluated with a simple solver, performing standard inference, and then this inference is compared (using special heuristics) with the students solution.

2. Operational RUC "Component of detection of skills to simulate the simplest situation in the problem domain using frames" and several informational RUCs (fragments of prototype frames, in FRL language of knowledge representation [Rybina, 2014]) provide the functionality declared in the course "Introduction to Intelligent Systems", "Expert Systems", "Intelligent information Systems". Students create prototype frames defined by a tutor [12], then by comparison with the reference frames the level of skills of a students is detected. A complete history of student actions is saved and can be used to reproduce student's logic of reasoning.

3. Operational RUC "Component of detection of skills to simulate the simplest situation in problem domain using semantic networks" and several informational RUC's (fragments of semantic networks) provide functionality declared in the courses "Introduction to Intelligent Systems", "Expert systems" and "Intelligent Information Systems". Students construct a fragment of a semantic network for a given problem domain, and then on the basis of comparison with reference fragments of the semantic network the level of their skills is defined with the help of expert techniques.

4. Operational RUC "Component of detection of skills to build components of a linguistic model of business prose sublanguage" and several informational RUC's (dictionaries, fragments of business texts, etc.) provide the functionality declared in the course "Intelligent interactive systems". Students do control tasks of creating lexical, syntactic and semantic components of a linguistic model for a business prose text sublanguage, and then the level of their skills is defined with the help of a special expert techniques. To identify the skills/abilities of students to solve both formal and Non-formalised-problems in the ontology "Automation of physical installations and scientific research" the operating RUC "Design of automation of physical installations", which provides the following functionality in the appropriate course/discipline [Rybin, 2011]: development of block diagrams of ACS; calculation of stability of ACS; the choice of ACS elements.

03 Intelligent Decision Support

It is important to note that in the development of tutoring impacts such as "Training with IES" for different formalized courses/disciplines the most important task is building of problem domain models (including those based on knowledge, containing certain types of NE-factors [Rybina, 2008]). Another important task is implementation of "consultation with IES" mode, in which there are scenarios of dialogues with the student. In this dialogues a considerable attention is given to explanations, tips and / or verification of the next stage of solving the problem, etc. Here we could apply multiple operational RUC's from the basic AT-TECHNOLOGY workbench (communication subsystem, universal AT-solver, an explanation subsystem, etc.), as the development of tutoring impact is a task of creating a complete IES. Informational RUC's are also used (knowledge based fragments from previously created teaching operations "Training with IES", fragments of user dialogue scenarios in "Consultation with IES" mode, etc.) and operational RUC "Explanation component" provides assistance at every stage of the solution of educational problems particularly, gives hints of the next stage, gives explanations like "how" and "why" as well as makes at visualization of inference.

Conclusion

Currently, we are doing a pilot software study, re-engineering and further development of all components of intelligent technologies of tutoring IES construction. In addition, we are working on implementation of Non-formalized techniques for solving tutoring problems in other courses of various ontologie's (in particular the "Dynamic intelligent systems", etc.)

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Bibliography

[Rybina et al, 2016] G. V. Rybina and V. M. Rybin and E. S. Sergienko. Some features of development and using of tutoring integrated expert systems in educational process mephi. In: Proceedings of the VI International Scientific and Technical Conference, 18-20 February, Minsk. 2016.

[Rybina, 2011] G. V. Rybina. Intelligent tutoring systems based on integrated expert systems: the experience of the development and use. IJ Information-measuring and operating systems, No.: 10, pp. 4–16. 2011

[Rybina, 2014] G. V. Rybina. Intelligent systems: from A to Z. Monography series in 3 books. Vol. 1. Knowledge-based systems. Integrated expert systems. Nauchtehlitizdat, 2014, Moscow. p.224,

[Rybina, 2008] G. V. Rybina, Theory and technology of construction of integrated expert systems. Monography. Nauchtehlitizdat, 2008, Moscow. p.482,

[Rybina, 2014] G. V. Rybina. Fundamentals of building intelligent systems. Tutorial. Finance and Statistics, 2014, Moscow. p. 432,

[Rybin, 2011] V. M. Rybin. Intelligent control based on dynamic integrated expert systems. IJ Information-measuring and operating systems, No.: 6, pp. 16–19. 2011.

[Rybina et al, 2013] G. V. Rybina and Y. M. Blokhin and M. G. Ivashenko. Some aspects of intelligent technology for integrated expert system construction. IJ Devices and Systems. Control, monitoring, diagnostics, No.: 4, pp. 27–36. 2013.

[Rybina and Blokhin,2015] G. V. Rybina and Y. M. Blokhin. Modern automated planning methods and tools and their use for control of process of integrated expert systems construction. IJ Artificial intelligence and decision making, No.: 1, pp. 75–93, 2015.

[Rybina et al, 2012] G. V. Rybina and M. V. Yusova and E. V. Churdalev. Ontologies in the training of expert integrated systems. IJ Information-measuring and operating systems, No.: 8, pp. 13–20, 2012.

[Rybina, 2011] G. V. Rybina. Instrument complex AT-TECHNOLOGY to support building integrated expert systems: general characteristics and development prospects. IJ Devices and Systems. Control, monitoring, diagnostics. No.:11, pp. 17–40, 2011.

[Smirnova, 2012] N. V. Smirnova and A. Y. Schwartz. Motivational and volitional component of the student model in intelligent tracking systems. Part 1. IJ Artificial intelligence and decision making, No.:1, pp. 65–80, 2012.

[Nye, 2015] B.D. Nye. Intelligent tutoring systems by and for the developing world: A review of trends and approaches for educational technology in a global context. International Journal of Artificial Intelligence in Education, No.: 25. pp. 177–203. 2015.

[Gavrilova et al, 2016] T. A. Gavrilova and D. V. Kudryavtsev and D. I. Muromtsev. Knowledge Engineering. Models and methods: A Textbook. // Lan, Saint Petersburg, 2016. p. 324,

[Kehayova et al, 2016] I. Kehayova and P. Malinov and V. Valkanov and E. Doychev. Architecture of a Module for Analyzing Electronic Test Result. In: Proceedings of 2016 IEEE 8th International Conference on Intelligent Systems (IEEE IS'16). 2016, Sep. 4-6.

[Bonner et al, 2015] D. Bonner and J. Walton and M.C. Dorneich and S.B. Gilbert and E. Winer and R.A. Sottilare. The development of a testbed to assess an intelligent tutoring system for teams. In: Workshops at the 17th International Conference on Artificial Intelligence in Education, AIED-WS 2015; CEUR Workshop Proceedings, 2015, Sep. 4-6.

[Durlach, 2012] P.J. Durlach and A.M. Lesgold. Adaptive technologies for training and education. Cambridge University Press, London 2012, p. 360

[Conati, 2012] C. Conati, Student modeling and intelligent tutoring beyond coached problem solving. IJ Adaptive Technologies for Training and Education, No.:1, pp. 96–116, 2012

[Galeev et al, 2004] I. Galeev and L. Tararina and O. Kolosov. Adaptation on the basis of the skills overlay model. In: Procedings of the 4th IEEE International Conference on Advanced Learning Tecknologies (ICALT 2004), 2004,Sept.

[Gribova et al, 2015] V.V. Gribova and A.S. Kleschev and D.A. Krylov and F.M. Moscalenko. The basic technology development of intelligent services on cloud platform IACPaaS. Part 1. The development of a knowledge base and a solver of problems, IJ Software engineering, No.:12, pp. 3–11, 2015. âĂŞ Smolensk: Universum, 2016. Đć. 3. Đą.171-179

[Gribova, 2016] V.V. Gribova and G.E. Ostrovskiy, Intelligent learning environment for the diagnosis of acute and chronic diseases, Proceedings of the XV national conference on artificial intelligence with international participation KII-2016), 2016, Oct. 1-4,

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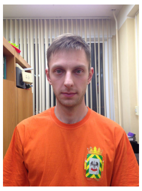

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