The possibilities of intelligent learning environments for inclusive distance education

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Abstract. The paper deals with the introduction of intelligent learning systems (ILSs), which are replacing the electronic learning resources (ELRs). Their main task is to build an individual learning path based on the logical inference's tools. The development of student's models, subject area, learning scenario and the tools for controlling competences are key conditions for designing such systems. The Moodle technologies have been chosen as the main platform for designing the intelligent distance inclusive education environment.

1. Introduction

Over the last decades, the term inclusive education has become a familiar term in Russia. Inclusive education allows children with disabilities to get any education they prefer as other school-aged children. Inclusive education is a child's right, not a privilege.

It is necessary to create, develop and implement information educational technologies in inclusive education environments.Due to the specifics, the already created software products do not fully meet the demands and requirements of both teachers and children with disabilities and the best solution is the intellectualization of the inclusive learning environment.

The last decade's trend in high school is a transition from a knowledge approach to a competence approach. It requires the entire educational process's transformation aimed at incorporating a modern student into it on the subject-subject basis through the creation of innovative educational environments. The scientific community understand the educational environment as the totality of social, cultural and other conditions in which a person studies, as well as the set of educational services that are actually accessible to members of a given territorial community [6]. The philosophy of education considers the educational environment as the design of a multidimensional space that is adequate to the students' needs and corresponding to the modern culture's trends and dynamics.

2. Expert-learning and adaptive learning systems

Methods and tools of artificial intelligence, in particular, expert-learning systems (ELSs) are actively used in order to design these systems. The integration of computer-based learning technologies with expert systems is a basis of expert-learning systems. They provide a combination of competences and qualified specialists' experience with the didactic effectiveness of program-methodological complexes that control and manage the learning process [3, p.121]. The knowledge base allows educators to take into account different levels of trainees' prior knowledge and to form personalized learning path based on the tools of logical inference.

To solve the low-structured problems based on reference knowledge and knowledge acquired by students is their main purpose.

Inclusive education uses ELSs for solving the following problems:

- to manage learning process considering student's prior knowledge and his/her health status (personalized learning path's formation);
- to diagnose and forecast the progress of mastering subject's learning materials by students with disabilities and correcting a sequence of the learning materials' presentation.

The issue of effectiveness is considered to be one of the most important issues, therefore we note that the quality of ELS's work depends, first of all, on the possibility of accumulating and applying knowledge about each student's learning progress. It is very important in order to select individual learning influences and manage the learning process for forming a set of competences. However, the ELSs' development and application for students with disabilities reveals a number of problems:

- a lack of highly qualified specialists (not only educators, but also medical staff), who can jointly solve problems of forming and formalizing knowledge based on the student's health status;
- a lack of necessary (sufficiently large and well-structured) volume of design and practical tasks, tests and other qualimetric materials that take into account the perception of the learning material by students with poor hearing and eyesight;
- a lack of tools for inclusive learning process organization, although the priority approach to the modern project tasks' performance is based on teamwork;
- a lack of good explanatory abilities. There is no differentiation of explanations depending on the health limitations and user experience in ELTSs.

An equally well-known type of intelligent computer-based learning systems which are used to manage the learning process are adaptive learning systems (ALSs). They realize the feedback between a student and these systems.

Of late, much has been said about the focus of learning processes on the particular person's interests and talents. However, often students who differ from the main group in the perception of learning and communication processes or the perception of a particular educator may be deprived of attention, may be considered to be incapable. Students with disabilities are the most vulnerable category of students. For example, Swedish specialists identified in their research works that students with disabilities often misunderstood educators (Bergshtrom, 2004). We propose to create an individual learning path for each student with disability based on methods and models of neural networks theories, graphs, fuzzy data sets, classifications, and agent-based systems.

In computer-based learning, the specialists point the following levels of learning system adaptation to each learner with disability's needs:

- categorical adaptation (the first level adaptation);
- group adaptation (the second level adaptation);
- personal adaptation (the third level adaptation) .

The first level adaptation is the broadest and it assumes the adaptation of students with reduced mobility, poor hearing and eyesight to computer-based learning. The intelligent learning systems provide users with the following opportunities: training, knowledge testing, assignments, help and background information, video lectures, presentations, questions to an educator, conferences, forums, chats, e-manuals, comments during lessons, exercises with simulation systems, and etc.

The second level adaptation takes into account the psychological orientation, student's age, the chosen speciality, and training program. Adaptation to this group of students is based on the goal of training, and in accordance with the role policy of each student.

The greatest degree of adaptation to a student with disability is achieved at the third level where it is taken into account the available level of competences, personal characteristics, and health status. It takes into account the background of learning, including individual learning, learning at specialized schools/ regular schools with inclusive programs.

In order to adapt computer-based training systems to persons with disabilities, educators use various methods, classified by Brusilovsky P.L.:

- curriculum sequencing;
- adaptive presentation;
- intelligent analysis of student solutions;
- interactive problem solving support;
- adaptive navigation support;
- example-based problem solving;
- interactive collaboration support[5].

ALSs' design for persons with disabilities raise a number of questions, in particular, related to the training program's content, learner's model (that differs from the standard one in many aspects), and special training scenario. The choice of tools for monitoring competences and the formation of a personalized learning path is also different from the generally accepted ones. The subject area needs special attention, since knowledge is of a quantum nature: they contain methodological (theoretical), control and design information. In order to develop ALSs for students with disabilities, it is very important to use the gained experience as units of hybrid knowledge (documents, emodels, edesigns, question-answer documented dialogues, etc.).

In our opinion, the ALSs' application in the intelligent learning environments development for students with disabilities is more productive, since there is no complicated preparatory stage associated with the knowledge base formation in ELSs.

3. Organization of intelligent learning environment

The intelligent learning environment (ILE) is a complicated information and communication system with internal and external sources of knowledge and with intelligent sensors. It is based on the principles of personalized learning, the synergy of formal and informal learning, and the competence formation based on both learning and real knowledge, the active use of simulation systems, virtual worlds and augmented reality.

Formal learning is extremely formalized, orderly organized by the programs and courses, related to certain organizational and time frames, the last step of which is getting a certificate. This kind of training is the most effective for the implementation of learning objectives related to the acquisition of the required set of competencies, including the advanced competences. The main advantage of formal learning is the rigidity of time frame during which the learning objective must be achieved.

Today the main platforms of formal network training are Moodle and Blackboard.

Moodle is the automated learning environment, containing a set of management tools for the educational process, a number of roles (student, educator, administrator and others), user-friendly interface. Moodle embodies the theory of social constructivism in learning.

Blackboard is the automated learning environment, containing a set of management tools for the educational process, a number of roles (student, educator, administrator and others). Blackboard embodies the linear learning theory.

However, formal training is not always acceptable for students with disabilities, therefore, as knowledge and competences are acquired by them, they become increasingly oriented towards informal learning, connected with getting necessary information from various sources: experts, Internet, etc.

A person lives in a society, communicates with people, and he/she learns through the social environment, as well as his/her behaviour changes based on experience and communication. Social learning also refers to informal learning, it is close to social networks (SocialMedia), their organization and work. Social networks are focused on the concept of lifelong learning. But for the informal exchange of knowledge and skills between individuals with disabilities, it is necessary to create special conditions, implemented, in particular, through computer-based technologies. The main task at the same time is to ensure discussion and solution of problems by the definite group of participants and at the definite time.

Informal learning platforms are numerous social networks, primarily, professional and business ones such as Linkedin, ResearchGate, etc.

The beneficial effects of using social networks for training people with disabilities are the following: the significance of the discussion, effective collaboration, search tools and information resources, etc.

A powerful tool of informal learning of people with disabilities is Massive Open Online Courses (MOOCs). They allow a large number of students being far from each other to get an open access to the course's content at any convenient time.

The most effective approach to intelligent learning environments organization is the synergy of formal and informal learning where formal learning based on network platforms should play a dominant role.

The Institute of Distance and Further Education of the Ulyanovsk State Technical University (IDFE UlSTU) has been using Moodle since 2007. It has the richest experience (over 15 years) in the development and application of distance learning environments (http://ido.ulstu.ru).

The structure of the intelligent corporate learning environment is given in Figure 1.

The Moodle technologies are selected as a tool platform for developing an intelligent learning environment for the inclusive distance learning system.

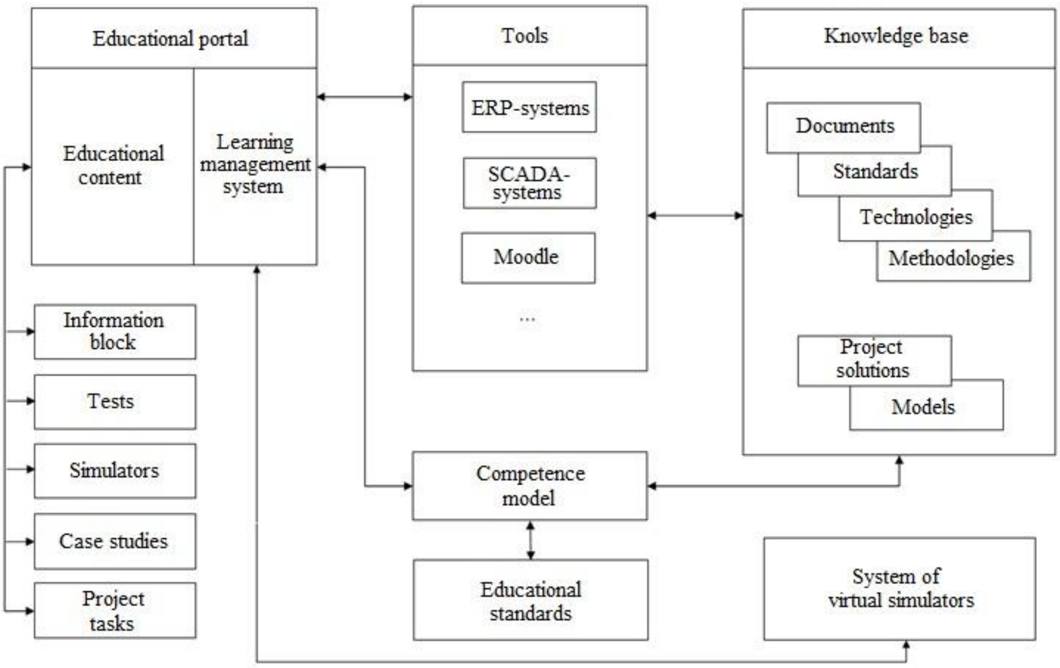

Figure 1. The structure of the intelligent learning environment.

4. Models and methods of intelligent learning environment

In order to implement the principles of intelligent environment organization and functioning for inclusive distance education we propose a number of models and methods:

1) a dynamic multilevel domain model; 2) an overlay learner model;3) a model of learning process scenario as a dynamic oriented graph;4) a method for controlling and diagnosing of a learner's qualitative characteristics;5) a method for generating the dynamic adaptive personalized path of a learner; 6) a method for integration of based learning platform with social networks and online learning technologies.

We propose two approaches to the development and integration of models and methods.

The first approach is concerned with the representation of a subject domain model as an associative multi-level model, the use of modified classification method based on the fuzzy Kohonen maps as a basic tool for monitoring and diagnosis of learner's dynamic competences, and the proposed method of generating personalized learning paths.

The second approach is associated with the ontological representation of a subject domain and the development of the method of generating dynamic learning path based on this subject domain.

The above-said models and methods are implemented in Moodle as a mobile application. The basic parameter comparison of these approaches– the effectiveness of training – has shown good results in both cases.

5. Virtual simulation systems

To acquire practical skills is an obligatory requirement when students study special subjects such as radio-engineering, instrument engineering and computer science. Simulation systems can help to solve this problem for children with disabilities.

After analyzing the methods and tools for simulation systems, we identified a set of basic approaches.

1. A scenario approach. It is based on the training scenario. The variants of actions are proposed a student at each stage of the scenario. If the answer is correct, a student goes to the next stage. The main disadvantage of this approach deals with spending too much time to design complex simulation systems.

2. An automaton-based approach. The models of simulation system's states are discrete and given as automaton models:

$$A=(S, D, Fs, Fd), \quad (1)$$

where S – a finite set of parameters characterizing an object's state;

D – a final set of controls;

Fs – output functions;

Fd – transition functions.

This model is almost never used alone.

3. An algorithmic approach. Generally, these simulators are developed for modelling the complex processes. The algorithmic approach based on mathematical models and numerical analysis to compute the system's data. Different tool environments of finite element analysis which solve problems in the field of mechanics, heat transfer, fluid dynamics, e.g., ANSYS, ABAQUS, are used to implement simulators,. The main disadvantages are the complexity of development and specialization.

4. A hybrid approach. This approach combines the strengths of automaton and algorithmic approaches. The basis of a simulator development is an automaton-based approach with expanding the complex logic through algorithmic modeling.

The basis of the implementation of simulator's system is the author's model of a virtual automaton-based simulator. A distinctive feature of this model is the availability of functional blocks (groups of states) and the error states, allowing the authors to extend the class of learner's diagnosable errors.

The model of a virtual simulator is as follows:

The simulator = (a set of states, a set of control actions, a set of rules, a set of functional blocks, a set of error states), where:

a set of states are the states determined by the space of simulator settings,

a set of control actions are a set of possible user's actions with a simulator;

a set of rules are a condition for change of a simulator's state from one to another;

a set of functional blocks. A functional block is a separate part of a simulator, that independently performs its task and does not overlap with other blocks;

a set of error states are a set of states that characterize the non-functional simulator.

Rule = (condition, control action, next state), where

state is a state in which the simulator should apply the rule,

control action is an action of a trainee which starts changing the state,

next state is a state in which the simulator will be after the application of the rule.

Functional block = (a set of rules, a set of target rules),

where a set of rules are rules that are executed within the functional block;

a set of target rules means that each block has its own purpose (e.g., to set the start mode), the last rule that is applied to achieve the purpose of the block is the target rule.

A narrative description of an algorithm of simulator development is presented in Figure 2.

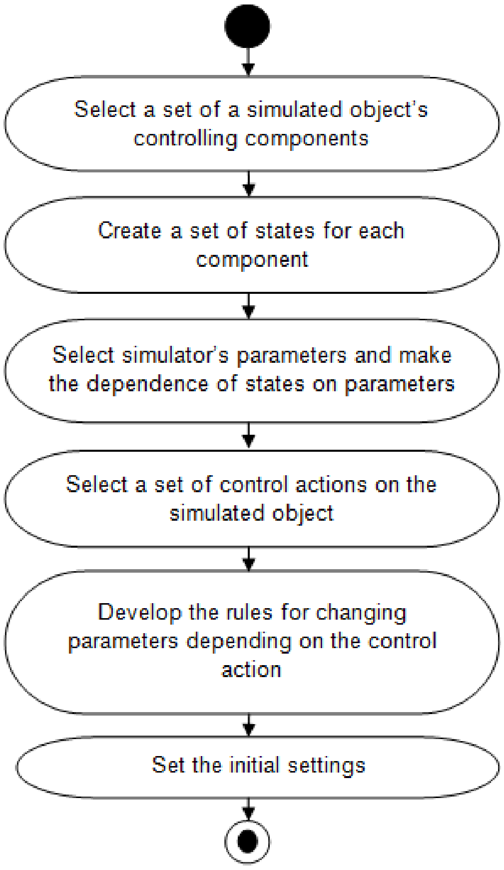

Figure 2. A narrative description of an algorithm of simulator constructions.

6. Method of actions' analysis and learner's errors diagnostics by a simulation system

To check learner's skills in a simulator he (she) is given exercises. They are characterized by the initial and final states:

Exercise = (an initial state, a final state),

where an initial state is a state from which the exercise should be started;

a final state is the state in which the exercise is considered to be done.

During the exercise, the learner generates a control action in the simulator. Start the step counter, every control action increments the counter by 1. The control action initiates a change of the simulated object's state. The simulated object's state after the clock cycle t is denoted as S(t). The rule used for transition from state S(t-1) to S(t) is denoted as R(t).

The authors classified learners' errors and developed rules to define them.

The loop:

$$S(t) == S(t-n), n=1..t \tag{2}$$

Back to the state that it was in the past, a special case – there is no change of state after the control action.

Unchanged state

$$S(t) == S(t-1) \tag{3}$$

The control action doesn't change the simulator's state. The state of simulated object's is equal to the previous state, i.e. a special case of loop.

A simulated object's error

$S(t) \in$ a set of error states

The user set the simulator in a faulty state. The current state belongs to a set of error states.

Achieving the goal again:

$\exists b \in$ a set of functional blocks $\wedge R(t) \in$ a set of target rules of block b $\wedge \exists n \neq t$: $R(n) \in$ a set of target rules of block b

A learner changed a parameter the second time, e.g. he (she) first set a 10-second period, then an 8-second period.

Transition between blocks

$\exists b1, b2 \in$ a set of functional blocks $\wedge R(t) \in$ a set of rules of block b1 $\wedge \exists n \neq t$: $R(n) \in$ a set of target rules of block b2

The learner first performed the exercise within one functional block, and then he started performing tasks in the framework of another block, e.g., he began to set the period to 15 seconds, didn't finish and began to set the internal start mode.

Reusing a functional block:

$\exists b \in$ a set of functional blocks $\wedge R(t) \in$ a set of rules of block b $\wedge \exists n \neq t$: $R(n) \in$ a set of target rules of block b

A learner began to change the parameter changed before he did it.

Using a functional block without achieving any goal:

$\exists b \in$ a set of functional blocks, $\exists k: R(k) \in$ a set of rules of block b $\wedge \nexists n$: $R(n) \in$ a set of target rules of block b $\wedge S(t) \in$ a set of final states of the exercise

A learner performed an unnecessary action that does not influence on the result of the exercise, e.g., a learner started to adjust the amplitude of the signal when it was not required to complete the task successfully.

Figure 3 presents a narrative description of the search algorithm of learner's error actions.

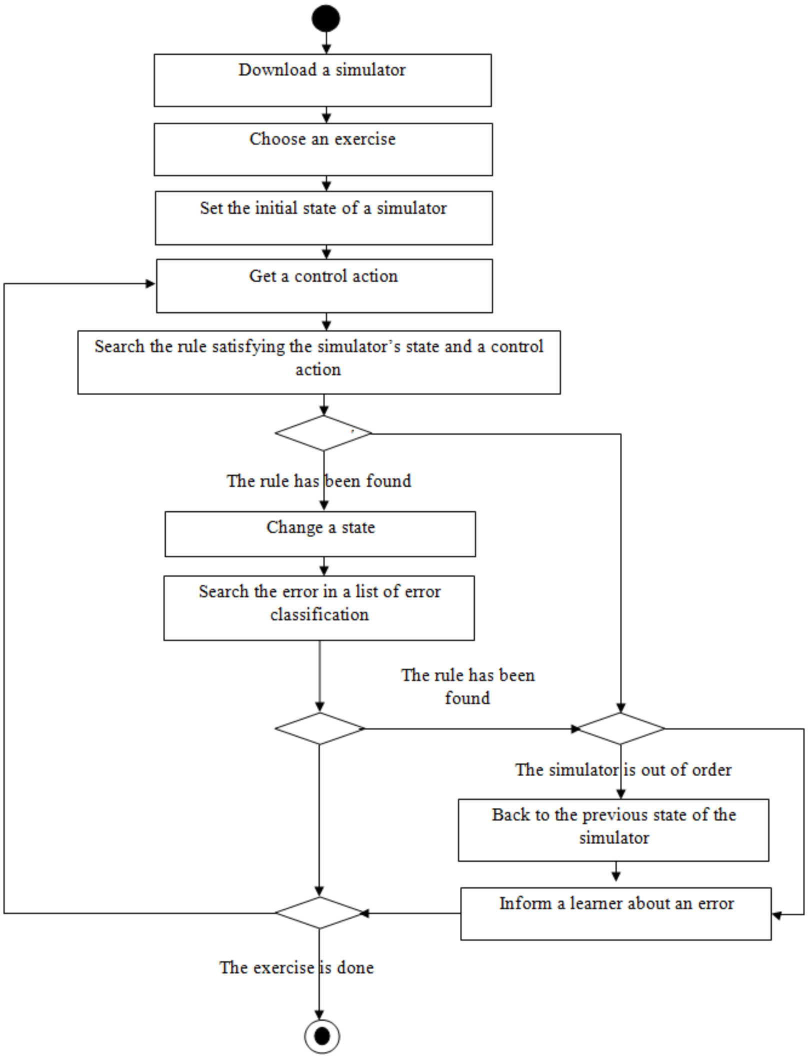

Figure 3. A narrative description of the search algorithm of learner's error actions.

7. Conclusion

The new method of the personalized learning scenario formation based on the interaction mechanisms of the expert learning system model with the domain model allows reducing the period of training to 10-15%. Increasing the effectiveness of training people with disabilities via complex automated systems with artificial intelligent tools contributes to the personalized learning process and allows educators to make a flexible change of strategies based on adaptive learning systems.

8. References

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