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Various Aspects of Intelligent Collaborative Educational Systems

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Abstract. In connection with the transition to a knowledge-based economy, at a time when a key factor in the development of society is the accumulated human knowledge and skills, as well as the availability of a wide range of users, intelligent systems are becoming very popular. Accordingly, the demand of the ergonomic and effective means of designing this class system is growing as well. The most time-consuming and most important stage of intelligent system development is the formation of the system knowledge base which ultimately determines the efficiency and quality of the entire intelligent system. Knowledge representation and processing models and methods as well as the intelligent system development techniques operating on the basis of these methods and models have a crucial role in relation to this.

The article explores the different aspects of intelligent collaborative educational systems, describes the overall structure of an intelligent collaborative educational system and reflects the different steps of development the system.

Keywords: self-directed learning; intelligent collaborative educational system; knowledge base; inference engine; extended semantic network.

I. INTRODUCTION

One of the characteristics of the emerging global information society is the creation of a new educational paradigm – "education as a tool of social welfare". On the one hand, rapid and constant technological change creates massive demand for life-long further education. On the other hand, regarding human rights this means that any member of the public, regardless of their age, social status and location, is meant to be provided with educational services at any time and in any field.

"ES 2020" strategy was defined on the 3rd of March, 2010, in the European Commission communication "Europe 2020: a strategy for smart, sustainable and inclusive growth" and was approved on 17th of June, 2010 by the European Council. The strategy "Europe 2020" is the European Union's growth and employment program of this decade. The emphasis is on smart, sustainable and inclusive growth, in order to overcome the structural weaknesses of the economy, to improve its competitiveness and productivity and underpin a sustainable social market economy. One of the "ES 2020" priorities is "Smart growth - an economy based on knowledge and innovation" which include "Education, training and lifelong learning" and "Digital Society" [1].

On the other hand, contemporary societies face new challenges such as how to organize educational processes in such a way that graduates become the so-called knowledge workers in the full sense of this term [2].

II. SELF-DIRECTED LEARNING AND COLLABORATIVE EDUCATION

Self-directed learning has been studied for a while now. The term "Self-directed learning" is defined as a process in which individuals take the initiative (with or without other people's help) in determining their learning needs, defining learning aims, determining the people and learning resources, selection and implementation of the most appropriate learning strategy as well as in assessing the results [3]. It was established that this was mostly characteristic of adults.

Knowledge workers carry a major role in today's society. Knowledge workers are knowledge executives who know how to allocate knowledge to productive use [4]. A knowledge worker must constantly learn innovative knowledge to be competitive. This makes employee training functionality one of the priorities of staff management functions within modern organizations. A large problem with global virtual organizations, though, employees are scattered around the world, making this functionality difficult to implement [5]. Thus, knowledge worker training is possible mostly by following a self-directed learning path.

Self-directed learning is a complex concept: competence relating to the learner's ability to take responsibility for their own study process, defining

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aims, tasks and needs when developing ideas and alternative perspectives, planning one's time in finding the right material; self-evaluation; the ability to find one's adviser; the ability to think critically, and to find internal resources for self-motivation. When there is no motivation, self-learning does not exist.

The collaborative educational systems tend to implement exactly this idea – the metaphor of "self-service", that is, the user can freely choose how the training process should be organized on his or her terms. Undoubtedly, such a training model is used and is useful only if the students are able to manage their own study process.

Collaborative education is an approach to training which seeks to create groups of students for finding common solutions to any problems. Collaborative education is based on the idea of learning being a natural social act in which the participants talk to each other and the lesson takes place in the process of communication [6]. This type of education does not involve a set of techniques and methods in relation to training; it is a philosophy and a way of life in which every person is responsible for their own actions, including training and respect towards their colleagues' abilities and contributions [7].

The authors mentioned in this article [8] note that the students with a high level of self-motivation are able to clearly formulate their own solutions and ways of understanding things which leads to a better understanding and application of the material by the members of the group.

In all real-life situations where people have to work in a team there is communication and interaction between these people; this reveals their personal abilities, characteristics, each person's investment in the work etc. The main idea of collaborative education is based on the collaboration of the group members rather than competition when every individual would be opposed to the other members of the group. The developers of this approach combined three main ideas into a single process:

- collective learning,
- mutual evaluation,
- learning in small groups.

Herewith appears a problem - how to divide users into collaborative learning groups, which criteria it is advisable to take into account in doing so. One of the ways – to divide knowledge workers into groups for collaborative learning based on the level of knowledge and current competence of each participant, taking into account also his/her cognitive and social abilities.

Knowledge workers are characterized by a set of competences describing key qualities, behaviors, knowledge, abilities, and other characteristics that are necessary to achieve the standards of quality and efficiency of work. In this case one of the methodological problems is the choice of a rating scale. In addition, it is necessary to identify the most important competences by limiting the total number of them. On the other hand, a list of competencies should be relevant and, therefore, a need exists to determine how often this list will be updated [9,10].

Why is it valuable to use the collaborative educational system for studying? The authors of the article [11] note that collaborative education provides greater human cognitive development because the students:

- are actively working with partners in promoting the synthesis of information rather than memorizing it mechanically;
- acquire a lot more knowledge in a situation where they are given the opportunity to work with several different people's points of view;
- talk to each other and during this intellectual exercise they find their own judgment justification and reasoning;
- formulate and defend their views whilst creating their own unique conceptual structure during this process rather than rely solely on expert opinion or textbooks.

III. COLLABORATIVE EDUCATIONAL SYSTEM

The educational system is interrelated education and innovation process as well as the set of process management which works with the aim of providing people with educational services. This innovative activity includes the educational content update, pedagogical technique and method activating, the need to support new educational standards as well as keeping up with scientific developments. The organization of the educational process, namely, the options of choosing the training content, profile and outline, aims at reaching the training and development plan and providing the system effectiveness.

The educational system is rather complex – each of the components can be regarded as a subsystem or as an indivisible whole which derives from a common system [12].

This depiction makes it possible to determine the structural elements of the educational system:

- aim of the educational system;
- management of the educational system;
- members that interact with one another to implement training services;
- educational programs;
- educational content;
- educational-pedagogical activity;
- labour intensity of the educational system;
- information.

The functional elements of the educational system are the mutual relations of structural elements arising from the work process of the system participants.

The collaborative system is a system in which many users or agents are involved in a joint operation, often in different locations. The collaborative systems of the great family of shared usage are distinguished by the fact that the participants of these systems work together to achieve a common aim and they feel the need to interact with one another, that is, to share information, exchange requests etc. [13].

The collaborative systems let you change the organization of science, research and studying by merging the people together as well as the power of computers whilst using new ways of distributing information. Such systems are used in all areas: in administration, business, education, culture and the like. The collaborative systems in the field of education are collaborative educational systems.

A collaborative system has the following characteristics [14]:

- the system elements – both users and agents – interact with each other and affect the behavior of the system;
- the system components use shared resources to achieve both their separate and also common goals;
- the system has permanently open channels of communication between the users and the agents;
- the agents do not possess antagonistic interests.

The key tasks of the collaborative educational system are considered:

- the creation of a group of students at the basis of a deep diagnosis of each participant;
- the creation of the academic program taking into account the characteristics, training goals and objectives as well as the necessary set of competencies of the group of students;
- the creation of the group of teachers and the support staff based on employee characteristics and the academic program;
- developing a set of methodology for the particular academic program;
- the evaluation of the academic results comparing the acquired competences and the existing standards of the students;
- the determination of the labour utility and labour intensity.

The overall scheme of the educational process contains the following activities:

- building the knowledge, skills and competence model;
- student model building and updating;
- curriculum model creation according to the student and competence models;
- the maintenance support of the training process.

An inspection takes place during this process in order to establish whether the created study program corresponds to the student model (specialty, learning objectives, and levels of knowledge, skills and competence) as well as the competence model. If there is a match, the study program is considered to be set up, otherwise the process is repeated (see Figure 1).

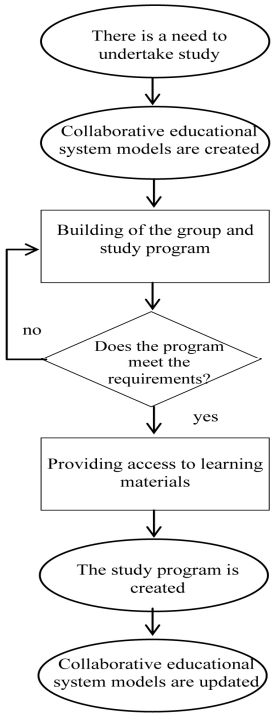

Fig.1. Academic program development process

IV. INTELLIGENT COLLABORATIVE EDUCATIONAL SYSTEM AND STRUCTURE OF IT

Artificial intelligence methods are used within an intelligent collaborative educational system in order to provide better user support for the educational system and it is based on four elements: interaction which is the resource sharing technology in education; tools required for storing data; intelligence for enhancing the decision-making of the educational process; joint action. There are these following main reasons for support of the investment of intelligent collaborative educational systems [15]:

- flexibility – the learning process can happen at any time, any place, there is access to all the different learning materials;
- collaboration – the intelligent educational system allows receiving instant feedback and necessary advice;
- motivation – multimedia resources that are used in intelligent educational systems can make studying fun;
- tools – the intelligent educational systems are able to collect and summarize detailed information, such as, for example, notes, projects, essays etc., and to give relevant information about the student activities;

– the reduction of the required resources – new technology extends the time and reduces the space.

The intelligent collaborative educational system is a modern tool for new knowledge and skill acquisition (see Figure 2).

Within the intelligent collaborative educational system the common structural fragment consisting of the major subsystems and data flows between those are represented in Figure 3.

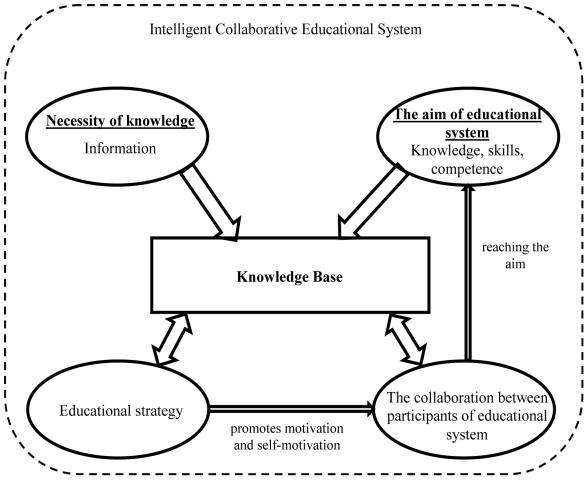

Fig.2. The acquisition of new knowledge in intelligent collaborative educational system

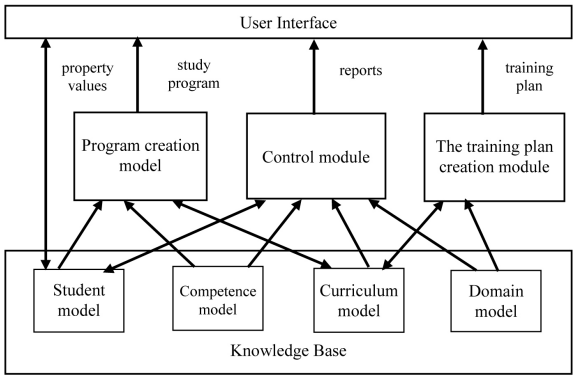

Fig.3. Fragment of intelligent collaborative educational system structure

Strategies for curriculum development and learning content management are included into the educational content model. The student model contains information about students, their set of characteristics (personal data, the level of knowledge etc.). Competence model is the set of necessary competencies (study objectives) established by assessing the requirements of the certain industry, and which is compared to the students' competence. The environmental subject model involves study object (courses, assignments, tests, control issues etc.)

In the basis of the main module operations are appropriate models. The rest of the modules provide auxiliary functions.

Since intelligent collaborative educational system by its very nature is a distributed system, the role of modules is provided by according agents which interact with each other dynamically. The required set of functions is provided by collaboration of the agents. In order to perform the tasks successfully an agent should be able to implement both intelligent behavior (choice of plan, problem decomposition, and task distribution) and reactive behavior (timely response to new information, changes to the data, etc.). Intelligent behavior is ensured by a combination of decision-making requirements for the selection of a plan as well as decomposition and task distribution implementation with the rules of collaboration. Reactive behavior is provided with a level of control that responds to changes in the working memory (for example, determining new aim, reports on changes in the existing data, tasks or responsibilities) [16].

V. KNOWLEDGE BASED DEVELOPMENT

When developing an intelligent system it is necessary to fulfil the following tasks [17]:

– identifying a subject oriented environment tasks;
– the creation of a subject oriented environment description for each task;
– the placing of any intelligent task;
– intelligent task solution methods and their corresponding algorithm selection or development.

After completing this work it is possible to start the system conceptual design and a knowledge based moulding.

Intelligent systems are based on the knowledge base that contains all the information that the system uses in a systematized manner. Thus, within the intelligent systems all the information that is used and processed is provided in a semantically structured, unified knowledge base which on a semantic level reflects a complete view of the world where this system "lives". The processing machine of the knowledge is a set of independent agents that interact with each other only through the knowledge base.

Knowledge base must include all the information that is necessary for agents that work with semantic memory, organizing joint activities for the purpose of conveying intelligent system tasks [18].

In order to develop a knowledge base it is needed to clarify the environmental structure of the subject, namely, the research object and subject of the research.

Accordingly, the basic components of the knowledge base of intelligent collaborative educational system, namely, academic and science objects corresponding to the subject oriented environment units may be the following:

– the academic program elements that describe a specialty, specialization, aims, objectives, total amount and deadlines;

- the structure elements of the study program related to the curriculum, basic courses, specializing courses, description of the practice areas;
- the students are described by the elements, namely, the group size and level of preparation;
- a set of methodological material items;
- the methodological techniques and training elements are described by elements;
- competences describe the elements;
- the test group elements – tests, control tasks, etc.;
- the elements of the teachers and school support staff descriptions;
- the final report items;
- labour intensity calculation elements;
- a set of regulatory documents describes items.

A comprehensive model for the representation of knowledge recommendations does not exist, but some criteria have been developed. For example, in one of the works [19] it is determined that if the subject oriented environmental concepts are difficult, there are many relationships with the notions of judgment and type of hypotheses, then it is appropriate to use the network models. In this case the hypotheses are related to the recommendations, diagnosis, predictions and other decisions that are determined by the specifics of subject oriented environment.

The concept of semantic networks of knowledge representation is based on the idea that all knowledge can be represented as a set of objects, or concepts, and links, or relations, between them.

According to the semantic network example, it is possible to determine the database (working memory) and knowledge-based difference. Subject oriented environment is its own possible entity of a set of states. This set which is reflected through common terminology, concepts, relations and laws creates a knowledge base in an intentional semantic network form. However in every particular situation these subject oriented environment entities possess specific characteristics. These specific data are reported in the extensional semantic network (data base or working memory). Working memory is used to store temporary data. It contains information on the objectives, current tasks, completed tasks, incoming and outgoing messages and short-term liabilities.

The advantages of semantic models of information processing [20]:

- the representation of knowledge with semantic networks to significantly simplify the knowledge integration process which is implemented as the identification and bonding of integrated semantic network synonymic elements;
- correctly established intelligent system knowledge base in the form of the semantic network completely eliminates the duplication of information within the knowledge base;
- the knowledge reflection in the form of semantic networks for simple associative access to different types of knowledge-based fragments;
- the semantic models of knowledge processing are well suited for asynchronous parallel information processing.

The semantic knowledge processing model is an abstract multi-agent system composed of semantic memory which stores the semantic networks as well as the semantic network processing-oriented agent sets [20].

As the formal basis of the intelligent system a special kind of representation and processing models of semantic knowledge are considered and they are based on semantic networks.

The article [5] has offered to use the extended semantic networks [21, 22] which can be considered as the semantic network model for the improvement of logical and computing aspects. In extended semantic networks, nodes can correspond not only to objects or concepts, but also to relations, logical components of information, complex objects, etc. To everything that can be regarded as an independent unit, its own node must correspond. Thus, nodes of a different type are entered – nodes corresponding to names of relations, as well as a special composite element called connection node. They are connected by marked edges with nodes taken from the array of the above-mentioned nodes. As a result, a fragment appears that corresponds to elementary situations, i.e. objects that are bound by relation. Such a fragment is called an elementary one. The basis of extended semantic networks is a set of nodes D from which elementary fragments

$$D_0 (D_1, D_2, \dots , D_k / D_{k+1})$$

are compiled, where D_0 stands for relation name; D_1, D_2, ... , D_k – for the objects participating in relation; D_{k+1} is for the connection node denoting the whole array of objects participating in the relation. This node is also called the s-node of elementary fragment; $D_0, D_1, D_2, \dots , D_{k+1} \in D$, $\kappa>0$.

VI. INFERENCE ENGINE

The solver is implementing a certain type of judgment in the intelligent systems as well as the search algorithm in the knowledge base, conflict resolution strategies and confusion and error handling mechanism. The fact of working memory interpretation process within the requirements is defined by the logic output.

Within the semantic network models direct judgment chain algorithm is often used and it is based on three basic methods [23]:

- the coating method is based on the comparison of individual fragments of the semantic

network; a successful coating is when the semantic network fragments are identical;
- the intersection search method determines the location of nodes which is the junction of particular ways;
- the specialized methods are based on the tracking of the relationship characteristics of network nodes.

Unfortunately, in the basis of the direct judgment chain process is a re-reading algorithm that reduces the logical output implementation efficiency. To overcome these drawbacks, for various semantic network models the use of other approaches to the logical output organization was offered [24, 25, 26], but still the problem remained, therefore, it is appropriate to design such a logical output method that complies with the following essential requirements [24]:

- the output method should be based not on re-reading algorithms, but should be based on the algorithms based on the output of the search process of the current situation analysis;
- the output method must be based on the effective output procedures;
- the output method has to be unified, that is, there should be a unanimous output method used to develop the knowledge representation model;
- the output algorithm must be universal, that is, it should allow handling both clear and fuzzy procedural-declarative knowledge.

VII. CONCLUSION

The article describes principles for development of intelligent collaborative educational system which are based on the knowledge representation of semantic network model; the main tasks of the system are formulated; certain problems that need to be addressed.

The proposed development version of an intelligent collaborative educational system which is based on multi-agent technology has a number of advantages compared to the traditional system of this type because the intelligent agents provide the academic process with flexibility and dynamism.

The described methods and models creation is continuation of this article authors' work which is devoted to development the intelligent collaborative educational system for knowledge workers, and it might be useful for these kinds of intelligent system developers.

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