E-LEARNING SYSTEM CONTENT AND ARCHITECTURE EVOLUTION

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Abstract. Along with the development of technologies, we face new opportunities and offers to improve the process of learning – rapid expansion of knowledge as well as increase in number of fields of interest etc. Significant factors are quality, form and availability of education. Therefore this article will discuss e-learning via agile e-learning information system which has two perspectives. The first is agile content and system structure and the second is agile infrastructure architecture.

Keywords: E-learning; Agile; Cloud computing; Ontology

1 Introduction

E-learning is based on use of educational materials (such as audio and video records, photos, different maps, documents, presentations, etc.). These materials are called Learning objects. Learning objects are described with the Learning object metadata. There are several standards that could be used. At the moment the most widespread systems of e-learning are individual (unrelated to other learning systems); they only store the learning materials (learning objects) that are input (are stored in a database called learning object repository) and they do not collaborate with any external systems.

Adaptive e-learning algorithm considers all the information from a student model and according to it provides one or other learning object [1]. The adaptation is organized in two levels – to a group of students and to an individual student according to his/her model. [2] It is possible to achieve this adaptability not only by introducing the possibility to operate with the parameters of texts and learning processes but also in an architectural level. The way of putting the adaptability into effect through usage of the cloud computing will be described in this case.

Main question for this research is how to make learning content available, agile and adaptive by using intelligent tutoring system and latest technologies. How to connect agile learning content with agile systems?

The research goal is to develop intellectual tutoring system based on agile structure and architecture. Major research in this field is made on systems that concentrate on learners testing and static learning content publishing in e-environment. Completion of tests and *.pdf file publishing doesn’t solve the problem concerning processing and presentation of rapidly changing information. Therefore it is necessary to adjust the resources of those who educate and maximize efficiency of the education process.

Research is in its initial stage, therefore additional guidelines and aspects are being developed in order to create a real agile e-learning system. This system is going to ensure that learning materials would be reusable and system’s technological resources – used dynamically, by using cloud technology. The efficiency of completed system will be shown by indices of use of technological resources, costs and results given by learners after acquisition of learning objects.

So, the organization of this paper is as follows. The following section briefly reviews the curriculum content management for agile e-learning content. After describing e-learning systems architecture concepts in Section 3, the agile principles will be review in Section 4. The final section provides a short description and a conclusion for our work - agility in curriculum content management.

2 Agile e-learning system structure

The agile e-learning system is a system that has adaptable, reusable and easy changeable content. We offer systems content adaptability describe using ontology, i.e., defining rules or statements, learning objects metadata and build simple reasoning mechanism for linking information (retrieval of information) -that has been described within curriculum and learning objects repository (see Figure 1). These rules have been given in OWL language (Web Ontology Language), OWL is the most recent development in standard ontology languages, endorsed by the World Wide Web Consortium (W3C) to promote the Semantic Web vision.

In the system, there is a service that makes the defined business processes work and also keeps track of the operations with objects performed by users, and Artificial Intelligence search inquiries. To achieve load changes of the operations in case of a rapid increase in the number of users exploiting several forms of demanding resources, a part of resources is moved to Cloud.
The academic staff should observe the main condition – to precisely define all parameters of object metadata and, if necessary, supplement the already existing object metadata with new parameters. Defining of LO (learning objects) parameters is established by Draft Standard for Learning Object Metadata which determines the parameters of metadata.

To provide the interaction between topic and learning objects, the OWL Ontology is used in description of links (see Figure 2). The ontology approach is a powerful modeling approach; however, it without domain analysis for particular types of applications, the ontology approach remains a virtual philosophy [8]. Ontology uses the metadata of curriculum to create semantic web or theme and the web of learning objects. This approach describes rules that are taken into account when all the learning objects and metadata added to the learning object repository are further headed to the web of links.

![Figure 1. Curriculum structure](image)

When changes are made, one of the rules generating links between the objects and the topics, new information structure is created. Also if the changes are made in the metadata of the learning object, a different information structure is created (see Figure 1).

![Figure 2. Learning objects retrieval schema](image)
3 Architecture of e-learning systems

All components, what we discuss in first sections (flexibility, adaptability, robustness, agility and changeability) are found in all of architectures and physical levels. The agility is in organizational level (object metadata) and in technological (Cloud) level too.

Figure 3. Typical e-learning system architecture

There are several projects and researches on this topic, but it doesn’t cover our idea for 100%. As one of examples is Yu-Liang Chi “Ontology-based curriculum content sequencing system with semantic rules” where is analyzed ontology based curriculum content sequencing and E. Kontopoulos *, D. Vrakas, F. Kokkoras, N. Bassiliades, I. Vlahavas “An ontology-based planning system for e-course generation”, where also we can found some common ideas and approaches. Our goal is to develop agile e-learning system with agile architecture, adaptable resource consumption and adaptable learning content.

Figure 4. Adaptive E-learning system

The classical architecture (see Figure 3) of an e-learning system shows that all objects are stored in resources that are accommodated by the university. Exceptions are those cases when third parties or other companies are the providers of the e-learning system. The university system provides all the services, processes and, of course, the technical resources. E-learning system set is constant at the beginning; in case of expansion, new equipment (servers, network connection systems), services (faster Internet access), staff (information system administrators) are introduced to level the expansion with the current load. It is possible to estimate the growth of technical demand in advance by following the statistics of the load.

Indicators of the user load can change. In case when rapid increase in the load indicators is followed by a fail, system downtime occurs. It occurs because the demand for the resources is smaller than the offer. It means that all available resources are not used, but we still need to maintain them [7]. The system results in losses.

Systems that change the architecture (see Figure 4) by acquiring a part of their resources from the Cloud, allow us to adjust the available resources in accordance with the indicators of the load. These changes imply partial assignation of the business processes and storage of relevant information to the management of the system holder – the university. Learning materials, backups and all the information of dynamic character is held on the Cloud. This collaboration between the resources of the university and the possibilities offered by the Cloud provides the adaptability of the system in a more effective way; information contained by Cloud can be accessed much faster, volume of the resources can change dynamically and the access is permanent.
4 Agile principles in content structuring and system architecture

One of the most unpleasant factors regarding the information systems is that in case of introduction of changes these systems have to be modified or created anew. It leads to consumption great amount of time, human and financial resources. One of the ways of solving these problems is creation of agile IS [3]. These systems are of dynamic character – the provided aggregate of their options can be altered in a fast and simple way. A basic rule has to be followed – we have to take into consideration agile organization, because the technology cannot manage the agile organization processes without an overall unified plan of the action.

What basically is the agile IS (information system)? The definition of these systems still has not been worked out. Several authors/specialists have various views on what is agile IS and how it differs from the notion of IS that is familiar to us. For example, Steven Alter (1999a) has defined IS [3] as "special case of work system". Agile IS are characterized as organizations good organization: “…if the information system is under agile, the organization cannot respond to market opportunities of face challenges in a timely manner.”[5] This need for agility in academic level we can characterized as the same – if academic environment don’t work in a timely manner, the result (students knowledge) will go down. The definitions of the notion agility also differ, for example, it is described as swift initiative or rapidity and astonishment. Agile systems are dynamic enough to change in an organic way and are based on interactive and enterprising bottom-up concepts. There are cases when agile organization and agile IS are looked upon as the same concept; however, this article describes agile IS that operates in accordance with agile organization [4].

Manifesto for Agile Software Development [6]:
- Individuals and interactions over processes and tools;
- Working software over comprehensive documentation;
- Responding to change over following a plan.

The notion of agility can be described as robustness, adaptability and flexibility. All these factors by interacting with each other provide the changeability of the system. Agile IS can be described with the notion of Changeability [8]. Changeability is created by taking into account four factors that must be provided in systems. These aspects can be implemented in the e-learning by foreseeing algorithms that operate with the parameters defined for the objects and by mutually linking these objects and also by using key-words or other metadata element or combination of elements. Automatization of the linking as well as maintaining the automatization in case of deleting links or changing the number of the parameters. Thus we create agility in the link structures and object parameters.

The emphasis in such system is to put on dynamic links and parameters. Linking of the objects can be implemented by the key-words that create a mutual net of the objects, i.e. the united net of objects will contain only the objects that are marked by the same key-words. Though we have to take into account that a single object can represent web of several objects; it depends on the added parameters. When adding a new object, it is important to enter its metadata correctly, and it will adapt itself in the overall structure. It is important while adding a new learning object to learning objects repository to fill its metadata correctly, then the new learning object will adapt itself in the overall learning objects structure automatically. The benefits of such approach are the following: economy of time, because we do not have to define the link to the object (feature of Moodle); structuring of the curriculum allows us to plan the topics of the course more effectively and therefore allows to provide comprehensive and detailed layout of the course.

Users of the system do not have to perform manual linking by adding or deleting objects and their parameters. The search system depends only on the entered parameters; the search services will indicate and connect the inquiry with the objects available.

5 Conclusion

Modern e-learning systems mainly concentrate on student testing and static learning content presenting. Development of reusable learning content provides opportunity to develop dynamic curriculum exposition. Such approach connected with student model provides foundation for adaptive learning. It is important to present the right knowledge on the right context on the right time – it improves the quality and the theoretical knowledge of the learning. To solve context problem semantic web and ontology should be used. Question for further research is how to implement curriculum topic map structure with metadata and semantic connections of the learning objects, to show the predictable context.

The processing and interpretation of the learning objects is only one of the ways – in future it will be possible to process the test system and the active learning in the same way. These are the opportunities and future work agile IS is one of the vital turns in the future (and in present), because in the business or any other field the ability to change is very important; the slower changes are been made the more resources are being wasted, and it puts us in the losing position. To implement enterprise agility, you need to start with the agile organization and the simplest process of simplification. The Cloud Computing paradigm secures that agile IS can provide the dynamics and the economy of resources from the point of view of finance as well as human resources. As it is known, saved
resources always give a positive boost and open new opportunities for successful further development. Modern technologies along with up-to-date approaches to the development and exploitation of IS, open the way to development and exploitation of agile IS.

The dynamic aspect in the development of the agile IS structures is achieved largely due to the ontology and rules defined in OWL language. Previously made rules (rule based systems) allow us to reduce the time used for the system exploitation and let the modeling rules to be interpreted in the format of OWL rules, thus developing possibilities of the learning as a set of business processes.

Cloud Computing combined with learning rooted in the rules is the future-way of dynamic e-learning development.

In the future it is required to study the boundaries of the system dynamics, as at the moment it is only possible to identify the dynamics in certain borders, i.e., it is possible to predict the amount and the architecture of certain changes.

References


CLASSIFICATION OF DISTANCE LEARNING AGENTS

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Abstract. Implementation of agent based intelligent technologies in the environment of distance learning can individualize learning, enable the optimal use of learning resources and ensure effective interaction with all participants of the learning process. The paper presents agent classification for the modern distance learning environments, based on Anderson and Garrison’s model of interaction modes in distance learning process. All components of the learning process model and the interaction of agent groups are distinguished, and the functions of such groups are described.

Keywords: distance learning, agent, classification.

1 Introduction

In distance learning there is an attempt to replace human relations, which appear in direct contact with a learner in traditional studies, by effective interaction with the learning environment. However, the need for monitoring a learner, following his progress, providing timely relevant information, offering assistance, and communicating remains. These problems in distance learning are solved by implementing and applying technologies based on intelligent software agents. Furthermore, a lot of routine and time-consuming functions of a teacher and student can be computerised, especially those relevant in application of virtual learning environment.

An intelligent agent is a computer system situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives [16]. Imam and Kodratoff [15] define an intelligent agent as “a system or a machine that utilizes inferential or complex computational methodologies to perform the set of tasks of interest to the user”. According to Weiss [25], “as an intelligent entity, an agent operates flexibly and rationally in a variety of environmental circumstances given its perceptual and effectual equipment. Behavioral flexibility and rationality are achieved by an agent on the basis of key processes such as problem solving, planning, decision making, and learning. As an interacting entity, an agent can be affected in its activities by other agents and (perhaps) humans.”

Hence, intelligent agents are used to model rational behaviour in a certain operation diapason. Intelligence also means that agent activities are based on certain logics which can be compared to human logics: the software developed according to certain objectives simulates human logics and activities and thus software technologies approach human perception, intelligence and operation.

Intellectualization and individualization of learning by applying agent technologies enable us to eliminate the barriers naturally emerging in the distance learning process. Effective learning environment would be the one which creates clear, purposeful and support-based learning environment, though the student studies alone, and enables him to interact efficiently with other participants of the learning process.

Although there are a number of works on agent technologies applied in distance learning, a single generalising approach is still missing. For example, there is no single classification for educational agents. An established classification system would allow systemising the approach and would facilitate the analysis of agent technologies and application in distance learning.

This paper suggests classifying learning environment agents on the grounds of the Anderson and Garrison’s model [1] of the interaction modes in the distance learning process. The most frequently used general agent classifications are introduced in part 2 of this paper; the conception of agents applied in the learning and existing educational agent classifications are presented in part 3; the expanded model of interaction modes in the learning process, which illustrates current distance learning process, is presented in part 4. Agent classification, on the grounds of expanded learning process, is given in part 5.

2 Diversity of Agent Classification

It is clearer to analyse and use agents in different environments by making reference to their division into certain classes according to their general characteristics, i.e. by classifying them. There are different classification schemes that may be used to define agents. Nwana’s conception of agent typology, classification according to the types, is used the most widely in scientific literature.

Classification by Nwana. Nwana [20] identifies some aspects for agent classification:
- agent mobility. According to their capability to move among networks, agents are devided into static and mobile;
- agents can be deliberative and reactive;
agents may be classified by their key characteristics: cooperation, learning and autonomy. Four agent types can be singled out according to these minimal characteristics (Figure 1): 1) collaborative agents, 2) collaborative learning agents, 3) interface agents, and 4) smart agents. However, an agent that belongs to a specified class may also combine other characteristics.

Figure 1. A Part View of an Agent Typology [20]

agents may be classified by their key roles. For example, WWW agents that are called information or Internet agents. There may be other classes by minor roles: report agents, presentation agents, help agents, etc.

the category of hybrid agents, which covers philosophies of two or more agents, is also included.

According to all the examined categories of agent types Nwana [20] has identified seven agent types, considering that this list is more arbitrary than definitive:
1. Collaborative agents.
2. Interface agents.
4. Information/Internet agents.
5. Reactive agents.
6. Hybrid agents.
7. Smart agents.

In accordance with Nwana, there might be some applications in which agents from two or more categories are combined and we refer to these as heterogeneous agent systems.

Classification by Brustoloni. In Brustoloni’s [6] taxonomy there are three agent classes: regulation agents, planning agents and adaptive agents. Regulation agents do not plan and learn; they simply react to some changes and always know what to do. Planning agents plan and use elements of artificial intelligence. Adaptive agents not only plan but also learn.

Classification by Gilbert et al. In order to determine agent characteristics, Gilbert et al. [13] have introduced model 3D in which the agency can be roughly qualified by the agent’s position in 3D space where intelligence, autonomy and social ability correspond to the dimensions. So that the agent would be assigned to the system, it must meet a minimum level of characteristics of each dimension.

Classification by Franklin and Graesser. Franklin, Graesser [12] have presented the classification according to the biological and computational model emphasizing major autonomous agent classes: biological agents, robotic agents and computational agents. In turn, in the dimension of the type they have classified computational agents in software agents and artificial life agents, and in the dimension of the class divided software agents into task-specific agents, entertainment agents and viruses. The authors consider that further subclassifications can be made taking into account the control structure, environments (database, file system, network, the Internet), language of design or application.

Classification by Davis. The classification according to Davis [8] is based on three intelligent characteristics of the agent: reflective, reactive and meditative.

Classification by Wooldridge. Wooldridge [27] introduces four classes of agents:
- logic based agents;
- reactive agents;
- belief-desire-intention agents;
- multi-dimensional architecture (decision-taking is implemented via different software dimensions each of which rate the environment by particular abstraction level).

Classification by Russell and Norvig. Russell and Norvig [21] classify agents in four categories, from simple to complex:
- simple reflex (stimulus-response) agents. These agents respond to stimulus. They have no memory, they simply respond to the changes in the environment;
- reactive state agents (“agents that keep track of the world”);
- goal-based agents. The agents can plan their activities in their environment;
- utility-based agents which have acquired some human characteristics. As authors refer, the word “utility” here refers to “the quality of being useful”. There also exist other agent classifications, but their essence, in accordance with Wooldridge [27], is that they shift from abstract agent definition to more precise definitions of structure and agent operation, and also to analysis of advantages and disadvantages of architecture. For example, there are many agents developed to operate on the Internet, their type is the same; however, their denotation and functions of performance are different.

Quite often agents are defined by the roles they perform. Although, according to Wooldridge, Jennings, and Kinny [28], agent roles is more abstract definition than agent types. The authors compare agent roles with persons’ roles in the company, i.e., the company has roles such as “president”, “vice president”, and so on. In the company the individual may provide different roles in different periods, but in a small company he can execute various roles at the same time. One or another role is defined by four attributes: responsibilities, permissions, activities, and protocols.

Usually agent roles depend on the functions they perform.

3 Educational agents

The common goal of the educational agents is to facilitate the learning and support the learner’s activities. There is no single agent classification or unified classification system based on defined agent roles. The definition of the educational agent is also rather broad. According to Chou et al. [7], “an educational agent is a kind of computational support, which enriches the social context in a social learning environment either by providing virtual participants to enhance the member multiplicity of communities or by supporting facilities to foster communication among real participants”. In her definition Landowska [17] indicates common characteristics of the agent such as intelligent and autonomous and appeals to agent functions: “An educational agent is an intelligent and autonomous part of a learning environment introduced in order to assist a student or a teacher in the completion of their tasks. An agent can also autonomously perform tasks related with the management of learning resources or the achievement of internal educational goals”.

Dowling [9] notes that in the learning environment both the teachers and the students can perform different roles at the same time. Electronic environment allows identifying these specific roles and distinguishing different functions that can be accomplished via different agent configurations.

Many scientists refer to the classification of educational agents introduced by Chou at al. [7] which is based on agent operation roles and functions in the learning process. In this classification agents are distinguished into pedagogical agents and personal assistants. In turn, pedagogical agents are distinguished into two groups: authoritative teachers (tutor, coach and guide) and learning companions or co-learners (peer tutor, tutee, simulated student, collaborator, competitor, trouble-maker, critic and clone). Personal assistants are grouped into teacher’s assistant and student’s assistant [7].

Other authors use either more common (teacher agents, pedagogical agents) or more precise terms (recommender agent, learning companion, collaborative learning agent, monitoring agent, facilitator agent, etc.) which are ungrounded by any classification scheme but simply defined by the functions performed by agents. An animated agent is also often called a pedagogical agent [5], [24].

For example, Lee et al. [18] states that in collaborative e-learning environment agent roles may be of two categories: facilitating learning process and facilitating the social interaction. Baylor [4] presents two types of educational agents: agents as intelligent tutors and agents as cognitive tools. Erlin, Norazah and Azizah [11], on the grounds of works of many authors, identified the following roles of agents in the collaborative learning environment: monitoring agent, facilitator agent, mobile agent as, an artificial tutor agent, information agent, question agent, assistant agent, student agent, teacher agent, etc. „The architecture of the system and the role given to each agent depend on both the type of application and the global functionalities of the system” [11]. According to these derived roles, the authors sort all the agents into four wider agent groups: a) information and internet agents, b) collaborative agents, c) mobile agents, d) and interface agent.

Sometimes there is no deep interest in precise agent definitions on the whole and the term ‘pedagogical’ is satisfactory, same as widely used Johnson’s definition, cited by Dowling: pedagogal agents are autonomous agents that support human learning by interaction with learners in interactive learning environment [10].

Consequently, agents model existing and eventual student and teacher roles; and diversity of these roles depends on the mode to learning, objectives and multimedia. In traditional learning both the teacher and the student perform various roles and functions in different situations; therefore, innovations, dynamism and various skills continually raise new roles and demand for new functions. However, alternation of roles in traditional learning is more conventional due to direct interaction with the learner. In distance learning the role and functions of intelligent agents should be defined clearer. General classification of educational agents is too abstract. Consequently, it would be purposeful to carry out the classification of educational agents closely with the learning process.
4 Expanded model of interaction modes in distance learning process

Modern distance learning environment is complex – a student becomes a part of the heterogeneous environment: he/she interacts with the computer, the teacher, other learners and learning content, and all this process is surrounded by a large flow of information. Also the learning process requires an active student role and his/her ability to communicate successfully and learn independently: it means to choose the information and learning material according to the learning aims, define learning terms and learning pace personally, etc. These tasks are not easy.

Distance learning processes are the subject of research of many scientists [19], [14], [26], etc. It is widely used the Anderson and Garrison’s [1] model of interaction modes in distance learning process. The authors expanded the Moore’s [19] structure of three distinct types of interaction in distance education: learner-content, learner-instructor, and learner-learner. In the Anderson and Garrison’s [1] model of interaction the three main components of the learning process (student, teacher and content) and the six types of interactions (student-student, student-teacher, student-content, teacher-teacher, teacher-content and content-content) are distinguished and described (Fig. 2). This structure is considered to be classic in distance learning, however, it is also appropriate for traditional teaching.

Anderson [3] has expanded [1] the model for the semantic network. The author has introduced student, teacher and content agents with their special functions. This model is a theoretical option for possible agent application.

Erlin, Narazah and Azizah [11] have applied [2] the model, which basically corresponds to the Anderson and Garrison [1] model of interaction modes, to classify the interaction-related agents. The authors have linked communication tools and their use in asynchronous and synchronous communication with cluster of agents: interface agent, information agent and the Internet agent (to make the interaction of the model) and cooperation agent (it operates on behalf of student, teacher, and content). As we can see, the object of the authors is interaction and they do not analyse the agents related with the components of the learning process.

Since the environment plays an important role in the modern distance learning, Targamadze and Cibulskis [23] have extended the Anderson and Garrisson’s [1] model of interaction modes in distance learning process by adding to it the learning environment and possible interaction links (Figure 3).

![Figure 2. Modes of interaction in distance education [2]](image)

![Figure 3. Expanded model of interaction modes in distance learning process [23]](image)
According to the authors, "limited interaction between student and teacher in distance learning process is usually compensated through higher interaction with learning content. Application of information technologies in distance education has brought another type of interaction – interaction with learning environment. Students’ and teachers’ interaction with learning environment is as much important as interaction with learning content and can partially compensate weaker interaction between teacher and students. In some cases environment can also interact with learning content by performing automated content modification and adaptation to learners needs” [23].

5 Classification of educational agents on the basis of expanded model of interaction modes in distance learning process

The expanded model of interaction modes in the distance learning process, proposed by [23] Anderson and Garrisson [1], better reflects the modern distance learning process. The components of the model of interaction are supplemented with the environment and the interaction list – with three new interactions: student-environment, teacher-environment and content-environment. This extended model of the distance learning process illustrates the links among all the components included in the distance learning (student, teacher, environment, and content) and the interactions between them. The learning environment is a system which includes all the implements (service, search systems, communication environment, etc.) in virtual environment used by the learner. Content is the variety of learning materials (lecture syllabus, tasks, document sets, diploma works, e-books, videos, etc.). Interaction, mutual influence, is an integral part of the learning process in which, besides knowledge creation and exchange of information, there are other social activities: enhancing student motivation, support, assistance, etc. Interaction has direct impact both on the learning process itself and on the consequent student outcomes. However, assurance of interaction is quite complex. There is a common problem in the distance learning when the learners are unable to have actually effective social interaction due to lack of skills (including the information technology skills) and the lack of the ability and motivation to communicate with teachers and peers. When design of the interaction in the learning environment is completed and functions of interaction are transferred to intelligent agents, it can be achieved that all possible types of interactions are ensured and all objects are used more efficiently. According to Sharp and Huett [22], "interaction does not just happen; it must be facilitated by intentional efforts on the part of the designer.”

By adding agents to the model, we can design a learning system in which each part of the learning process can be constructive for the learner and used to help him/her learn. This expanded model of interaction modes in distance learning process can be used for classification of distance learning agents (Figure 4).

![Figure 4. Expanded model of interaction modes in distance learning process, using agents](image-url)
Learning process agents are divided into two types: **component** agents and **interaction** agents. Component agents are divided into groups depending on learning subjects or objects (student agents, teacher agents, content agents, and environment agents). Interaction agents are divided into nine groups according to interaction links (student-content interaction, student-teacher interaction, teacher-content interaction, student-environment interaction, teacher-environment interaction, content-environment interaction; and student-student, teacher-teacher and content-content interactions). Agents division into types and groups and descriptions of group functions are presented in Table 1.

**Table 1. Components of learning process, groups of agents and agent functions in an expanded model of interaction modes in distance learning process**

<table>
<thead>
<tr>
<th>Category</th>
<th>Group of agents</th>
<th>Functions of agents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Environment agents</td>
<td>Recording of interactions, maintenance of operation in different environments, analysis of applied environments.</td>
</tr>
<tr>
<td>Interaction agents</td>
<td>Student - Content interaction agents</td>
<td>Delivering content according to individual goals or needs. Individualization of learning. Processing, sorting, selecting and/or suggesting materials from various sources.</td>
</tr>
<tr>
<td></td>
<td>Student - Teacher interaction agents</td>
<td>Supporting and motivating the interaction between student and teacher.</td>
</tr>
<tr>
<td></td>
<td>Teacher - Content interaction agents</td>
<td>Assisting a teacher in developing and updating the content. Informing the teacher about changes of materials in environments which are monitored by agent.</td>
</tr>
<tr>
<td></td>
<td>Student - Environment interaction agents</td>
<td>Assisting and guiding a student in interaction with the environment.</td>
</tr>
<tr>
<td></td>
<td>Teacher - Environment interaction agents</td>
<td>Assisting and guiding a teacher in interaction with the environment.</td>
</tr>
<tr>
<td></td>
<td>Content - Environment interaction agents</td>
<td>Supporting and facilitating the application of the material used in the environment. Monitoring the content and environment, coherence analysis between sources, supplying links to additional sources.</td>
</tr>
<tr>
<td></td>
<td>Student - Student agents</td>
<td>Activating student collaboration, encouraging group learning and communication. Discussion support. Formation of a group model from single student models. Mobilization of students similar needs.</td>
</tr>
<tr>
<td></td>
<td>Teacher - Teacher agents</td>
<td>Maintaining thematic teacher networks activity.</td>
</tr>
<tr>
<td></td>
<td>Content - Content agents</td>
<td>Maintaining cohesion of learning objects.</td>
</tr>
</tbody>
</table>

The table above indicates summarized agent’s functions when the agent operates as assistant. Student and teacher models provide certain information about these teaching process subjects as users, help to recognize, evaluate and attribute them to users group, and they also initiate certain actions in connection with the groups. A lot of other roles may be allotted to agents: learning companion, critic, troublemaker, etc. When agent roles are different, their functions change as well; besides, the types of interaction can also be changed. Different types of agents used in agent systems operating together facilitate to achieve tasks and tackle problems in a more flexible way. They can also ensure the system’s higher realibility: if one of the agents is unable to solve the problem, the other ones takeover the task. Distribution of functions among different types of agents is in progress during the system design process.
6 Conclusions

Agent classification enables systemising the approach to them and facilitates to perform more purposeful analysis and application of agent technologies. There are different classification principles; however, there is no common classification. Usually scientists refer to the classification scheme by the agent types according to Nwana [20].

Neither definition of educational agents nor classification is well-established. The ground for agent classification is different and miscellaneous.

The classification of agents presented in this paper and based on the Anderson and Garrison’s model of interaction modes in distance learning process reflects learning activities better and helps to identify necessary agent functions more accurately. There are two types of agents in the learning process: component agents and interaction agents. Agents of components of the learning process (student, teacher, content, and environment) act as assistants of teacher and student; they update, choose, accumulate content, maintain work and analyse different environments. Interaction is mutual impact between components such as student-content, student-teacher, teacher-content, student-environment, teacher-environment, content-environment, student-teacher, teacher-teach, and environment; and agents maintain and strengthen these interactions and operate as activators of the learning process.

References


THE LEARNING PATH AND THE RESEARCH OF ITS EFFICIENCY DURING SCORM COMPLIANT E-LEARNING COURSES

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Abstract. This article briefly reviews SCORM 2004 standard, analyzes the possibilities of the modelling of learning paths when creating SCORM compliant e-learning courses. In the article there is carried out the data analysis of activities and progress reports of e-learning course with stated optional learning process; the efficiency of learning paths chosen by students is assessed; as well as created learning path model of the course under consideration is described.

Keywords: virtual learning environment, learning path, learning sequence, SCORM standard, e-learning course.

1 Introduction

Learning at distance becomes more and more popular. Traditional lectures in classrooms are replaced with learning in virtual learning environment. Although distance learning gives students better learning liberty it requires high students’ motivation to learn, well-developed independent work abilities, personal responsibility and discipline [4,6,9].

Authors emphasize that on purpose to guarantee the quality of distance learning and to improve the learning process it is necessary to create such learning environment that would encourage a student to learn. [8,13,15,17]. One of the most important elements of this learning environment is e-learning course. Having modern tools for creating e-learning courses it is possible to create SCORM compliant e-learning courses. SCORM standard warrants the effective reuse of e-learning content [1,2,3]. Learning process control opportunities originated in SCORM 2004 standard enable to model different learning scenarios in virtual learning environment.

The purpose of this article is to review the possibilities of the modelling of different learning paths when creating SCORM compliant e-learning courses, to evaluate the dependence of student learning results on a chosen learning path, to change a learning path model of e-learning course under consideration of the data analysis results.

Research methods: the analysis of scientific literature, data analysis.


Sharable Content Object Reference Model (SCORM) is one of the most significant and widely used specifications for learning content packaging [1,3]. The latest version of SCORM is SCORM 2004 which contains three parts: Content Aggregation Model (CAM), Run Time Environment (RTE), and Sequencing and Navigating (SN) [3, 20].

Content Aggregation Model describes the ways in which SCORM materials are organized and packaged so that they can be exchanged between different learning management systems. The SCORM course is made up of Assets, Sharable Content Objects. Assets are electronic media displayable by browsers. Types of assets include html pages, image files, video files, and audio files [3,19]. Asset does not communicate with the run-time environment delivering it. A Sharable Content Object represents a collection of one or more assets. A Sharable Content Object represents the lowest level of granularity of learning resources that can be tracked by a Learning Management System (LMS) using the SCORM Run-Time Environment. [3,11].The structure of the course content is defined in imsmanifest.xml where as the metadata of each learning resources is described by the corresponding XML files (Fig. 1).

Figure 1. Conceptual diagram of SCORM course content [19]
The SCORM run-time specification controls how the LMS launches content and how the content then communicates with the LMS. SCORM 2004 Sequencing and Navigation defines a standardized way of sequencing the learning content and learning activities for a particular student. Basically, it provides means for specifying so-called learning paths, which can branch according to the current learning situation.

3 Creating Different Learning Paths using the SCORM 2004 Specification

SCORM 2004 sequencing and navigation model enables the course designers to define learning process, i.e. to determine in what order course activities will be presented to a student. Learning process can be either static or can depend on student’s results during learning. SCORM Sequencing and Navigation specification organizes learning activities in an Activity Tree [10,11,14,20].

An Activity Tree is an hierarchically structured list of parents (clusters) and children. Each children activity in an Activity Tree uses a learning resource. When the children activity is delivered to a user the corresponding learning resources is launched. Clusters are any node in an activity tree and its immediate children[14]. In the figure given below course consists of Cluster A, Cluster B, Cluster C and Cluster D. The Cluster B includes learning materials and a self-test; the Cluster D consists of test passing instructions and a check test.

Figure 2. Course Activities tree

At the cluster level, in an activity tree, general sequencing strategies can be set. These sequencing strategies are known as the „Sequencing Control Mode“ [14]. The main sequencing control modes are „Choice“, „Flow“, „Forward only“, „Choice Exit“.

Sequencing rules can be attached to each activity. Each sequencing rule includes a group of conditions and a corresponding action. The main conditions of sequencing rules are the following: „Attempted“, „Objective measure known“, „Objective status known“, „Activity progress known“, „Satisfied“, „Completed“, „Never“, and „Attempt limit exceeded“. The main actions of sequencing rules are the following: „Stop Forward“, „Traversal“, „Disabled“, „Hidden From“, „Choice“, „Skip“, „Continue“, „Exit All“, „Exit Parent“, „Previous“, „Retry“, „Retry All“.

Activities can be associated with one or more Learning Objectives [11]. Learning Objectives can be used as conditions for the sequencing rules. Depending on responses to learning activities, learning objects may be satisfied or not, leading to different content sequencing options.

Rollup Conditions are used for forwarding conditions “Satisfied”, “Completed”, “Attempted”, “Known” from a child to its parent (cluster) learning activities. When creating sequencing rules for course activities it is possible to design various e-learning paths. The main types of e-learning paths are the following:

1. A learning path with stated optional learning process. 
2. A learning path with stated strictly successive learning process. 
3. An adaptive learning path dependent on a student’s results during learning process.

Combining these three main types of e-learning paths it is possible to obtain new learning path models. If learning sequences are not stated for the e-learning course students can easily choose learning process: what learning materials to study first of all, which course activities focus on, and which course activities to omit. In figure 3 you can see the model of the e-learning course with stated optional learning process with the longest and the shortest learning path.
Figure 3. Learning path model with stated optional learning process

The final test is the only compulsory activity of the course. So, the shortest learning path includes only the activity of the final test. It is evident that such a learning path model demands high personal responsibility and discipline from students. Self-tasks are very important when participating in e-learning courses with stated optional learning process. They should help a student to evaluate gained knowledge and to get motivation for further study.

The learning path with stated strictly successive learning process consists of successively presented all course activities. Only after the accomplishment of all the activities of the e-learning course students can pass the final exam.

Figure 4. Learning path model with stated strictly successive learning process

Strict control of the learning process is typical for this e-learning path model. Such e-learning path model is efficient provided that e-learning course requires successive study of learning materials; if a student does not accomplish the first course activities and does not gain necessary knowledge he or she will not be able to continue the course.

The third type of a learning path is an adaptive learning path dependent on a student’s results during learning process. To design e-learning courses with a stated adaptive learning path, first of all it is necessary to plan activities whose results influence further e-learning path activities. In the context of an adaptive learning path to control a learning process tests are used. The tests are associated with one or more Learning Objectives. Learning objectives can be associated with the separate questions of the test. To control the learning process there are defined sequencing rules which, depending on achieved learning results, direct the learning process in the right direction. In the figure 5 you can see the model of the adaptive learning path. In this model test activity has two sequencing rules created: the first rule is connected with the learning objective OBJ-1, and the second is connected with the learning objective OBJ-2. If a student does not reach the learning objective OBJ-1 the sequencing rule returns him or her to the previous section to repeat its content. If a student does not reach the learning objective OBJ-2 he or she must repeat the test once more.
4 Research design

The experiment took place at Vilnius Gediminas Technical University. For the analysis of the e-learning paths there was chosen SCORM compliant Multimedia course created with a help of Authoring Tool. This e-learning course has been created for students of Master’s study program Information Technologies of Distance Education.

The purpose of this course is to introduce the students with the principles of using multimedia in e-learning courses, to some technologies, tools and techniques associated with the creation of interactive multimedia elements for e-learning courses, to enable the students to re-design their e-learning courses into interactive and media-rich ones. The course topics include multimedia concepts and principles in e-learning, multimedia elements, multimedia creation tools and technologies, integration multimedia elements in e-learning courses.

The course learning material is presented in four sections. These course sections start with a page presenting the goals. Next, there are pages for presenting learning material. After the theoretical background, self test are presented. At the end of each section the summary and future references are given. The last course sections are: homework, final test. The homework section starts with a page presenting the homework goals. Next, there is page for presenting homework tasks. The final test section includes test passing instructions and a check test.

The evaluation for the course is carried on two components, a course homework requirement and a final test at the end of the semester. The course homework includes tasks to create and integrate multimedia elements in e-learning courses.

The Multimedia course has been delivered in virtual learning environment Workplace Collaboration Learning System (WCL) for two years up to now. 50 students attended the experiment. During the experiment, the students did not have traditional lectures in classrooms. They studied learning material in virtual learning environment, solved problems in course discussion forum; communicate with course instructor and other students in a course by e-mail, made self-tests, did homework and passed final test. There was not strict learning process defined for the course under consideration. So, the student could easily choose an acceptable learning path: either to study learning materials successively or to accomplish self-tests; either to select the sections of learning materials at discretion or even to omit some sections.

5 The results of data analysis

During the analysis of students learning paths there were researched students’ activities and progress reports generated by WCL system. During the analysis of students learning paths there were researched students’ activities and progress reports generated by WCL system. In accordance with the final marks students were divided into three groups: the students who had high achievement (90%-100%), the students who had moderate achievement (70%-80%) and the students who had low achievement (50%-60%).
The students of different groups spent different number of hours in virtual learning environment. Those students who had low achievement devoted the least time to study. The students who had high achievement took an active part in the learning process and spent much more time in virtual learning environment.

The course consists of learning and assessment activities. Course homework and course learning material are presented in course content pages. The course content pages are HTML pages with the appropriate JavaScript code that makes the pages interactive. The course learning activities are associated with course content pages. When the learning activity is delivered to a user the corresponding course content page is launched.

Students’ activities and progress reports generated by WCL system registers how many times a student launched an appropriate activity and show the status of activity performance. If a student launched learning activity just for once this activity is registered as an accomplished activity. The majority of students who had high and moderate achievements fully accomplished the study of learning materials. Whereas the students who had low achievement gave very little attention to this section. The major part of the students in this group omitted some learning activities. Figure 8 presents the number of students who completed learning activities, in percentage terms (M1-M16 – learning activities).
Self-tests was attractive to the students of all groups under consideration. Students could make self-tests with no limit. An analysis showed that the students who had low achievement performed self-tests more often than the students of other groups. Figure 9 presents the average number of self-tests attempted (ST1-ST4 self-tests).

![Figure 9. The average number of self-tests attempted](image)

However, when comparing the results of self-tests it has been found that only a small number of students with low achievement managed to get maximal marks for self-tests. Those students who did not give much attention to the study of learning materials just guessed the answers of self-tests.

![Figure 10. The number of students who get the best marks for self-tests, in percentage terms](image)

Data analysis showed that the students who get the worst marks did the course out of continuity, they gave little attention to the study of theoretic materials; they did homework and passed the final test without gaining necessary theoretic knowledge. Course structure with stated optional learning process did not guarantee sufficient learning control. The students who got good marks successfully completed all sections of theoretic materials passed self-tests and passed the final test only on completing all course activities.

### 6 Modified learning path model

Data analysis showed the disadvantages of course structure. It was resolved that Multimedia course should be modified introducing the learning process control. New learning path model was designed combining two types of e-learning paths: a learning path with stated strictly successive learning process and an adaptive learning path.

On purpose to ensure a successive study of learning materials a successive learning process must be established with a possibility to return to previous sections of the course: „Flow=True“ and “Forward Only=False”. A student can join activities that should be evaluated only when he or she completes the study of theoretical materials and reach set learning objectives. The stated for the course rule „Rollup Rule=All” defines that e-learning course is completed only if all its activities are completed. Such control of learning process guaranties a successive learning process and suggests the straightest learning path to the final aim. A student has a possibility to change learning process repeating the separate sections of the course.
Figure 11. The structure of e-learning course at the level of the course

On purpose to guarantee the satisfactory level of the acquisition of theoretical materials every learning material section has a successive learning process: „Flow=True” and „Forward Only=False”. The self-tests of learning material sections have learning objectives which are achieved only when a student gets the maximal mark for a self-test. Learning process rule created for self-test returns a student to a previous page to pass the test once more if his level of gained knowledge does not correspond to the stated learning objective. Stated in the section rule „Rollup Rule=All” defines that the section is completed only if all its activities are completed. Such control of the learning process ensures the completion of all the learning activities of the section. The shortest learning path of the section includes all learning activities.

Figure 12. The structure of e-learning course at the level of the section

Learning objectives created for homework and the final test define the minimal requirements for the passing of these activities. Learning process rules created for homework and the final test do not allow continuing the course if stated learning objectives are not achieved.

7 Conclusions

1. Carried out analysis of SCORM 2004 showed that creating SCORM compliant e-learning courses is possible to design different e-learning paths combining three main types of e-learning paths: a learning path with stated optional learning process, a learning path with stated strictly successive learning process, an adaptive learning path.

2. Data analysis showed that the model of a learning path with stated optional learning process does not ensure satisfactory learning process control and it is suitable only for those students who are able to apportion their learning time rationally, to evaluate their knowledge correctly and to control learning process responsibly.

3. Adjusted e-learning path model includes a successive learning process; there are created sequencing rules for self-tests which require to repeat self-tests until stated learning objectives are achieved. There are learning process rules for homework and the final test which do not allow continuing the course if stated learning objectives are not achieved.
References


ADAPTATION OF INTELLIGENT KNOWLEDGE ASSESSMENT SYSTEM BASED ON LEARNER’S MODEL

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Abstract. The Department of Systems Theory and Design of the Faculty of Computer Science and Information Technology of Riga Technical University has been developing the concept map based intelligent knowledge assessment system IKAS already for five years. The paper gives the outline of adaptation mechanism which is under the development and will be integrated with IKAS. The adaptation mechanism is based on learners’ psychological characteristics. Learning styles have been chosen as the most widely used psychological characteristic. Several models of learning styles are overviewed and the Felder-Silverman model has been chosen as the most appropriate for IKAS. For explanation why more flexible adaptation mechanism is needed in IKAS its architecture and functionality is presented. The conception of the design of adaptation mechanism which will be implemented in a user modeling shell AGENT-UM is described.

Keywords: adaptation, user modeling, learning style, intelligent knowledge assessment system, production rules

1 Introduction

Results of many conducted researches show that e-learning systems which incorporate adaptation to the learner are more efficient and useful in comparison with systems which have no adaptation features [8, 17]. Adaptive e-learning systems are capable of delivering personalized study materials. In addition, those systems could choice presentation format which is most suitable for each particular learner. Therefore, adaptive e-learning systems become more and more popular nowadays and developers try to incorporate adaptation functionality in almost any new e-learning systems.

One way how to provide adaptation in the e-learning system is the use of a learner’s model. The learner’s model is a record that reflects specific characteristics of the learner that uses e-learning system. Examples of data that are hold in the learner’s model are the general information about the student (such as the username, the profession), student’s knowledge level in specific area and student’s mistakes, physiological and psychological characteristics of the student [7, 25].

This paper is focused on psychological part of the learner’s model, because psychological characteristics of the learner significantly influence a study process [7]. Design of adaptation mechanism based on learner’s psychological characteristics is presented in this paper.

Adaptation mechanism is designed for the concept map based intelligent knowledge assessment system IKAS. The system which has been developed by researchers from Riga Technical University during last four years has a couple of areas where adaptation based on learner’s psychological characteristics could be successfully applied in order to enhance system’s functionality [1]. At present those areas include selection of appropriate task for each particular learner and selection of the most suitable type of help for each learner.

The paper is organized as follows. Section 2 gives a brief overview of learner’s most significant psychological characteristics that influences a study process. In Section 3 architecture and functionality of IKAS is described. In Section 4 design of adaptation mechanism based on learner’s psychological characteristics for IKAS is presented. At the end of the paper conclusions are given and future work is discussed.

2 Overview of learner’s psychological characteristics

Different factors that influence learning process are considered in a student’s model. Those are demographic factors, professional factors, ability and proficiency, knowledge level, physiological factors, emotional state, mental state and others [7, 14, 25]. Among those factors are learner’s psychological characteristics that attracted much attention of developers of e-learning systems in the recent years [4, 7, 8, 12, 17, 18].

Learner’s psychological characteristics related mainly to human mind and memory. Unique set of those characteristics for each learner results in individual differences of information perceiving, processing and storing [24].

There is plenty psychological characteristics of the learners used till now. Most known characteristics are learner’s intellectual abilities (abilities to learn), cognitive style, learning style, temper, brain dominance [7,
Examples of specific characteristics are inductive reasoning skills, working memory capacity, procedural learning skills, information processing speed, associative learning skills [19].

Review of available literature shows that the most widely used psychological characteristic of a learner is his/her learning style. A learning style is defined as a characteristic of cognitive, affective, and psychological behaviour that serves as a relatively stable indicator of how a learner perceives, interacts with, and responds to the learning environment [5]. Study of learning styles started in 1970s [24] and many learning style models have been developed till now. A learning style model divides learners into several categories depending on psychological characteristics and defines effective teaching strategy for each category. Most known learning style models are Myers-Briggs model [3], Kolb model [13, 20, 24], Honey-Mumford model [3, 20], Felder-Silverman model [3, 9, 20, 22], Grasha-Riechman model [3]. The list of dimensions within mentioned learning style models is given in Table 1.

Table 1. Learning styles proposed by some known models

<table>
<thead>
<tr>
<th>Learning style model</th>
<th>Dimensions within the model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kolb model</td>
<td>Converger/Diverger</td>
</tr>
<tr>
<td></td>
<td>Assimilator/Accomodator</td>
</tr>
<tr>
<td>Honey-Mumford model</td>
<td>Activist/Reflector</td>
</tr>
<tr>
<td></td>
<td>Theorist/Pragmatist</td>
</tr>
<tr>
<td>Felder-Silverman model</td>
<td>Sensory/Intuitive</td>
</tr>
<tr>
<td></td>
<td>Visual/Verbal</td>
</tr>
<tr>
<td></td>
<td>Inductive/Deductive</td>
</tr>
<tr>
<td></td>
<td>Active/Reflective</td>
</tr>
<tr>
<td></td>
<td>Sequential/Global</td>
</tr>
<tr>
<td>Grasha-Riechman model</td>
<td>Competitive/Collaborative</td>
</tr>
<tr>
<td></td>
<td>Avoidant/Participant</td>
</tr>
<tr>
<td></td>
<td>Dependent/Independent</td>
</tr>
<tr>
<td>Myers-Briggs model</td>
<td>Extravert/Introvert</td>
</tr>
<tr>
<td></td>
<td>Intuitive/Sensing</td>
</tr>
<tr>
<td></td>
<td>Feeling/Thinking</td>
</tr>
<tr>
<td></td>
<td>Judging/Perceiving</td>
</tr>
</tbody>
</table>

Kolb’s model was the first learning styles model. The model was developed by David Kolb in 1984 and the model is based on four-stage learning cycle. According to Kolb’s theory each learner goes through four stages during learning process – concrete experience, reflective observation, abstract conceptualization and active experimentation. However, Kolb’s experimentations revealed that despite of fact that a learner goes thorough all four stages two of these stages stay dominant for each individual learner. Based on the results Kolb created a learning style model. In his model “Converger” uses abstract conceptualization and active experimentation, “Diverger” tends to concrete experience and reflective observation, “Assimilator” uses reflective observation and abstract conceptualization and “Accomodator” uses concrete experience and active experimentation.

Honey – Mumford is the second learning styles model that was developed in 1986. The model is also based on Kolb’s theory about four-stage learning process. Four learning styles that presents in the model are “Activist”, “Reflector”, “Theorist” and “Pragmatist”.

Grasha-Riechman and Myers-Briggs are other rather popular learning styles models that use their own theories (different from Kolb’s theory) for identifying learning styles. There are 6 learning styles in Grasha-Riechman model and 8 learning styles in Myers-Briggs model

It is worth to add that some learning style models have also questionnaires that could be used to determine learning style of a particular learner. Those questionnaires could be easily built into the e-learning system and it become possible to use learning styles afterwards for adaptation purposes. Some practical examples of use of learning styles in e-learning systems are described below.

In Arthur system [8] course materials could be presented in three different forms – audio, visual and text. Each student receives course materials in a format that is the most suitable for him. For example, a student with verbal learning style receives course materials in textual format; in turn, for visual student materials in visual format are presented. Thus, correspondence between learning style and teaching style is achieved.

The Feedback System [18] provides personalized feedback for each learner taking into account his/her learning style. The following types of feedback are available in the system – definition, example, question, scaffold, picture, relationships, application and exercise. For example, verbal student will receive feedback in a form of definitions, visual student will receive feedback in a form of pictures and active student will receive feedback in a form of exercises.
Examples of other e-learning systems in which adaptation based on learning styles is used are the Multimedia System [17], the Concept Map Based System [4], Lecompas5 [12].

Our analysis of learning style models shows that the most widely used model nowadays is Felder-Silverman learning style model [9]. The model was developed by Richard Felder and Linda Silverman in 1988. The model is popular due to three reasons. Firstly, the model has many dimensions, and therefore, more accurate classifications of learners could be made. Secondly, the model defines a teaching style for each learning style within the model, and thirdly, the model has a well structured and easy to use questionnaire to determine learning styles. Therefore, Felder-Silverman learning style model is used in adaptation mechanisms in IKAS as well. Description of learning styles according to Felder-Silverman model is given in Table 2. More detailed description of this model could be found in [3, 20, 22].

<table>
<thead>
<tr>
<th>Learning style</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory</td>
<td>Concrete, pragmatic, focused on facts and procedures</td>
</tr>
<tr>
<td>Intuitive</td>
<td>Conceptual, innovative, focused on theory</td>
</tr>
<tr>
<td>Visual</td>
<td>Give preferences to pictures, diagrams</td>
</tr>
<tr>
<td>Verbal</td>
<td>Give preferences to texts or audio</td>
</tr>
<tr>
<td>Inductive</td>
<td>Prefer explanation from concrete to general</td>
</tr>
<tr>
<td>Deductive</td>
<td>Prefer explanation from general to specific</td>
</tr>
<tr>
<td>Active</td>
<td>Learn through experimentation and collaboration</td>
</tr>
<tr>
<td>Reflective</td>
<td>Learn through thinking things while staying alone</td>
</tr>
<tr>
<td>Sequential</td>
<td>Learn sequentially in a small steps</td>
</tr>
<tr>
<td>Global</td>
<td>Learn in a non-linear manner jumping from one topic to other</td>
</tr>
</tbody>
</table>

Felder-Solomon questionnaire [6] was designed in order to identify student’s learning styles according to Felder-Silverman learning style model. Using the questionnaire learning styles in the following four dimensions could be identified – sensory/intuitive, visual/verbal, active/reflective, sequential/global. The questionnaire contains 44 questions and it is available online.

For purposes of adaptation mechanism under consideration Felder-Solomon questionnaire was modified slightly. Changes made in the questionnaire are described in Section 4.

3 Architecture and functionality of the concept map based intelligent knowledge assessment system

The system, for which purposes an adaptation mechanism is intended to be developed, is the concept map based intelligent knowledge assessment system (IKAS). This system has been developed by the researchers from the Department of Systems Theory and Design of the Faculty of Computer Science and Information Technology of Riga Technical University. The system allows the teacher to assess student’s knowledge regularly, that is, at each stage of the study course, and to use assessment results for the analysis and the improvement of learning content and teaching methods. At the same time the student can use the system for knowledge self-assessment in order to control and to keep track of his/her own learning progress.

The developed IKAS consists of three modules. The administrator’s module allows managing data about users (learners and teachers) and study courses providing functions of data input, editing, and deleting. The teacher’s module supports teachers in construction of concept maps. The main functions of this module are the following: editing and deleting of concept maps, evaluation of learners’ completed concept maps and assigning the scores which characterize the level of correctness of learners’ concept maps. The learner’s module includes tools for completion of concept maps given by a teacher and for viewing feedback after the solution is submitted. The modules interact sharing a common database where data about teachers and their courses, learners, teacher created and learners’ completed concept maps, as well as learners’ final scores are stored.

IKAS supports the following usage scenario. A teacher divides a study course into N stages and defines all concepts and relationships between them. Using the system’s graphical user interface, a teacher prepares concept maps for each stage. The system supports teacher actions for drawing concept maps on the working surface. During knowledge assessment or self-assessment students get a task (a concept map) that corresponds to the current stage of learning process (Figure 1). After finishing the task, a student confirms his/her solution and the system compares concept maps of the student and the teacher. The final score and the student’s concept map are stored into the database, and a student receives feedback about correctness of his/her solution.
Figurer 1. IKAS working surface

More detailed description of the IKAS could be found in [1, 10, 16, 23].

The system has already reached the certain level of maturity and has been used successfully in practice. Nevertheless future enhancement of the system should be done in order to make it even more useful. For example, the system has minimal functionality in adapting to a user at present. There are at least two ways how adaptation mechanism based on learning styles could be applied in IKAS. Firstly, a learning style could be used to select appropriate type of task for each particular learner. There are two types of tasks currently implemented – “fill-in-the-map” tasks where the learner should fill the given skeleton of a concept map with missing information (the learner should either give names to concepts or to links or to both) and “construct-the-map” tasks where the learner creates a concept map by himself using given lists of concepts and links [2]. At present the teacher chooses which type of task will be given to all students. Our aim is to use learning styles in order to provide for each learner the type of task that best suits him/her.

Secondly, learning styles could be used to select appropriate type of help for each learner. There is a possibility for the learner to get one of three types of help for unknown concepts – definition (formal definition of the concept), explanation (free text explanation of the concept) and example (visual example of the concept) [2]. In the system’s current version the learner defines manually what type of help will be used for all unknown concepts. Our aim is on the basis of learner’s learning styles provide the type of help that best suits him/her.

The next section describes usage of learning styles in IKAS in more details.

4 Design of adaptation mechanism

Adaptation mechanism which we design for IKAS will be presented in a form of user modelling shell (UMS) [15]. UMS is an external system that is used for learner’s modelling purposes. UMS gathers and stores information about learner’s knowledge, personal characteristics, goals and preferences, thus assisting the target e-learning system in adapting to users.

High level design of a user modelling shell AGENT-UM for IKAS was already presented in [15]. The AGENT-UM is an external agent-based user modelling shell that is supposed to supply IKAS with user modelling functionality. The AGENT-UM was designed to provide the following services for IKAS – get general data about a learner from his/her answers in questionnaires, infer assumptions about a learner based on his/her interaction with IKAS, infer additional assumptions based on initial assumptions, represent and store all student’s data in a student model, supply IKAS with current information about a learner. Thus, application of the AGENT-UM in general could assist IKAS much in modelling a learner and in adapting the learning environment for each individual learner needs.

In this article we describe in details use of learning styles in AGENT-UM. We believe that incorporation of learning styles will make the first significant step toward realization of adaptive behaviour of IKAS.
Figure 2 demonstrates the architecture of adaptation mechanism (AM) for IKAS based on learning styles.

AM consists of three parts. The administrator’s part is used for editing description of learning styles. The teacher’s part is used for viewing students’ models (learning styles). The student’s part is used for filling learning styles questionnaires and for viewing and editing personal learning styles.

AM and IKAS have the common database. Two shared storages are Users and Student models. Users that are managed from IKAS are common for both systems. It means that users that are authorized to use IKAS have access to AM as well. Need to point, that AM has no separate login functionality. In order to access AM user should login into IKAS first and then switch to AM. Switching is performed automatically without need to reenter credentials and with saving initial login role (for example, if the user is logged into IKAS as a Teacher, he/she will be switched to AM also as a Teacher).

The storage “Student models” is managed by both sides – AM and IKAS. IKAS fills a student model with the following data – the general information about the student (name, surname, student card number, email, group, login name, password, role), student’s preferences (GUI language, themes, colors, preferred type of help), student’s results in knowledge assessment and student’s mistakes (wrong edges). AM adds appropriate learning style to a student model. Content of a full student model that is used by IKAS to make necessary adaptation of learning environment is shown in Figure 3.

![Figure 2. Architecture of adaptation mechanisms for IKAS](image)

**STUDENT MODEL**

- **General Data**
  - Name
  - Surname
  - Card number
  - Email
  - Group
  - Login name
  - Parole
  - Login role

- **Preferences**
  - GUI language
  - Themes & colors
  - Type of help

- **Knowledge & Mistakes**
  - Scores for filled maps
  - Assimilation degrees of concepts
  - Wrong edges in maps

- **Other characteristics**
  - Learning styles

![Figure 3. Structure of a student model used in IKAS](image)
AM is used by three types of users. Functions that are available for each type of user are summarized in Table 3.

Table 3. Functions available in AM

<table>
<thead>
<tr>
<th>Type of user</th>
<th>Available function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrator</td>
<td>Adding description of learning styles</td>
</tr>
<tr>
<td></td>
<td>Setting a default learning style</td>
</tr>
<tr>
<td>Teacher</td>
<td>Viewing learning style of a specific student</td>
</tr>
<tr>
<td></td>
<td>Viewing aggregate learning style of a group of students</td>
</tr>
<tr>
<td>Student</td>
<td>Filling questionnaire about learning style</td>
</tr>
<tr>
<td></td>
<td>Viewing personal learning style</td>
</tr>
<tr>
<td></td>
<td>Modifying personal learning style</td>
</tr>
</tbody>
</table>

Let’s describe functions available in AM in more details. Administrator is responsible for adding description of learning styles in AM. Description of learning styles will be used by students and teachers afterwards like a glossary that could help in interpreting students’ models. Administrator will set a default learning style as well. A default learning style will be attached to those learners who don’t fill questionnaire about learning styles. Research on learning styles shows that a dominant learning style exists for modern learners [17]. Modern students are active (they like real word problem solving), visual (they prefer visual presentation of information) and global (they study in non-linear manner jumping constantly from one course subject to other subjects). This dominant learning style will be set as a default learning style in AM.

Teacher in AM could view either a learning style of a specific learner or an aggregate learning style of a group of students. Inspection of the learning style of a specific learner could help a teacher to choose teaching methods that are the most suitable for that particular learner. Those teaching methods could be used by a teacher during private consultations with that learner. In turn, inspection of an aggregate learning style for a group of students could help a teacher to understand what type of learning styles dominates in the group and what teaching methods are the most suitable for the whole group. Those teaching methods could be used by a teacher in a classroom while working with a group of students.

In order to get a personal learning style the student must fill modified Felder-Solomon questionnaire about learning styles. After filling the questionnaire the student will be able to see his profile with dominant learning styles. Textual explanations to each dimension will be given as well in order to provide the possibility for a student to understand better his/her learning style. In addition, the student will be able to modify his/her learning style if he/she concludes that values for some dimensions are set wrong. Research on learning styles shows that sometimes questions from questionnaires could be wrongly interpreted by students [21]. This results in incorrect identification of learning style for a particular learner. Therefore, it is strongly recommended to give opportunity to the student to set his/her learning style by him/herself based on description of learning styles.

As it was mentioned before the original Felder-Solomon questionnaire was modified taking into account specific of AM for IKAS. Felder-Solomon questionnaire in its original version contains 44 questions and allows identifying four dimensions of learning styles – sensory/intuitive, visual/verbal, active/reflective, sequential/global. For purposes of AM only three dimensions are used – visual/verbal, sequential/global and active/reflective. Dimension “Sensory/Intuitive” is not used in AM because learner’s characteristics that come from this dimension (see Table 2) could not be applied for adaptation of IKAS at present. In addition, eleven questions that belong to “Sensory/Intuitive” dimension could be removed from questionnaire. Thus, it will require for learner to answer 33 questions to identify dominant learning styles in three remaining dimensions.

Dimension “Visual/Verbal” is used to determine type of help (definition, explanation or example) that is the most suitable for a learner. Dimension “Sequential/Global” is used to determine type of task (“fill-in-the-map” task or “construct-the-map” task) that is the most suitable for a learner. Dimension “Active/Reflective” is supposed to be used for determination of appropriateness of using concept maps for knowledge acquisition. Results of recent research in learning styles shows [4, 17] that modern students are active students who like constructive approach to knowledge acquisition. Therefore, one of methods that could satisfy requirements of modern learners to knowledge acquisition is the use of concept maps. Using the results of two questionnaires – identification of students’ learning styles in “Active/Reflective” dimension and determination of satisfaction of using concept maps for knowledge assessment – we could conclude afterwards whether active students are dominant or not and whether concept maps are accepted by active students as a good tool for knowledge acquisition.

Let’s describe in more details how learning styles in “Visual/Verbal” and “Sequential/Global” dimensions are supposed to be used for adaptation purposes in IKAS. In [11] the idea of using production rules for adaptation based on learning styles was proposed. Therefore, the following production rules could be generated for adaptation of IKAS:

Rule 1: \( IF \text{ Learner} = \text{"Visual"} \ THEN \text{TypeOfHelp} = \text{"Example"} \)
Rule 1 says that if a learner belongs to a visual type of learners then visual examples about the usage of concept will be presented to the learner when he/she asks for help. Rule 2 says that if a learner belongs to a verbal type of learners then either definition or explanation will be provided for problematic concepts for this learner. Definition will have a priority one. If for a particular concept a definition is not given then an explanation will be offered for that concept. Rule 3 says that if a learner belongs to a sequential type of learners then “construct-the-map” type of task will be given to him/her. “Construct-the-map” type of task allows learner to control the process of creation of concept map from the very beginning. A learner could sequentially and incrementally construct the concept map placing the most important concepts first and then adding less relevant concepts to the map. Rule 4 says that if a learner belongs to a global type of learners then “fill-in-the-map” type of task will be given to him/her. In this type of task a learner should place missing information (concepts or links) on the map. “Fill-in-the-map” task require from a learner a global vision of the subject. A learner could be able to see "the whole picture" in order to deal successfully with that type of task.

At the end let’s describe scenario of using adaptation mechanisms with IKAS. When student login into IKAS for the first time he is kindly invited to go to AM and fill questionnaire about his learning style model. If a learner ignores invitation a default learning style model (visual-global-active) is set for that learner. If a learner accepts invitation he/she is directed to AM where he/she fills Felder-Solomon questionnaire first and then views the results on his/her dominant learning styles. A learner may correct learning styles manually if he/she concludes that learning styles set after filling questionnaires were incorrect. After that a learner switches back to IKAS and starts with knowledge assessment routines. At the same time IKAS reads learning styles of a learner and adapts immediately content and presentation of assessment tasks. Thus, adaptation of e-learning environment is achieved.

5 Conclusions and future works

In this paper a conception of adaptation mechanism (AM) based on learning styles is presented. The adaptation mechanism is designed for the concept map based intelligent knowledge assessment system (IKAS) that has been developed by researchers from Riga Technical University and has been already used successfully in practice. Proposed AM is a part of user modeling functionality required for adaptation of IKAS. AM will be used for adaptive selection of type of tasks and type of help for each specific learner.

The first version of AM will offer the following functionality to its users. Students in AM will be able fill questionnaire on learning styles and inspect and modify their learning style models afterwards. Teachers will be able to inspect individual and group learning style models in order to see the dominant learning styles for an individual or a group.

Future enhancement of the adaptation mechanism could be related with implementation of teaching styles into AM. It would be useful to have a library of teaching styles and to display appropriate teaching style next to learning style models. For example, teacher could look at a group learning style model and read immediately about the teaching style which is recommended for that particular group. This will make adaptation mechanisms even more useful.

References


