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DATORZINĀTNE

COMPUTER SCIENCE



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INTELLIGENT SYSTEM FOR STUDENT KNOWLEDGE ASSESSMENT

INTELEKTUĀLA SISTĒMA STUDENTU ZINĀŠANU VĒRTĒŠANAI

A. Anohina, G. Stale, D. Pozdnyakov

Intelligent system, student knowledge assessment, concept map

1. Introduction

Knowledge assessment is an essential part of teaching and learning and it performs a number of functions in the learning process. However, knowledge assessment can reduce cumulative effect from learning if it is not well-thought-out and aptly implemented. Two problems, i.e. assessment of learning results instead of the learning process and ignoring of knowledge self-assessment, have made a basis of a research project conducted by the department of System Theory and Design at Faculty of Computer Science and Information Technology at Riga Technical University. The ultimate goal is to develop an intelligent software system for assistance of a teacher in improvement of the learning process, comparing desirable and true student knowledge characteristics at each stage of the learning process and providing opportunities of knowledge self-assessment for students. The project has the nature of interdisciplinary research as it is based on integration of methods and research results of e-learning, pedagogy and artificial intelligent and their embodiment into the intelligent software system.

Given paper describes the general conceptual model and functionality of the above mentioned system, as well as the use of concepts maps as a tool for facilitation of student knowledge self-assessment in the learning process. The remainder of this paper is organized as follows. Section 2 describes some problems of knowledge assessment, which have led to development of the intelligent system for student knowledge assessment. Section 3 defines the notion of concept map and discusses questions related to creation of concept maps and advantages of their use in the learning process, as well as gives a demonstrative example of a concept map for the course of databases. The use of concept maps as a tool for the assessment of student knowledge at each stage of the learning process is considered in Section 4. Some related works are discussed in Section 5. Section 6 describes the general model of the system, interaction between the system and its users and gives detailed representation of functionality of the system by means of use case diagrams. Finally, Section 7 draws some conclusions and presents some directions for future work.

2. Some problems of knowledge assessment

Knowledge assessment is an essential and integral part of teaching and learning. It has a vast set of various methods and performs a number of functions in the learning process simultaneously. However, the main value of knowledge assessment lies in feedback which

gives important information both to a teacher and to a learner. Results of knowledge assessment are indicators of quality of the teacher's job. The learner can learn from them, what knowledge and skills he/she has mastered and at what level, as well as they have influence on formation and development of the individually - psychological characteristics of the learner and comprehension of the learner's place in the society.

An obvious truth is the fact that there is a strong connection between student knowledge assessment and improvement of learning quality. Any learning course has its achievable objectives which are defined by the teacher, being based on overall aims of curriculum, employers' requirements and existing standards. These objectives are expressed in desirable characteristics of student knowledge. The characteristics consist of knowledge content and knowledge depth. In turn, true student knowledge characteristics are formed during the learning course. Comparing desirable student knowledge characteristics with true student knowledge characteristics, it is possible to determine, how much effective the learning course was. The situation when such comparisons are made at the end of the learning course is typical and it can also be observed at Riga Technical University. It is so-called final knowledge assessment or the evaluation of the learning result and in this case it is impossible to determine, how the learner's cognitive processes have developed, at what learning stage he/she has met difficulties which as a result have led to incomplete or insufficient development of knowledge and skills and it is also already late to start any remedial actions. It is important to determine strong and weak places of a learner in time, in order to plan the learning process which will be based on the former and will compensate the latter [1]. Thus, it is useful to compare desirable and true student knowledge characteristics not only at the end of the learning course, but also at each stage of the learning process that would allow to change learning methods in time and, thus, to promote the learning course towards achievement of desirable knowledge characteristics. Hence, it is necessary to assess both the process and its result. The evaluation of the process helps to find out diligence of a student, an attitude system in communication, to concretize selection principles of learning content, to analyze suitability of content and quality of chosen methods [2]. However, such comparisons are usually ignored in the learning process, as they demand additional time and cost.

The fact that such important form of assessment as knowledge self-assessment is very often omitted in the learning process is the next problem of knowledge assessment. For example, the typical assessment forms which are used in a greater part of the learning courses at Riga Technical University are tests, exams, course and laboratory/practical works. In any case students get marks or recognition that work was or was not passed. However, the main thing is to involve a student in assessment of his/her activity, then he/she reveals results of his/her activity [2]. Self-assessment has an important role in the learning process for many reasons:

- as a result of self-assessment the learner comes to conclusion about his/her abilities, skills and features of character;
- knowledge self-assessment allows to activate the learner in the learning process, disciplines and motivates him/her, thus, promoting more realized approach to the learning process and performance of tasks;
- knowledge self-assessment activates cognitive activity of the learner, making him/her to think about acquired knowledge and skills and to ask to itself questions where and why he/she has made mistakes in some task;
- the regular knowledge self-assessment allows to prepare for a final assessment such as an exam;

- providing opportunities of knowledge self-assessment, the teacher can inform about what are his/her expectations from the learning process and what the learner should know, in order to determine that he/she has mastered the teaching material.

However, knowledge self-assessment often passes unnoticeably for the teacher, when the learner performs tasks, compares his/her activity to activity of other learners or discusses learning-related questions with classmates. For this reason the learner in knowledge self-assessment often uses other criteria, than the teacher for the learner knowledge assessment. It is possible to provide an objective knowledge self-assessment and, thus, to improve quality and efficiency of the learning process by means of corresponding computerized tools.

3. Concept maps

Concept maps are a specific way of cognition facilitation and a method for representing and measuring an individual knowledge [3]. They are an alternative tool for teaching through building various associations and for knowledge assessment and their increasing by means of concept map expansion.

Concept maps provide a visual representation of concepts and their relations within particular domain. Concepts are stated as words representing events, objects, principles, ideas and other things that are important within domain and they are depicted as nodes of rectangular or other geometric form. Concepts are conceptually and logically related by arcs and these relations can be represented in two ways:

- as lines connecting concepts, or
- as lines together with linking words written on them and explaining relationship between concepts.

Two theories of cognitive psychology are used in creation of concept maps:

- assimilation theory which states that memory is hierarchical and new information is processed and saved within the existing structure;
- associationist theory which defines that the structure of concepts in our memory is not hierarchical.

Students during learning can create a concept map to make sure that teaching material and the relations between studied concepts are correctly understood. In turn, concept maps assist the teacher in tracking of student understanding of teaching material and of student knowledge organization in the general context of the learning course. Creating such maps the person acquires a view about conceptual and logical relationships between concepts and their hierarchical structure. The steps of creation of hierarchical structure of a concept map are the following:

1. step To define the purposes of modeling and the main interesting questions.
2. step To write down the main concepts.
3. step For the main concepts to write down the subordinated concepts and to connect them in a general structure.

The advantages of the use of concept maps are the following according to [3]:

- recall is easier using associated key concepts because less time is required and the recall itself is more complete;
- main ideas are more clearly defined, and the relative importance of each idea is clearly indicated;
- links between concepts are immediately recognizable because of their proximity and connection;

the concept map of each stage is not anything else, than extension of the concept map of the previous stage.

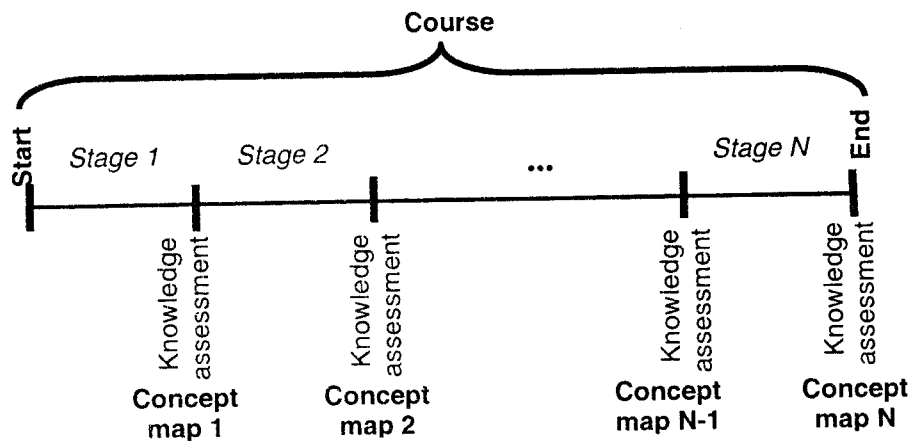


Figure 2. The use of concept maps for student knowledge assessment during the learning course

5. Related works

The idea to computerized concept mapping is not new at all. A number of commercial and non-commercial graphical software packages and tools already exist, for example, AXON Idea Processor (web.singnet.com.sg/~axon2000/), Inspiration (www.inspiration.com), SMART Ideas™ (www2.smarttech.com/st/en-US/Products/SMART+Ideas), Knowledge Manager (www.knowledgemanager.us/), IHMC CmapTools (cmap.ihmc.us), and others, which allow to capture and visualize ideas and knowledge. These products provide such functions as concept map construction, navigation and sharing, and can be used as a useful learning tool, but they do not assess created concept maps.

One of the powerful concept map based assessment tool is COMPASS (COnccept MaP ASSEssment tool) [5]. It is a Web-based system that provides assessment of the learners' knowledge level through various concept mapping tasks and supports the learning process generating the informative and tutoring feedback after the analysis of a learner's concept map.

The other example of assessment tool based on concept maps is described in [6]. It has two versions: one of them supports the task of filling in the blanks of incomplete structure of a concept map, other offers an opportunity to freely construct a concept map. Both versions provide evaluation and hint functions.

Both known systems consider assessment as a discrete event, while the system described in this paper supports process oriented learning and allows the teacher to extend the initially created concept map for the new stage of assessment.

6. Description of the system

6.1. General model

The general model of the software system which will assist in the assessment of student knowledge using concept maps is shown in Figure 3.

The primary users of the system are a teacher and a student. The teacher in a graphical way supplies to the system the concept maps of his/her learning courses and sets their characteristics.

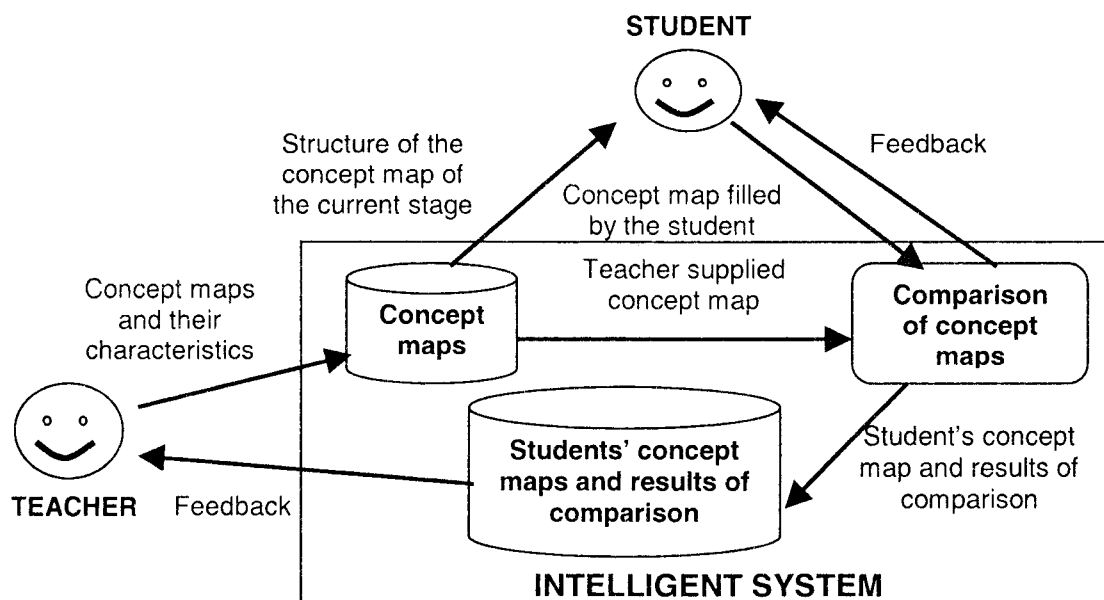


Figure 3. The general model of the system

The student working with the system gets the corresponding concept map. The appearance of the concept map depends on the learning stage. At the first learning stage an empty structure of the concept map with one or several initial concepts is offered to the student. At other stages the structure of the map comprises not only initial concepts, but also concepts which the student has correctly inserted at the previous stages. In any case those concepts which the student should insert into the map are placed close to the structure of the concept map. After receiving of the student solution the system compares the concept map that the teacher has supplied to the system and the map of the student. The system saves results of comparison and the map of the student and gives a feedback to the student about correctness of his/her solution. The teacher can examine students' concept maps and results of comparison at any time.

Comparing the concept maps of the teacher and the student the system determines how many correct important and less important conceptual links (Section 3) are on the map of the student. For each link the certain number of points is given. The student in the form of feedback receives total sum of points and a list of correctly placed and related concepts. The same feedback information is also available to the teacher.

6.2. Functionality of the system

In order to understand functionality of the system and to make it clear for potential users, we decided to represent the main functions by means of use case diagrams. UML Use Case Diagrams is a popular way to describe the main aspects of functionality of a system. Notation which is used in our paper can be found in [6].

The most general use cases are depicted in Figure 4. There are two primary actors: a teacher and a student. Their use cases correspond to the interaction of the teacher and the student with system described early in subchapter 6.1.

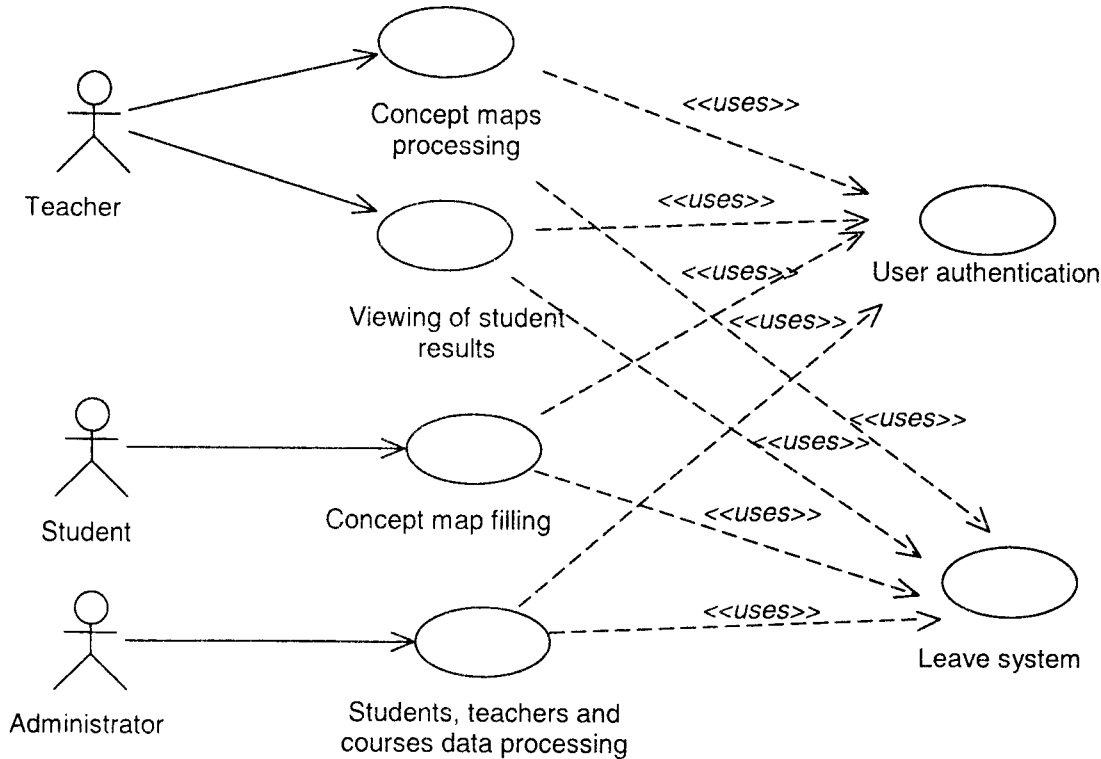


Figure 4. The general functionality of the system

The third actor – administrator - was introduced during the system design. The administrator is responsible for the system maintenance, so he/she inputs both initial data about teachers, students and learning courses, and initial user names and their passwords. Administrator’s data processing function also includes editing and deletion of the information about students, teachers and learning courses.

In order to get an opportunity to carry out his/her functions, the user should be authorized by the system before entering in it. Authorization includes supply of a user name and a password. This function of the system is depicted by the use case "User authentication" (Figure 4). Undoubtedly, the system should provide the exit of the user from the system (the use case "Leave system").

In more details the system provides the following functions for the teacher:

- automatic providing of information on the learning courses taught by the teacher;
- automatic providing of information on students which study a given learning course;

- tools for creating new and editing already existing concept maps for each learning course;
- tools for viewing student filled concept maps and results of their comparison with the map of the teacher.

Use cases of the concept map development function are shown in Figure 5. In order to create a concept map, the teacher should choose a learning course from the list of his/her courses, draw the concept map and define the date when the map will be published (that is, will become available to the students).

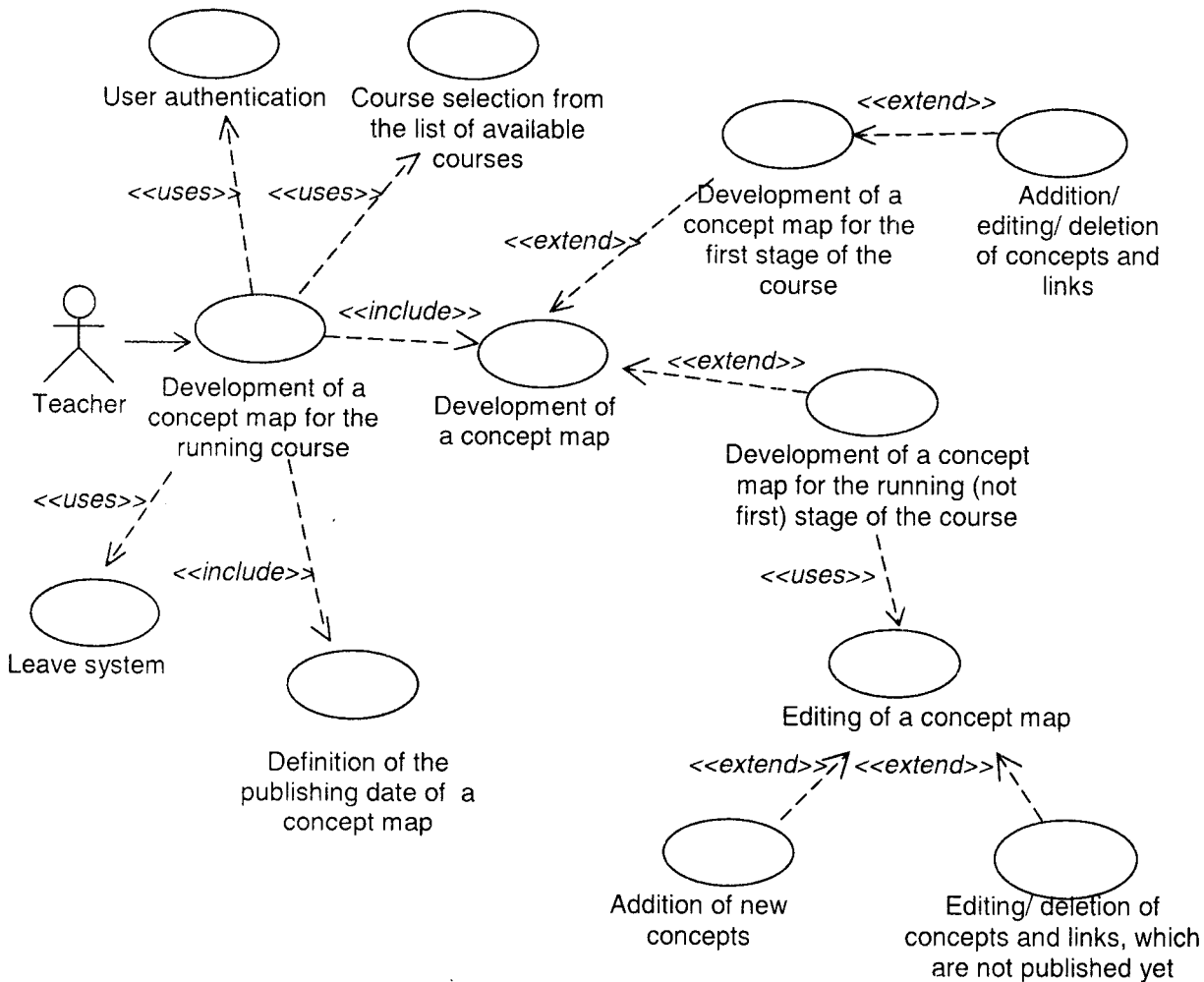


Figure 5. Teacher use case: development of a new concept map

As mentioned before, a concept map of any stage excepting the first stage consists of the map of the previous stage of the learning course, therefore, the system distinguishes two use cases (Figure 5): when the teacher creates a concept map for the first stage of the course (the use case "Development of a concept map for the first stage of the course"), and when a concept map is created for other stages (the use case "Development of a concept map for the running (not first) stage of the course"). In the first case the teacher can freely add, edit and

delete any concept or link. In the second case he/she can edit and delete concepts and links only from the concept maps which are not published yet.

In order to view student results (Figure 6), the teacher should select one of his/her courses and then choose the student. It is possible to choose the student either from the list of students of a given group, or from the list of all students who study the given course. As soon as the concrete student is selected, the teacher should choose the learning stage which interests him/her. Then he/she can view both the student concept map, and results of its comparison with the map of the teacher.

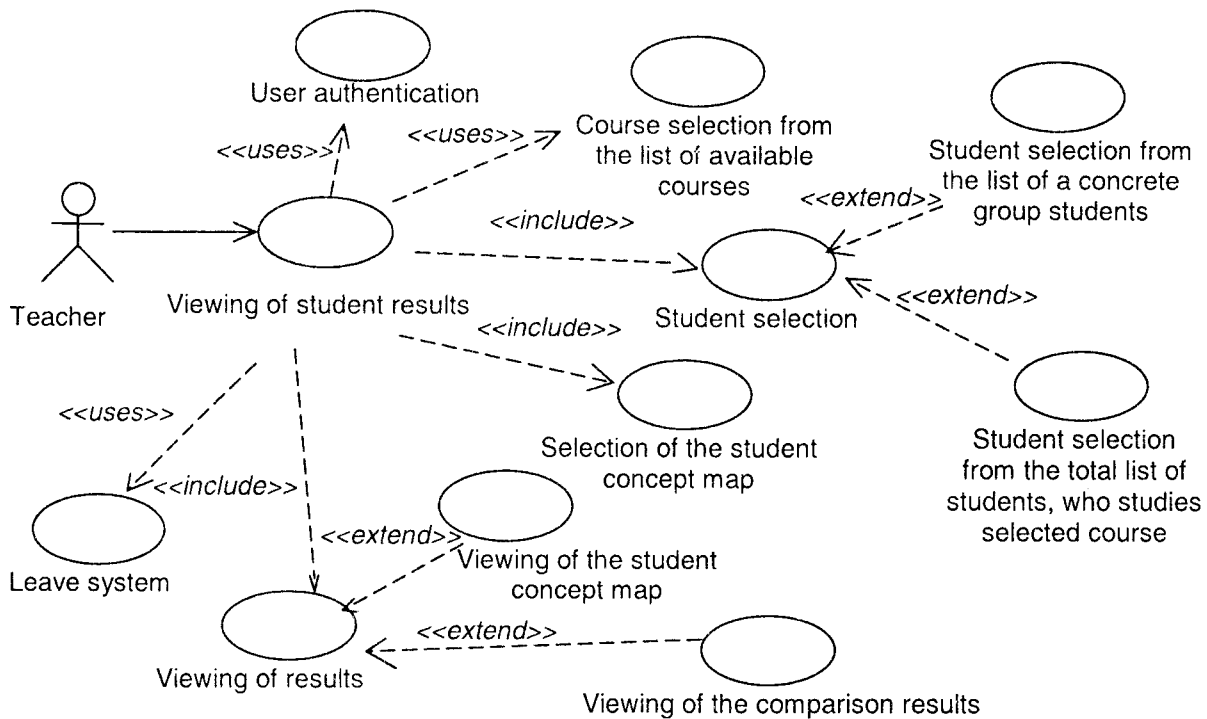


Figure 6. Teacher use case: viewing of student results

In order to carry out the concept map filling (Figure 7), the student should:

- to choose a learning course from the courses available to him/her;
- to choose a learning stage of a given course;
- to insert missing concepts into the concept map;
- to confirm the execution of the task.

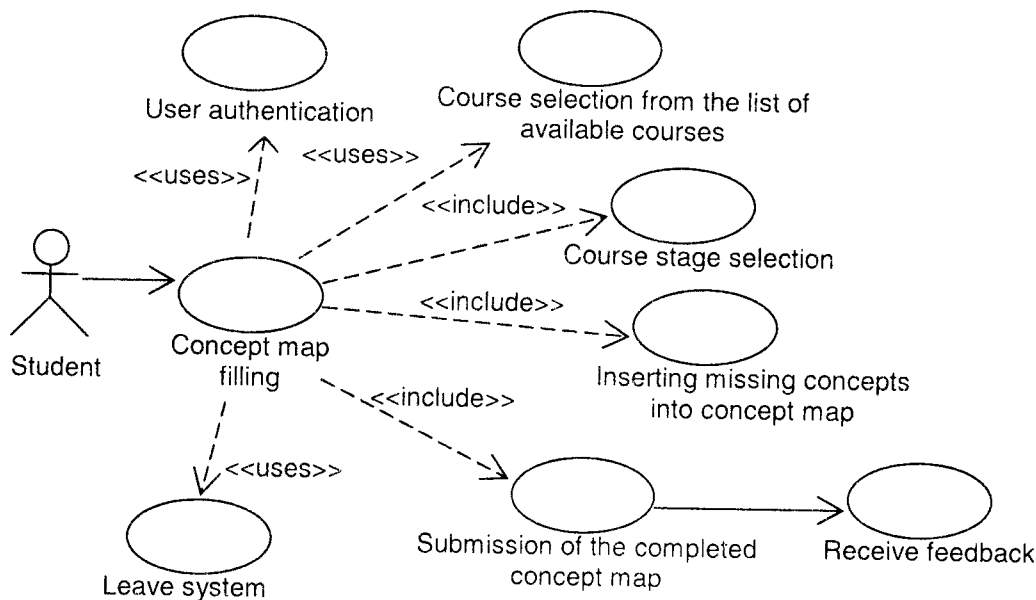


Figure 7. Student use case: concept map filling by the student

After that the system carries out comparison of the maps of the teacher and the student and gives a feedback to the student. The student is not allowed to view or reenter once completed concept maps.

7. Conclusion and future work

Given paper pays attention to such questions related to development of the intelligent system for student knowledge assessment as problems that has led to the idea of the system development, concept maps which underlie the system and their use in the learning process, conceptual model and functionality of the system.

At present the system is in a stage of implementation. The further plans include its testing on the various type of learning courses. In case if the chosen approach and the system will show their viability, the project results can be used for improvement of quality of the learning process both at Riga Technical University, and at other higher schools.

The system has a huge potential for further evolution. First of all in the future it is possible to provide opportunities to specify in concept maps not only concepts, but also type of link between them, for example, "include", "is a part of", "consist of" and so on. Further it is necessary to increase intelligent abilities of the system, which at present are not high enough. In this direction it is possible to build in more intelligent algorithms for comparison of the concept maps of the teacher and the student, to provide opportunities of generating by the system recommendations related to the teaching material that the student should revise to fill gaps in his/her knowledge, and also to implement summarization of data about student solutions, in order to delivery statistics to the teacher about what concepts more often are incorrectly related, which ones often remain not inserted.

References

1. Prets D. "Izglītības programmu pilnveide. Pedagoģa rokasgrāmata"// Apgāds Zvaigzne ABC, Rīga, 2000, p.93.
2. Škoļņikova T. "Vērtējuma un pašvērtējuma mijiedarbības studiju procesā"// Mijiedarbības pedagoģijas aktualitātes: zinātnisko rakstu krājums, Liepāja, 2000, 212-217.lpp.
3. Croasdell D.T., Freeman L.A., Urbaczewski A. „*Concept maps for teaching and assessment*"// Communications of the Asociacion for Information Systems, 2003, vol.12, pp. 396-405.
4. Gouli E., Gogoulou A., Papanikolaou K., and Grigoriadou M. "COMPASS: an adaptive Web-based concept map assessment tool"// In: Proc. of the First International Conference on Concept Mapping, 2004.
5. Chang K. E., Sung Y. T., and Chen S. F. "Learning through computer-based concept mapping with scaffolding aid"// Journal of Computer Assisted Learning, 2001, vol. 17, pp. 21-33.
6. "UML Use Case Diagrams: Tips and FAQ"// In: Object-oriented analysis and design course, Heinz School of Public Policy and Management, 1999. - <http://www.andrew.cmu.edu/course/90-754/umlucdfaq.html> (last visited 29.09.2005)

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Ahohina A., Štāle G., Pozdņakovs D. Intelektuāla sistēma studentu zināšanu vērtēšanai

Vērtēšana ir neatņemama mācību procesa sastāvdaļa un pastāv cieša saikne starp studentu zināšanu vērtēšanu un studiju kvalitātes uzlabošanu. Salīdzinot vēlamos studenta zināšanu raksturojumus, kurus definē pasniedzējs, pamatojoties uz kopējiem mācību programmas mērķiem, darba devēju prasībām un esošiem standartiem, ar patiesiem studenta zināšanu raksturojumiem, kas veidojas mācību kursa laikā, ir iespējams noteikt, cik efektīvs ir bijis mācību kurss. Šādas salīdzināšanas ir lietderīgi veikt katrā mācību procesa etapā, lai savlaicīgi mainītu apmācības metodes un tādējādi virzītu mācību kursu uz vēlamu zināšanu raksturojumu sasniegšanu. Taču, šādas salīdzināšanas parasti netiek veiktas mācību procesā, jo tās prasa papildus laiku un naudas resursus.

Vēl viena zināšanu vērtēšanas problēma ir saistīta ar to, ka bieži vien mācību procesā ir izlaista tāda svarīga vērtēšanas forma kā zināšanu pašvērtēšana. Tā aktivizē kāpmācāmo, tā arī viņa/viņas kognitīvus procesus, veicinot apzinātāku pieeju mācību procesam un uzdevumu izpildei. Tātad, nodrošinot zināšanu pašvērtēšanas iespējas ir iespējams uzlabot mācību procesa kvalitāti un efektivitāti.

Dotajā rakstā ir aprakstīts konceptuālais modelis un funkcionalitāte intelektuālai sistēmai, kuras nolūks ir atbalstīt pasniedzēju mācību procesa uzlabošanā, salīdzinot vēlamos un patiesos studenta zināšanu raksturojumus katrā mācību procesa etapā un nodrošinot iespējas studentu zināšanu pašvērtēšanai. Jēdzienu tīkli, kas veido sistēmas pamatu, tiek apskatīti kā rīks zināšanu pašvērtēšanas sekmēšanai mācību procesā.

Ahohina A., Stale G., Pozdnyakov D. Intelligent system for student knowledge assessment

Knowledge assessment is an integral part of the learning process and there is a strong connection between student knowledge assessment and improvement of learning quality. Comparing desirable student knowledge characteristics which are defined by the teacher, being based on overall aims of the curriculum, employers' requirements and existing standards, with true student knowledge characteristics which are formed during the learning course it is possible to determine, how much effective the learning course was. It is useful to make such comparisons at each stage of the learning process that would allow to change learning methods in time and, thus, to promote the learning course towards an achievement of desirable knowledge characteristics. However, such comparisons are usually ignored in the learning process, as they demand additional time and cost.

The next problem of knowledge assessment is the omission of such important form of assessment as knowledge self-assessment. It activates both the learner and his/her cognitive processes promoting more realized approach to the learning process and performance of tasks. Thus, providing knowledge self-assessment opportunities it is possible to improve quality and efficiency of the learning process.

Given paper describes the conceptual model and functionality of the intelligent software system, which purpose is to assist the teacher in improvement of the learning process, comparing desirable and true student knowledge characteristics at each stage of the learning process and providing opportunities of knowledge self-assessment for students. The concept maps which make a basis of the system are considered as a tool for facilitation of knowledge self-assessment in the learning process.

Анохина А., Штале Г., Поздняков Д. Интеллектуальная система для оценки знаний студентов

Оценка знаний является неотъемлемой частью процесса обучения и существует крепкая взаимосвязь между оценкой знаний студентов и совершенствованием качества обучения. Сравнивая желательные характеристики знаний студента, которые определяет преподаватель, основываясь на целях учебной программы, требованиях работодателей и существующих стандартах, с истинными характеристиками знаний студента, которые формируются в течение учебного курса, можно определить, насколько эффективным был учебный курс. Такие сравнения полезно делать на каждой стадии процесса обучения, что позволит во время менять методы обучения и таким образом направлять учебный курс на достижение желательных характеристик знаний. Однако, такие сравнения обычно игнорируются в процессе обучения, поскольку они требуют дополнительных временных и стоимостных затрат.

Ещё одной проблемой оценки знаний является вычеркивание такой важной формы оценки как самооценка знаний. Она активизирует как ученика, так и его/ее познавательные процессы, способствуя более осознанному подходу к процессу обучения и выполнению заданий. Следовательно, обеспечивая возможности самооценки знания, можно улучшить качество и эффективность процесса обучения.

Данная статья описывает концептуальную модель и функциональные возможности интеллектуальной системы, цель которой содействовать преподавателю в совершенствовании процесса обучения, сравнивая желательные и истинные характеристики знаний студентов на каждой стадии процесса обучения и обеспечивая возможности самооценки знаний для студентов. Карты понятий, которые лежат в основе системы, рассматриваются как средство способствующее самооценки знаний студентов в процессе обучения.