

# Study course structure personalized planning using concept maps

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**Abstract.** Personalized study planning framework consists four graphs for personalized study planning: a graph representing a conceptual structure of study program; a graph representing study course; a graph visualizing each topic of study course using concept map; a graph representing learning objects. This paper describes third graph – a graph for study course topic structure displaying and knowledge assessment. Course topic displaying with concept map is integrated with author’s previous research results about personalized study planning. Authors describe concept map based knowledge evaluation system integration possibilities with personalized study planning prototype and usage in personal study planning. The main result of the research shows that personalized study planning prototype SPS can be integrated with the concept map based knowledge evaluation system IKAS to personalize study planning.

**Keywords:** personalized education, graphs, concept maps, knowledge assessment.

## 1 Introduction

In this chapter the framework of personalized study planning is described which is based on the set of graphs and was elaborated in previous research [1].

To fulfill the personalized study planning starting from creation of study programme plan and ending with the choice of learning objects, there is developed the framework of personalized study planning based on the following set of graphs (Figure 1) [2, 3, 4]:

- a graph representing a conceptual structure of study program  $G_1(V_1, Q_1)$  allows to design individual study plan;
- a graph representing study course  $G_2(V_2, Q_2)$  allows to develop individual learning scenario;
- a graph visualizing each topic using concept map  $G_3(V_3, Q_3)$  ensures mapping of each topic to the corresponding concept map;

- a graph representing learning objects  $G_4(V_4, Q_4)$  describes each concept with learning objects.

The graphs of personalized study planning framework are related. At the first, learner needs to create individual study plan – select courses to include in individual study plan (graph  $G_1$ ). After that learner can choose the study courses which he/she wants to master. Study course structure is described using graph  $G_2$  and that allows to develop individual learning scenario. In course structure graph  $G_2$  learner needs to choose course topic and at the next level graph  $G_3$  describes the concepts of each topic and their mutual relationship. The fourth graph  $G_4$  of the framework of personalized study planning describes the learning objects of topics and concepts, that are available for acquiring knowledge.

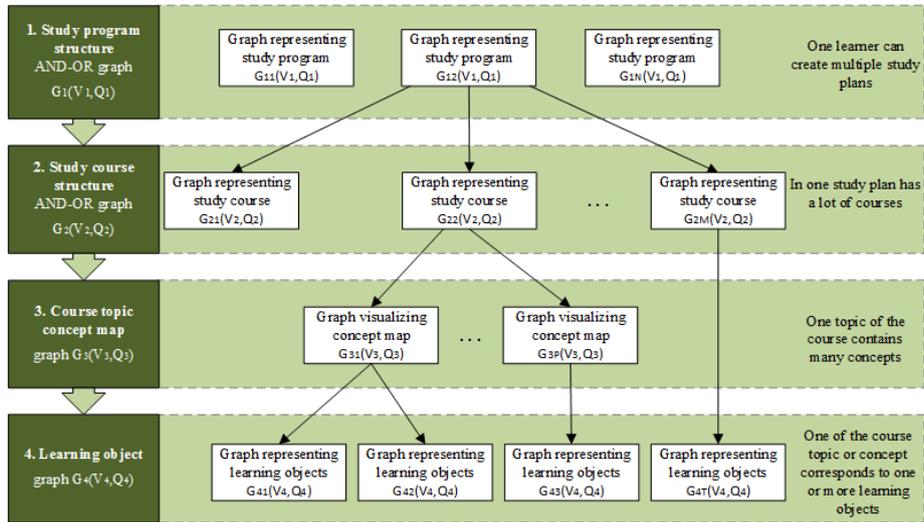


Fig. 1. General structure of personalized study planning framework (adapted from [5])

This framework allows any learner to tailor a study programme by adapting the modularized curriculum structure and to choose the suitable learning strategy for each study course [5, 6].

In order to execute a personalized study planning framework, a prototype has been developed – a Study Planning System (SPS) which has been developed according to the personalized study planning framework. This prototype allows to individually visualize and design the study plan according to the graph  $G_1(V_1, Q_1)$  as well as the choice of a study course according to the graph  $G_2(V_2, Q_2)$ . Whereas the graph for representing learning objects  $G_4(V_4, Q_4)$  is not visually represented in the prototype, still, input of learning objects is provided. The graph for presenting course topics with a concept map  $G_3(V_3, Q_3)$  is not implemented in Study Planning System prototype. In this paper authors describe graph  $G_3(V_3, Q_3)$  integration possibilities with concept-map-based knowledge assessment system IKAS. Next chapter describes graph  $G_3$  more detailed.

## 2 Concept Maps of the Course Topics

According to Figure 1 in course structure graph  $G_2$  learner needs to choose course topic and at the next level graph  $G_3$  describes the concepts [7] of each topic and their mutual relationships. Concept maps were introduced in 1972 by J. D. Novak [8]. A concept map is the presentation of knowledge in the form of a graph [9]. Graph  $G_3(V_3, Q_3)$  is used for representing the concepts and their relationships. It includes a set of un-empty nodes  $V_3$  representing concepts, and a set of un-empty links  $Q_3$  representing the relations between concepts. The relation between concepts is described by the semantics of the links. A concept describes an event or an object. Two or more correlated concepts form a sentence [8]. Another concept map characteristics are cross links, these are relationships between concepts from different domains. Cross-links help us to see how some domains of knowledge represented on the map are related to each other [8].

Concept maps can be helpful in the study process and when evaluating knowledge [10, 8]. They laconic reflect all acquired concepts to learner. Concept maps can be displayed in some number of levels: small concept map for displaying the study course, a large concept map for displaying the study program, to demonstrate the concept cross links. The hierarchical arrangement of the concept maps shows learning sequence of the concepts [11].

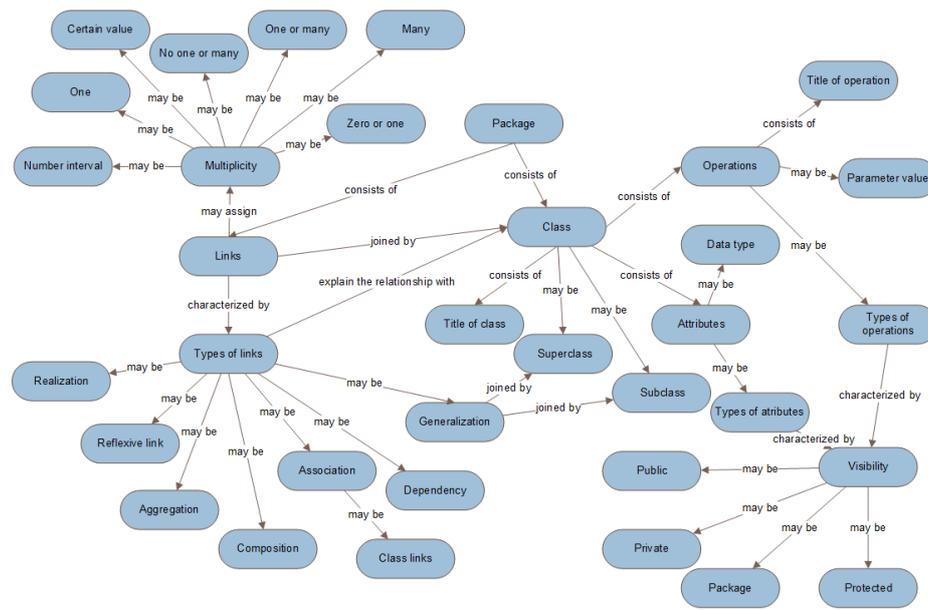
If concept maps are used for showing the structure of the course topic, the learner perceives the training as “conceptually more transparent” [8]. Not all learners identify the most significant concepts successfully, but a concept map helps to acquire them. Concept maps reflect the structure of learner knowledge. Study courses that include remembering lots of facts, dates, names, equations etc. can become boring for the learners, while the use of concept maps allows them to control the course and acquire it successfully [8].

Various displaying types of concept maps shows about domain complexity [12]. For displaying simple structures linear, tree, cycle and the stars type of concept map are used. However, for complex structure displaying network type concept maps are used [10].

To draw a concept map, the authors of work [8] have identified the following steps:

- Domain selection. Identification of the issues to which answers should be provided with the help of concept maps, for example, in relation to the course "Object-oriented modeling" teacher can ask questions - "What is the class?" "What are the components of the class?" etc.;
- Identification of the key concepts that apply to this domain - teacher should choose main concepts from the course that leads to the completion of the course objectives. So identify all the key concepts that are answers to the questions raised in previous step;
- Construction of a preliminary concept map, moving of concepts together with linking statements, which explains the relationship between the two concepts;
- Revision and improvement of created concept maps;
- Determination of cross links.

The graph  $G_3$ , shown as a concept map, can be oriented or undirected. Figure 2 depicts an example of concept map of the graph's  $G_2$  topic "Components of class diagrams".



**Fig. 2.** Components of class diagrams

Since the concepts of the graph  $G_3(V_3, Q_3)$  are connected with the topics of the course structure graph  $G_2(V_2, Q_2)$ , learners can personalize the way of acquiring knowledge about the specific concept.

### 3 The Opportunities of Integration of Personalized Study Planning Systems with IKAS

The personalized study planning system framework contains graph  $G_3$ , which allows to present the content of topics, each of which is presented as a set of concepts, but that is not realized in the personalized study planning system prototype SPS. Consequently, in order to fully realize the individualized study planning framework the concept-map-based knowledge assessment system IKAS has been selected. Since 2005 IKAS is being developed by Riga Technical University Department of Artificial Intelligence and Systems Engineering [13], and the process of IKAS development and improvement will continue also in the future [9].

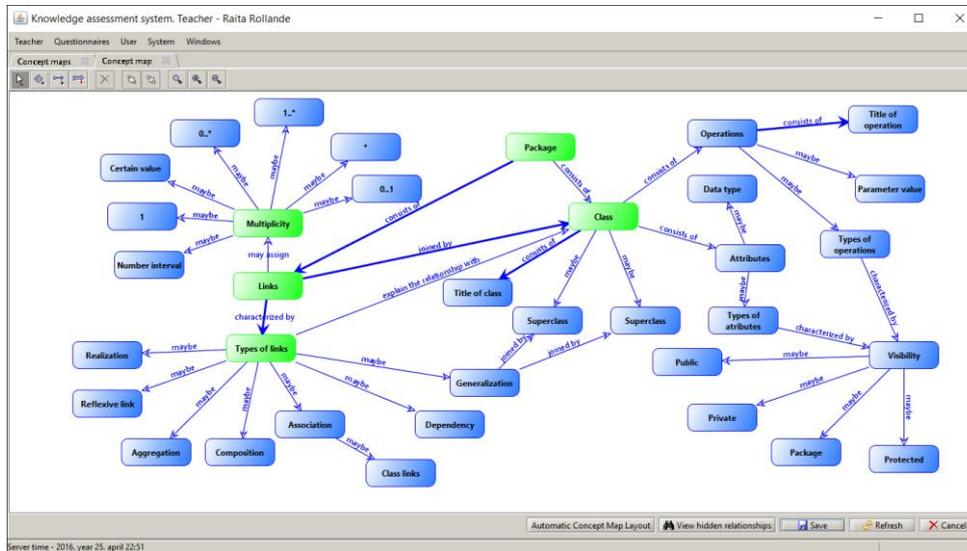
In personalized study planning system prototype SPS learners establishes their individual study plan (according to the graph  $G_1$ ), then he chooses courses from created study plans to start training and open course structure (according to the graph  $G_2$ ). From the course structure the learner chooses the course topic. The course topic learning steps

are possible in two ways: selecting and acquiring learning objects (according to the graph  $G_4$ ) or constructing a concept map (according to the graph  $G_3$ ) using IKAS, as well as the learner's knowledge assessment. If the learner after the graph  $G_2$  has chosen to continue to work with the graph  $G_4$ , then, to carry out knowledge test, he or she must return to IKAS which supports graph  $G_3$ . IKAS is knowledge assessment system that assesses the learner's knowledge of the study subjects, by comparing teacher-made concept map with concept map constructed by the learner. It has two groups of users - learners and teachers.

Before learners can create their own concept map, teachers must define their concept map first. The IKAS and its environment are described in [14]. Opportunities for teachers to work with IKAS are the following [15]:

- To create concept maps and to define their characteristics such as initial degree of difficulty, task completion mode, permission to use support, assessment time, etc.;
- Creating concept maps, to use important and less important relationships, as well as 6 kinds of linking phrases (is a, kind of, is an example, is a property, value, part of, and linguistic relationship);
- To use synonyms of linking phrases;
- To filter and to view students' results;
- To manage students' incorrect relationships in order to improve study courses and your concept maps;
- To manage the calculation process of students' results by changing coefficients affecting students' scores;
- To view statistics concerning students' use of support;
- To create questionnaires and to offer them to students;
- Defining a questionnaire, to use 4 kinds of questions (essay, multiple choice, multiple response, and ranking questions);
- To filter and to view students' answers on questionnaires;
- To view system demonstration and training files;
- To change user information;
- To change user interface settings.

Figure 3 shows the teacher's access mode to create a concept map of the topic "Class diagram components". Concept map consists a total of 35 concepts. Based on the concept of map structure analysis, as initially defined concepts are five: "Package", "Link", "Class", "Types of links", and "Multiplicity". Other concepts of the trainee should be placed in by themselves.

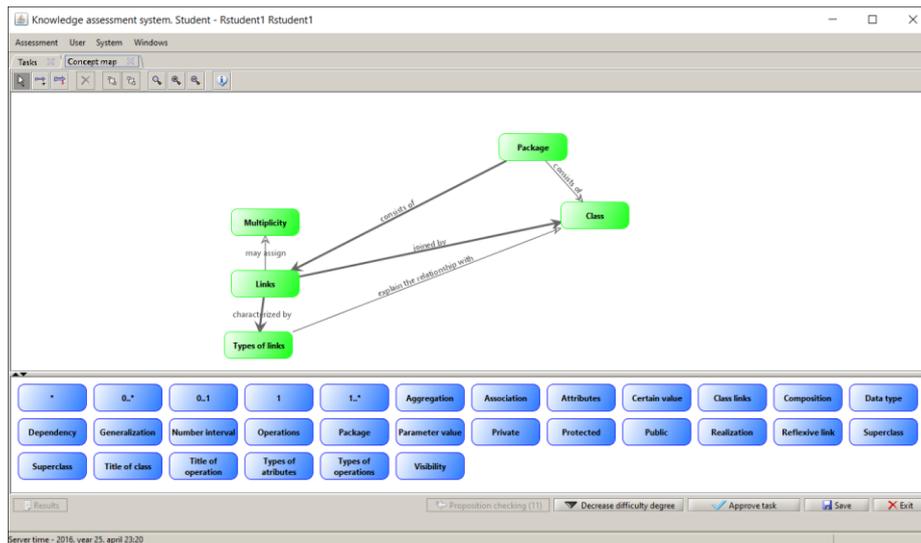


**Fig. 3.** IKAS teacher access mode to create a concept map of the topic "Class diagram components"

Learner opportunities to work with IKAS [15]:

- To assess your knowledge level by completing concept map based tasks;
- Working with concept maps, to use important and less important relationships, as well as 6 kinds of linking phrases (is a, kind of, is an example, is a property, value, part of, and linguistic relationship);
- To correct mistakes made at the previous assessment stages until you have not finished the last assessment stage of a course;
- To perform more difficult tasks at the next assessment stages if you are successful in the current one;
- To use rich student's support (checking of propositions, insertion of additional concepts, reduction of the degree of task difficulty, explanation of concepts) in order to complete a task successfully;
- To receive three types of concept explanations: definition, description, or example;
- To manage types of concept explanations you want to receive or to trust the choice of the most suitable type of explanations to the system;
- To manage your student model in order to gain personalized assessment experience;
- To receive rich feedback (quantitative data, concept maps with highlighted incorrect relationships, concept mastering degrees, individual study plan, and other) concerning your task solution;
- To provide feedback to the teacher on the knowledge assessment method and usage of the system through the offered questionnaires;
- To view system instruction files;
- To change user information;
- To change user interface settings.

Figure 4 shows the window of the student's interface for starting the completion of a concept map for topic "Class diagram components" created in IKAS system's learner access mode. Initially, in the concept map creation window learner see 5 concepts initially defined by a teacher, selected on the basis of the concept map structure analysis. Other concepts are visible at the bottom of concept map creating window.



**Fig. 4.** Concept map creating window for topic "Class diagram components"

Learner create the concept map with shown in the bellow concepts and connect them. To understand the concept, the learner can open help window, where the concept definition, description and example are displayed.

To connect the concepts the IKAS program window with 6 types of linking phrases are offered and learner must choose the most appropriate linking phrase between the two concepts.

Once the trainee has completed a concept map, he/she activates the button <Confirm task>, after which IKAS compares teacher defined concept map with a learner developed concept map and after the button <Result> activation is eliminated detailed learner concept map assessment (Figure 5).

In Figure 5 can be seen that the learner in task execution result gained 58,40 points, which is 81,11% of the maximum collectable 100%. Concepts with whom the learner is not very familiar with and are managed poorly are displayed below. Thus, the learner has information on the concepts, which he needs to repeat again. To study concepts, learner needs to open personalized study planning system SPS to acquire the study subjects using learning objects. After acquiring course topic teacher input mark in course structure graph ( $G_2$ ) and flag that a course topic is acquired and selects next topic for constructing concept map.

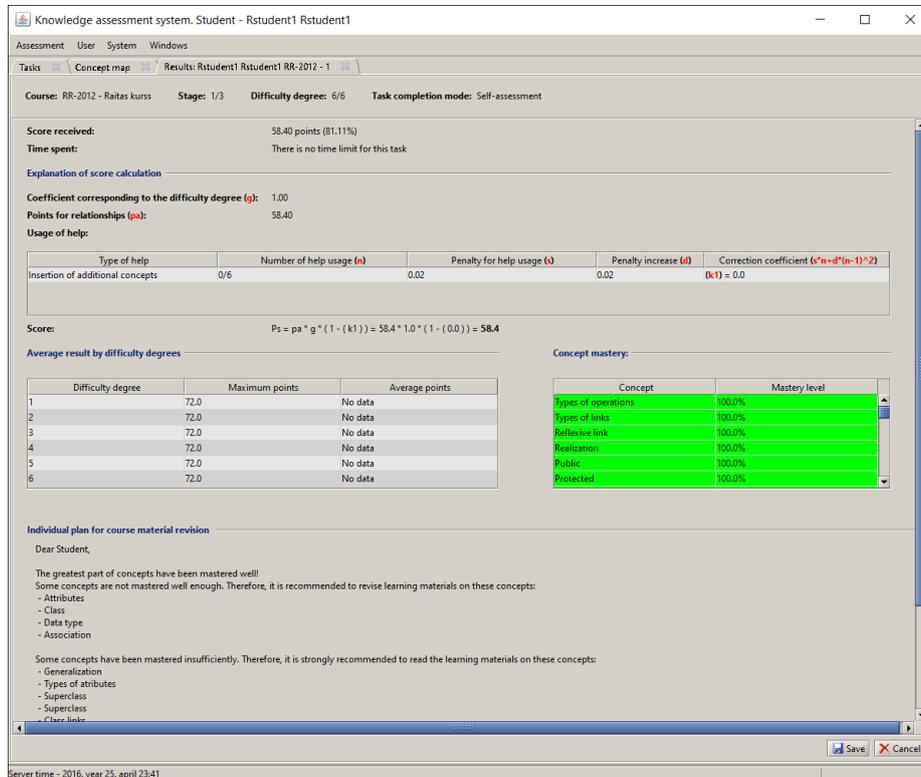


Fig. 5. Learner learning result window

IKAS has three-tier architecture. There are three conceptual elements: the database server, the client application and the application server. Such architecture increases response speed and ensures security of the system [14].

The personalized study planning system prototype SPS does not include a learner's knowledge test, while IKAS does. Therefore, the learner can develop his/her own study plan in the personalized study planning system, determine the sequence of acquiring topics, then select concepts by using IKAS, move to SPS in order to acquire the learning objects and then come back to IKAS in order to carry out a knowledge test. After the knowledge test, the learner marks that the topic is acquired in the personalized study planning system, and starts acquiring the next topic. The learner continues the task sequence to acquire all the other study course topics until the whole study plan has been acquired.

## 4 Conclusion

This paper shows integration of personalized study planning framework graph  $G_3$ , which allows to present the content of study course topics, using concept maps based knowledge evaluation system IKAS, that allows to learn study courses and assess

knowledge. Authors describe integration opportunities of concept map based knowledge evaluation system with personalized study planning prototype and usage in personal study planning. Such integration approach allows to extend functionality of both systems: personalized study planning prototype SPS and concept map based knowledge evaluation system IKAS. Integration results demonstrate that IKAS can be part of other system architecture.

Personalized study planning framework has modular structure, which facilitates integration. Further integration of research and extension functionality of personalized study planning prototype SPS can be implemented using other study planning and organizing systems such as Moodle.

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