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Interactive concept maps in intelligent educational web systems

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The constant availability of huge repositories of professional and educational information, the continuous emergence of new educational resources leads to profound changes in educational processes and methods of obtaining and improving knowledge and skills. Intelligent educational portals should be built by forming an ontologically-oriented model of educational content, which provides formalization of information, ontological modeling of the subject area and didactic function, which provides presentation and visualization of the required educational information.

In [1] the influence of visualization on the effectiveness of training in the field of computer science is investigated. Emphasis is placed on the importance of visualization tools and increasing user interest when visualization is involved. The method of visualization of professional and educational information in the form of concept maps of different types has become widespread [3]-[11]. In previous studies [12] it was proposed to build a didactic ontology based on the concept-thesis model (CTM), and also presented a way to visualize the ontology in the form of semantic-didactic maps.

The aim of the work is to develop a method of automated construction of interactive concept maps in ontology-oriented web systems. The task is to provide a convenient display of graphs for users of the educational web system using content formalization based on the concept-thesis model [12].

The construction of interactive concept maps proposed in [2]-[8], [10] is based on the ontological modeling of the subject area, carried out by an expert in manual mode, and this involves significant labor and time costs. At the same time, the approach to domain modeling based on semantic networks and Semantic Web for educational systems has a number of difficulties [13]. In particular, this approach requires a complete detailed picture of the

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domain, the so-called problem of "knowledge totality" of the educational system [13], when it is necessary to formalize all objects and relationships between them. It can cause serious difficulties and often leads to formalization of knowledge, which in this educational context are not of didactic importance [13].

It was proposed [12] to build a didactic ontology based on the concept-thesis model (CTM), and also presented a method of visualizing the ontology in the form of semantic-didactic maps. Such a map is a directed acyclic graph, the vertices of which are concepts, and each of the arcs indicates that the concept-beginning of the arc didactically precedes the concept-end of the arc. In this case, the so-called center of the graph is the concept for which the map is built. The map sequentially shows all connections, starting from the central concept with didactically preceding concepts (left part of the graph) and all connections, starting from the central concept, with didactically following concepts (right part of the graph) [12]. The approach to the formalization of learning information on the basis of CTM has a number of advantages for application in educational systems, due to the focus on the use of informal areas of natural language information in combination with semantic formalization of key concepts. This is well suited for didactic tasks of educational web systems. However, CTM provides opportunities for automated construction of concept maps.

Elements of CTM are the result of formalization of didactic text performed by an expert using an interactive web interface. CTM is used to solve a number of problems in information and educational systems, including automation of knowledge control, automated construction of the terminology vocabulary of the course, automated construction of didactic ontology, automated construction of individual learning environment, etc. Further expansion of the scope of CTM to solve the problem of building interactive concept maps in educational systems is effective in terms of optimal use of human labor.

T elements include concepts and theses. Theses are a natural expression of knowledge in the subject area in the form of fragments of educational text and media content. Concepts set: $C=c1,\ldots,cn1$. A thesis is some statement about a concept. Theses set: $T=t1,\ldots,tn2$. Each thesis relates to one concept. This relation is given by the mapping: $CT:T\rightarrow C$. In turn, each concept can have any number of theses described by the relation: $TC: C\rightarrow 2T$. Assignment of theses and concepts to a certain class performed by the corresponding mappings: $TClass=T\rightarrow TClasses$, $CClass=C\rightarrow CClasses$.

The proposed method of formalization of content and ontological modeling of the subject area educational resources was implemented on the portal [14].

To implement such classical relations as "part-whole" and "subtype of type", "instance of type", the corresponding relations are introduced in TM. The presence of classical relations for semantic networks in TM brings it closer to the first, but, as mentioned earlier, the use

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of semantic networks to knowledge modeling for presentation to the student has a number of disadvantages. Therefore, within the formalization of educational content based on CTM, it is recommended to use the relationship taking into account the current didactic need. Among the main recommendations here, we note the following: 1) try to indicate the relationship of each concept to some parent or main with one of the three relationships: part-of, is-a, instance-of; 2) do not try to carry out too detailed formalization of connections between the concepts of educational content, leaving this function to natural fragments of content stored in theses. The essence of these recommendations is to follow the principle of the least necessary and most didactically appropriate formalization, which provides moderate complexity, natural expressiveness and clarity of graph visualizations in the educational system.

An algorithm for constructing a map of a certain area of educational content has been developed, which combines a set of concepts, providing their decomposition and visualization of relations. In Fig.1. an example of a comprehensive map of the content area, implemented on the basis of the proposed algorithm on the portal [14]. The interface of the system implements a concept map in the form of an interactive graph with the functions of scaling, searching for concepts on the graph, navigation and processing of user interaction with visualized objects (Fig. 2). The function of displaying the aggregate textual-media information about the concept-node in the graph is given, which is based on the display of the corresponding theses of the concept.

The subsystem for building concept maps is integrated with the software of the ontology-oriented content management system of information and educational portals. The subsystem includes server modules for working with didactic ontology based on CTM and client components for generating data about the vertices and edges of the graph and interface components for responding to user interaction. The Vis.js library is used as a basis for graph visualization.

The system was tested in the learning process and received positive feedback from users as a convenient means of visualizing new information for study.

The problem of interactive visualization of concept maps in ontology-oriented portals with the use of subject area formalization on the basis of CTM is considered in the work. The CTM has been modified by introducing a number of basic relations into the model, as well as a means of decomposing information about concepts. The method of constructing a map of concepts is presented, which provides clarity of presentation of educational content in the form of a map, implements interactive display of natural information about the selected concept, search of concepts with navigation to the target concept. Implemented software system provides an interface for formalizing educational content on the basis of CTM, provides storage and display of educational materials and implements the proposed method of constructing interactive concept maps [14].

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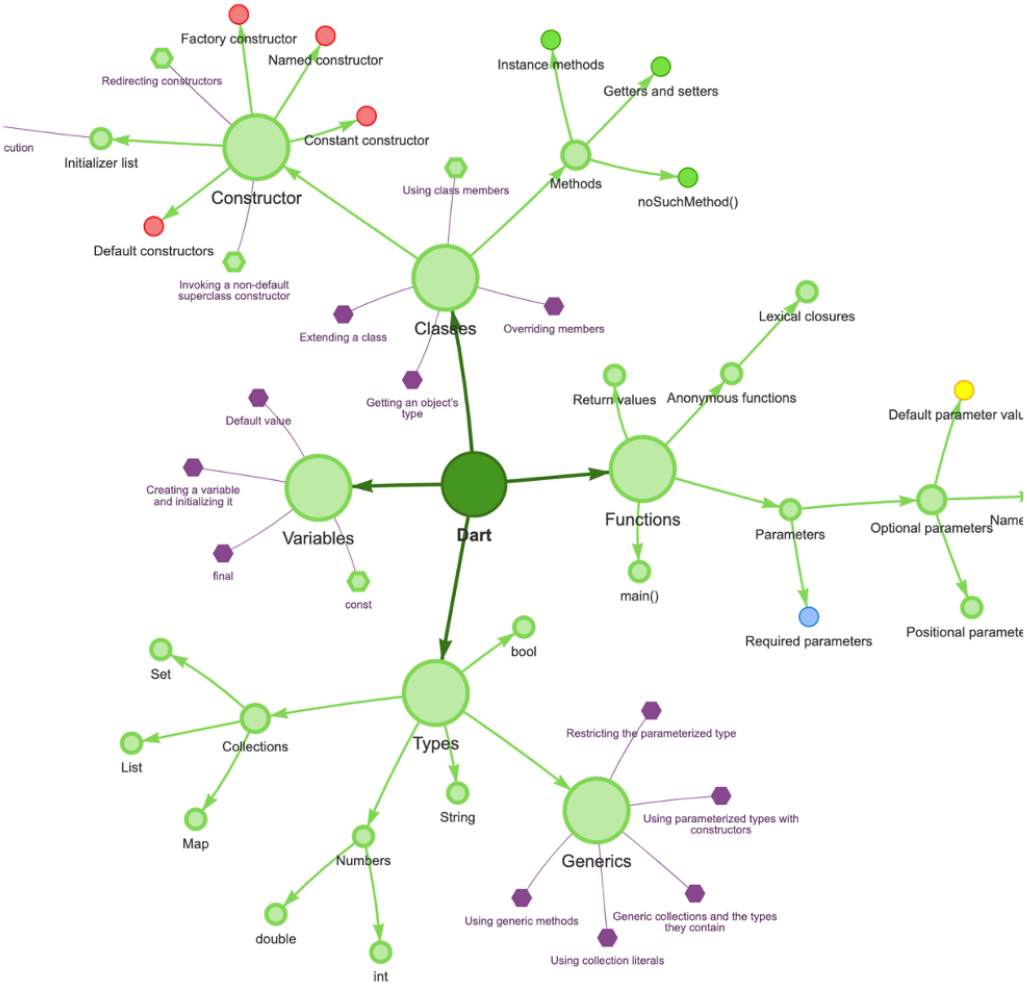

Fig.1. An example of a comprehensive map of the content area, implemented on the basis of the proposed algorithm

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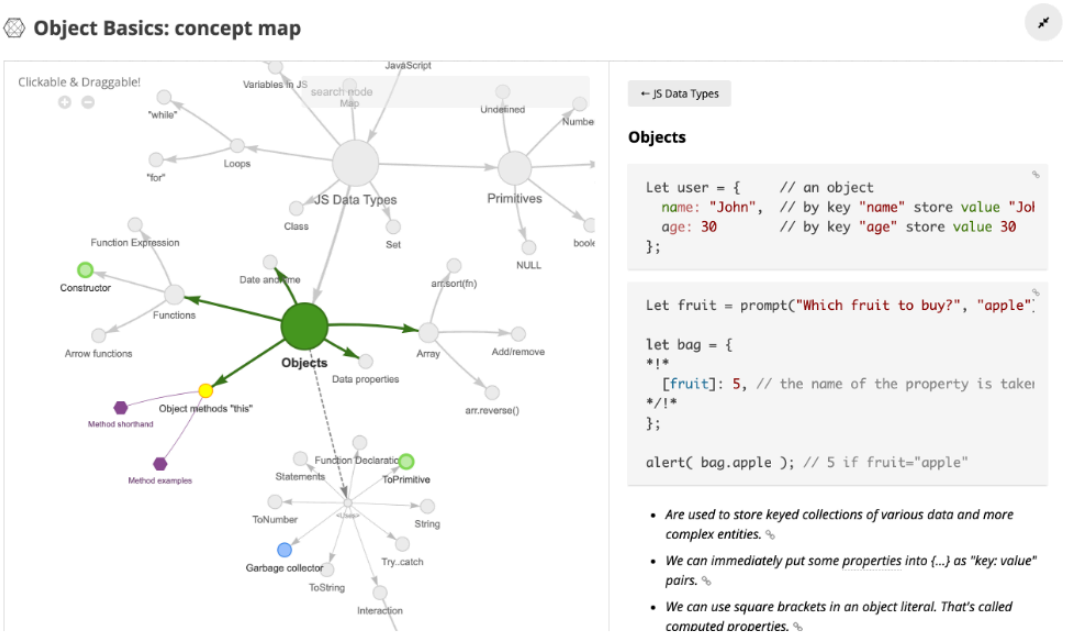

Fig.2. An example of an interactive interface of concept map

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