Cognitive Maps in the Process of Educational Communication

Paul Tarabek 1), John Tarabek 2)
1) Mathematical Department, College of Applied Economy, Prague, Czech Republic, EU
2) Educational Publisher DIDAKTIS, SK 81104 Bratislava, Slovakia, EU
For correspondence please contact: didaktis@t-zones.sk

ABSTRACT

Scientific knowledge as a result of the cognitive process of a scientific community is characterized by a coherent system of scientific concepts, terms, facts, laws, and principles and the connections between them which comprise theories and their applications and interpretations in reality, and cognitive, modeling, application, and interpretation methods and procedures that the given science makes use of. Scientific knowledge systems are organized in scientific models described by words, symbols, or figures which comprise patterns. The scientific conceptual models are adapted to the purposes of education in a process of an educational communication of science called also the curriculum process. In the first phase of this process the communicative scientific conceptual knowledge system is constructed and visualized by way of cognitive maps of a content knowledge to be taught. This system is adapted to the cognitive level of knowledge recipients in the second phase of the curriculum process. The cognitive maps of educational content and its parts are created in the third phase of the curriculum process – teaching, instruction, and learning.

Keywords: educational communication of science, curriculum process, curriculum transformation, cognitive map

INTRODUCTION

Scientific knowledge as a result of the cognitive process of a scientific community is characterized by a coherent system of scientific concepts, terms, facts, laws, and principles and the connections between them which comprise theories and their applications and interpretations in reality, and cognitive, modeling, application, and interpretation methods and procedures that the given science makes use of. Scientific knowledge systems are organized in scientific models described by words, symbols, or figures which comprise patterns. Mental patterns have to be visualized in order to communicate them to other people. According to Halloun [7] and Hestenes [8, 9] the notion of a model as a unit of coherently structured knowledge is the core of the any scientific theory. According to Carl Wieman [15], recipient of the Nobel Prize in Physics in 2001, “novices see the content of physics instruction as isolated pieces of information. Experts – i.e., physicists – see physics as a coherent structure of concepts that describe nature and that have been established by experiment.” According to Coponen & Pekkonen [5, 6] the analysis of a topological structure of the concept maps shown “that experts’ maps are characterized by conceptual coherence and hierarchies, which are inbuilt in the network-structures. In novices’ concept maps similar features are found in the best cases, but many novices produce maps with poor coherence and a lack of organizing hierarchy.” The problem of poor structure of mental conceptual knowledge systems in pupils’ and students’ minds is an old one [3, 4, 10, 11, and 12]. Concept maps are one possible way to solve this problem [11, 12]. Educational communication of science offers another way to solve it – using cognitive maps of a content knowledge and educational content in teaching and instruction process.

EDUCATIONAL COMMUNICATION OF SCIENCE

The communicative conception of science education means the continuous transfer of the knowledge and methods of science into the minds of individuals who have not participated in creating them. This process, called the educational communication of science, is performed by various educational agents – teachers, curriculum makers, textbook designers, university teachers, educational scientists and does not mean only a simple transfer of information, but it also involves teaching and instruction at all levels of the school system, the study, learning, and cognition of pupils, students and all other learners, the assessment and evaluation of learning outcomes, curriculum composition and design, the production of textbooks and other means of educational communication and, in addition, university education and the further training of teachers. The theory of science education concerning the process of educational communication deals with the scientific conceptual knowledge system of a given science. This conceptual knowledge system (CKS) takes several variant forms during the course of the educational communication of science and it passes through several knowledge transformations. Science education has to follow a complete path of transformations and forms of scientific knowledge, and, in the process, the variant forms of the conceptual knowledge system of science correspond to qualitatively distinct phases of curriculum process. The curriculum process in science education as the complete continuous transfer of scientific knowledge and methods into the minds of learners is realized by means of the sequence of variant forms of curriculum P0 – P6 (as phases of the curriculum process) that are mutually interconnected through curriculum transformations CT1 – CT6 (see Fig. 1). The variant forms of curriculum are as follows: P0 – scientific system, P1 – conceptual curriculum, P2 – intended curriculum, P3 – project (formal, written) curriculum, P4 – operational curriculum, P5 – implemented curriculum, P6 – attained curriculum. The first and only “non-curricular” member (P0) of this sequence is the scientific system of a given science. Two
transformation lines move through the curriculum process: the first of these lines is the sequence of the phases of curriculum process P0 – P6 (variant forms of curriculum) that are interconnected through curriculum transformations CT1 – CT6. The second of these lines is the sequence of variant forms of conceptual knowledge systems (CKS) that are interconnected through knowledge transformations KT1 – KT6. The CKS are also called the content knowledge (CK) of a given science/subject in phases 2 – 5 or educational content in phases 2 and 3 [1, 2, 4, and 13].

The first three transformations of the curriculum process correspond to the curriculum development and design. The fourth and fifth transformations take place during the education. The sixth transformation takes place in the subsequent practice. In the curriculum theory, this theoretical conception covers many important aspects of the school educational process in its complexity by means of a relatively simple and comprehensible process chain.

**COGNITIVE MAPS**

The set of concepts connected by the cognitive links [14] and symbolic forms of these links (expressed by a mathematical formulas or word propositions) comprises the structure of declarative (conceptual) knowledge. The common/scientific conceptual knowledge system at the epistemological layer S3 or imaginary common/scientific system at the epistemological layer S2 can be visualized by way of cognitive mapping. The cognitive maps in the first phase of the curriculum process express and visualize the structure of the communicative conceptual model of a given science or its selected part as a selected content knowledge to be taught in the third phase of the curriculum process – teaching, instruction, and learning.

The creation of the cognitive maps comprises several stages:

**First stage (conceptual curriculum):**
1. Description of the content knowledge to be taught by key concepts, selected knowledge and concepts related to them;
2. Analysis of key concepts and knowledge (cognitive architecture, all important relations, etc);
3. Synthesis – creation of a structured conceptual model of the content knowledge;

**Second stage (intended curriculum):**
5. Concretization of the structured conceptual model with texts, images, and examples adapted to the pupils’/students’ age, knowledge, preconceptions, etc;
6. Creation of the educational content as structured intended curriculum.

**Third stage (project/written curriculum):**
7. Transformation of the educational content into a set of cognitive maps visualizing its structure for pupils and students.

The cognitive map of the mathematics content knowledge for elementary schools in the phase 1 is presented in the Fig. 2. The selected cognitive maps of the mathematics educational content for elementary schools in the phase 3 are presented in the Fig. 3, 4, 5, and 6.

**REFERENCES**


FIGURE 1. Curriculum process in science education and its phases – variant forms of curriculum and corresponding variant forms of CKS

CKS – conceptual knowledge system of a given science – content knowledge in the phases 2 – 5

KT – knowledge transformations, CT – curriculum transformations

T7 – “non-educational” member of the sequence of the curriculum transformations

P0 – “non-curricular” member of the sequence P0 – P6
FIGURE 2. Cognitive map of mathematics (arithmetic) content knowledge in the phase 1 of the curriculum process – conceptual model of the mathematics (arithmetic) for elementary schools

Arrows mean hierarchical relations or expression of composition, double arrows mean causal relations or effects, lines mean connections between objects and concepts or semantic images.
FIGURE 3. Semantic images of cardinal numbers in the educational content for elementary schools (grade K1) in the phase 3 of the curriculum process (CP)

FIGURE 4. Semantic images of ordinal numbers and arithmetical progressions in the educational content for elementary schools (grade K2) in the phase 3 of the CP

FIGURE 5. Semantic images of the decimal number system and positional notation of numbers in the educational content for elementary schools (grade K2) in the phase 3 of the CP

FIGURE 6. Semantic images of the comparison (>, <, =), in the educational content for elementary schools (grade K2) in the phase 3 of the curriculum process (CP)