Chapter 39
Conceptual Principles of Engineering Education Based on Evolutional-Activity Approach

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ABSTRACT

The concept of education using an evolutional-activity approach is presented. This approach resolves the problem of continuous self-development of specialists in their professional activity. The conformity of their evolution to individual and social changing needs is supported by development of skills for reliable generation of a new valuable knowledge in the right time and in the right place of the professional space. This new knowledge becomes a basis for generation of time- and energy-effective engineering solutions, including unique ones. The novelty of the proposed approach comes from the establishment of an axiomatic basis. The core categories of the basis are activity classes. The whole conceptual framework and fundamental laws are represented as consequences of initial axioms and postulates of the basis. This approach allows the higher education pedagogy to overcome the conceptual crisis, which resulted from the variety of existing conceptual frameworks.

INTRODUCTION

The education level of an engineering community is the most important factor for sustainable economic growth and improvement of global competitiveness. As productivity growth largely depends on technological innovations, one of the priority tasks of education development is to support creation and distribution of structural and technological innovations. The innovations in higher education, as in any other area of activity, are founded on a fundamental theoretical base.

The education system is looking for an answer on how to make a subject of the world transformation closer to a certain productive activity. How to place the subject into events, and how to involve the subject in the events?

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Since the number and complexity of situations in the outer environment constantly grow, the system of managing the organization of processes for the generation of adequate solutions of the productive tasks must be able to acquire new qualities, to increase its capacity for development and implementation of solutions, i.e. be able to continuously evolve.

This work presents the methodological foundations of axiomatically constructed evolutional-activity (EA) education. The methodology provides a transition from the traditional representation of information through knowledge and skills (Hauke, 2015), modules (Unesco, 1989), competences (Hodge & Harris, 2012) to a qualitatively new information representation based on the primary axioms of the subject's activity. It also creates conditions for the development of emergent engineering solutions with new functions and properties. A remarkable feature of the proposed approach is the wider adoption of decision-making algorithms that are prevalent in nature: methods of selection, evolution, and adaptation. In general, these methods belong to the class of heuristic self-organization.

BACKGROUND

Explicit modeling, as a method of scientific cognition, has the following notable feature. In phenomena under study, only essential things are modeled. A model should incorporate main characteristics, parameters, and their interrelations, so it can facilitate deeper understanding of a phenomenon. This is the outline of the conventional approach of explicit modeling.

The main drawback of the conventional deterministic decomposition method is unacceptability of losses, even of insignificant elements in the coefficient matrix of the equation system. In the selection processes, the processes of choosing the important things and eliminating the insignificant ones, according to defined criteria, are necessary. The implementation of this approach by a learning system in the real world is not effective due to difficulties to adaptation and flexibility.

Human intelligence, as a complex self-learning system, is exhibited in the following abilities.

1. The ability to learn, including information acquisition from direct interaction with the outer world, integration of the information into the internal model, and achievement of understanding (i.e. perform connection of the acquired knowledge with facts and phenomena of reality). The learning aptitude is related to the desire for a system to permanently improve the internal model of the external world.
2. The ability to manage the mental activity, that is, the ability to abandon conventional patterns and find new, actual, specific relationships.
3. The ability to possess a mental memory, to transmit messages to other intelligent people, and to create a signal system for this purpose.

Implicit modeling is more adequate in the learning process of complex systems. Implicit modeling requires tools that allow reproduction of a desired behavior of the complex system under study. The tools by themselves may form another complex system, which can be understood more easily than the original system. An implicit model allows experimentation, but it lacks one of the features of explicit modeling, which is comprehensibility of the functioning or solubility of the result obtained. The result of the implicit modeling is not an identification of a "black box," but creation of its model in the form of