COMPREHENSIVE FRAMEWORK FOR SCIENTIFIC AND TECHNOLOGICAL LEARNING PROCESSES

Kurki-Suonio Kaarle, Kurki-Suonio Riitta
Department of Physics, University of Helsinki – Finland

Learning and research are interpreted as hierarchically different stages of the same Great Process of creating knowledge. This identification of learning with science leads to far-reaching conclusions on the nature of both learning and science. The Great Process is maintained by two basic motives, understanding and usage. The first motive gives rise to the scientific process, the second to the technological process. Both are interactions of observation and human mind or of Nature and Theory. The process as a whole is embedded in and interacts with the social environment. Hence, the social process is always present as the third component.

Science changes the Theory. It proceeds from Nature to Theory improving our conceptual understanding of Nature. Entities, properties, phenomena and causal relationships are perceived and conceptualized on the primary qualitative level of language. In a threshold process leading to the quantitative level they are quantified into quantities, laws and theories representing hierarchically different levels of concepts. Science has a fractally two-way dynamics consisting of the opposite subprocesses of representation or "how" and interpretation or "why". Representation is primary. "Why" can be approached only through "how". The concepts are born as representations of their perceived meanings, but their increasing generality makes them a chain of ever deeper interpretations. The achievements of science are unifying ideas.

Technology changes the Nature. It proceeds from Theory to Nature making use of the conceptual understanding to control and elaborate Nature. Its two-way dynamics of usage and need consists of the opposite subprocesses of application and invention. The technological process creates a hierarchy of "technological systems" subject to the well-developed theory of systems analysis. The achievements of Technology are inventions.

The processes feed each other. Understanding generates applications. Application creates new phenomena for the scientific process to understand. The results of technology become new entities of Nature. Realization of scientific experiments is possible only through the technological process.

This basic processual structure is inherent in all learning right from the very beginning, formation of sensual perceptions. While perceptions are based on external excitations, the "structure of mind" regulates their possible nature. The mind has an active role. It selects and shapes the "messages" to create sensations and adapts itself accordingly. We are bound to perceive our surroundings in terms of space and time, in terms of entities with properties and of phenomena as changes of the properties. Observation and mind are, thus, inseparably intertwined through simultaneous processes of representation and interpretation. The Gestalts perceived become structural entities of the mind. They are meanings "understood" before there is even a possibility for language or words.

Also the technological process is inseparably included in the creation of sensations. Adaptation to the real existence of the perceived entities, phenomena and properties is essential in the perception process of the child. The Gestalts are loaded with practical potential. The meanings are based as much on their "usage" as on their role as organizing

Gestalts of the surroundings. The presence of the social process is most obvious. All the life of a child is guided and maintained by social interactions.

This processual structure is preserved throughout the Great Process from unconscious interaction of observation and mind to conscious learning and up to systematic research. The degree of consciousness increases but the basic nature of the process remains. In science, as in sensual perception, meanings are born first. Conceptualisation of the meanings leads to creation of language, terminology, formulae and equations etc. as abstract representations. The whole conceptual structure is a hierarchical net of conceptualised Gestalts. Each concept consists of experimental, theoretical, as well as scientific, technological and social components, inseparably intertwined as they are in the formation of sensual perceptions.

Analysis of the structure of the Great Process has led to a long-standing project of "perceptional approach" of didactical physics at the Department of Physics in the University of Helsinki. It is intimately coupled to the education of physics teachers. It involves analyses of the treatment of different physical subjects, development of teaching practices, of students' experiments and demonstrations, planning of courses and writing of textbooks for different school levels etc.

If the idea of the Great Process is adopted, learning is seen as the personal Great Process of the pupil. The task of the teacher is to help his process to proceed. Thus, the "perceptional approach" is basically a constructivistic approach. Inseparability of the three processes is seen essential in line with the ideas of the STS-movement of education. Separation of science and technology from each other or from their social interactions is fatal for both. The nature of learning as perception brings the problem, how to induce creation of meanings in the pupils mind. Meanings are primary, representations secondary. Only meanings already understood can be conceptualised, represented by words, symbols, equations and algebraic structures. Interaction of observations with mental pictures becomes central. Analysis of the basic Gestalts on different areas of physics is required to find proper empirical strategies.

The teacher should consciously encourage the simultaneous use and growth of all four subprocesses of the science-technology cycle. He should abandon the naïve theorism of the traditional axiomatic approach, based on interpretation and application only, to save the pupils' ability to see the Nature in science. Scientific ideas and meanings of concepts cannot be learned from axioms, algebraic expressions and equations.

He should similarly reject naïve empirism asking the pupils to invent the laws of Nature from their own experiments, and help them to do meaningful observations and experiments with expectations based on their mental pictures. In his modern enthusiasm about problem solving he should also avoid easy limitation to the invention process and consciously formulate the problems to become also problems of representation, interpretation and application to make the pupil's process to continue.