INFORMATION MODELLING AS DIDACTIC CATEGORY IN PHYSICS TEACHING

Ryszard Jasek* , Czesław Kizowski**
Wyższa Szkoła Inżynieryjno Ekonomiczna w Ropczycach*, PL
Uniwersytet Rzeszowski**, PL

Streszczenie
Modelowanie informacyjne – jako kategoria dydaktyczna w nauczaniu fizyki
Ważnym i aktualnym kierunkiem rozwoju współczesnych procesów poznawczych jest modelowanie z wykorzystaniem elementów informatyki. Modelowanie informacyjne może być odnoszone do wszystkich aspektów rozwoju społeczeństwa, tj. kulturowego, naukowego, technologicznego i edukacyjnego. W artykule przedstawiono zastosowanie teorii informacji do modelowania procesu dydaktycznego w zakresie nauczania fizyki. Rozważano zagadnienia tworzenia, przetwarzania oraz wykorzystania informacji jako kategorii dydaktycznej. Zaproponowano konstruktywistyczny model efektywnego nauczania i uczenia się.

Abstract
In the present time modelling which uses information science is an important and relevant direction of modern cognitive processes development. Information modelling is relevant to all aspects of the society development such as cultural, scientific, technological and educational.
The article presents the use of an information theory for modelling didactic process in teaching physics. The issues considered are creating, processing and using information as didactic category. The constructivist model of effective teaching and learning has been suggested.

1. Introduction

Nowadays, society possesses new techniques of creating, storing and sending information which have a considerable impact on the way of its functioning. It is possible to shape human's way of thinking and existential needs, including a need of knowledge through using different techniques of influence. Knowledge is closely related to possessing of information, speed of its processing and effective way of its storage on such a level so as to make it easily acquired. The scope of knowledge and skills essential to functioning of a human in modern society is very wide, whereas growth of information and speed of its processing exceeds human's perceptive abilities[1] [1].

Acquiring general knowledge in the scope of basic laws of nature and specialist knowledge in a professional field is an essential factor of efficient functioning of a human in society.

A necessity of searching for an optimal variant in teaching of a subject appears. The optimal variant of teaching is the best forward-looking solution in which aims of teaching derive from philosophical anthropology and developmental psychology [7]. It seems that one of possible new solutions is information modelling with the use of communication technology and applying constructivism to pedagogical practice as a philosophy of teaching and learning.

[1] A term 'information modelling' functions in information a technical science, especially in informational and measuring technique [2]. A term 'modelling of information' functions in didactics of physics.

2. Basic notions concerning information modelling

Notions such as information, message, communication have a meaning of original terms which excludes possibility of defining them precisely with the use of simple, original terms. However, it is possible to illustrate them by examples of working definitions related to science disciplines and didactics of physics [2].

Information is everything which can be used for more effective choice of activities which lead to a specific goal. Information as defined can be an observation, a picture, measurements, numerical data, publications etc. Information possesses its form and value which is characteristic for a tested object.

Information object is a living organism, a structure of matter, technical devices and systems created by chosen objects, scientific publications, and didactic compilations. Information object consists of a material-energetic signal and information properties ascribed to it.

Message is a certain symbolic construction which can be assigned some information in an explicit or ambiguous, definite or random way. Message is a distinctive sign-pictorial form defined on a physical object [2].

Communication (medium) is a suitably coded sequence of information consisting a certain amount of information.

Thesaurus (a resource of knowledge) – this term refers to a resource of human's knowledge which is stored in people's minds, to a resource of knowledge of civilization stored in data carriers that are accessible and possible to use, and to students' resource of knowledge.

Language – is a system of socially created, universally binding signs, symbols and rules defining their use which function as a tool of social communication [6]. There are some artificially created languages which are mainly languages of scientific disciplines.

3. Connection between language models and a model of language of physics

Research of language in a scientific sense was undertaken about forty years ago. Together with science development, national languages have stopped being sufficient for accurate description of scientific issues. Artificially created languages have begun to be introduced. The first language that had been introduced was the language of mathematics. At the beginning the language was simple and very functional. Some elements of language of mathematics have merged into national languages taking though different linguistic forms in individual language groups. Linguistics could use theoretical constructions appropriate to every scientific discipline [4].

A model of language of physics has a two-level nature. Logical statements concerning abstract models are built on one of the levels, and interpretations of these symbols are performed on the second one. This two-level structure reveals while describing physical phenomena with the use of language of mathematics where two languages appear: first of them is the language of mathematics symbolism, the second one however, is the natural language enriched with specialist terminology [4]. The knowledge of language of mathematics and natural language in school didactics is crucial. The most characteristic feature of language of physics is its **terminology**. Physics terms denote names of objects, things, phenomena and are closely related to theoretical conceptions of physics. Terminology undergoes evolution together with development of physics. At the same time these changes are caused by development of natural language and theories of physics.

The next feature of language of physics is its **metaphorical structure**. This feature is connected with creating new terms and words by physicists, e.g. photon, spin, well of potential, quantum dot, nanotechnology.

Another feature of language of physics is its **polymorphism**. Terms in physics are mainly polysemantic. In spite of polysemy, physicists are able to communicate because the skill of receiving information depending on the context is brought to perfection.

The next feature of language of physics is its **esotericism**. It means that the language is understood within a narrow group of initiated and makes certain ennoblement to them.

A feature which mostly distinguishes language of physics from other languages is its **coded character** connected with the use of language of mathematics.

The language of school physics differs from everyday language on every stage of teaching in terms of its meaning and syntax. This language refers to language of mathematics, pedagogy, psychology, it uses literary language and at the same time introduces rules and notions which exist in physics.

4. Information modelling

A description in broadly interpreted linguistic language (weakly or strongly formalized language of scientific disciplines) is an information model in information sciences.

In didactics, transfer of knowledge (information) undergoes information modelling. The main idea of information modelling related to widely understood processes of reality cognition is defining in an open way structuralized stores of knowledge, formal systems of science, technical means of communication creating a common system of reference (so called basis) between an object of cognition and a subject of cognition and action [2].

The basis consists of:

- physics quantities, laws, rules, theories,
- material and abstract hybrids,
- symbol constructions – abstractions of mathematics,
- technical means of realization of communication processes.

Describing reality with the use of abstract notions (signs, symbols, pictures) and symbol constructions which belong to communication spheres is an activity within the scope of information modelling both qualitative and quantitative. Information modelling can have local or global range and can be realized by an individual, collective or civilized subject.

The main problem of information modelling in didactics of physics is a choice of scientific information and transposing it to a level of school teaching. The object of modelling is information concerning phenomena of physics influence, structures of matter, measurement and research procedures and practical application of physics theories in relation physics $\Leftrightarrow$ didactics of physics.

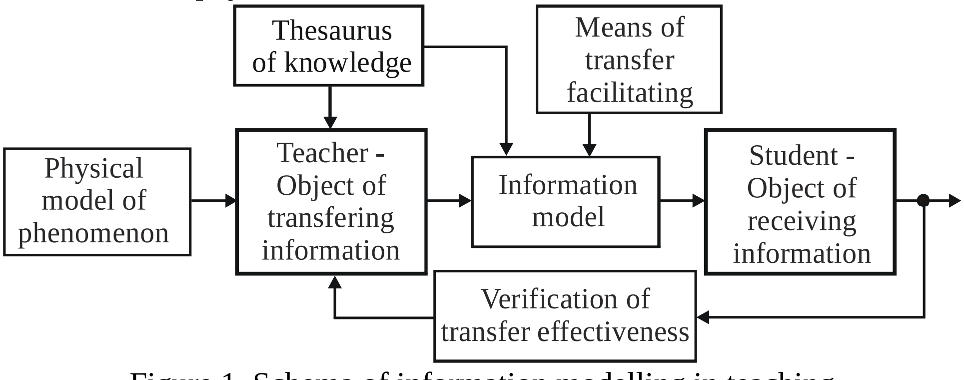

Figure 1. Schema of information modelling in teaching

Information description performed in a language adapted to a level of education and students' perception abilities is an example of information modelling, which can be applied in pedagogical practice. Processing information which retains the above mentioned features of information modeling is a didactic category.

4.1. Characteristic of information model

Information model is distinguished by its susceptibility to formalization treatments which consist in decreasing the scope of interpretation, however, it does not require any changes of rules of creating formalized quantitative pictures of reality.
Information model requires:

- standardizing of terms categories used in the common scope of creative-interpretative activities based on human knowledge resources;
- establishing rules of creating detailed information models based on open indication of:
  - a) formal systems of science (paradigms, axioms, laws and theories);
  - b) assumptions that simplify created descriptions of reality and limits of their application;
  - c) structure and place of use of models (conventional level of cognition);
  - d) routes of sending signals of communications and informational objects connected with the realized process of cognition.

5. Functions of information models in didactics of physics

Introducing rules of information modelling into a didactic process requires:

- being acquainted with didactic structure of knowledge of physics which is shown by figure 3 supplemented with the language of description.
- diagnosing of students' popular knowledge – there is a difference between a teacher's knowledge and an individual student's knowledge. The difference is not only qualitative but also quantitative consisting in the fact that separate elements are defined in a different way and connected with different relations,
- specifying ways of transferring information which concern forms (linguistic, acoustic, pictorial).

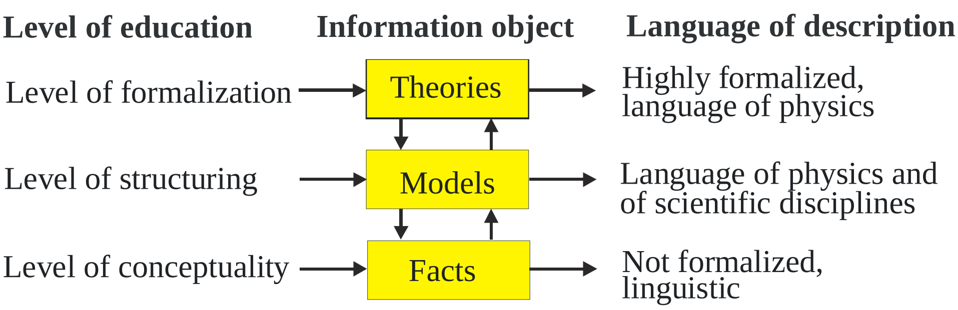

Figure 2. Didactic structure of knowledge of physics [5]

- Models are used when a certain field of phenomena is described with the help of another field which is examined better and is easier to be understood.
- Character and degree of simplification of reality represented by model might change together with flow of time.
- One of important functions of information model is its justification – explanation of real occurrences and facts in a light of previously acquired knowledge which simplifies, and so to speak, guarantees understanding of taught material.
- As a result, new structures of knowledge are created.

With reference to natural sciences, information models require experimental verification.

5.1. Using models in didactic practice

Modelling as a method of cognition as well as of teaching consists of four basic links:

1. Determining specified properties of an examined object-original, setting the aim (formulate a problem).
2. Building or choosing a model (object, phenomenon).
3. Model examination based on material or mental models. In this situation a model is an object of dissertation, studies and is subjected to real or invented influence, its “reaction” is recorded and conclusions are drawn.
4. Transferring the information obtained in the course of examination of a model on an original (object, phenomenon). Information model becomes a bridge between theory and reality when it “takes part” in a process of transferring information. It allows verifying assumptions of theory and above all enables students to use the theory.

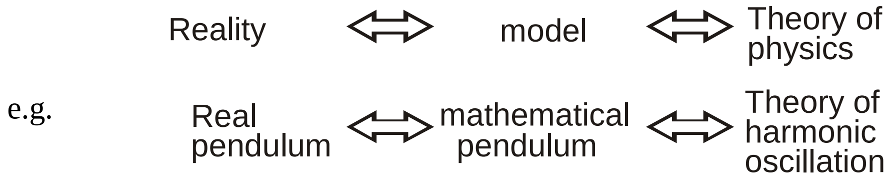

Figure 3. An example of applying information model in practice

6. Constructivist view on teaching and learning with the use of information modelling

Constructivist perspective of teaching and learning process is emphasized by an initiative of students in the result of which students construct their own knowledge and do not acquire it as something passed on by a teacher. Each student creates his own principles and models. Learning is a self regulating mental process in which mental constructs are adjusted to new activities. Constructivism as theory allows possibility of discovering the reality through realization of certain activities. They are observation, experiment, formulating hypotheses, analysis and creating conclusions. Constructivist teaching and learning uses patterns (constructs). Applying information modelling with the use of information technology as means of transferring and processing information in a process of teaching and learning becomes a natural thing. Knowledge acquired in this way depends on subjective cognitive abilities of students as well as social influence and skills of acquiring and processing of information. It is illustrated in figure 4.

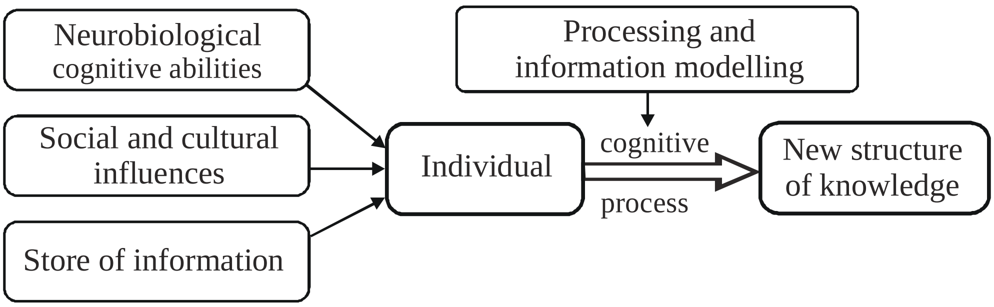

Figure 4. Factors conditioning cognitive process

The aim of learning is constructing one’s own store of knowledge and ability to use it in confrontation of observations and analyses as well as store of information that had been previously discovered or transferred. Students search connections among facts, analyze them and anticipate relations among them. Constructivist model of education serves as a facilitator in higher cognitive processes, analysis, synthesis and assessment. Cognitive activities undertaken in a process of acquiring knowledge are actively directed. Therefore, students influence elements of environment that they try to get to know, they learn how to observe changes and how to interpret a chosen aim. Effectiveness of their actions is signified by realization of these actions referred to a real problem illustrating real world. Information obtained during cognitive process supply the knowledge existing in students' minds. The picture of reality created by experience ultimately undergoes verification (reorganization) consistent with the reliable model of this reality.

6.1. An example of applying forms of information modelling to teaching physics

The process of enriching knowledge consistent with the structure of knowledge already possessed is crucial in teaching. Discovering a new law or a new element is rated among such processes. A new element of knowledge is included in the existing structure. The matter becomes complicated in a situation where there is no such an agreement, and a necessity of reorganizing appears which needs changing one's own knowledge (changing of model) which is already possessed.

In physics, there are such discoveries which do not completely fit into the current structure of knowledge. The theory of relativity can serve as an example here. What comes from Einstein's theory of relativity is that mass is dependent on speed according to a formula shown in figure 5. The change of mass in a function of speed with which a certain object is transferred can be presented with the use of model represented e.g. by a mathematical formula. Examining of this model with the use of information theories and technologies is information modelling leading to a conclusion represented by a graph (figure 5b) and as a result, to reorganization of knowledge.

a)

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

b)

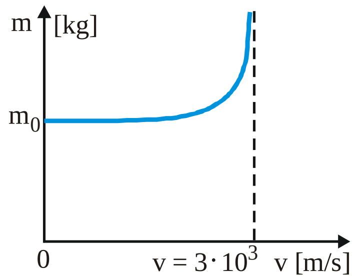

Figure 5. An example of a model introducing new theories to education [10]
a) mathematical model, b) graphic interpretation

The essence of Einstein's discovery consists in introducing a radical change to a fragment of knowledge structure regarding understanding of mass. This type of change is called reorganization. Similar line of reasoning can be related to other phenomena, for instance to photoelectric phenomenon, etc.

6.2. Conditions of undertaking knowledge reorganization by students

Process of teaching might end with an easy statement of potential agreement and keeping interest or statement of agreement and remembrance. Fulfilling these conditions means understanding. When process of teaching ends with a statement of contradiction to the current knowledge, it leads to knowledge reorganization. Conditions of undertaking knowledge reorganization by students can be presented as follows:

1. A serious incompatibility with existing structures should appear.
2. A new concept must be generally understood.
3. It must be initially possible to undertake.
4. It should be potentially crucial, e.g. it should explain something important, open new branches of interests or applications.

On the basis of constructivist methods of teaching four conditions can be gathered. They should be fulfilled by a teacher in order to cause the occurrence of students' knowledge reorganization:

1. A teacher must identify general knowledge possessed by a student with the application of suitable techniques, e.g. conversation, discussion with students, tests, observations, etc.
2. Some doubts concerning accuracy of general knowledge of a given issue should be triggered off. The most effective way of achieving it is by showing incompatibility with experience or with common sense.
3. Introducing new ideas: it is best realized by method of inspiration with the use of information technique which stimulates students' invention.
4. Creating opportunities of applying new ideas in such a way to make a student trust them in order to produce necessary links with already possessed knowledge.

In the process of teaching the function of a teacher is being changed. A teacher is becoming a creator within the scope of acquiring and processing of information. While planning didactic actions a teacher's aim of prime importance should be a problem: **to teach, not to impart knowledge**, so as students could transfer their knowledge and skills that they had acquired as part of a course in physics to other branches of science or to their lives in general. Is it possible that education of physics will cause that students will become more creative in their lives and will learn some methods of acquiring knowledge which then can be applied to other spheres of life? Will they be equipped with scientific knowledge and abilities to use it both immediately and later on?

7. Conclusion

Introducing constructivist solutions to a new model of education realized with the application of information modelling with the use of modern communication technologies may bring effects in the form of:

- active learning about the world by students;
- developing creative thinking among students which is an activity that allows intuitive prediction;
- making educational process similar to scientific research;
- getting students being interested in creating knowledge;
- learning how to take part in discussion, how to cooperate and reflect on something;
- abandonment of teaching for the sake of learning undertaken by students.

Certain operations and schemas of operations which correspond with logical structures exist in human thinking. They shape physics and its didactic structure. Development of physics defines opportunities and directions of development of many scientific disciplines as well as material and information technology. Physics also acts as integrating science for many scientific disciplines and modern research methods. Speed with which the simplest modern terminology is becoming distant from everyday language is a threat for integration of knowledge. It means that new techniques and methods of modern education and communication should be searched. The method of education as well as ways and techniques of its realization in didactic practice that are suggested in the article might be a certain solution.

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