

# ONTODIDACTICS WITHIN THE DEVELOPMENT OF MODERN NATURAL SCIENCE AND TECHNOLOGY EDUCATION

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## Article published:

A.Broks. ONTODIDACTICS WITHIN THE DEVELOPMENT OF MODERN NATURAL SCIENCE AND TECHNOLOGY EDUCATION. – Proceedings of 7<sup>th</sup> IOSTE Symposium for Central and Eastern Europe „Science and Technology Education in Central and Eastern Europe: Past, Present and Future”, Siauliai, Lithuania. – Siauliai University Publishing House, 2009 (pp.31 – 35).

## Abstract

Traditions and innovations in our modern life and education are discussed. Systems theory based modern structure of Natural Science and Technology Education (NSTE) has been developed and compact overview of author's main ideas for innovative research and development of General NSTE are presented. Some newly developed principal core structures of NSTE are reported and ontodidactics as innovative didactics within the development of modern general NSTE has got a special attention. A set of main aspects of ontodidactics as well as development of systems thinking as fundamental background for future life and education progress are discussed.

Key words : science education, crisis of science education, systems thinking, content of education, curriculum development, modern didactics, modern pedagogy.

## 1. Introduction: traditions and innovations

This is not typical research paper with corresponding formal structure because it's prepared to continue presentation of author's ideas in English to our Western as well as other post-soviet colleagues in Eastern Europe (Broks, 2002;2005;2007;2008).

Now it's time again of serious changes in our life and education. For many people and countries now there are changes within changes, what means complex overlapping of local and global political and economical changes.

Scheme No 1

### Modern innovations – bridges to our future life and education



To meet these changes and to solve coming new problems there is an actual need to increase **effectiveness** of NSTE. We need appropriate development - innovations in

corresponding subject Didactics and Pedagogy, we need taking away traditional isolating gaps between different branches, stages and kinds of education. Special accent has to be made on General Science Education as fundamental background of modern professional Science and Technologies Education (NSTE) as well as of modern General Education for all. Need for modern content of NSTE today is becoming of special actuality because of rapid development of e-education technologies within modern pedagogy of NSTE.

Systemic concept of *Education as a specially organized gaining of life experience for life* has been discussed in author's previous IOSTE symposium report (Broks, 2007). There were three general components of our educatedness as main characteristics of human's life experience: *knowledge, skills and attitudes*. Humans gain life experience part by part, comparing and connecting these parts: *cognition* is the background for *consideration*, which, in turn, is the basis for purposeful *behavior*.

Systemic relations between modern Science, Technology and Education as well as General and Professional NSTE has been discussed last year in Krakow (Broks, 2008). Traditionally in our school systems Professional NSTE is dominating and today this is one of the points why do we need serious improvement - development of modern General NSTE. Therefore it is actual to pay special attention to principal difference in understanding concept "didactics" by professional scientists/engineers and science educators – in professional NSTE this concept traditionally is understood only as content and methodology of corresponding Science and/or Technology itself.

## 2. Didactics and Pedagogy within general structure of NSTE

Today for innovative development of NSTE we need much broader approach to traditional concept of Education in general and particularly to traditional concepts of Didactics and Pedagogy.

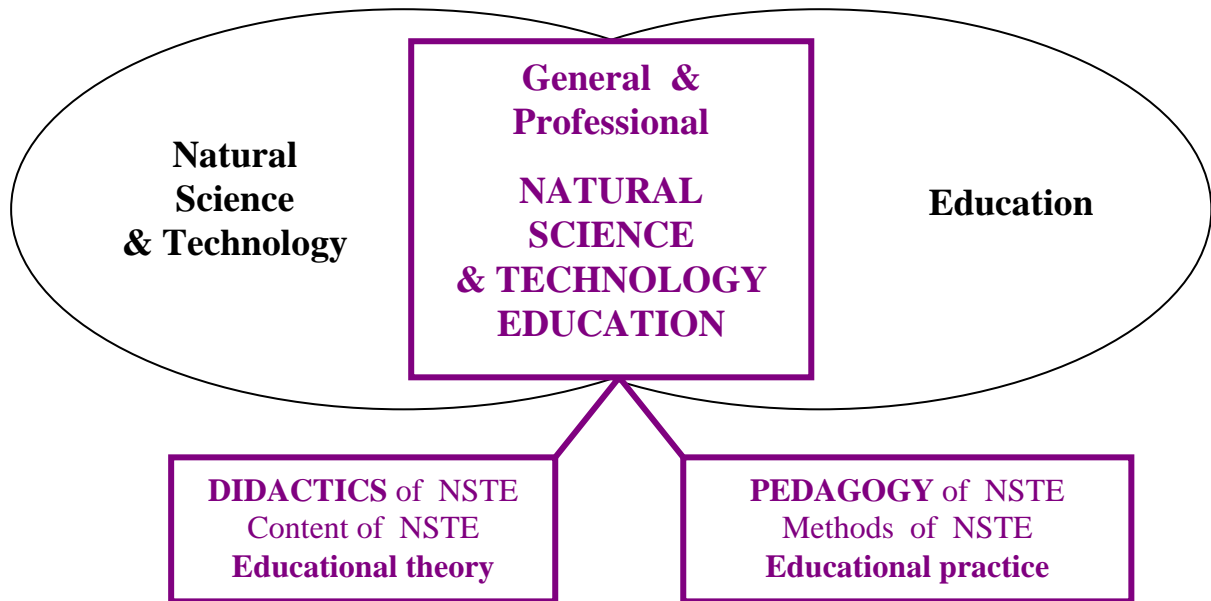
Subject **Didactics** (Physics Didactics, Chemistry Didactics etc.) today – it's the theory of educational content what arises from appropriate branch of science and/or technology. **What and why** to realize in corresponding educational process as a whole – these are two basic questions in didactics. Content of education determines goals, aims, tasks and objectives to follow in pedagogy. Didactics have to provide definite guidelines for educational practice – pedagogy, what includes also purposeful content of educational programs (curricula).

Subject **Pedagogy** (Physics Pedagogy, Chemistry Pedagogy etc.) today – it's the practice of implementing educational content in pedagogical process. **How** to realize given content of education - it's the only one basic question in pedagogy today. Pedagogy has fundamental connection with psychology because educational process involves creative interaction of teachers and scholars as humans.

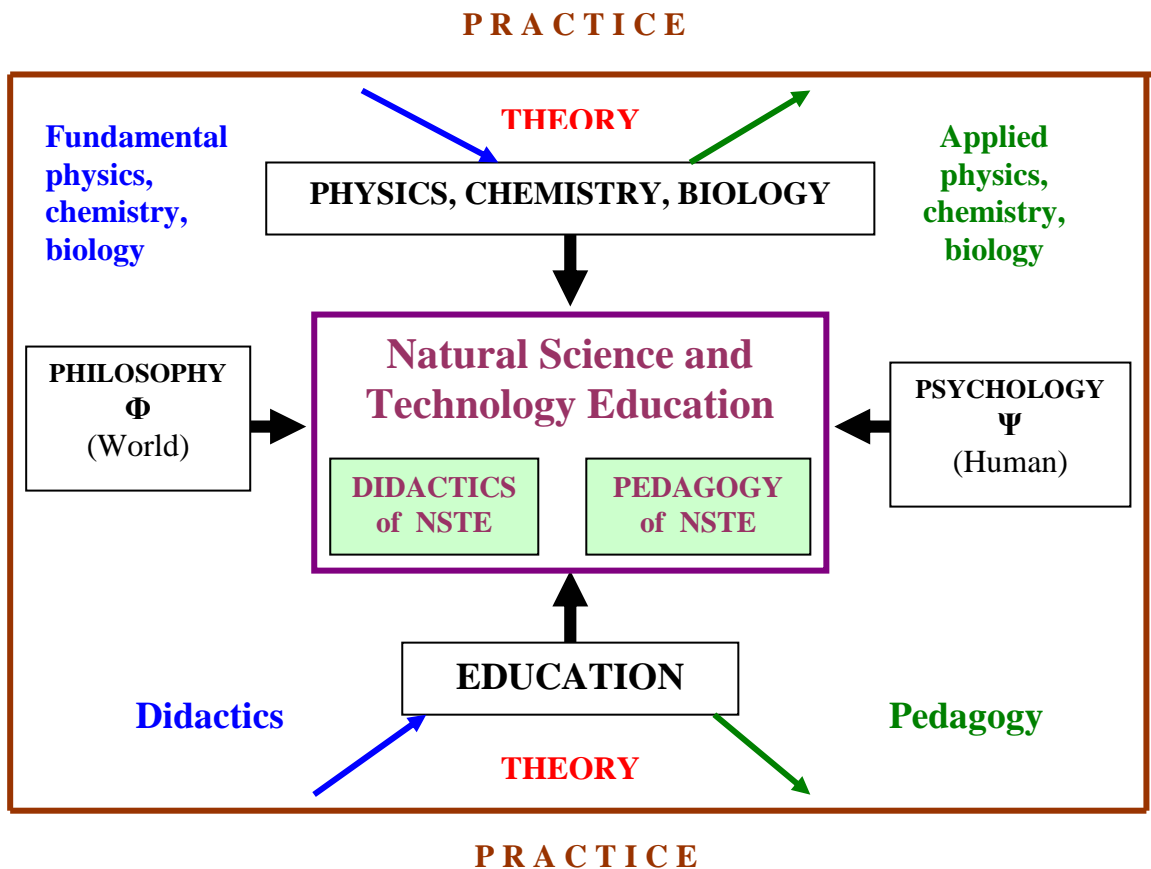
For successful development of modern NSTE today we need **systemic overlapping** of modern Science and Technology content and methodology with general concepts and structures of modern Education (Scheme No 2).

Didactics and Pedagogy of NSTE within a more detailed environment of fundamental and applied science, theory and practice, philosophy and psychology are presented in scheme No3.

### Genesis of Natural Science and Technology Education



### Detailed environment of Natural Science and Technology Education



Finally, there are two systemic innovations within traditional terminology. Firstly, term “education” is interpreted as more general term what includes terms “didactics” and “pedagogy”. Secondly, term “didactics” is used in the meaning of the theory of educational content, but term “pedagogy” corresponds to practical realization of given educational content. Didactics as the theory of education starts from life practice, but pedagogy serves to bring back given educational content into corresponding life practice. In other words, today with account of increasing complexity of our modern life, search for the answer to the question “what education (life experience) for what life?” brought modern Didactics out of traditional Pedagogy.

In according to develop innovations in Didactics the term “ontodidactics” as innovative didactics has been renovated (Broks, Voitkans, 2006). Origins for such renovation go back to author’s doctoral studies when he has studied not only solid state physics but also actual problems of higher education didactics (Sokolovskis, 1973). Another impact came from original General Physics courses of R.Feynman and his suggestions how we can improve our Science education ( Feynman, 1968).

### 3. Ontodidactics as innovative approach within modern NSTE

There are two fundamental branches of innovations in modern NSTE. These are innovations in Didactics (ontodidactics as development of new educational content) and innovations in Pedagogy (implementation of e-education technologies in pedagogical process).

With account of general and professional education the scheme No4 has been developed to visualize interrelations of corresponding terms.

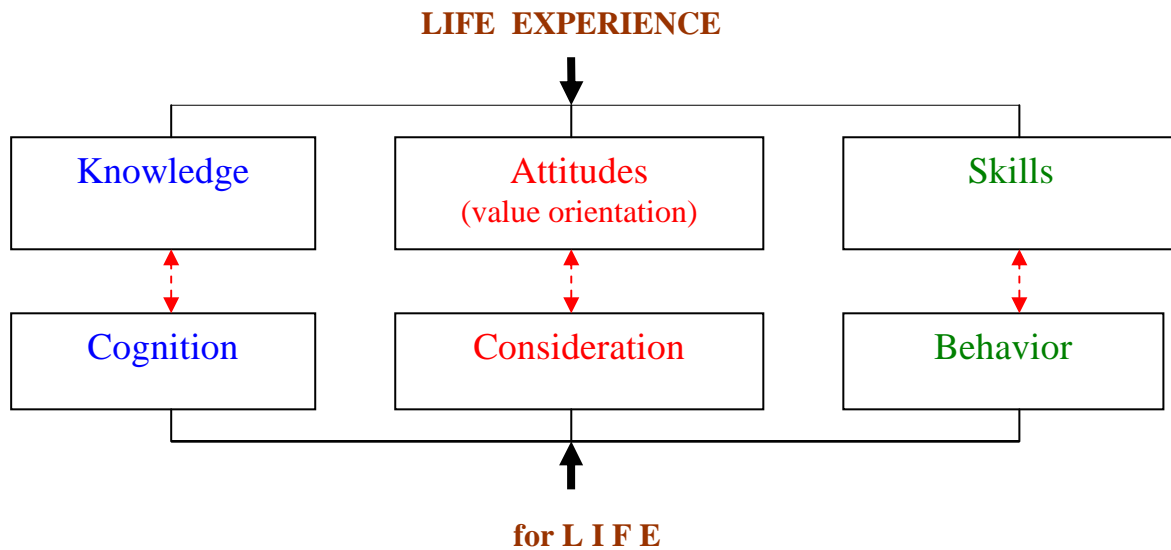
Scheme No 4

#### General map for orientation in research and development of NSTE

| N S T E             |           | Traditional | I n n o v a t i v e      |
|---------------------|-----------|-------------|--------------------------|
| <b>General</b>      | Didactics |             | <b>Ontodidactics</b>     |
|                     | Pedagogy  |             | e-education technologies |
| <b>Professional</b> | Didactics |             | <b>Ontodidactics</b>     |
|                     | Pedagogy  |             | e-education technologies |

According to author’s proposed version innovative development of modern educational content - ontodidactics starts with already mentioned extended systemic definition of education as **life experience** (knowledge, attitudes, skills) **for life** (cognition, consideration, behavior) (Broks, 2007). Today we need much more opened as traditional NSTE approach for modern development of General NSTE, integration with modern innovative educational theories has become very important.

## Principial structure of modern educational content



There are three main aspects of the following development of corresponding NSTE ontodidactics. According to scheme No5 they deal with three systemic (interrelated) modules which are representing connections of cognition process with gained knowledge, consideration process with formed attitudes and behavior process with developed skills.

**First aspect** deals with reconstruction of “knowledge – cognition” module of modern NSTE.

This is very traditional and basic module of human’s life experience for life. The problem is that today we have gathered tremendous amount of information and it is very important to select only this part of it what do we need to turn in definite human’s personal knowledge. **What knowledge for what life?** – this question has become of special interest. What information is needed today – answering this question we can select appropriate information for transformation into corresponding knowledge.

Along with the task to select appropriate information for including in corresponding educational programs (curricula) there is another very actual problem – we need to develop **modern arrangement or classifications of already existing knowledge**. We need to build systems of knowledge in order to be able to manage corresponding information resources. We need serious innovation of educational materials (books, internet resources etc.) what again means innovative – ontodidactic approach to the content of modern education.

In other words, education starts from gaining corresponding knowledge. There are serious problems today due to information explosion, but in general it is not enough for life practice to have only knowledge. Knowledge makes only one part of life experience for life.

**Second aspect** deals with the development of “attitudes – consideration” module within modern NSTE.

It’s well known, that finally we need to develop corresponding skills for different applications of gained knowledge. It’s truth, but before we use some definite knowledge, we need to value this usage - is it good to realize this application of given knowledge in real life. This aspect is not very clear discussed and developed in traditional Western education.

Development of **value orientation** is very important within the development of modern General Education and particularly General NSTE. Development of value orientation abilities (including self-evaluation and other kinds of valuations) is becoming more and more actual because there is serious need to increase individual as well as collective responsibility of modern people when living modern life. It becomes a fundamental part also within modern NSTE. Traditional attitude towards such unpopular term as “upbringing” along with popular terms “teaching”, “learning “ has already generated many unwanted problems today.

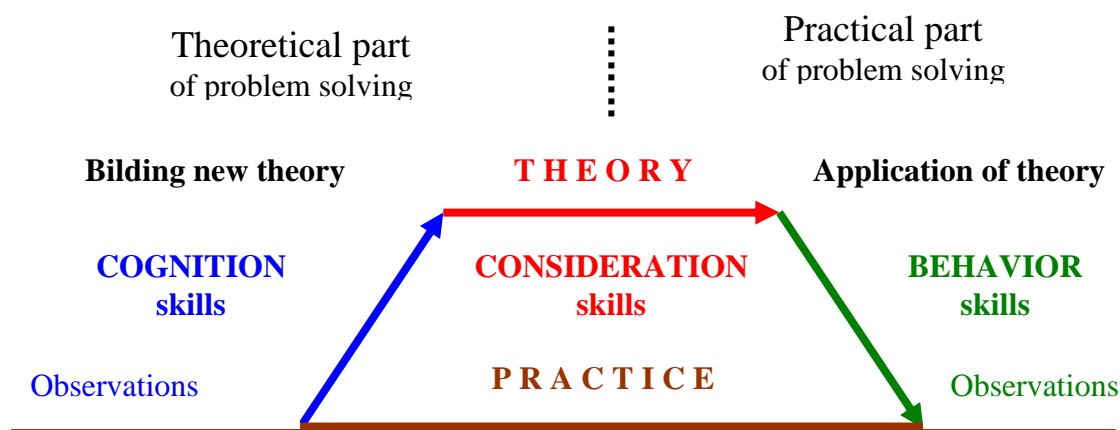
**Third aspect** deals with innovative development of “skills – behavior” module of modern NSTE.

It's concerned with well known but usually not completely realized in practice statement that most valuable life experience for life is **a general set of problem solving skills**. Problem solving as a typical our life process means more or less independent and creative (constructive) search for prior unavailable life experience or new application of already existing life experience on the way to satisfy some actual human's life need. The process of gaining appropriate problem solving skills during pedagogical process today is well known as “constructivist approach” and corresponding pedagogical methodology is called “constructivism”.

According to the universal structure of human's purposeful actions or life fractal “cognition-consideration-behavior” all problem solving processes have the same universal structure (Broks, 2005). Therefore it becomes clear what are the fundamental problem solving skills which have to be developed. They form a system of skills what includes **cognition skills**, **consideration skills** and **behavior skills** (scheme No5).

Scheme No 6

### Problem solving skills as the set of fundamental life skills



Problem solving skills are universal systemic – interrelated skills within the frame of General Education as well as General NSTE.

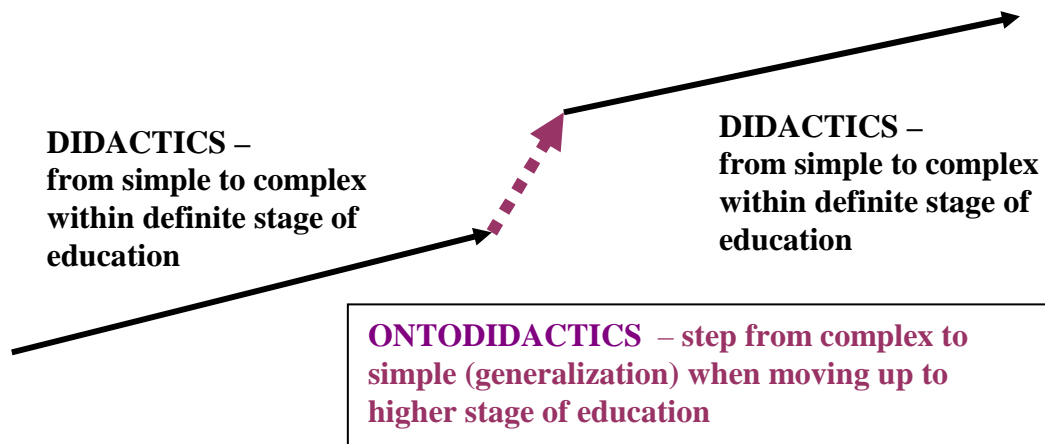
By the way, constructivism in modern pedagogy can be viewed as theory what includes earlier developed behaviorism and cognitivism.

**Finally there is one more very important aspect** for the development of ontodidactics. It deals with corresponding reconstruction of a given educational content according to the principle “**from complex to simple**”, when moving up to higher level of generalization as well as abstraction. It's taking place always when we are moving up to

higher stage of education (from preschool to primary – secondary (lower, upper) - tertiary stages of educational systems). Definite attempt to start realization of this principle has been made in our latest research activities (Broks, Voitekans 2006;2007,2009).

Scheme No 7

### Multilevel structure of NSTE – unity of didactics and ontodidactics



### Conclusions

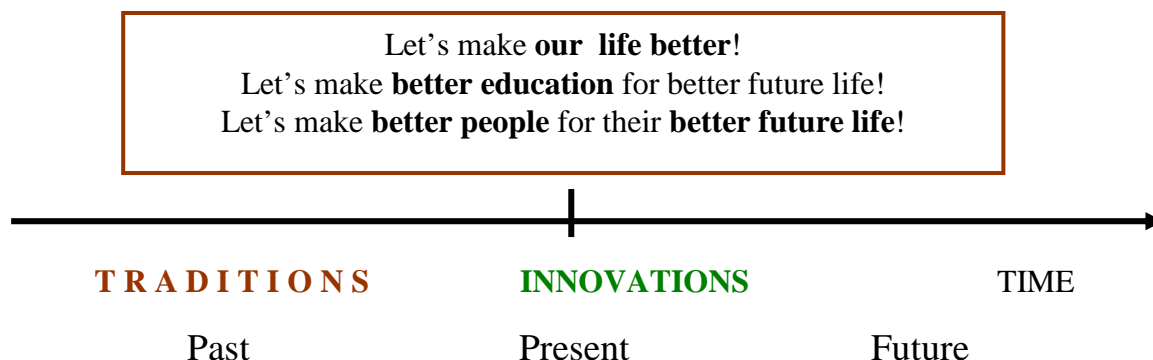
When we are looking for higher effectiveness of our education the need for serious changes (transformations) within traditional content and methods of NSTE has become of great importance. Development of ontodidactics as well as e-education technologies are of special interest.

At the same time it's actual to make a note that traditions are very strong and innovative approaches are not popular. Observing very fast changes of our life today, it seems that getting answer to the question “what education (life experience) for what life?” has to be delegated to the next generations of educators. Older generation has to help them with their fundamental experience. Ontodidactics is just one area for corresponding cooperation of old and new generations of educators.

Finally there is an **overall task** for all coming generations and all kinds of innovative development of education – **purposeful development of humans' systems thinking**. All provided in this article schemes demonstrate definite structures of corresponding concepts and serve as definite projects' maps – technical drawings for realization of these innovative structures in real practice. But first we need to prepare people to understand these drawings on the basis of their systemic competence in modern life and education. Usually it's not the appropriate task for ordinary representatives of traditional pedagogy today.

Development of SISTEMOLOGY OF EDUCATION (Broks, 1999; 2001) as applied systems theory in education has to be understood theoretically and then realized in practice.

## Let us work for better life and education in our future !



Finally let us repeat once again: **the one who changes** in accordance with the progressive development of things and processes in the world today **will survive and live better**. Innovative partnership of existing old and new coming generations of educators will help to solve modern complex problems of our education.

Good luck to all of us!

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