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Epistemological and Psychological Fundamentals of the Didactics of Science

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Abstract

The Didactics of Science extends Didactics, as a discipline, beyond the pedagogical school frame. The models constructed in the last decades have aimed at supporting students in their learning process and preparing them for professional and social complex situations, related even to the cultural environment and family. In this respect, the curricular decisions do not refer only to the wider, general frame of applying Didactics to Mathematics as a discipline. The theoretical framework of the Didactics of Science epistemologically consists of a set of notions introduced by specialists in their analyses upon the Didactics of disciplines, by means of an assimilation process involving representation and clarification of concepts, as well as their articulation in theories and paradigms. The Didactics of Science pleads for a model in which the teacher acts as mediator between pedagogical sciences and the students’ psychological profile.

Keywords: cognitive obstacle; didactic transposition; conceptual texture; observation of learning concepts; didactic engineering.

1. Introduction

This paper investigates the didactic process of building the discipline’s psycho-pedagogical paradigm, integrated and developed within the sciences of education. The research aims at conceptualizing and developing a psycho-pedagogical paradigm for the Didactics of the discipline (with applications and examples from Mathematics). In the present educational and training context, it becomes essential to establish the theoretical and methodological scope. The research hypothesis has been stated in agreement with the purpose of the research. Developing a pedagogical paradigm for the Didactics of a discipline proves its effectiveness if it is built on the articulation of two models: 1. Application of the general education and training theory to the teaching, learning and evaluation processes related to a certain discipline (see the model of applied didactics/teaching
methodology). 2. Relating the training issues to the epistemological and psychological structures of a discipline, for different school and age levels.

2. Research objectives

The object of the research is the process of building the Didactics of the discipline, integrated and developed within the sciences of education. The research aims at designing and elaborating a psycho-pedagogical paradigm for the Didactics of the discipline (with applications and examples from Mathematics) in the context of the problems of education and training in the contemporary Romanian society, as well as establishing the theoretical and methodological bases of the domain.

In agreement with the research aim, the research hypothesis was formulated as an elaboration on a paradigm of the Didactics of the discipline, which will prove its efficiency through articulation of two models:

1. Applying the general theory of education and training to the problems associated with the teaching-learning-assessment of a specific school discipline.
2. Reporting on the problems of training in terms of the epistemological and psychological structures of a discipline, for different school stages and ages.

The research objectives are specific to fundamental research, as well as historical and comparative investigations, and aim at improving the system of planning the training process. The intention is to verify the hypothesis in relation to the research aim. The research objectives are:

1) highlighting the theoretical and methodological bases of curricular planning required in elaborating the paradigm of the Didactics of the discipline;
2) reviewing the literature and identifying the relationships between General Pedagogy and Applied Pedagogy, which operate within the process of model planning, in the context of the teaching-learning-assessment of a discipline.
3) establishing the bases of Applied Didactics related to objectives, curricular contexts, methodology, teaching activities, learning, assessment and curricular planning of activities.

3. The research methodology

The research methodology, designed according to the research objectives, aims and resources, consisted of:
- a theoretical research: a review of psychological literature, sources, concepts, dictionary entries for certain notions;
- a study on relevant curricular documents: curriculum, school programs, textbooks, teacher’s books, the methodology for various disciplines;
- the bibliographic method: a review of the theory on the Didactics of the discipline;
- the monographic method: used in the analysis of the socio–educational phenomenon of designing and applying the Didactics of Mathematics, in the particular cultural and economic context of the educational policy;
- the comparative historical method: a synchronic-diachronic approach to the evolution of teaching Mathematics and the Didactics of the discipline;
- the survey: evaluating and reaching theoretical validation as achieved by neutral experts, whose analyses and comments on our hypothesis relied on qualitative parameters;
- the method of theoretical modeling: drawing diagrams and synthetic schemes to represent findings on the Didactics of the discipline.

4. Epistemological fundamentals of the Didactics of Science

The Didactics of Science promotes an internal perspective (research, intervention), which foregrounds the
conditions and the originality of what we could call school-content creativity. 
We shall mention some principles and objectives characteristic of the Didactics of Science model: 
clarification, on a more general level, of the notion of didactic transposition in terms of the connections 
established between knowledge and practice; 

promoting didactic scientific and technological research, with the purpose of building concepts;

a) overcoming certain restrictions of Applied Didactics by introducing new concepts, which may offer a new 
reading scheme for the correlation between General Didactics – Applied Didactics, didactic transposition, 
didactic contract, conceptual field, concepts and conceptualization, obstacle objectives, from a cognitive-
epistemological perspective (Lupu C., 2008, p. 175).

b) building a theoretical framework by articulating the concepts mentioned above, which are used not in 
opposition with the principles of Applied Didactics, but with a view to enhancing cognitive and epistemological 
understanding, improving the didactic research methods not so much on the theoretical level, but rather on the 
practical level, establishing connections between scholars in the field (professors, scientists, experts), scholars in 
the Human Sciences (psychologists, historians, curriculum designers and teachers).

4.1. Aspects of the structure of the Didactics of Science

Viviane De Landsheere analyzes the following frame concepts of the Didactics of Science: 1) cognitive 
obstacle; 2) didactic transposition; 3) conceptual texture; 4) conceptual field; 5) observation of learning concepts; 

The cognitive obstacle, seen and understood as epistemological imbalance (Piaget), can be pedagogically 
exploited. It is essential in the Didactics of Science, as the teacher knows how to create the didactic speech, with 
a distinction between focusing on the student and focusing on the learning content. Another aspect, which the 
teacher needs to understand and exploit, consists in distinguishing between objective and subjective obstacles.

The didactic transposition is the complex, epistemological, psychological and pedagogical action of making 
the transition from theoretical, scientific knowledge to pedagogical knowledge. Didactic transposition means a 
permanent balance between scientific logic and pedagogical logic, as both contribute to facilitating 
understanding. The process of didactic transposition covers the next steps:

1. Pedagogical processing and scientific knowledge transformation according to a logically determined 
process;

2. Didactic planning of knowledge, designed and controlled by the teacher, includes: a) providing learning 
opportunities (the student’s cognitive activity in a specific context); b) formulating the target solution with 
possible answers; c) applying and evaluating the solving process, in agreement with each student’s learning style;

3. Correct management of the learning process in terms of each student’s pedagogical time;

4. Drawing an intra/interdisciplinary correlation between pedagogical and social knowledge;

5. The didactic transposition specific to Mathematics has a trans-disciplinary value, which makes it applicable 
to other disciplines as well.

The conceptual texture designates a limited set of key concepts in a field and has an integrated character. 
Constructivist pedagogy focuses on building a model for the Didactics of Science and deals with the logic tree of 
subordinate notions, seen as cognitive maps, conceptual mental training networks (J.P. Astolfi, M. Develay, 

The conceptual texture of training is characterized by Astolfi in the next coordinated methodology contexts:
1. Formulating a series of full phrases in simple, concentrated, laconic expressions in Mathematics (theorems, 
definitions). 2. Developing these phrases as phrases which operate upon the data of the problem which is to be 
solved (the theorem becomes operative once the theorem’s hypothesis is known); 3. Ranking the phrases 
vertically and horizontally (every assertion incorporating others more elementary);
4. Underlining the logical implications occurring in relation to different contents (theorems, connections between theorems).

The conceptual field completes the didactic transposition, which is not mere selection and transformation of a science’s objects. Didactic transposition needs to take into consideration all the trees and relatively anarchic structures of scientific knowledge. The solution proposed to articulate the concepts involves relating them to real-life complex situations, which may be solved by means of these concepts. The basic idea is the one launched in the 60s by the great American cognitive and educational psychologist J. S. Bruner, the basic structure of discipline.

The observation of scientific knowledge is presented by Viviane De Landsheere as a theme of research in the Didactics of Science. Two types of observation are underlined:

- Observation which precede perception, representation and scientific knowledge;
- Observation which enhance the meaning and relevance of scientific knowledge. The Didactics of the discipline uses both types of observations. The two types of observation should be ensured by at least two of the following features: research control, resuming assumptions, inquiring into new viewpoints; systematizing the relations between empirical observation and scientific construction achieved in class and, especially, through individual study.

We consider that the notion of didactic contract performs a key role in achieving the model of the Didactics of Science since it transposes didactically the scientific knowledge from the basic structural level of training (see the constant correlation teacher-student).

4.2. The model of the Didactics of Science

In our opinion, the model of the Didactics of Science may be expressed through the scheme below, representing the relations involved in the didactic transposition of the didactic contract, the teacher-student relationship, which has as epistemological and psychological finality the internalization and understanding of the scientific concepts used by the teacher.

We are reproducing this model, adapted after G. and J. Pasteaux:

<table>
<thead>
<tr>
<th>Scholar scientific knowledge</th>
<th>Significant social practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching interpretation</td>
<td>Didactics- the conceiver</td>
</tr>
<tr>
<td>(socio-cultural, economic, civic)</td>
<td>(author of programs)</td>
</tr>
<tr>
<td>Pedagogically transformed scientific knowledge to be learned by the student</td>
<td>Teacher’s work in directing the learning process</td>
</tr>
<tr>
<td>Knowledge learned by the student</td>
<td>Knowledge assimilated by the student, exploited on a middle and long terms</td>
</tr>
<tr>
<td>Activity of pedagogics-ing/didactics-ing science</td>
<td>Socio-cultural exploitation of the school practices</td>
</tr>
<tr>
<td>Openness towards socio-professional career and community life</td>
<td></td>
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</tbody>
</table>

Table 1. Model of the Didactics of Science
5. Conclusion

The facts presented in the introduction imply and generate the research problem, namely, the theoretical and methodological fundamentals of the teaching-learning-assessment process of a school discipline, in the context of the contemporary world.

The analysis of the synthetic grid of the experts’ questionnaire, leads to the conclusion that all the descriptors have a percentage of 70% and the correlation coefficient \( \beta = \frac{\alpha_1 + \alpha_2 + \alpha_3 + \ldots + \alpha_n}{n} = 0.88 \), which validates the hypothesis.

In conclusion, we propose a model of cognitive architecture, which enables the student’s cognitive development. This model is based on theoretical and experimental results achieved in cognitive psychology. We present it as a possible model of cognitive development applicable in the Didactics of Science:

a) Argumentation of the knowledge base; b) Development of working memory size; c) Change (optimization) of the rules of knowledge production; d) Optimization of accessing knowledge from the long-term memory;

e) Improvement of cognitive development under the influence of meta-cognitive development (knowledge which the subject has and the operation of which he may improve) (M. Develay, 1996,p.154.).

We appreciate that this model is complementary with the didactic transposition model. It can perform an important role in developing the Didactics of Science, designing it as an architecture which allows the student to lead a social life, maintaining his internal, decisional autonomy, based on his own knowledge and capabilities.

References