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Didactics of Informatics: from the Formation of the Scientific Field to the Conjunction among Research and School Practice

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Abstract. In this article we attempt a short description and study concerning the basic concepts of Didactics of Informatics. Particularly, we discuss about the required didactic transposition of scientific concepts, meaning the mechanism that allows the transition from the scientific knowledge to a "teaching subject" and the teaching contract that determines the interaction in the classroom. We also consider the students' representations regarding Informatics technologies and notions, and the socio-cognitive conflict procedures that should be favored in order to promote the necessary conceptual change.

1. Introduction

The problems of school learning and didactics, the effort to support the development of knowledge in the context of individual or collective situations of teaching, preoccupy both the scientific research and the educational community. In this context, Science Teaching was developed for examining and improving the procedures of transmitting and acquiring knowledge [1]. Science teaching studies the situations under which subjects do or do not learn and focuses on the particular problems that are risen by either the content of knowledge to be acquired, or the skills to be developed [2].

Science Teaching has progressed significantly during the past two decades. The first efforts for creating a theoretical framework that would overcome the then prevailing empiricism were in the field of Didactics of Mathematics [3]. The three main axes of that framework are putting interest in: the epistemology of knowledge, the construction and acquirement of knowledge from students and the introduction of this approach in real school situations [1]. Lately, efforts for an inter-disciplinary approach have been taking place, allowing the appearance of common concepts for the didactics of several fields. In this article these concepts are studied under the prism of Didactics of Informatics while at the same time an endeavor to connect these concepts with issues arising from school practice is undertaken.

2. Didactics of Informatics: The Formation of the Scientific Field

For many years, empiricism and references from other fields were defining the place of Informatics in school. Recently, however, under the influence of constructivist approaches, the field of Didactics of Informatics tends to be considered as an autonomous scientific field. Didactics of Informatics is heavily influenced, among other things, by the rapid evolution of

software and hardware by the roles that reserves for programming (and programming languages) in school curricula [4].

Didactics of Informatics constitutes its scientific field on a common subject of study. This subject of study is concerned with the pedagogical use of software that is characterized by the broad utilization of programming features [5]. This integration takes place both at the level of *structure* (objects, actions, regular expressions etc) and at the level of *function* (types of problems for the solution of which a particular software could be used) [6, 7, 8]. These software have a dual dimension by *structuring the Informatics concepts* from the one hand and by offering *potential for information processing and problem solving* on the other hand [9].

Conclusively, an important part of Didactics of Informatics is the study of *knowledge* structuring (especially the aspects considered as fundamental concepts) and of the development of the technical and mental *skills* by the subjects that use computers and are involved with Informatics. These skills are ascertained mainly in the context of problem solving situations involving the use of computers [10].

However, which are the basic axes that direct the formation of the scientific field of Didactics of Informatics and which are the methodological tools in use? Surveying the research and the relevant literature we can mention the following four:

- The development of the subject matter that are studied under the prism of the *didactic transposition* and of the *social practices of reference.*
- The strategy for the construction of knowledge and learning that require the study of the *representations*, of the *conceptual change* and of the *problem solving procedures.*
- The construction of teaching situations which take into account the *didactic contract*, the *problem situation,* etc.
- The teaching interaction such as the *teaching assistance*, the *cognitive and the sociocognitive conflict* and the means that mediate this interaction.

3 Basic Concepts of Didactics of Informatics

3.1 Didactic Transposition of the Scientific Concept of Informatics

Didactic Transposition was originally used in Mathematics Teaching [11]. This concept defines the general mechanisms that allow the transition from a "field of scientific knowledge" to a "teaching subject". Starting from the discrimination between "scientific knowledge" (as it is produced by scientific research) and "knowledge-to-be-taught" (as it can be observed in school practice), Didactic studies the way concepts are being transposed. Didactic transposition does not only describe the way a "scientific knowledge" changes to "knowledge-to-be-taught", but it intersects the teaching spectrum and it is closely related to the place, the audience and the teaching goals (and by doing so it influences dramatically the curricula).

The "content of knowledge to be taught" originates from "scientific knowledge", namely the knowledge that is identified by the scientific community as such. For instance, "Operating Systems" comprise a subject - content that is not possible to be taught as it is, at least not outside the place that it is being produced, the Universities. Specific mechanisms should be set up to extract this knowledge from its original place and to introduce it to teaching practice. Since such functions are operating, the "content of knowledge to be taught" is indisputably different from the scientific knowledge that is being used as its

reference. The epistemological milieu for the "content of knowledge to be taught" is also different, as it is the meaning and the range of the concepts that built this content.

Consequently, the concept of didactic transposition implies that the transition from scientific knowledge to "content of knowledge to be taught" is not direct. Didactic transposition in this context should be regarded as a two-stage process (figure 1) and the transpositions that take place should be categorized respectively: an external and an internal transposition.

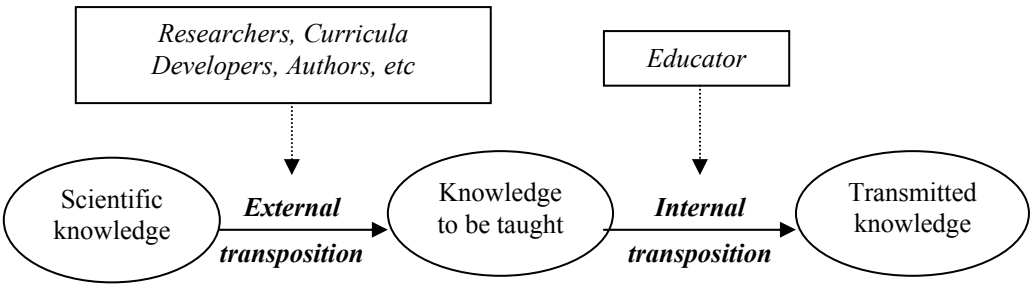

Fig 1. The stages of didactic transposition

The specific adjustments-transpositions each educator produces are being made during the second stage of the process. Therefore, educators enter in the second stage and their responsibility during this transposition is rather restricted. However, didactic transposition on behalf of the educators involves the structuring of the courses based upon scientific knowledge, taking into account the orientations and the guidelines set by the curricula ("content of knowledge to be taught") in order to adjust them in their classroom.

3.2 The Social Practice of Reference in Informatics

The theoretical framework of didactic transposition is not adequate in the field of Informatics to answer the question of the transition from the scientific knowledge neither to "content of knowledge to be taught" nor to the knowledge that has been constructed by students. Informatics concepts do not merely comply with a procedure of didactic transposition as it has been described in the previous section. School knowledge does not only come from the scientific community as it is being produced in Universities but it is also influenced by other factors. These factors, mainly of social origin, are studied under the term "social practices of reference".

These "social practices of reference" were suggested in the context of Science Teaching, in addition to the didactic transposition, to distinguish the multiplicity of the potential sources that inspire and lay the foundations for the *validity* of school knowledge [12]. The social (or sociotechnical) practices of reference find specific application in Informatics, since in modern society these practices of reference are amplified by artifacts such as electronic games, cinema, etc.

Science Teaching and the Informatics Teaching do not adopt the exclusive focus on the "texts" of knowledge and the subsequent underestimation of practices (including the attitudes and the social roles) that give meaning to these "texts". They both suggest the idea of "social

practices of reference" that consist of the examination of the ways in which the production activities, the techniques or even domestic activities could play a reference role for scientific school activities. Thus, the concept of the social practices of reference enlarges the context within which questions regarding teaching issues are answered. The social practices of reference play important role in the area of Informatics. This fact is further supported by the broad diffusion of Informatics technologies in students' environments. Students bring to schools nowadays lots of Informatics "knowledge" obtained from environments external to school. Moreover, in the case of Informatics, the social practices suppress the division between the "Informatics-subject-of-study" and the "Informatics-medium" since they focus on problem solving [13].

Many social practices dictate schools to incorporate them in their everyday work. Usually, these practices are entering schools urgently, under heavy social demand, and afterwards educators try to devise specific theoretical contexts to support these practices educationally. A characteristic example is that of Informatics and its introduction to education. A lot of students gain knowledge in Informatics outside schools, while Informatics is adopted by schools mainly because of external, social pressures under the increasing digitalization of society. This implies that Didactic transposition is directly influenced by the "social practices of reference". Informatics area consists of many social practices of reference. Such references are those held by students from electronic games that are affecting significantly their representations and consequently the logic of operation that they form in their minds about the information system. Figure 2, shows the concept of didactic transposition in the area of Teaching Informatics as related to the social practices of reference and the knowledge that have eventually been obtained by students.

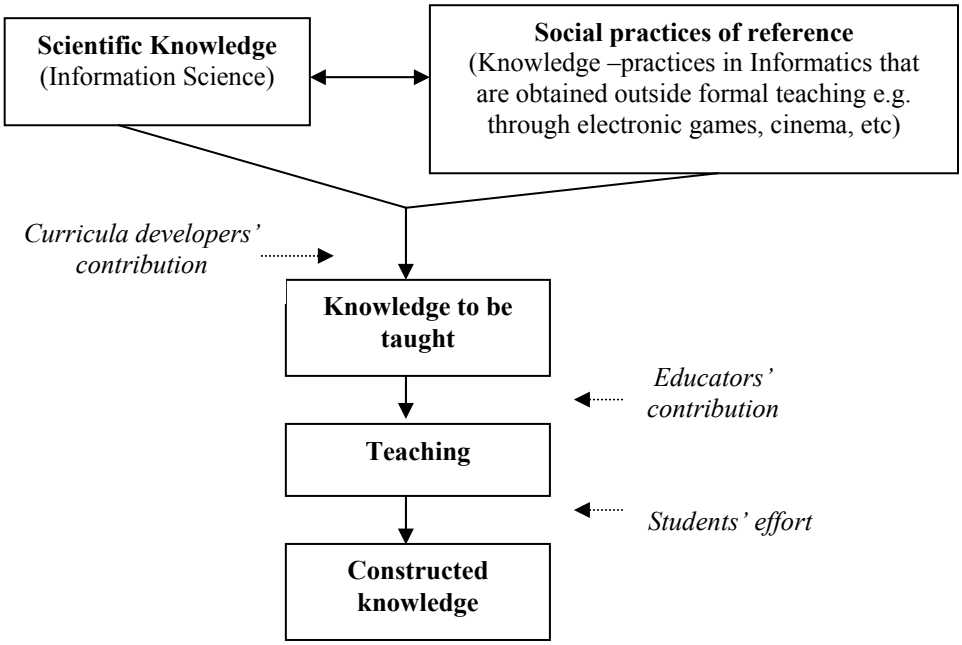

Fig. 2. The levels of the didactic transposition

Informatics and computers are tools for many professions and professionals, intervening between a large scale of social practices: automatic control, operational research, data base research, communication through computer networks, word processing etc. Therefore, it is necessary to conduct studies on how these practices could result in references for the development of teaching situations and the ways these practices could be transformed. An important issue in this context is to avoid a simplistic technique of teaching specific computational tools.

3.3 The Didactic Contract in Informatics Classroom

The term didactic contract was coined originally under the Mathematics Teaching framework. Soon, it was used in the teaching methodologies of other subjects as well. *Didactic contract* formulates one of the ways to model the constructivist conception of learning. It functions mainly with implicit (and not explicitly stated), rules that define the relationships between educators, students and knowledge. This contract specifies the roles, the position and the functions of each part in that relationship. It predetermines the anticipated activities for both educators and students, each part's position towards knowledge-to-be-processed as well as the general conditions within which the relations to knowledge are progressing during teaching [3]. The mutual obligations of the two parts become clear: the educator is there to teach while the student is there to learn.

In the context of Informatics courses (but also in the context of using Informatics for teaching other subjects), didactic contract should take into account the hardware and the software that goes with it. It is also important to note that there have not been any studies on how the terms of the didactic contract are being formed among students, teachers and the computer systems.

3.4 The Importance of Representations for Informatics

Representations are products and at the same time processes of our intellectual activities and they aim, to some extent, to make present what is absent. Representation is a human activity that is constituted by the production of symbols that substitute other (normally absent) entities. The human mind is the foundation for psychologically oriented representations, cognitive products that reproduce what humans gain from their interaction with the world. The concept of representation is intertwined with the research on teaching and appears more often as a sine qua non tool for the educators who want to realize the cognitive functions of their students and the ways they realize reality [14].

Studying and analyzing the representations formed by students on technologies and on the basic Informatics concepts is one of the main interests of Didactics of Informatics. Educational psychology and Didactics use the concept of representation, mainly because of the serious difficulties that educators face during the teaching of the scientific models and concepts. Representation, on behalf of didactics, refers to a personal theory (form of "knowledge", structured, hierarchically organized and at the same time a set of rules), that is constructed by a certain person (some person's representation), at a certain moment, to realize the organization and the arrangement of the facts under study (representation of an object, a thing) or to face a certain situation [14].

The study of Representation takes into account the epistemological frame of reference that characterizes each subject matter. Consequently, when the question of the didactic role of representations into a Didactics of Informatics or teaching with computers milieu arises,

some special aspects of the issue should be clarified. Regarding the Didactics of Informatics it is purposeful to examine the representations that are related to the specific concepts of Computer Science (such as the concept of memory, the information processing, the programming structures etc.) [15, 16, 17]. In the framework of teaching with computers, students' attitudes towards the Informatics concepts and the new technologies should be studied as well as the ways students represent the technological objects they are interacting with.

The representations that students form during their interaction with hardware and the representations on the processes they utilize when working with information systems, is a rather inadequately studied domain of research [18]. The interaction between these representations and the actual employment of information systems by children is also another interesting subject for study. Analyzing and reorganizing the representations has broader implications that surmount the borders of education and deal with issues regarding the conception and the development of software, the Human Computer Interaction and the interface design.

Teaching of Informatics or teaching with computers could not be realized until we understand the ways their representations are formed. In this context, a representation is related to the deviation from its relative concept and could produce two different attitudes (figure 3) on educators:

- To regard this representation as an error that should be eliminated. In this case, teaching should not be interested in representations.
- To regard this representation as an explanatory system that should be understood and analyzed as an impediment to overcome or as a supportive-tentative point aiding the approach to the concept. Constructivist approaches for teaching and learning are inclined to this approach.

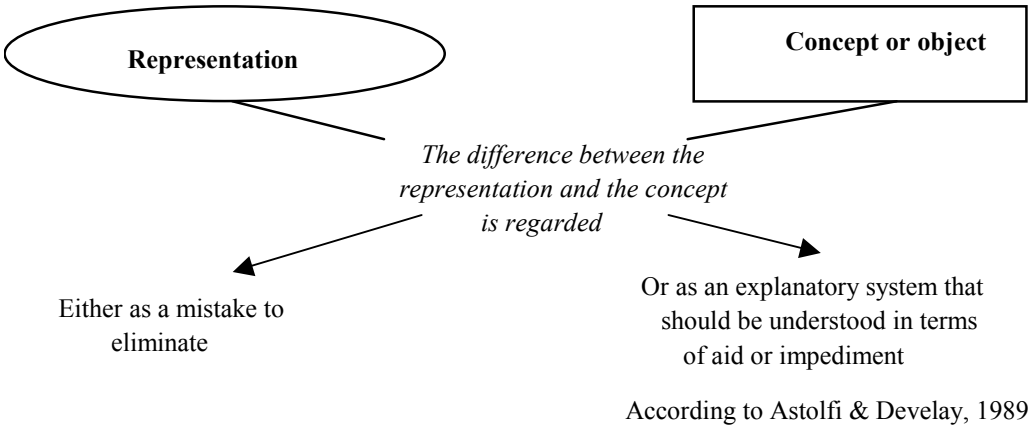

Fig. 3. The concept of representation

3.5 The Socio-cognitive Conflict in Informatics Classroom

An interesting concept in Science Teaching is that of socio-cognitive conflict. This concept considers learning as a personal constructive process that goes through cognitive conflicts originating from social causes [19]. It is connected to the concept of cognitive conflict. A

cognitive conflict develops whenever a discrepancy, an incompatibility appears between the thoughts and the actions of a person. This incompatibility, which could be insensible in its first stages, becomes a source of tension and could mobilize the development of new conceptual structures.

On the development of the concept of sociocognitive conflict L. Vygotsky's theory [20] has played an important role. Vygotsky's theory emphasizes the role of adults' language to the transmission of knowledge and to the cognitive evolution of children. Vygotsky states that the direction of the cognitive development does not advance from individual to social but rather from social to individual. Therefore, learning is primarily of social nature. In this context each interpersonal process transforms to an intrapersonal one: each process appears twice in the cultural evolution of children, initially, at a social level (between persons) and then at an individual level (within the child). The dynamic of the cognitive development derives basically from a social communication conflict.

The importance of this theory is exceptional in the context of Didactics of Informatics. The conflict as an incompatibility between the subjects of analogous cognitive potential when they try to solve a problem or to reason on a subject, creates a mechanism that aids children's thought to progress on a higher level balance. During this process, when someone facing a problem state judgments on how to overcome it, receive from their social environment controlled responses that support, quite often, opposite positions. Individuals, then, realize that apart from their judgments there are other speculations, while at the same time sociocognitive conflict offers them new information and thus enables them to create a variety of responses.

A socio-cognitive conflict, for being productive, should function among individuals with different levels of cognitive development. However, this difference should not create a long distance between them. Classroom surveys have shown that among pairs of students working together, sociocognitive conflicts emerge, that are solved instantly, usually by adopting the suggestions of the most active student, or the student that gives the most suitable answers. This has important didactic implications since an educator could suggest the appropriate questions or arrange the appropriate situations in order to create the social conflicts that will lead to the cognitive evolution. The activation of sociocognitive conflicts during teaching situations contributes to the evolution of students' representations and the amendment of those representations regarded as "mistaken" from a scientific point of view [2]. The way Informatics courses run (laboratory structure, teamwork, constant interaction between educator-students-hardware-software) and the use of computers in the teaching of courses, favors the creation of sociocognitive conflicts since teamwork is the most common practice.

A main teaching goal, during Didactics of Informatics, or teaching with computers should be the creation of cognitive or sociocognitive conflicts. These conflicts are an indispensable element of *conceptual change* that is a crucial part for both teaching and learning process.

3.6 Didactics of Informatics and Conceptual Change

Research on students' representations leads us to conceive learning with conceptual change terms [1]. Conceptual structures created in the minds of the learners are not static but rather they are in constant change as more knowledge is acquired. Therefore, it is necessary to understand not only the way knowledge is organized and represented but also the way the existing cognitive structures are transformed during the acquirement of new knowledge. Additionally, understanding the ways conceptual change is achieved, is crucial for a holistic theory of learning and could affect teaching approaches significantly.

When students entering a new field of study, (even if it is about a modern subject such as Informatics), not only hold previous "knowledge" and perceptions on the concepts, the activities and the objects of that field, but, also they hold concepts that are different from the models and the concepts constructed by the scientists of the respective field. From a teaching point of view, the discrepancy between the students' representations and the scientific concepts [4, 14] in the field of Informatics, is useful to be studied in terms of conceptual change.

The conceptual change approach, which allows for renovation of the Science and Informatics Teaching settings, is placed among the constructivist perspectives of learning. This approach focuses on the ways students' representations change and the overcoming of the epistemological obstacles.

Under this prism, the teaching intervention should aim to motivate all the cognitive aids that will help students to construct new knowledge and to provoke (gradually) the necessary disagreements that modify during a long term the ways of their cognitive functioning. The underlying hypothesis to this approach accepts that the evolution of the cognitive system causes gradual internal restructuring that modify at a long term the cognitive functioning of the individual. In such approach, the mistake and its recognition is fundamental to the development of knowledge. In teaching programming, for example, the approach that favors the sociocognitive conflicts and promotes conceptual change of the knowledge through the search and the amendment of the mistakes in the code (debugging), comprises a fruitful teaching approach.

4 Discussion

This article attempted a brief account and analysis of the basic concepts that comprise the field of Didactics of Informatics. The contemporary approaches of psychology of learning and the Science Teaching build a new basis for the activities that should be developed in the context of Informatics courses. The existence of an "informal" but rather robust teaching contract, determines to a large degree the interaction and the evolution of the teaching practice in Informatics Classroom. Scientific knowledge is subjected to transposition in order to be transformed to knowledge- to- be- taught. This position is valid for Informatics, too. However, when Informatics becomes the subject matter, it is affected by other practices of reference held by students. Representations held by students on Informatics technologies affect the ways students conceive and use computers. The reordering and the evolution of these representations is a crucial point of the teaching practice and could be theorized through sociocognitive conflict procedures (that should be favored in Informatics classroom) and procedures of conceptual change.

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