

Chapter 51

Theory of Nuclear Concepts: A New Approach to Understand and Represent Cognitive Structures

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ABSTRACT

The Theory of Nuclear Concepts (TNC) is based on prior theories and ideas coming from Ausubel and Novak among others, who argue that concepts are organized hierarchically around general concepts. But the TNC differs from them in holding that the students' cognitive structure is organized around specific concepts that are not the most general, but only the most significant for the students. TNC also argues that, as a result of the learning progresses, the students' cognitive structure is transformed into a simpler structure. The associated technique to represent the cognitive structures is "Pathfinder Associative Networks" and to obtain them, it was developed GOLUCA software, which serves as a support on the analysis and representation of cognitive networks. The TNC has been used to understand and evaluate the cognitive structures of students and teachers in real situations.

INTRODUCTION

The Theory of Nuclear Concepts has the theoretical framework of cognitive science, but differs of others cognitive theories on elements like the hierarchical organization of knowledge, proposing a

geographical organization, presents an alternative of subsume concepts, defining nuclear concepts, and facing the increasing complexity of cognitive structures, propose the idea of "paths of least cost."

Most research on TNC has been developed by the official research group Ciberdidact, created at

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the University of Extremadura (Spain) in 2005, and has already obtained sufficient results to show the possibilities of the TNC in education research. It has been applied to various fields (computers and education, learning evaluation), teaching in various areas (nursing, computer engineering), but especially on Mathematics Education.

Between the lines of research developed by this group, highlights one that try to deepen into the knowledge of the cognitive structure of students from the standpoint of a theory also generated by the group: "Theory of Nuclear Concepts." The main object of Theory of Nuclear Concepts is study the psychological aspects that occurs in students mind during the teaching-learning process, how to represent, describe and study them.

As examples of the most recent applications, the TNC has been used to understand and evaluate the cognitive structures of students and verify the educational possibilities of the learning environment called PmatE, applied to the teaching and learning of the arithmetic operations, in primary education. As another practical aspect, Ciberdidact group is developing two studies that propose the development of mathematics teaching sessions based on TNC, and also propose the assessment of students' learning based on the changes produced in their cognitive structure.

The TNC uses a specific technique, the path-finder associative networks. These networks are graphical representations of the structure of knowledge that represent the relationships between concepts in the cognitive structure of an individual. To obtain these networks we can use the GOLUCA software.

The above investigations, conducted by the research group Ciberdidact, were involved mathematics teachers and students of Portuguese schools.

BACKGROUND

The Theory of Nuclear Concepts

The origins of TNC date back to 2002, during the investigation of the doctoral thesis of Casas (Casas, 2002), studying the mathematical concept of angle. In this research (Casas & Luengo, 2004) is reflected on how the student's mind works, how they understand the basic mathematical concepts, how to represent the cognitive structure of students in a theme and how to apply these representations for research and educational use. Results were found that could not be explained on the basis of existing theories, so it required a new one (Theory of Nuclear Concepts), building on previous theories.

The theoretical foundation of TNC is based on the learning theories of Ausubel, Novak and Hanesian (1978), but proposes some differences with these theories in particular as related to the organization of knowledge, introducing new theoretical alternatives (Casas, 2002): geographical organization of knowledge, nuclear concepts and paths of least cost.

Geographical Organization of Knowledge

TNC does not agree to the hierarchical organization of knowledge and proposes a "geographical" organization. This kind of organization is a metaphor to explain that, like what happens with the knowledge of a map, at the start of construction of such knowledge it is not organized around general concepts that are derived from others (in the geographical analogy, we might consider as such the country, region and major cities), but about concrete concepts (in the geographical analogy might be landmarks that are familiar to the subject). According to this theory, the acquisition of a concept is similar to the acquisition of geographical knowledge, where there are points

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