MEANINGFUL LEARNING AND TWO LEVELS OF FOCUSED AND DIFFUSE THINKING MODES: A PRACTICAL EXPERIENCE IN THE PHYSICS LECTURE

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Abstract

Meaningful learning theory, which underlies any constructivist theory, is very important in all teaching-learning activities. In this theory new information acquires meaning through interaction with specifically relevant knowledge from the learner's cognitive structure. In addition, nowadays, Neuroscience recognizes two thinking modes, the so-called diffuse and focused thinking modes. This offers opportunities for designing new learning-teaching strategies. This paper takes into account both modes of thinking in the design of a procedure to achieve the significant acquisition of an organized knowledge structure in a teaching-learning situation. Under a constructivist focus, both thinking modes are useful to achieve integration between specific ideas, individual attitudes, and other topics related to meaningful learning. Unlike our previous work, in this paper we highlight two levels of action in which learning-teaching educational activities can be performed. In each of them, the alternation of diffuse and focused thinking modes takes place. In the first level, the lecturer shows students basic concepts about a subject while the learners' previous knowledge is stimulated. If there are lacks, the lecturer should observe how long it takes students to build cognitive bridges and carry out the transition from mechanical to significant learning. The second level aims at more advanced objectives and tasks to be learnt. However, it is necessary to verify that meaningful learning has occurred in the first level. Thus, the procedure depends on the previous level and different tasks must be taken into consideration in order to proceed. This strategy considers the complexity and progressivity of meaningful learning at both levels. This technique has been used in an undergraduate Applied Physics course and has proven to be very useful for the comprehension of a variety of concepts in physics and its applications. Results illustrate a theoretical method and its application to nerve conduction where concepts such as potential, electrical capacity, electrical resistance and so on are considered in the first level of the procedure. More advanced concepts such as rest potential, action potential and RC circuit are used in the second level to understand nerve conduction from the perspective of physics. Outcomes reveal meaningful learning indicators in which the learning process is complex, progressive and critical.

Keywords: Meaningful learning, learning strategy, diffuse thinking mode, focus thinking mode.

1 INTRODUCTION

Nowadays, meaningful learning theory plays an important role in the teaching-learning process. Although, this is not a new theory, it is really powerful because it considers meaning, comprehension and transferability. Meaningful learning is an underlying concept in several contemporary views of learning [1]. Through it, significant conceptualization can be achieved in a collaborative context that facilitates the negotiation of meaning which enables concepts to be 'captured' [2).

Studies of neuroscience, learning science, developmental psychology and cognitive psychology have converged on a new understanding of the workings of the brain [3]. Researchers have found that there are two fundamentally different modes of thinking: focused and diffuse [3], [4]. These new findings have significant implications for what educators teach and how students learn. On the other hand, it is said that thought must produce action rather than /linger in the mind and lead to indecisiveness [5].

In accordance with this, in previous work, the first author of this article developed a methodology where he took into account the findings of Neuroscience about diffuse and focused modes of thinking [6]. The methodology was applied to the teaching-learning process, specifically in a module about fluids in an Applied Physics course. It was the first practical experience in which the author attempted to obtain meaningful learning in one educative episode. Despite the good academic results obtained in

assessments of the module, it cannot be considered a well-established procedure. For this reason more experiments should be performed with this methodology.

Our goal is to design a method to achieve meaningful learning where we consider diffuse and focused modes of thinking in a particular teaching-learning situation. Unlike our previous work, the procedure is developed in two action levels during educative activities. In each one a relation is established between two states of thinking and processes such as progressive differentiation and integrative reconciliation. From the point of view of physics, the main ideas are applied to nerve conduction.

Our paper is organized as follow: section 2 presents the theoretical foundations that underlie the design of the methodological strategy, which is presented in section 3. In section 4 the results are discussed. Finally, in section 5 the concluding remarks are presented.

2 THEORETICAL FOUNDATIONS

This subsection briefly describes some issues that theoretically support this work.

2.1 Meaningful learning

Meaningful learning is a learning method where new ideas, symbolically expressed, interact with previous knowledge [7]. In this process, new knowledge acquires meaning for the learner, whereas previous knowledge provides a greater cognitive stability to the new meaning. Meaningful learning theory has constructivist psychology as fundamentals.

This interaction occurs in a substantive and non-arbitrary manner. The term substantive manner means that it is not literal. Non-arbitrary means that the interaction occurs only with specifically relevant previous knowledge of the learner's cognitive structure [7].

The necessary conditions to establish meaningful learning are potentially significant material and predisposition to learn.

Cognitive structure can be considered as a dynamic structure characterized by two main processes, progressive differentiation and integrative reconciliation. In the former, new meanings are attributed to a particular subsunsor or anchor (previously learned concept) because of successive use of this 'anchor' for giving meanings to new knowledge. The latter eliminates apparent differences, resolves inconsistencies, integrates meanings and makes high orderings [1]. Through these processes, the learner organizes his cognitive structure hierarchically in a certain knowledge field.

Along with the student's previous knowledge, progressive differentiation and integrative reconciliation, there are other variables that facilitate meaningful learning. These include content sequential organization, consolidation, previous organizers and language [8]. The first allows the student to organize the subsunsor, taking into account the hierarchy of the content system. The second is related to the previous knowledge domain. The third shows how new information and previous knowledge of cognitive structure are related and differentiated. The fourth is used in the exchange of meanings.

In meaningful learning, strategies and instruments are very important too. Among them, we can consider the previous organizers, conceptual map, V-diagrams and collaborative activities. The conceptual map is useful in progressive differentiation and in integrative reconciliation of concepts. V diagrams highlight the interaction between the conceptual domain and the methodological domain when knowledge is generated from central issues. Collaborative activities enable meaning exchanges and negotiation and emphasize the teacher as mediator role [8].

Conceptual field theory provides new ideas about cognitive development and is compatible with the meaningful learning theory that is interpreted in terms of progressivity and complexity [9], [10], [11]. Some of its central aspects are listed below:

- Conceptualization is the core of cognitive development.
- Situations give meaning to concepts.
- The domain of a set of interrelated problem-situations, with different levels of complexity, is a slow process, with ruptures and continuities.

There is a dialectic relationship between the conceptualization and the domain of a conceptual field. The more significant the learning becomes, the more elaborate, richer, more differentiated and more capable of giving meaning to new knowledge the "subsunsor" or anchor is.

2.2 Focused and diffuse modes of thinking

Researchers have found that people have two fundamentally different modes of thinking: focused and diffuse. The first occurs when people concentrate intently on something they are trying to learn. The second is a more relaxed thinking style and is related to a set of neural resting states [4].

In the first mode, if people have a thought, it takes off, moves smoothly around on the underlying neural pathway. It appears to bounce around the anchors when people are able to figure out the problem they are trying to solve. As well as the case when people are trying to understand how something is related to something with which they are quite familiar. Since the problem arises when new ideas or approaches are required in the job, people need a different way of thinking to cover this lack of thought pattern. If someone has not tackled a particular problem before, he or she does not even have a clue about the corresponding thought pattern to be used. To reach this new thought pattern people need the diffuse mode of thinking, so, they have to train to obtain a big-picture perspective. People can make new neural connections that travel along new pathways and they cannot focus in as tightly as they often need to, to finalize any kind of problem solving. But they can at least get to a starting point from which they can begin to solve the problem or issue. Now as far as neuroscientists are aware, it seems people cannot be in both thinking modes at the same time. But both modes complement each other [4].

3 METHODOLOGY

We focus on a methodological procedure where the authors link meaningful learning to two fundamentally different modes of thinking.

3.1 Observation

Meaningful learning must be a goal in teaching. In practice, many circumstances do not allow this objective to be achieved. The student often feels that everything is too complicated than it really is. Therefore, it is more likely that he prefers to learn with rote learning rather than meaningful learning. Then, it will be observed that there will be few skills to link relevant elements of the cognitive structure with new information and to carry out the progressive transformation of the new information and the previous concepts.

3.2 Hypothesis

Neuroscience tells us that the brain, in the process of thinking, works in two ways that are complementary. If this is true, the characteristics of these states could be taken into account in the processes of progressive differentiation and integrative reconciliation in teaching-learning events. At the same time, it is said that thought should produce action. It is likely these two statements can be used as a reference to establish states for meaningful learning.

3.3 Method

The study involves two classes of students that belong to the Pharmacy Degree (Universidad San Jorge, Spain). In order to achieve a collaborative process several working groups were formed. The teacher's role was to act as mentor in student learning.

Our methodology is very similar to previous ones [6]. However, unlike in previous work, we highlight two action levels in which learning-teaching educational activities can be performed. In the first level, we find out the previous knowledge of students. In the second, we present more advanced information about the content system. In each level, the teaching-learning process should begin with more general terms rather than with formal, abstract and mathematically sophisticated terms. Here, the word terms refers to concepts, propositions, procedures and ideas. The general and specific terms must be worked on from the perspective of differentiation and integration as shown in "Fig. 1". Concepts should be exemplified and dealt with in teaching situations.

We relate the features of the diffuse mode of thinking with the procedure indicated so far. Therefore, the conditions that characterize this mode of thinking are simulated during the teaching-learning process. The teacher should take suitable precautions to encourage that the interaction takes place in a relaxed context, without worries and with positive attitudes toward learning. Here, we can establish a metaphor, “the analysis of concept, problem or learning element should be allowed to spread like a free particle in space”. In terms of neuroscience, this is really similar to the diffuse mode of thinking. It

is clear that the interaction with the new information is inevitable, but in a first approximation, it is not necessary that the student understands all the ideas that come over to him. Instead of obsessing over specific details, the student should be placed in a position of flexibility so that the idea has more space to travel. This is a slow process where both new knowledge and the anchor will progressively grow. Therefore, the students should not pay great attention to the quantitative aspects. Besides, the learners should not focus on topics that do not have general prospects.

When the differentiation and integration process is performed again, we can relate them to the focused mode of thinking. Then it is necessary to focus attention on specific aspects that relate to existing knowledge and new information because the subsunsor must be stabilized. This anchor is activated and new meanings are obtained. Focusing allows the subsunsor to be more stable, clear and differentiated. In this way the learner enhances the development of meanings.

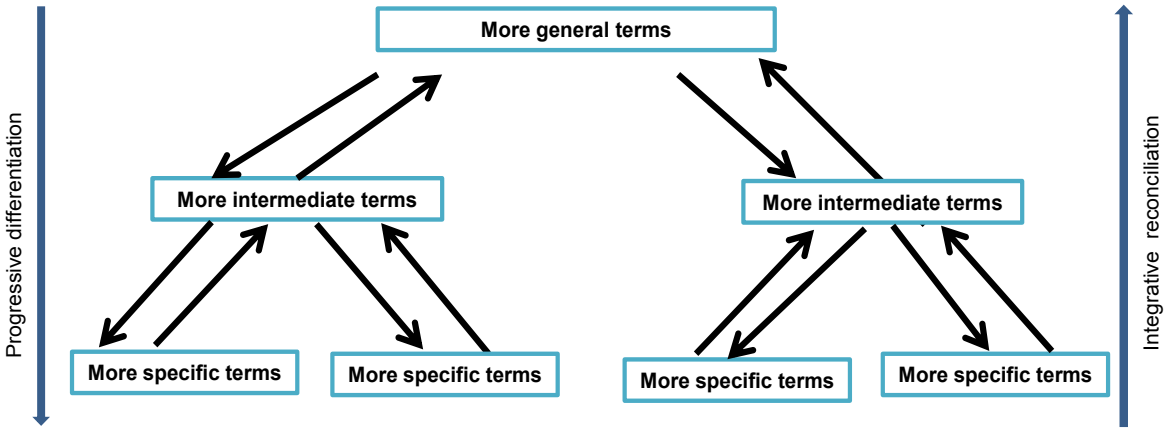

Figure 1. Progressive differentiation and integrative reconciliation.

It is well-known that brain combines diffuse and focused modes to complement each other. Similarly, our procedure can be alternated in order to achieve progressivity of learning during the differentiation and integration process. Thus, we can go up and down the conceptual hierarchies several times. This combination can be done several times until evidence of meaningful learning arises.

The same procedure is applied in two action levels. However, in the first one, the lecturer should observe how long it takes students to build cognitive bridges and carry out the transition from rote to meaningful learning. Then, if there is evidence of learning, we might pass to the second level with a more advanced purpose than the first level.

Strategies and instruments of meaningful learning, specific to each situation, should be applied throughout the development of educational activity.

We are interested in applying this approach to a practical experience in the physics class. This example is devoted to explaining nerve conduction from the perspective of physics. Consequently, it is necessary to use some basic concepts like potential, electrical capacity, electrical resistance, etc. All these concepts are useful in both action levels. Now, we are interested in the generation and propagation of nerve impulse. Nonetheless, the procedure is exactly as Fig. 1 showed. The tree categories are the same as in Fig. 1 (more general, more intermediate and more specific terms).

4 RESULTS

The methodology is applied to the study of nerve conduction. Problems-situations are shown in the two action levels. These appear in increasing order of complexity. Here, situations refer to a statement of a physical situation, problem and questions. So, situations could give meaning to concepts. Progressivity and complexity can be observed in all figures. For more details, see figures from Fig. 2 to 4. In each one, the first differentiation and integration process is related to the diffuse mode of thinking. This stage should be executed under declared conditions for diffuse mode of thinking (section 2.2). The second differentiation and integration process is related to the focused mode of thinking. At this moment, the conditions mentioned above (section 2.2) are applied. Next, the procedure can be applied several times until the evidence of meaningful learning appears. In other words, the procedure is alternatively repeated in the two modes of thinking. This process is

progressive and complex. In this case conceptual maps are effective tools. These maps are built by the students in a cooperative way. The negotiation process involving all participants, the educational materials and atmosphere were remarkable. V-diagrams might be used for establishing interaction between the conceptual domain and the methodological domain. Here, the first signs of meaningful learning should appear. If so, learning should continue with the method. On the contrary, if learning is not apparent, it makes no sense to continue with it.

In pedagogical terms, it is essential to generate a variety of situations according to Vergnaud's theory [9], [10]. Some situations are presented below and are typical representations of the method applied.

In the first action level, we use situations 1, 2, 3 and 4. Situations 1 and 2 correspond to the movement of a particle without and with energy losses, respectively (see Fig. 2).

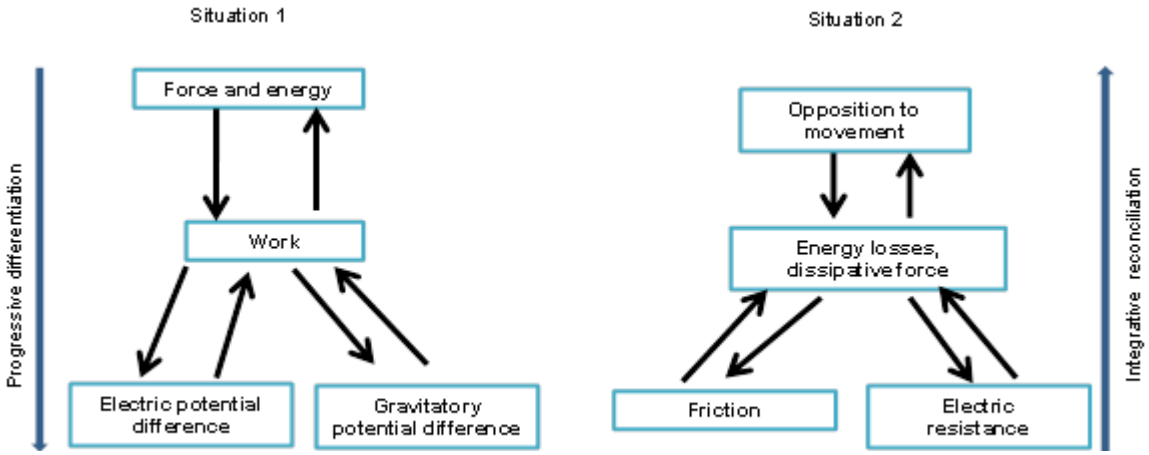

Figure 2. Progressive differentiation and integrative reconciliation. Situation 1 and 2 in the first level.

Situation 3 corresponds to the storage of charged particles whereas situation 4 is devoted to the intensity of the electric current flowing through an electric circuit (see Fig. 3).

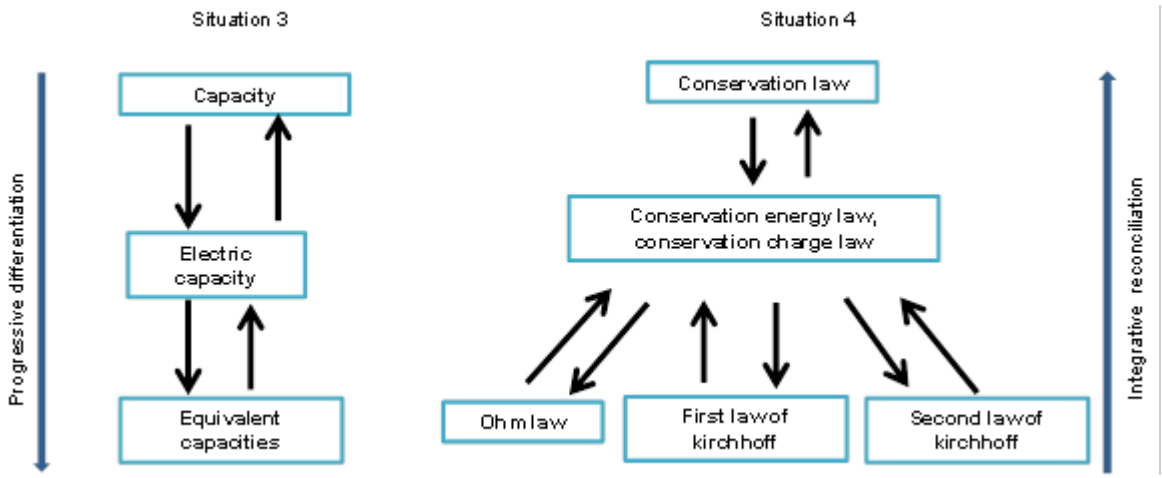

Figure 3. Progressive differentiation and integrative reconciliation. Situation 3 and 4 in the first level.

In the second action level, crucial topics about nerve conduction can be found with the same differentiation and integration scheme mentioned above. Now, cognitive structure has more stable meanings.

From the point of view of Biology, axon structure and generation-propagation of nerve impulse are explained. Next, an axon physical model like cable is presented. This has new physical parameters as mentioned above. The new concepts are rest and action potential, axon and membrane resistance, axon and membrane electric capacity, axon and membrane current intensity, and RC electric circuit. Of course, model physics includes biological terms such as myelin, Ranvier nodes, etc.

With this outlook new situations are necessary. Situation 5 corresponds to the physical magnitude associated with the cable model whereas situation 6 is devoted to the intensity of the electric current flowing through an electric circuit (see Fig. 3).

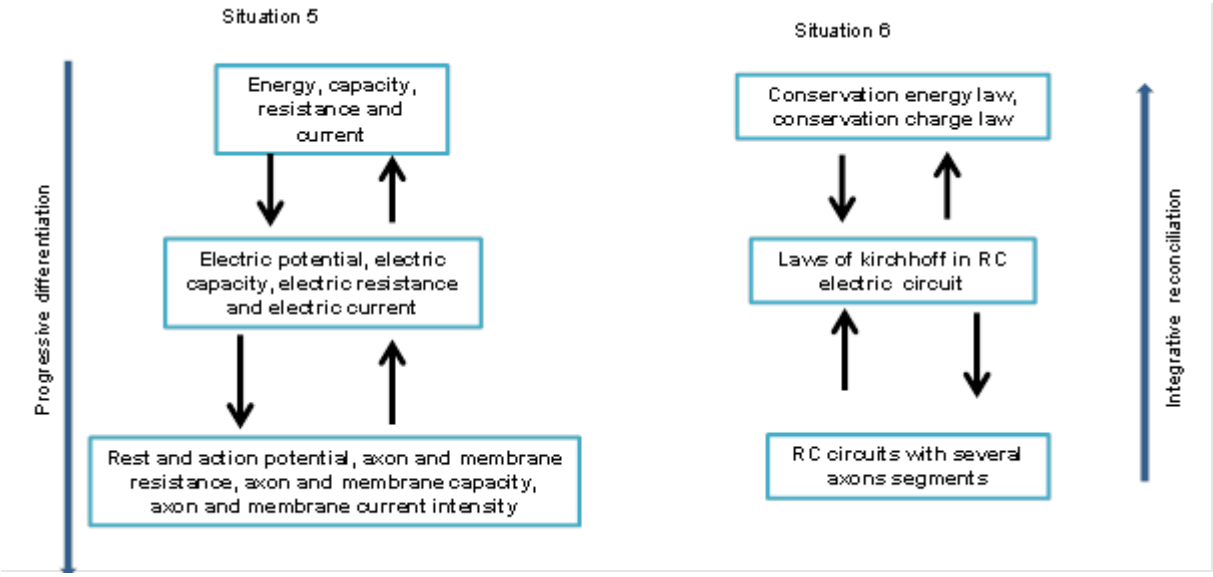

Figure 4. Progressive differentiation and integrative reconciliation. Situation 5 and 6 in the second level.

Although not emphasized a lot, the method is applied considering the critical aspects of meaningful learning. Meaningful learning is characterized by diversity of strategies, questions instead of answers, variety of teaching materials, learning by error, student as recipient renderer, semantic awareness, unlearning and knowledge as language [1]. Also, this is progressive and complex.

The purpose of this paper is not to make quantitative estimates. But, it is noteworthy that most of the students who performed the assessment of this subject were able to pass the exam.

5 CONCLUSIONS

A method to achieve meaningful learning which considers diffuse and focused modes of thinking in a particular teaching-learning situation has been created and piloted.

The use of the variables, strategies and instruments facilitate significant learning in the modes of thought in which the brain works.

It seems there is evidence of meaningful learning when this method is applied.

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