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Research paper

Neurobiology of Navigation and Learning: Fourth Dimension Cartography

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Abstract

The present article sheds light on new representations of learning. The proposition deals with a representation of learning in four dimensions, in which the highlight is on the navigation across space as a new perspective on the phenomenon of learning. This perspective allows for some aspects of the phenomenon and attempts to show experimental proposals on the matter. Three of the dimensions are based on learning theories: Vigotsky's Meaningful learning; Piaget's self-directed learning through discovery; and Vigotsky's Social Learning. A fourth dimension would be the physical space itself. Animals navigate in different ways through the world. *Navigation:* the process of *being* in this world is the basis of learning.

Keywords: *learning theories, online navigation, page Web, representation of learning, space.*

1. Introduction

The book on educational psychology of Ausubel, Novak and Hanesian appears for the first time in 1983 and 1998. This fact would be a milestone in the development of the new theories of learning. In this book, Ausubel and his colleagues proposed an orthogonal of learning that we present in fig. 1.

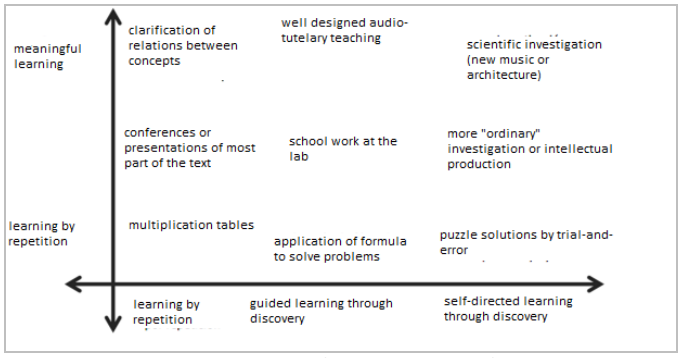

Fig 1: Orthogonal between meaningful learning and self-directed learning through discovery. Ausubel, Novak and Hanesian, 2009.

In this representation, the authors elaborate a mapping of the relations amongst learning by repetition and through discovery. In this mapping, school learning works are distributed according to their complexity.

On the other hand, a study was carried on in which different authors tackle the relation between socio-cultural factors and the cognitive development. This relation has a key role in education, and a link has been pointed out between Vigotsky, Piaget, Bandura and Bruner's theories. (Vielma & Salas, 2000)

From the field of Neuroscience, there has been progress in the last few decades related to new techniques in the study of the nervous system and its operation in animals, as with non-intervening systems in humans (fNMR, CAT, among others).

There is also a wide range of sources and techniques that have proved the reproduction of hippocampal neurons and their role in experimental learning, and also the association of this limbic structure in navigation processes (O'Keefe & Nadel, 1978; Burgess, Maguire, O'Keefe, 2002; Burgess, 2008; Buzsáki, 2013). In this sense, the work of Burgess is highlighted in relation to the participation of hippocampal neurons. (Place, border and grid cells).

In order to illustrate this point, the example of the Morris Tank has been used as an experimental paradigm. So, using this technique, it has been shown that the specific damage into rat's hippocampus is related with a loss of the learning faculties (Vicens, Redolat & Carrasco, 2003).

In the present article, we attempt to provide arguments for an integration of learning theories from the perspective of three authors: Ausubel, Piaget and Vigotsky, to whom we will propose as the first three dimensions of learning. In addition, we add a fourth dimension: the physical space in which living beings unfold. This physical space, in this sense, performs the function of acting as a dialectic/ dialogic backbone that allows for the operation of the animals nervous system.

Therefore, the challenge that we propose consists in the integration of dissimilar learning theories into a single system of references. As a previous example, Gimeno & Pérez (2008) gather two educational approaches together. The first approach includes conditioning-associationist theories. The second approach corresponds to mediating theories that includes various trends such as cognitive theories - Gestalt theory (Brunner, Piaget, Ausubel and

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others) - and finally Vigotsky and Luria's genetic-cognitive psychology.

We attempt to show the predictive consequences of this approach in order to open a path in the multidimensionality of this learning phenomenon. The objective of this paper is to highlight *navigation* as the basis of learning.

2. Development

Although it is true that the space defined in figure 1 shows a surprising theoretical space, since the normal one is seen as a crossroad of basic coordinates that corresponds to length, width and height. We pinpoint the fact that we are dealing with conceptual spaces; those coordinates correspond, in the first place, to Ausubel's proposals of reception learning and also discovery learning, which has been associated to Piaget's theories.

This bi-dimensionality allows for the analysis of learning – especially in scientific work in labs- and also to provoke an integration of two viewpoints in orthogonal; a plane or physical representation of *learning*.

This plane is represented in dimensions that simplify the world into its indications, which are functional for an analytic interpretation. This interpretation requires a simplification – more necessary in the academy than in schools - with students treated and analyzed through a more personalized manner in controlled experimental conditions.

Our proposal advances a third dimension: the one that considers social learning that we assimilate to Vigotsky's (2009) conceptualization (fig. 2).

If we consider the social dimensions in processes of learning – the process of learning is associated to various phenomena – we would see ourselves impelled from considering this social dimension for a better integration of the learning phenomenon. We consider, thus, a new variable that is functional to the tridimensioning of the analysis system proposed by Ausubel; fact that allows for a new analytic basis.

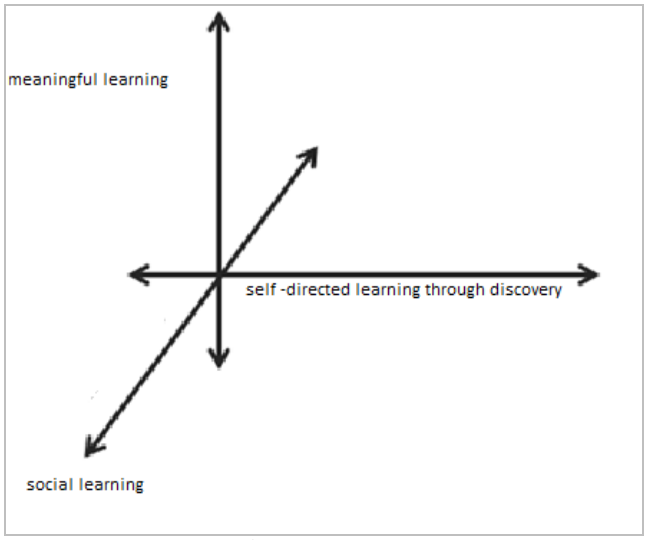

Fig 1: Tri-dimensionality of the educative space including the social dimension of learning, close to the conditions of more complexity within the phenomenon of learning.

Thus, we attempt to define a relation between the positions of the subject in the plane of that space. This is an interesting exercise in order to visualize in terms of what can be controlled in the methodology of teaching and learning. In order to visualize this situation, we should ask ourselves What happens in a zero condition? That is to say, when the values of the variables are reduced to a null expression, and on the opposite, when the values are led to the maximum of the same variable.

Therefore, following Ausubel's proposal, situations such as scientific or musical creations, seen from one side of the social dimension, could be considered as a collective activity, as in the case of participating within a coordinated and complex social action, student's movement, a conference, a collective creation, participating in a music concert, a play, etc. Tasks that can be socially expressed in a local, national or international leadership. On a smaller scale, at the school level, a round of questions could be done with classmates, feed or protect the other person, etc.

In conditions of null social dimension (this is an hypothetic situation, of course), the experimental conditions in which the behavior of an isolated individual is analyzed, classical example of behaviourist experiments is what characterizes a stage within the development of experimental psychology. Fig 1 shows the space on the proposed plane (Ausubel, Novak y Hanesian, 2009).

On the other hand, if we consider our spatial proposal that constitutes a fourth dimension, we obtain the hypercube represented (Fig. 3). Interpretations arise such as those that point out an individual in a process of learning; this individual would be moving through space, navigating on it, repeating experiences, incorporating new situations to his own experience.

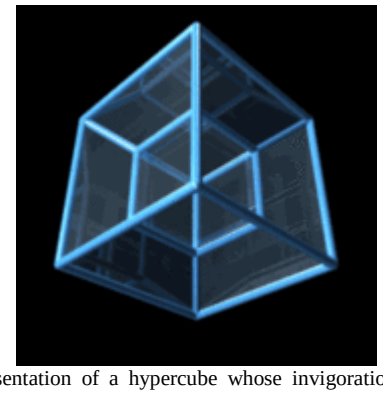

Fig 2: Representation of a hypercube whose invigoration (available in public networks) makes possible to imagine the interpretative conditions of a hyperspace.

For instance, a rat that learns to locate a platform within the Morris tank, allows for the spatial movements which through consistent repetitions signals a learning that can also be facilitated by keys from the environment.

We anticipate that an injury in the hippocampus region, which experimentally provokes impossibility for learning, corresponds to a situation in which the "space" variable is null. In mathematical terms, this corresponds to zero value.

For humans, the illustration of this issue is represented in the case of Alzheimer, whose initial symptoms reveal a spatial disorientation that leads to the misplacement in the patient.

Another classical example for our study is the case of the patient named MH (Milner, 1985) to whom doctors removed the hippocampus in order to cure temporal disabling epilepsy. HM is able to learn simple motor tasks, although he completely lost the ability to remember. This case depicts how short term memory is not transferred to long-term memory.

3. Discussion

Psychology's classical viewpoint on learning constitutes a theoretical paradigm that has developed into various conclusions and manners on addressing how people learn and how do we teach things. The technical devices related to registers and the current analytical instruments applied from this same paradigm strengthen and confirm their results and theoretical predictions (Kantrowitz,

2014), marking the birth of the safety belt from the investigation program, (IP) (Lakatos, 2007), along with disciplines such as the one that Ledoux calls behaviourology; an independent discipline from psychology (Ledoux, 2012).

Thus, a more inclusive approach to the topic is mandatory. This approach has to interact between different disciplines and theories; their predictions, results and discoveries.

Accepting the multidimensionality of this learning phenomenon, there has been interpretations of classical phenomena from the study of clinical cases and experimental situations. This allows for some predictions applied to experimental conditions.

Ausubel, Novak and Hanesian's comments open the possibilities for a mapping universe that could be of interest:

"A considerable amount of misunderstandings in the discussion concerning school learning is due to the fact that some people do not recognize that meaningful learning and learning through repetition are not precisely dichotomous. Although both types of learning are qualitatively discontinuous in terms of the psychological processes underlying each of them, and, for this very same reason, they could not be placed in opposite sides of this continuum, there are types of transitional learning that share some of the characteristics of the afore mentioned types of learning (for instance, learning about representations, or learning about names of objects, events or concepts). Furthermore, both types of learning could co-occur" (Ausubel, Novak, Hanesian 2009: 34-35).

The attempts of simplification on this common ground have been controversial in regards to the evidence related to the similitudes between theories, although we can notdeny that differences are still notorious (Vielma & Salas, 2000).

On the other hand, regarding Vigotsky, Ivan Ivic points out the following:

"If we had to define Vigotsky's theory throughout key words and formulae, we definitively have to point out at least the following on is: the process of human sociability, social interaction, instrument and sign, culture, history and finally higher mental functions.And if we had to assemble these key words and formulae into one single expression, it could be told that Vigotsky's theory is a "socio-historical-cultural theory of the development related to the higher mental functions". Although this theory is usually known as "cultural-historic theory".

For Vigotsky, human beings are characterized by primary sociability. Henri Wallon expresses this same idea in a more categorical way: "individuals are genetically social" (Ivic, 1994: 3-4)

Nowadays, primary (and early) sociability presents the status of a scientific fact as a result of biological data. This data is related to the role that sociability plays in anthropogenesis, as well as those related to the morpho-functional of the newborn.

Gimeno and Perez, on their behalf, points out the following:

"Thus, it will be necessary to understand any phenomenon related to learning; to determine the development level reached concerning previous experiences. This fact implies considering the degree of complexity reached by the brain's functional structures. Therefore, and this is Vigotsky's most significant contribution, from a didactic perspective, the level of development reached is not static, but a wide and flexible interval" (Gimeno & Pérez, 2008: 49-50).

Therefore, and considering what has been discussed above, we can trace a path that shows how a living creature navigates through the surroundings. It can be drawn then that human beings –among other animals- are historical creatures. And what is more, there is a structural substratum necessary for its existence, as Burgess and O'keefe point out (2002; Burgess, 2008) related to place, border and grid cells located in the hippocampus.

Considering a multidimensional mapping it is possible to advance new perspectives on classical observations and cases related to neurology, neurosciences and learning processes.

Learning as a permanent human activity is subjected to different conditions that could be etiological factors presents in pathologies –or their therapies-, in which gradual or abrupt changes in space would produce new interpretations. This is the case of schizophrenia triggered in cases of migration, exiles or environmental changes in general.

4. Conclusion

We think that processes as the subjection of individuals into experimental conditions in virtual spaces- a condition in which human body could not move is a challenge that can be faced with convincing theoretical framework at hand. Likewise, situations in which patients suffer syndromes such as Korsakoff, Charles Bonner or Alzheimer could be reinterpreted, along with illnesses derived from autism.

From the educational perspective, a holistic viewpoint on learning allows for an integral close-up to classroom phenomena and, subsequently, to didactics. This viewpoint allows for new possibilities for considering learning as a complex and dynamic phenomenon, for whose analysis and mapping there is a variety of mathematical instruments such as Graph theory, complex stochastic systems and instrumental facilities for registering, along with advanced virtual reality techniques that could open new possibilities for the development and application of our viewpoints.

Finally, we consider that space seen from an architectural viewpoint becomes significant when educational facilities –and learning in general- have impact on people's becoming and transcendence through Heidegger thought: "building, dwelling, thinking" (2007).

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