Understand the evolution of a concept through the abstraction | concretization movement in teaching situations using analogies

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1. Introduction

In an interview in 2013, Emmanuel Sander (Sander & Bianchini, 2013) proposed two of the most interesting avenues for research in cognitive sciences. The first concerns research that questions the nature of learning. Fundamental questions of learning are : what happens to a person when he is confronted with an unprecedented situation? How does this situation create a new concept or transform one or more existing concepts? The second concerns research that questions the relationship between the abstract and the concrete. As human beings, we cannot deny the fact that we experience concrete situations and that, at the same time, we are able of having abstract thoughts. So what is the link between these two categories in learning situations?

This thesis work is intended to be at the crossroads of these two perspectives. Through the implementation of a learning device by analogies among Bachelor and Master students in Education Sciences, this research attempts to observe the evolution of concepts as well as to inform the relationship between abstract and concrete in the learning process.

Abstraction is an essential activity in human life. Removing someone the ability to abstract would force him to no longer be able to distinguish the elements around him, to no longer be able to discern what is common and what is different (Radford, Demers & Miranda, 2009). For Hofstadter and Sander (2013), abstraction is a generalization and allows the human being to "free himself from certain particularities to detect common points and [allow him to rely] on this capacity for abstraction to mobilize his past knowledge when confronted with a new situation" (p. 314). For these authors, abstraction is therefore "first and foremost the everyday tool of ordinary people for moving between categories and, quite simply, for perceiving the world and interacting with it" (Hofstadter & Sander, 2013, p. 314).

Like Yin and Yang, abstraction cannot be fully understood without referring to the concrete. This sensitive character of things allows the abstract to be situated, embodied, to be linked to experiences notably via tools and grants the possibility of making meanings emerge (Menary, 2010; Rowlands, 2010). For Wilenski (1991), the concrete "is that property which measures the degree of our relatedness to the object (the richness of our representations, interactions, connections with the object), how close we are to it, or, if you will, the quality of our relationship with the object" (p. 198). Fransisco Varela (1992) goes further by placing the concrete as the source of proper units of knowledge: "[...] the proper units of knowledge are primarily concrete, embodied, incorporated, lived" (p. 320).

A fundamental question is the relationship between abstract and concrete, because "on the one hand, since we are human, we always rely on concrete experiences […] ; but on the other hand, we are also constantly abstracting; in any new situation we encounter, we intuitively perceive some abstract core." (Sander & Bianchini, 2013, p. 22). For an individual, there is no hierarchy or unidirectional link between the abstract and the concrete. They form a whole that evolves over time in synchronized fashion (Roth & Hwang, 2006a; 2006b). These authors define this

movement as a double ascension abstraction | concretization. The abstract and the concrete are not separate distinctions, but are, on the contrary, increasingly linked in the process of abstraction (Hershkowitz, Schwarz & Dreyfus, 2001). The abstract and the concrete can therefore be perceived as feelings on the same continuum.

The analogy is “omnipresent in our mental activities” (Sander, 2000, p. 1). It is the very heart of thinking insofar as it is inseparable from categorization (Hofstadter & Sander, 2010). Learning by analogy has been widely studied (e.g. Richland & McDonough, 2010). As a process of formation and recovery of concepts (Sander & Bianchini, 2013), the analogy is both abstract and concrete. Based on the approach developed by Roth & Hwang (2006a, 2006b), it is possible to make the hypothesis that analogy creates fields of tension between various abstractions and/or concretisations. Analogy can be seen as a possible engine of this double ascension insofar as it creates or adjusts links.

Daily activity is composed of a succession of experiences that shape concepts found in literature as spontaneous (Vygotski, 1997), naive knowledge (Lautrey, Rémi-Giraud, Sander & Tiberghien, 2008) or preconceptions (Ausubel, 1968). A learner is therefore never totally virgin in the presence of a new situation. However, the concepts that underlie human thought are not rigid boxes that fit together like Russian dolls (Hofstadter & Sander, 2013). Concepts are dynamic, constantly changing distinctions and "the construction of new concepts can profoundly alter the concepts on which the same construction is based" (Hofstadter & Sander, 2013, p. 69). They are above all functional distinctions, in action, fulfilling functions of communication, meaning and understanding (Vygostki, 1997). This distinction makes it clear that not only someone's activity does express itself through previously constructed concepts, but it is also from this embodied activity that concepts are formed (Hutchins, 2010).

The school in general and the educational sciences in particular have addressed this central issue of abstraction capacity by proposing methods for abstraction (Barth, 2013). However, it must be admitted that there are certain limits to these practices: abstraction is an individual, situated and complex capacity that it would be dangerous to confine to a learning model, to a user's manual (Nonnon, 1997). Considering the role of analogies in cognition (Hosftadter & Sander, 2013) highlights that available concepts are not totally stabilized. They are in constant transformation. It is in situations and according to significant distinctions for the individual that some become relevant. In response, these concepts shape a particular view of the world.

This research aims to describe the processes of abstraction in teaching and training situations using analogies. Thus, learners' concrete experience is as important as their abstract experience. By implementing a device of learning by analogy, this work raises the following question: how does a concept emerge and evolve in a teaching/learning situation?

2. Methodology

This work is based on a three-part methodology relating to three different populations of learners. The goals of the research will be specific and will provide more precise answers to the research question in different ways. All will experience a device of learning by analogy as described below.

2.1. Populations

The first group (MASPE21) is composed of about thirty students taking a Master's course in science and educational practice at HEP Vaud. The second (BP23REC) brings together 380 Bachelor of Education students at HEP Vaud. For this second group, data will be collected during a first-year lecture on introduction to research. The last group (5-6P) consists of about 20 primary pupils aged between 7 and 12.

2.2. Research device

Here is an overview of the different moments of the research:

<table>
<tr><td>09 – 12.2018</td><td>MASPE21</td><td></td><td rowspan="4">5-6P</td></tr>
<tr><td>02 – 06.2019</td><td></td><td>BP23REC</td></tr>
<tr><td>09 – 12.2019</td><td>MASPE21</td><td></td></tr>
<tr><td>02 – 06.2020</td><td></td><td>BP23REC</td></tr>
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The research device is iterative and evolutionary according to the various intermediate results. Thus, the investigations carried out on the MASPE21 group will aim to test the learning by analogy device, to propose possible adjustments and to provide qualitative results on the understanding of the evolution of a concept. The BP23REC group will benefit from a proven device and will be the subject of a mainly quantitative investigation. The objective here will be to quantify the effect of learning by analogy on the evolution of a concept. Finally, the 5-6P group will be the subject of an ad hoc investigation with the aim of: a) testing different hypotheses highlighted by the other two groups; b) translating the system into terms of primary education. The research will take place over two academic years allowing an iteration in order to understand the processes involved.

2.3. Learning by analogy device

The learning by analogy device as imagined before the first empirical results will be in the form of specific tasks to be performed on an application. During these moments, either analogies are proposed by the teachers to the students and a question is asked, or students create analogies on the concepts studied. Based on socio-constructivist hypotheses, the device will then include a phase of discussion between peer around the different answers elaborated by students, inspired by the *Peer Instruction* device (Mazur, 1997).

2.4. For example

In the course taking by the MASPE21 group, one of the concepts studied is the coupling between the actor and the environment from an enactive perspective (Varela, Thompson, Rosch, 1993). Here is a series of questions that could be asked to students during the moment dedicated to learning by analogy:

a) How far can it be said that actor-environment coupling works like two gears that move in each other's direction? What are the limits of this analogy?

b) Rank these actor-environment coupling analogies from most relevant to least relevant:
    a. A married couple. Everyone must coordinate with his partner and from this union is created a superior entity: the couple.
    b. The shoe and the foot. By walking, and the shoe and foot transform and adapt to each other.
    c. The gear. When one gear wheel is put into action, the other follows the movement.
c) Imagine an analogy of actor-environment coupling.

2.5. Qualitative part of the research

The qualitative data in 1st person will be collected on the basis of dynamic recovery interviews (*entretiens de remise en situation dynamique*, Theureau, 2010) of 2 students from the MASPE21 group and 2 students from the BP23REC group per academic year. This will contrast the different results of the same group. In addition, an analysis of the answers and discussions on the platform may be the subject of a special investigation in order to collect data in 3rd person.

These data will be analyzed using Peirce's semiotics (Everaert-Desmedt, 1990 ; Thibaud, 1994 ; Fisette, 2009 ; Poizat, Salini, Durand, 2013). The strength of this analysis lies in the fact that it "makes it possible to grasp not only thought, but also learning and teaching as processes, without leaving the question of the content to which these processes relate undetermined" (Muller, 2004). They will also be analyzed as part of the "course of action" research program (*Cours d'action*, Theureau, 2010). In this way, a learner's generation of experience units can be updated and thus participate in the understanding of this process of concept evolution.

2.6. Quantitative part of the research

Quantitative data will be collected on the dedicated platform during the BP23REC lecture from February to June 2019. To date, many questions remain regarding the protocol to be implemented in order to propose relevant results. The challenge here is to collect quantitative data which, when crossed with qualitative data, will make it possible to better understand the evolution of a concept in its dimension of abstraction|concretization supported by analogies.

An important precision: one of the ethical guiding principles of this work is that, at a very least, it must not be done at the expense of the quality of the teaching offered. Ideally, the research device should encourage the student to learn and the teacher to regulate the learning process.

3. Results

3.1. Exploratory research

Two works related to this research were the subject of a communication. First, a poster was presented at a conference of the ARCD (Association pour des Recherches Comparatistes en Didactique - Association for Comparative Didactic Research) in June 2017 (Switzerland). It presented the theoretical framework of the work as well as the first results of exploratory

research carried out on a task of summarizing learning in the form of a diagram. This research made it possible in particular to work on the analysis of qualitative data in terms of double ascension abstraction | concretization. Second, a paper entitled Accessing Student Experience to Document Learning and Regulate Teaching was presented and discussed at a symposium in Toulouse (France) in September 2017 on the occasion of the 50th anniversary of the Educational Sciences. The aim was to show the conditions of access to students' experience in order to better understand the learning process and regulate teaching, in a very particular context where the researcher is also the teacher.

3.2. Expected results

The expected results of this research are as follows:

- A fine documentation, in first person, of the evolution of a concept ;
- A documentation of the thesis which proposes that the abstract and the concrete are two distinctions of a continuum ;

4. Bibliographie

Ausubel, D.P. (1968). *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart & Winston.

Barth, B.-M. (2013). *L'apprentissage de l'abstraction*. Paris : Retz.

Everaert-Desmedt, N. (1990). *Le processus interprétatif. Introduction à la sémiotique de Ch.S. Peirce*. Liège : Mardaga.

Fisette, J. (2009). L'icône, l'hypoicône et la métaphore : l'avancée dans l'hypoicône jusqu'à la limite du non conceptualisable. *Acta Semiótica et Lingvistica, 14*(1), 100–126.

Hershkowitz, R., Schwarz, B., Dreyfus, T. (2001). Abstraction in Context : Epistemic Actions. *Journal for Research in Mathematics Educ., 32*(2), 195–222.

Hofstadter, D., & Sander, E. (2013). *L'Analogie. Coeur de la pensée*. Paris : Odile Jacob.

Hutchins, E. (2010). Enaction, imagination, and insight. In Stewart, J., Gappene, O. & di Paolo, E. (Eds.), *Enaction: Towards a new paradigm in cognitive science*. Cambridge MA: MIT Press.

Lautrey, J., Rémi-Giraud, S., Sander, E. & Tiberghien, A. (2008). *Les connaissances naïves*. Paris : Armand-Colin.

Mazur, E. (1997). *Peer instruction: A user's manual*. Upper Saddle River : Prentice Hall.

Menary, R. (2010). Introduction to the special issue on 4E cognition. *Phenomenology and Cognitive Science, 9*, 459–463.

Muller, A. (2004). Approche sémiotique pour l'analyse a priori d'une tâche mathématique. In Moro, C. & Rickenmann, R. (Eds), *Situation éducative et significations* (pp. 247–270). Louvain-la-Neuve: De Boeck Supérieur.

Nonnon, E. (1997). Grandeur et misères des modes d'emploi pour l'abstraction. *Recherches, 27*, 85–113.

Poizat, G., Salini, D., & Durand, M. (2013). Approche enactive de l'activité humaine, simplexité et conception de formations professionnelles. *Education, Sciences & Society*, *4*(1), 97–112.

Radford, L., Demers, I., & Miranda, S. (2009). *Processus d'abstraction en mathématiques*. Ottawa : Centre franco-ontarien de ressources pédagogiques, Imprimeur de la Reine pour l'Ontario.

Richland, L. & McDonough, I. (2010). Learning by analogy : discriminating between potential analogs, *Contemporary Educational Psychology, 35*(1), 28–43.

Roth, W.-M., & Hwang, S. W. (2006a). Does mathematical learning occur in going from concrete to abstract or in going from abstract to concrete? *Journal of Mathematical Behavior, 25*(4), 334–344.

Roth, W.-M., & Hwang, S. W. (2006b). On the relation of abstract and concrete in scientists' graph interpretations: A case study. *Journal of Mathematical Behavior, 25*(4), 318–333.

Rowlands, M. (2010). *The new science of the mind: From extended mind to embodied phenomenology*. Cambridge : MIT Press.

Sander, E. (2000). *L'analogie, Du Naïf au Créatif*. Paris : Éditions l'Harmattant.

Sander, E., & Bianchini, F. (2013). The Central Role of Analogy in Cognitive Science, *Methode-Analytic perspectives, 2*(2), 21–26.

Theureau, J. (2010). Les entretiens d'autoconfrontation et de remise en situation par les traces matérielles et le programme de recherche "cours d'action". *Revue d'Anthropologie des Connaissances, 4*(2), 287–322.

Thibaud, P. (1994). La notion peircienne de métaphore, *Histoire Épistémologie et Langage 16*(1), 123–136.

Varela, F. (1992). The Reenchantment of the Concrete. In Crary, J. & Kwinter, S. (Eds.), *Incorporations : Zone 6* (pp. 320–338). Zone Books : New York.

Varela, F., Thompson, E., & Rosch, E. (1993). *L'inscription corporelle de l'esprit. Sciences cognitives et expérience humaine*. Paris : Seuil.

Vygotski, L. S. (1997). *Pensée et langage*. Paris : La Dispute.

Wilenski, U. (1991). Abstract meditations on the concrete and concrete implications for mathematics education. In Harel, I & Papert, S. (Eds.), *Constructionism: Research reports and essays, 1985–1990* (pp. 193–203). Norwood, NJ : Ablex.