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Constructivist spiral: an active learning methodology

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Based on the social-interactionist education theory and on the pedagogical practices in Western societies, this paper presents the constructivist spiral as an active teaching-learning methodology. It discusses the origins and utilization of active methodologies in higher education and focuses on problem-based learning, problematization methodology, the scientific method, and the use of narratives, simulations or role-playing in real practice scenarios. The exploration of the constructivist spiral, according to the movements "identifying problems"; "formulating explanations"; "developing questions"; building new meanings" and "evaluating processes and products", highlights similarities and differences in relation to the active methodologies approached in the paper. The educational intentionality behind the utilization of the constructivist spiral is revealed by the nature of the learning triggers that are used and by the transformative sense of reality derived from a critical and reflective posture in the interaction of "subject" and "object".

Keywords: Methodology. Teaching. Active learning. Higher education.

Introduction

In human societies, culture is instituted through the systematic acquisition of experiences. It results from man's relations to reality, and it can be oriented towards the reproduction or the transformation of such reality[1].

In the last four decades of the 20th century, investigations on culture, the mind, the brain, cognition and development brought new evidences in relation to learning, and the conceptions about this process and its translation into pedagogic practices were revisited[2]. Despite these investigations and the incontestable changes in the access to and dissemination of information, the pedagogy of transmission is still hegemonic, both in education and in professional qualification[3].

Particularly in the field of health, the combination between the pedagogy of transmission and the focus on the biological dimension of the health-disease process produces an education that is

decontextualized as regards the subjective and social dimensions of this phenomenon; fragmented in disciplines and in knowledge of basic and clinical areas; technicist and procedure-centered. Aiming to overcome the consequences of such orientations, there is a movement targeted at the production of changes both in relation to the use of active teaching-learning methodologies and to the promotion of a transformative education[4].

Active teaching-learning methodologies, particularly those with a problematizing focus, have been used in the education and qualification of health professionals as a strategy that aims to integrate different types of knowledge and to promote a critical and reflective attitude concerning practice[5-7]. One of these methodologies is the constructivist spiral[8]. Although it has been used in Brazil since 2004, it had not been explored and registered yet as a new methodological construction, considering its origins and theoretical bases.

In light of this context, this article aims to present and explain the methodology of the constructivist spiral. At the same time that the spiral considers the transformational character of education, it also recognizes that the educational system has "long-lasting effects that are not easily changed"[9] (p.29).

In terms of method of study, this work is designed as an essay. This modality is a critical and exploratory exercise about a theme that searches for a new form of looking at or investigating a subject matter in more detail[10].

Theories about the teaching-learning process

The pedagogic theories that explain learning consider: the "subject" who learns; the "object"; and the "mediation" between the subject and the object, which takes place in the interaction within a society. The distinct levels of importance that are attributed to these elements support the following theories: (i) environmentalist, (ii) innatist and (iii) interactionist, which, throughout time, have been translated into pedagogic practices.

The environmentalist theory focuses on the "object", represented by contents to be learned. Translated into the directive pedagogy, it values the teacher's role and believes that learning occurs through transmission of information[11,12].

In opposition, the innatist theory values the "subject", and learning is attributed to the hereditary and maturational factors of each person. It corresponds to a non-directive pedagogy that considers that the differences among individuals are insuperable, as they are biologically established[11,12].

The emergence of the interactionist or social-interactionist theory has promoted a re-reading of the explanations, which are apparently antagonistic, about what is acquired and what is innate. It focuses on the "mediation" that occurs in the interaction between "subject" and "object". According to this theory, translated into the constructivist pedagogy, hereditary factors and also the contents, culture and society interact in learning[13,14].

Characteristics and trajectory of the pedagogic practices

In western societies, educational practice followed an empirical course until pedagogy emerged as an area of knowledge, in the 17th century[15].

According to Gauthier and Tardif[15], the craft of teacher originated in ancient Greece, with the sophists, and formal education in slave societies reproduced the class distinction, transmitting values of the "free" men. These authors argue that the school as a formal teaching institution is a product of the Middle Ages. In medieval schools, pedagogic practice was based on repetition and inculcation of the values and interests of the clergy and nobility. The transition from feudalism to capitalism, with the ascension of bourgeoisie, promoted changes in the power structures, with repercussions in the schools, which started transmitting the values of the nations in formation, or of the State.

In the Modern Age, Renaissance and Enlightenment thinkers are recognized as the first authors to oppose traditional education. Even considering the humanistic ideas, centered on man instead of on scriptures, and rationalism, centered on reason, the pedagogic practice remained unaltered until the end of the 19th century and was transmitted as an unquestionable model that instituted a tradition[16].

In this scenario, the main innovation of pedagogic practice was formulated by Jean-Jacques Rousseau (1712-1778). This author moved the center of the learning process from the teacher and contents to the pupils' needs and interests. According to Edouard Claparède (1873-1940), the change in the centrality of this process can be considered a huge pedagogic revolution, comparable to the one Copernicus performed in astronomy[17-19]. However, this change produced results only at the end of the 19th and beginning of the 20th century, with the active school movement. Representing a renewed pedagogy in relation to the traditional one, this movement supported the creation of new schools and educational methods, oriented to active learning in view of people's daily problems[16,19].

Also in the early 20th century, the behaviorist conception was presented as an alternative to traditional pedagogy and, unlike the active school, had a broad adherence. Behaviorism focused on the conditioning of observable behaviors and became dominant in the school context between 1920 and 1970[15].

Even though hegemonic, conditioning had strong limitations to explain human thought. Thus, it enabled the emergence of a cognitivist conception that rescued the subjective elements of the learning process. To cognitivism, the focus of study of human thought was transferred to the learning processes, instead of behaviors[18].

Still in the 20th century, the main psychogenetic theories founded the constructivist conception in education[15,20]. Here, it is important to highlight that the point of convergence between cognitivism and constructivism lies in the opposition to the behaviorist explanation, as both

understand learning as a process of transformation of the "information that comes from the environment", which becomes a "symbolic representation" [15] (p.421).

In education, constructivism used elements of Jean Piaget's (1896-1980) genetic theory, David Ausubel's (1918-2008) significant learning, Henri Wallon's (1879-1962) integral education, and Lev Vygotsky's (1896-1934) sociocultural focus to conceptualize "learning as a process of construction of knowledge and teaching as a support to this process of construction" [16] (p.357).

To Salvador[16], the constructivist conception integrates explanatory principles about the school's social nature and socializing function, the role of the teacher and contents, and about the processes of construction, modification and reorganization of knowledge schemes and meanings. This conception has been an important reference in the shift from professionalizing or techno-scientific education to an education that transforms reality[1,6].

Active teaching-learning methodologies

The roots of the utilization of active methodologies (AM) in formal education can be recognized in the active school movement. Generally speaking, they are considered technologies that enable students' engagement in the educational process and develop their capacity for analyzing critically and reflecting on what they are doing[21,22]. They aim to promote: (i) proactivity, by means of students' commitment to the educational process; (ii) association of learning with significant aspects of reality; (iii) development of reasoning and of capacities to intervene in their own reality; (iv) collaboration and cooperation among participants.

According to Dewey[23], the utilization of educational challenges in the format of problems is coherent with the way in which people naturally learn. According to this author, education must be targeted at the experiences one lives rather than at the transmission of abstract themes.
Beyond students' engagement, Bruner[24] believes that the AC must trigger representations we construct about the world. Explored by means of narratives, these representations translate the interface between the individual and the social dimension, and allow to better access people's way of thinking, desires and interests in a certain culture.

Chickering and Gamson[25] included the use of active methodologies among the seven principles for a good educational practice. These authors call our attention to the performance of activities that involve students' cooperation, interaction, diversity and responsibility, especially in small groups.

Some educators approach the greater importance that is given to the learning method compared to the contents, especially if they are decontextualized. Saviani[26] and Libâneo[27] discuss these questions, highlighting two challenges: making active learning technologies accessible and considering a critical approach in the selection of contents shared with future generations.

In the last decades, diverse active methodologies have been developed, such as: problem-based learning (PBL), problematization, and learning based on projects, in teams, through games or

with the use of simulations. PBL and problematization will be explored in this article with the purpose of explaining the influence of these methodologies in the formulation of the constructivist spiral (CS).

Theoretical-methodological bases of the constructivist spiral

The constructivist spiral (CS) is a problematizing methodology conceived based on experiences that I developed as a teacher, in curricula that used active educational technologies. The first formulation was intuitive and originated in the interpretation of the findings of a study[8] that I carried out about PBL, in a medicine curriculum. This study, developed in a Master's program, revealed that, based on the processing of problems, the learning questions made by students presented greater discipline articulation than the tutor's guide written by teachers. Thus, the initial idea for the formulation of the CS was the principle of globalization, defended by Ovide Dècroly (1871-1932)[28]. According to this author, who is considered one of the pioneers of the AM, learning happens based on a view of the whole and, subsequently, it is organized in parts. Dècroly indicated an inversion in the literacy process, which should be triggered by the association of meanings in complete discourses, instead of by knowledge of isolated syllables[28].

Based on a constructivist conception of education and on the principle of globalization, I aggregated elements from dialogism, significant learning and scientific methodology to compose the theoretical framework of this methodology.

Regarding the social-interactionist theory, recent advances in the explanation of learning have shown that, as humans, we are biologically prepared to learn and this biological basis is modulated by experience and by the environment, in an active and permanent way. To Vygotsky[29], the interaction between "subject" and "object" and among people with different repertoires enables zones of proximal development that stimulate learning. Thus, having contact with more experienced people favors the resolution of problems that are impossible to be faced only with individual repertoires. The emphasis on context and on culture as elements that determine the learning process values the representations constructed in the production of knowledge and meanings[29].

The dialogic approach expands the social-interactionist basis. According to Morin[30], the principle of dialogism recognizes different explanations/perspectives in relation to a certain reading of the world and aims to associate the elements that compose it, connecting the whole to its parts. Even considering practically all the elements of dialectics, dialogism, instead of working with thesis-antithesis-synthesis, aims at the construction of a meta-point of view.

According to Sánchez[31], dialogism is an association that is, at the same time, "complementary, convergent and antagonistic", of processes or conceptions (p.173). Thus, the complementary relation between, for example, objectivity-subjectivity, discipline-interdisciplinarity, individual-collective is recognized. Morin[30] defines these relations as complementary and recursive. The conception of recursion can also be found in the proposal of spiral curriculum formulated by

Bruner[24]. According to this proposal, ideas must be elaborated and re-elaborated in successive visits, allowing for the construction of amplified understanding.

Concerning significant learning[32], previous knowledge is considered determinant in the construction of new knowledge and it must be possible to problematize it. In this sense, scientific spirit, supported by validated methods, must guide the construction of knowledge. As previous knowledge represents the "primary experience", Bachelard[33] argues that the formation of the scientific spirit requires that we adventure into the kingdom of the new by refusing previous knowledge. To this author, the first obstacle to the construction of new meanings is when we place "the primary experience above criticism"[33] (p.29). Thus, the search for scientific evidences is impelled by doubt or uncertainty[33] and also by epistemological unbalance[34].

Considering these references, I used the format of a spiral to represent the recursive, continuous, incomplete and unfinished movements of the learning process[1]. Employed since the Celtic culture, the spiral translates, symbolically, opposed or transformative forces. The idea of cycles also emerges in the interactionist theories[29,34], particularly in proposals targeted at interventions in the reality[35] and at the construction of products[36,37].

In relation to influences deriving from PBL and from problematization, it is important to highlight that both are also considered active and problem-based methodologies.

PBL has structured the use of active methodologies in the undergraduate curriculum. Initially, it was employed in the medical course of the McMaster University, Canada, at the end of the 1960s[5,38-40]. Even with no direct references to John Dewey's and Jerome Bruner's ideas in the formulation of PBL, we can recognize them in the utilization of problems and small groups and in students' active role. Today, curricula organized according to the PBL strategy can be found in the education component of diverse professions and in all continents. In Brazil, PBL was introduced in 1993, in postgraduate courses[41], and in 1997, in undergraduate courses[42].

The variety of practices that are called PBL and of indicators that are used to evaluate their results limits the interpretation of some findings mentioned in the literature[43-47]. Therefore, it is important to explain that the reference of PBL that I used in the construction of the CS was based on the seven-step method, as presented by Schmidt[38] (Figure 1).

In PBL, the problems are elaborated by teachers and must: be formulated according to a "neutral description of reality phenomena or events (…) in the most concrete possible way"[38] (p.15); activate students' previous knowledge; and present a cognitive challenge whose utility is recognized. Ideally, the tutor plays the role of facilitator of this process and the students must participate in a collaborative and cooperative way in the processing of the problem. Branda[39] and Venturelli[40] use more detailed presentations or presentations with a circular movement to represent PBL. Both include the stage of evaluation in their respective schemes, and Branda[39] refers to the problem as a problematic situation.

Figure 1. Steps involved in problem-based learning

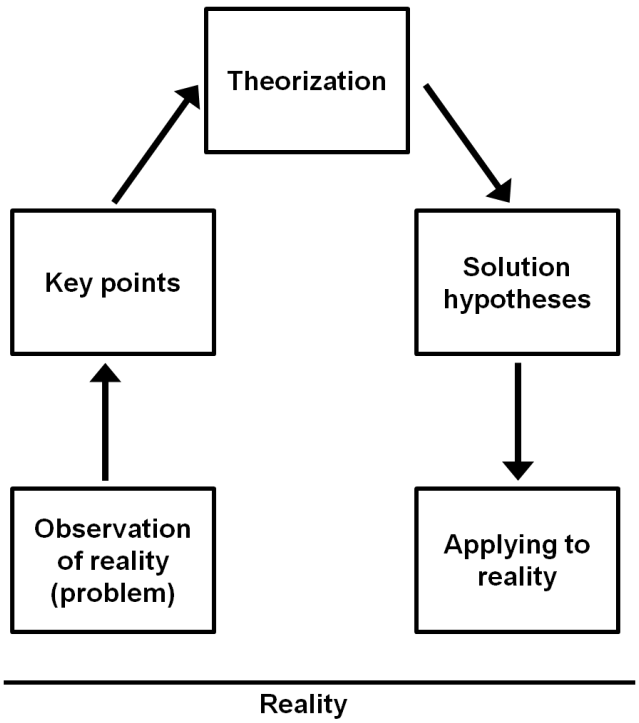
Step 1 - Clarify terms and concepts not readily comprehensible
Step 2 - Define the problem
Step 3 - Analyse the problem
Step 4 - Draw a systematic inventory of the explanations inferred from step 3
Step 5 - Formulate learning objetives
Step 6 - Collect additional information ouside the group
Step 7 - Synthesize and test the newly acquired information

Fonte: Schmidt, 1983, p.13

Problematization, in turn, has been progressively gaining ground in Brazil, particularly in the area of health[48,49]. Its origin was in 1960, when Charles Maguerez (1927-2003) idealized an arch to represent an educational approach directed at the training of workers. Although it presented some elements of the interactionist theory, the first version of the arch: had a strong economic orientation; did not involve formulation of problems; was fundamentally informative and centered on the teacher/instructor, while the workers played the role of reproducing knowledge[50]. Considering the movements of departure from and return to reality, Bordenave & Pereira[6] produced, in 1982, an adaptation of the arch that was strongly influenced by the ideas of Piaget, Vygotsky, Bruner, Freire and Ausubel. In this adaptation, the arch was directed at the solution of problems, based on scientific thought and guided by a dialectic perspective of man's interaction with reality[50] (Figure 2).

According to Bordenave and Pereira[6], although the teacher defines the set of problems to be observed, the problems are real. The students start with a "naïve" observation and, in the following stages, teacher and student participate actively in problematization and in the construction of an intervention in reality. The teacher's role is more propositional in theorization and in the formulation of solution hypotheses, acting as a source of information.

Figure 2. Stages of the Arch of the Problematizing Methodology



Source: Translated from Bordenave & Pereira,1982, p.10

Paulo Freire's method is also considered a problematizing form of education. It is oriented towards reality and presents three stages. The first focuses on the reading of the world, which is obtained through a thematic investigation, considering students' experiences. Based on generating words that were identified in this investigation, the second stage is thematization. In it, the meanings attributed to the generating words are shared, in order to support the third stage. In the problematization stage, subjects talk about and reflect on words and meanings, in order to transform the read world[1].

Finally, although students' action in real situations of professional practice is the less controlled AM, it is the most significant one due to absolute contextualization and theory-practice integration. It triggers lifelong learning, and real situations require total engagement, as they imply interventions in the identified problems by means of action-reflection-action[1]. The utilization of simulations of practice in controlled scenarios enables greater realism without presenting risks to the individuals involved[51,52].

The development of the constructivist spiral

The constructivist spiral was used for the first time in formal educational initiatives in 2004, in a specialization course of national scope[53]. In this experience, I expanded the use of CS triggers through the inclusion of narratives. The narratives brought students' subjective interpretations of the

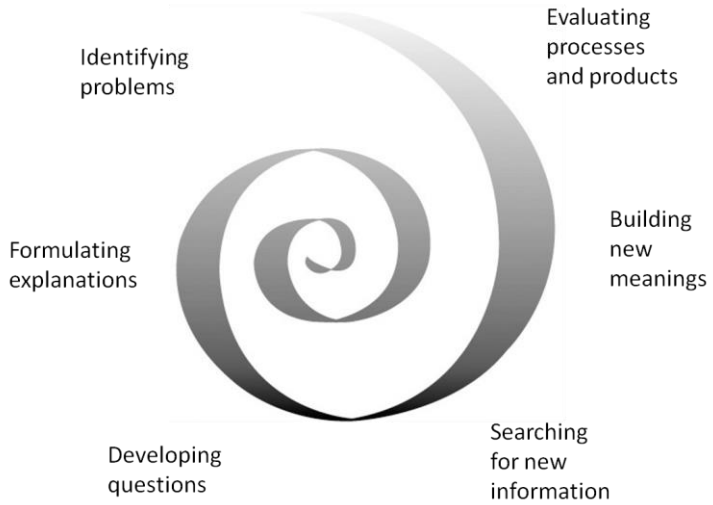
world, and this enabled to reduce the distance between the learning process and students' priorities and culture[54].

In the undergraduate level, the CS has been used since 2006 in the medical curriculum of a federal university[55]. In this curriculum, the use of narratives about simulated practice and students' productions, like clinical histories, was also included as triggers.

In 2009, the CS started to be used in educational initiatives related to professional improvement and specialization, constructed for the qualification of professionals working in the *Sistema Único de Saúde*[56] (SUS – Brazil's National Healthcare System), also in a national scope. In 2010, it was applied to High School[57], in an elective activity focusing on career choice. Since 2011, it has been used in Master's programs[58,59].

In relation to the spiral's movements, identification of problems, formulation of explanations and development of learning questions were called "provisional synthesis". Search for new information, construction of new meanings and evaluation constituted a "new synthesis" (Figure 3).

Figure 3. Schematic representation of the constructivist spiral



Source: Adapted from Lima, 2001

Considering the dialectical theory of knowledge[27], the "provisional synthesis" corresponds to the moment of synchresis, as a global and initial view of reality, and the "new synthesis", to the moments of analysis and synthesis. Through the search, the "new synthesis" represents the possibility of knowledge reconstruction in the light of science. Of the six movements of the CS, only the search is performed individually. The other movements are developed in small groups composed of eight to ten students and one learning facilitator, and they must establish a set of pacts for collective work.

In the "provisional synthesis", the processing begins in the students' interaction with the learning trigger. The triggers can be: (i) problem situations developed by teachers, (ii) narratives of practice delivered by students, (iii) products systematized through students' action in real or simulated scenarios. This diversity enables us to approach the teaching-learning process from different

perspectives, and it employs a spectrum that has: (i) more structured and controlled situations, like problem situations; (ii) semi-structured situations, like simulations; and (iii) less controlled situations, like narratives or products developed through action in real scenarios.

Identifying problems

In the CS, the identification of problems is subordinated to each student's previous knowledge, perceptions, feelings and values. The identified problems or challenges can be grouped by affinity and represent the point-of-departure of the teaching-learning process. Therefore, we do not deal with "one" problem to be recognized by the group's students, but with a set of problems resulting from different perspectives and interpretations.

Formulating explanations

Based on the identified problems, the revelation of each student's initial presuppositions about the occurrence of the problems aims at the sharing of the explanatory systems that justify the observed phenomena. These justifications originate hypotheses.

The formulation of explanatory hypotheses allows to recognize the rationalities and feelings that the participants associated with the identified problems. The higher the number of hypotheses, the higher the potential for producing encompassing explanations. Thus, together with the identified problems and challenges, the distinct explanatory systems represent the previous knowledge and the learning frontiers.

In the movement "formulating hypotheses", the repertoires constructed in each student's experiences must be respectfully considered. The recognition of inaccuracies, incongruences, ambiguities, incompleteness and other challenges should result in the development of learning questions.

Developing questions

The learning or research questions represent students' learning needs. The questions must focus on aspects that enable the group to amplify their understanding and their possibilities of intervention in a certain situation. The questions to be investigated must be collectively constructed and accepted, so that students can test the formulated hypotheses. It is important that all students research the same questions because of the strategy of validation of a certain knowledge by means of analysis and confrontation of different sources and authors.

Searching for new information

Based on facilities and difficulties in access to information and to remote databases, the facilitator must stimulate and support the development of capacities to search for knowledge. The analysis of search strategies and of the sources' level of reliability, as well as the critical evaluation of the production of the obtained information must be explored in the formulation of a new synthesis.

Building new meanings

In the CS, the reconstruction of the meanings that support our intervention in the world results from the confrontation between previous knowledge and new information brought by students. In this movement, the new information must be shared, with the purpose of verifying degrees of consensus among the diverse sources that were researched, and the consistence, coherence or scope of the explanatory systems found in the literature. Although new knowledge may be constructed in the "provisional synthesis", due to the exchange among participants, this construction assumes a scientific character in the "new synthesis", supported by better evidences. The confrontation among pieces of information in the "new synthesis" must recognize biases and mistakes in knowledge production, as well as the need for contextualization and defense of the ethical dimension in this production.

Evaluating process and products

Evaluation plays a fundamental role in the CS, as it is targeted at the improvement in or expansion of capacities for learning, working in groups and intervening in the reality. Feedback must be as clear and objective as possible, and it can include the impact produced by the observed performances. Due to these characteristics, evaluation in the CS has a formative nature[60], and it must be verbal and conducted at the end of each encounter.

All the students must conduct the evaluation, starting with self-evaluation and including metacognition[61,62]. Considered one of the main learning strategies, metacognition is an evaluation targeted at the identification of facilities and difficulties in the learning process. It aims to improve access to information, as well as information analysis and organization.

After self-evaluation, students must evaluate the performance of their peers and of the facilitator. At the same time, the facilitator must evaluate him/herself and provide feedback on the performance of each student and on the group's collective work.

Reflections on differential elements of the CS

Considering the influences of PBL and problematization on the formulation of the CS, the diversification, nature and processing of the triggers differentiate the CS from those two active methodologies. Regarding the role of the context in the triggers, the incorporation of the term

"situation" in the term "problem" points to the idea of situational interpretations for a given reality. In the CS, the conception of problem is aligned with the perspective employed in situational strategic planning. To Matus[63], a problem is an unsatisfactory reality or a challenge that generates curiosity, uneasiness or discomfort, and which can be transformed into a more favorable or desired reality.

This reference is a condition that also distinguishes the processing of situations used in the CS and which represent distinct interests and values. These interests and values belong to the students, when they interact with the situations, but also underlie the more structured aspects of phenomena. The students' problem situations, narratives or systematized products re-signify the proposal of a "neutral" problem conceived by PBL, either restricted to certain components of the phenomenon or presented only in the professional perspective or in the teacher's perspective.

Furthermore, the exploration of the context aims to amplify the technicist approach to education and professional educational, bringing elements that situate phenomena in a historical and cultural context of society. One of the functions of the context is to favor the individual-society articulation. Thus, contextualized problems reduce the distance between learning and life, and favor the recognition of culture and of the usefulness of new knowledge[54,64,65].

Independently of the trigger, rationalities and emotions must be explored in the CS. Maturana[9] highlights the biological character of emotions, relating them to our desires, intentions and preferences. According to this author, rationality is the expression through which we justify or deny desires, intentions and preferences. The articulated exploration of reason-emotion tends to expand critical conscience and to promote intellectual independence, by means of the recognition of how we produce culture.

Another relevant aspect is the identification of problems or challenges based on each student's global impression of the learning trigger, independently of lack of knowledge in relation to some term, as indicated in the first step of PBL. In the CS, the process starts with the students' provisional synthesis, instead of acknowledging elements or aspects they do not know. This difference tends to value the students' knowledge, although it can be incomplete, inaccurate or incorrect. A favorable atmosphere to the exposition of this knowledge is created, even if there is only partial undestanding of some term or aspect of the situation under analysis.

As for the teacher's role in the CS, he/she must act in a problematizing way, mediating learning. The focus must be placed on students' development of critical and reflective capacities. This development is enhanced: by the use of contextualized situations as learning triggers; by the confrontation between previous knowledge and scientific evidences; and by the problematizing approach, taking into account the understanding of methodology, critical stance, availability for dialog and respect to diversity[1].

Finally, in the evaluation stage, in addition to the analysis of the learning process, the group can evaluate its production and generate a new spiral to enhance or improve products.

Thus, based on experiences lived in the application of the CS, it is important to highlight that diversity and contextualization of triggers, the form of approaching students' previous knowledge and the

problematizing attitude, especially on the part of the facilitator, aim to produce a more critical and reflective education, instead of a technicist and reproductive education.

Potentialities and limits of the CS

Although there are studies that point to a higher learning potential when the context[2] is explored in the triggers, this hypothesis has not been tested in relation to the results of the CS yet, particularly in comparison to the other active methodologies.

Another potentiality is that when the learning questions are contextualized in the situation instead of being formulated in a generic or thematic way, they result in a more specific search and amplify the critical and reflective process in the production of knowledge and interventions, both in real and simulated situations.

In relation to the critical factors that are responsible for success, I believe that the main one is the teacher's action as a mediator of learning. Promoting an open environment that respects differences, as well as being committed to an ethical and scientific construction of knowledge tend to potentialize the transformative role of education. Thus, the teacher's understanding of the meanings of the CS movements and his/her problematizing position favor the students' scientific spirit, reflection and creativity.

As for limitations, considering an educational initiative, the isolated use of the CS methodology does not guarantee a transformative education. To achieve it, the school must: reflect critically on the selection and organization of the contents to be processed in the situations; focus on the development of scientific, critical and reflective thought; invest in the qualification of facilitators as problematizing agents; diversify educational scenarios and experiences; and orient education towards the relevant problems of the society in which it is included.

Final remarks

Independently of the utilization of the constructivist spiral or other active teaching-learning methodologies, it is necessary to bear in mind that inertia represents a strong obstacle to be faced when we search for changes in educational practice. The polemic, still current, in relation to the transfer of the center of the process from the teacher and contents to students must be contextualized in relation to the proposal of education and school that the society desires for its future generations.

According to Snyders[66], the roles of education and of the school cannot be subsumed under the discussion about teaching-learning methodologies. This author's recent productions highlight the importance of joy in the learning process and, although related to the lines of research that view the school as a reproducer of inequality, these studies argue that the same education that is necessary for reproduction can be in the service of awareness-raising and liberation. Therefore, the more active,

critical, and reflective this process is, the higher the chances for us to produce changes in education and in society.

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