Constructivism: Constructing Meaning or Making Sense?

Regina M. Panasuk, PhD
Professor of Mathematics Education
Graduate School of Education
University of Massachusetts Lowell
61 Wilder Street, O'Leary 526
Lowell, MA, 01854, USA

Sumudu Lewis, PhD
UTeach Program Director/Master Teacher
University of Massachusetts Lowell
One University Avenue
Lowell, MA 01854

Abstract

Since the constructivism was resurrected in 1974 under the new name, radical constructivism, it stormed into many fields, including education. An enormous attention has been given to its ideas, principles and claims. It inspired many mathematics and science education programs and curricula, by proclaiming progressive methods in teaching, and broadcasting ideas such as active learning, constructing and negotiating meanings, and other. Apparently, 'some like it radical', some called it a 'power model', but some expressed concern about it as the 'most dangerous' intellectual tendency. This paper examines and challenges some assumptions and claims associated with so called constructivist learning theory.

Introduction

In this paper we are re-visiting some issues related to constructivism. In particular, we attend to the pandemonium around the reductionist view on constructivism and its classification as learning theory. It is alarming that the most accessible and commonly used source of information, Wikipedia, provides wide audience with astonishingly confusing language, terms and descriptions of constructivism. On one page of The Free Encyclopedia, constructivism is defined as an epistemological perspective in philosophy, compared with other philosophical trends (e.g., positivism, objectivism), and is presented as a product of the work of many ancient and modern philosophers, not learning theorists or psychologists. On another page, constructivism is defined as learning theory, and much space is devoted to discussion about so called constructivist teaching and learning and different methods of instruction. Clearly, it gives a message to those who want to get a quick reference, that constructivism and learning theory are identical twins. This is akin to proposing a rationalist or empiricist learning theory, moreover a rationalist or empiricist teaching methods.

Our interest here is to discuss the predicament of the identification of constructivism with a learning theory, and the unwarranted and exaggerated promotion of the teaching strategies under the umbrella of constructivism as being superior to alternative strategies. We also provide our perspective on the transformation of this epistemological school of thought into a theory of knowing, and later on into a theory of learning, which have led to frenzy of sensationalizing constructivism in mathematics and science education. Developing our argument, we use the terms (e.g., psychological, philosophical, learning theory) with particular care.

Declining and raising

At the turn of the twentieth century, behaviorism was a widespread psychological perspective, which rendered explanations about learning processes based on the relationship between observable behaviors and environmental events rather than on internal processes.

Behaviorist psychologists and learning theorists built their theories on the overarching philosophical belief that there is a single reality, and that objective knowledge can be acquired. Within the paradigm of behaviorism, the study of psychology was concerned only with the objective data of behavior. While the behaviorist research tradition was not a homogeneous one, and there existed a number of different schools of thoughts, behaviorism uniformly held that psychology should be concerned with the behavior of organisms, and not with mental states or with constructing internal mental events (e.g., beliefs, attitudes), which are personal entities that do not present accurate objects for empirical study. Generally, avoiding reference to mental events and entities, the basic task of behaviorism was to specify types of association, to understand how environmental events control behavior, and to predict how behavior will change with changes in the environment. This behaviorist perspective was a dominant paradigm and the major framework in the field of educational research and practice.

On the other end of the continuum running from experience-behavior-centered position to a mind-cognition-centered position of knowledge acquisition, the cognitive scientists asserted that cognition played a crucial role in learning, and questioned the core of the behaviorist theories. McKeachie (1974), in his *The Decline and Fall of the Laws of Learning,* pointed out that the weakness of behaviorist learning theory "is more fundamental" when "applied to human cognitive learning" (p. 8). He continued saying that "the laws of learning" had been fallen from supremacy, and must be replaced by "more complex structures" (p. 8). He also suggested that behaviorist principle of the "*Law of Effect* and even the principles of knowledge of results can no longer stand as the major support of learning " (p. 9). Skemp (1981) asserted that while behaviorist theories were successful in bringing about observable learning outcomes in laboratory animals, those theories were not adequate in providing explanations for, and controlling the higher forms of learning, which differentiates humans from laboratory animals.

The anomalies within behaviorist theory and persistent presence of research into cognition resulted in the "blurring" of the behaviorist "paradigm" (Kuhn, 1970, p. 84) in the mid of the twentieth century. Kuhn (1970) posited that in scientific research "a new paradigm emerges, at least in embryo, before a crisis has developed far or been explicitly recognized" (p. 86). Kuhn continued saying that when the field "can no longer evade anomalies that subvert the existing tradition of scientific practice" (p. 6), and when the accumulation of anomalies in a theory is impossible to ignore, the scientists eventually recognize the need for a new paradigm.

Recognition of the inevitability of "scientific revolutions" (Kuhn, 1970, p.6), coupled with common sense, does not necessarily mean 'throwing the baby out with the bath water'. Whilst we are aware of the limitations of behaviorism, which is embedded in the foundational principles of the theory, simple logic tells that we should not totally ignore or dismiss behaviorist learning theories. On the contrary, it seems rather wise to admit that behaviorist researchers provided the field with some valuable ideas, and contributed to various research studies in psychology, education, and methodology of teaching. For example, we would not advise to overlook or totally discharge the behaviorists' suggestion to think about learning as change in behavior. Although, such definition of learning is limited and does not address the cognitive component of learning, nevertheless it is not fatally incorrect or useless. We will get back to this definition later on.

In summary, the behaviorist paradigm did not provide complete foundation to address higher forms of learning, including the acquisition of concepts in mathematics and science. Thus, the limitations of the behaviorist theories and the lack of explanations of cognitive processes of learning, fueled a crisis in the field of educational research and practice. If we agree with Kuhn (1970) who asserted that "there is no such thing as research in the absence of any paradigm [and] to reject one paradigm without simultaneously substituting another is to reject science itself" (p. 79), then we must acknowledge that von Glasersfeld 's (1974) timely publication, *Piaget and the Radical Constructivism Epistemology*, was indeed the convenient replacement for the behaviorist paradigm.

Pandemonium or panache?

Radical Constructivism first invaded the literature in 1974 in the introductory passages of *Epistemology and Education: The Implications of Radical Constructivism for Knowledge Acquisition* by Charles Smock and Ernst von Glasersfeld. The authors stated that knowledge cannot be communicated nor taught, but is created by the knower. This concept has been the key idea of the radical constructivism, which they called "a theory of knowledge" (von Glasersfeld, 1981, para 3) and later on a "theory of knowing" (von Glasersfeld, 1989b, last para).

Soon, the theory of knowing had became very popular for various reasons in many fields, including mathematics and science education. At the same time, this newly proposed theory of knowing caused apparent division into the camps of enthusiastic supporters and disgruntled opponents.

During the decades, von Glasersfeld produced many publications which rendered some appealing and unique ideas related to his vision on theory of knowing. However, he was neither clear nor consistent in presenting his thoughts and arguments. Through careful reflection upon von Glasersfeld's work one can notice that he himself had occasionally used language and terms (e.g., epistemology, knowledge, knowing, learning) inconsistently, and wrote disjointedly thereby inviting multiple variations and interpretations of his postulates. The inconsistency, at times long-winded writing, and his attempt to explain learning process, which is not a category of epistemology, from the outside field (e.g., philosophy), coupled with different approaches people used when reflecting upon von Glasersfeld's ideas, led to numerous free lance elaborations and interpretations. This created a chaos in the field of education, and produced more puzzles than clarifications and plausible explanations. Many researchers and educators from different fields, through imposing their own meaning on radical constructivism, addressed the most widely debated topic sometimes in a shockingly superficial way (e.g., collaborative learning is the most effective constructivist method) without much awareness of the intellectual value of the philosophical ideas of constructivism.

In addition, as Mathews (1998) pointed out, many authors due to "intellectual laziness [had] manifest[ed] in 'piggy-back' argument, or argument by citation" presented arguments through a secondary source without referring to the original document (p. xii). Such laxity has added to the confusion and the production of a variety of interpretations, definitions, versions, embellishments, and even uses that were different from or tangential to von Glasersfeld's ideas. Consequently, in now days, there are numerous versions and forms of constructivism (Colburn, 2000; Fox, 2001; Geelan, 1997; Good & Wandersee, 1993; Irzik, 2001; Mathews, 2000; Mayer, 1997; Ogborn, 1997; Phillips, 1995, 1997). With all these variations littering the literature, one can only be amused at the comparison of constructivism to a "secular religion" with many sects (Phillips, 1995, p. 5).

The immense interest to von Glasersfeld and supporters' writings appeared during the exact time of active criticism of behaviorism and the urgent need for something fundamentally different that would replace behaviorism as limited theory of learning. The replacement was found in the charming and enticed constructivism, which had been conveniently reduced from philosophical category into learning theory for education (von Glasersfeld, 1983b; Graffam, 2003; Lerman, 1989; Ogborn, 1997; Richardson, 2003; Staver, 1998; Tam, 2000; Uzumtiryaki, et al, 2010; Wheatley, 1991).

As a result, many educational programs have been developed and advocated to teach mathematics and science under constructivist label. These programs, though appealing in appearance, practically didn't show any significant learning outcomes (e.g., Klahr & Nigam, 2004). Many programs proclaimed glorified teaching strategies that presumably work well for some teachers who employed certain teaching strategies within selected topics at a particular grade level. While there exist generalizations of local successes, they have not been supported by empirical data, and at times have been exaggerated by anecdotal exaltations (e.g., Wadsworth, 1997). Ultimately catchwords and catchphrases such as constructivist teachers and constructivist learning environments are now in circulation and have been used, at times, as a shock absorber for ideas of fixing education with constructivists approaches. Regrettably, they are nothing more than an offshoot of unfortunate alteration of the constructivism as a philosophical perspective (von Glasersfeld, 1974) into so called constructivist theory of learning.

We have already mentioned that von Glasersfeld's imposing constructivism into education opened the gates for multiple interpretations and frenzy, which have erroneously led to epitomizing constructivism as a learning theory. Although we acknowledge and appreciate von Glasersfeld's contribution to epistemology, we argue that he crossed into the realms of education and merged his version of acquisition of knowledge as 'meaning making and interpreting' (von Glasersfeld, 1981a, 1981b, 1983a, 1983b; von Glasersfeld & Cobb, 1983) with the process of learning, thus diluting the effectiveness of his own epistemological ideas and exposing himself to criticism, and even disparaging by some authors (e.g., Suching, 1992). Ironically, instead of ending the recurrent "fads and foibles of educational practices" as he intended to (von Glasersfeld, 1974, p. xvii), he introduced a new craze, resulting in a series of haphazard recommendations, and administrative decisions for teaching mathematics and science.

Sharing our position on this matter, we make a strong point of distinction between learning theory and epistemology. While we believe in the impact of epistemology on education, we assert that constructivist epistemology belongs to another discussion. We join the group of those (e.g., Fox, 2001; Jenkins, 2000; Mathews, 2000) who have drawn attention to the predicament of accepting constructivism as a learning theory.

Defining terms and conditions

For the sake of consistency, we formulate a set of definitions of the key terms (i.e., theory, model, epistemology, knowledge, learning, learning theory) to refer to when building arguments. We undertake this task to substantiate our discourse and position when analyzing literature, and to avoid misinterpretation, as much as possible.

Theories and models: Let us say that a *theory* is a system of hypotheses and general principles that had been formulated to explain a phenomenon. A hypothesis is not an educated guess as presented in some textbooks. Rather, it is a statement that is based on observations that are intended to be tested. To examine the hypotheses by applying general principles, *models* are usually used. Thus, a model can be viewed as a means by which a theory in general and its hypotheses, in particular, can be tested. Based on the above, a model is not synonymous with theory, but it is a tool to test the theory. If the principles that are claimed to constitute a theory are ambiguous or inconsistent, then it becomes problematic to create a model that would provide an accurate testing of these principles. A fuzzy or poorly structured model or incorrect data assumptions in the model can result in erroneous conclusions.

Epistemology and knowledge: We accept a common definition of epistemology as a branch of philosophy that aims to understand the extent of our knowledge (both priori and posteriori), the standards and criteria by which we can judge the reliability and the limits of our knowledge, and the means by which we acquire knowledge. We would like to stress that epistemology does not address the processes of acquiring knowledge.

It is not an easy task to define what knowledge is due to its diverse use in various domains. It can be viewed as knowledge of a discipline (e.g., scientific knowledge, mathematical knowledge), or as the type of knowledge within one discipline (e.g., conceptual knowledge, procedural knowledge). In the broadest sense, one can define knowledge as the familiarity or acquaintance with facts, truths, or principles of something, which includes people, places, objects, events, phenomena, information, and skills. We do not support the notion that acquisition of knowledge by individuals is always indicative of learning (see definition of leaning below).

Nola (1997) listed six kinds of knowledge based on the grammatical use the word know. He contended that if one knows something, it does not imply that one knows how to create his or her own knowledge or that one's knowledge is acquired through experience alone. Nola (1997) thus warned that constructivists, who ignore the range of epistemic uses of the word know (i.e., knowing how, knowing that, knowing why, etc.), could do serious damage to the concept of knowledge with consequences in education because different versions of knowing require different kinds of teaching and learning.

Learning and learning theories: Before defining learning and learning theory, we believe it is critical to distinguish "spontaneous" learning (Vygotsky, 2004, p. 351), or "non-systematic learning", and "systematic learning" (Vygotsky, 1978, p. 85). Spontaneous or non-systematic learning occurs when a child defines his/her own program of learning, most likely unconsciously or unplanned (Vygotsky, 2004, p. 351). Systematic learning occurs when a child's learning program is predetermined by curriculum and supervised by a teacher (Vygotsky, 2004, p. 351). Here we give a definition of learning theory, whose object of investigation is systematic learning. We stress the difference between learning theory, psychology (e.g., Piaget, 1960), and genetic epistemology (e.g., Piaget & Inhelder, 1969) because they have different objects of investigation and different set of foundational principles, yet approached and treated sometimes as identical theoretical constructs.

Let us assume that [systematic] learning is both a process through which students extend past experiences and acquire skills for solving all sorts of problems and tasks, and an observable evidence of how the students respond to teaching. Mathematics and science learning involves a range of actions and experiences that include problem solving and inquiry, practice and memorization. It can be said that learning is a change in both cognitive structure and behavior. One can describe theory of learning as a group of concepts, definitions, and principles that have been formulated in an attempt to a) explain the means by which individuals display changes in cognitive structure, behavior, attitude, or beliefs as a result of different mental and physical processes, and b) assess the changes.

Being explicit about the use of terms *know*, *knowledge*, *learning*, and *learning theory* is essential to explain the process of acquiring and assessing knowledge. Moreover, being able to clearly show how knowledge is linked to learning is even more crucial to the development of a learning theory with a certain epistemological foundation.

Sorting out lilies from the field

The most significant conceptualizations (e.g., a theory) tend to offer a rather homogeneous view and overarching ideas. Given multiple principles and models within a theory, some diversity across the views seems natural because researchers and scholars study different hypotheses in different contexts and deduce different conclusions, ranging from specifics to general.

It is a daunting task to sieve out the essence of the constructivist theory of learning because of its heterogeneity and the existence of various perspectives and interpretations. Such existence itself is an indication of the 'blurring ' within the paradigm itself, which has no singular and coherent theory, yet consists of many competing conceptions and models. Many people, who called themselves constructivists, added their own visions and interpretations, sometimes even questioning the core of the theory. In Lerman (1989) we read,

> "Constructivism has been described by two hypotheses: (1) Knowledge is actively constructed by the cognizing subject, not passively received from the environment. (2) Coming to know is an adaptive process that organizes one's experiential world; it does not discover an independent, pre-existing world outside the mind of the knower" (p. 211).

Lerman (1989) never referred to von Glasersfeld (1983) who actually coined the idea and the term *radical constructivism*, and who suggested these two principles (Quale, 2007; Wheatley, 1991). Lerman (1989) presented his own interpretation of "radical constructivism" as "a relativist epistemology" (p. 217), referring to “weak” and “radical” constructivists (pp. 211-212), and outlined his aim to “examine what radical constructivism might mean in mathematics, and propose some implications for mathematics education” (p. 213). In the next sub-sections we analyze several premises that claim to be the principles of the so called constructivist learning theory.

Individuals actively construct their own knowledge; they do not passively receive it from the environment

Promoting constructivism, its advocates link it to “ideas of empowerment and emancipation,” thus presenting constructivism somehow superior to any other learning theory (Mathews, 1997, p. 5). This is evident from the claim by Wadsworth (1997), who stated that

> "Children learning science through the constructivist approach are noticeably different from children learning by a more passive method. They are generally confident speakers, prepared to listen to the ideas of others and to argue their own point of view. They can work collaboratively and set about finding ways of checking whether their ideas are valid" (p. 24).

This quote induces a discussion about active and passive learning.

The constructivist claim that "knowledge is actively constructed "(von Glasersfeld, 1991, p. 5), resulted in the self-reinforcing statements that "learning is an active process" (Duffy & Cunningham, 1996), and had seduced the educators to believe that if the students are not active in the classroom, then they are not learning. Von Glasrsfeld (1974) introduced radical constructivism first as an epistemology, referencing Piaget's work (1937/1953) in psychology, before Piaget called himself genetic epistemologist, as a scientific basis of his version of constructivism. Traditionally, it had been other way around; natural and social sciences, including psychology, built their principles on and drew from philosophical perspectives. If we assume that constructivism is one of the epistemological perspectives (e.g., Vico, 1710; Rubinoff, 1976), then radical constructivism seems takes a new direction from the historical tradition. Key concepts of Piaget's (1960) theory that described the mechanism of cognitive development via closely related "assimilation and accommodation" (pp. 7-8), are biological concepts *'going on'* psychological. Assimilation provides the platform for accommodation, modification and adaptation, i.e., construction of the new "re-presentation" (von Glasersfeld, 1984, p. 5) in the existing cognitive schema. Some (e.g., Cobb, Yackel & Wood, 1992; Tobin, 1998; von Glaserfeld, 1990) misinterpreted Piaget (1960), stating that reality is actively constructed, not passively assimilated from the environment. However, according to Piaget (1960), assimilation is not "a passive submission" (p. 8) but a process of incorporation of experience into already existing cognitive structure.

This notion of active learning versus passive learning is a fundamental malfunction imposed by constructivist learning theory. In our view, learning is an active process by definition of learning in any educational discipline. It is a cognitive process, and all cognition is undoubtedly active as it involves some sort of the action in the brain. If there is no brain activity, there is no learning. But of course, not every brains activity can be qualified as learning. In this connection, we point out that listening to a teacher is not necessarily a form of so called passive learning in comparison to talking and doing, which have been solely viewed as active learning. Apparently, Clements and Ellerton (1992) have an opposite view on mathematics learning, asserting that

> “mathematical knowledge is not something that is acquired by listening to teachers or reading textbooks, but is something that learners' themselves construct through actively seeking out, and making, mental connections. When someone actively links aspects of his or her physical and social environments with certain numerical, spatial, and logical concepts a feeling of ‘ownership’ is often generated” (p. 263).

First of all, the word 'feeling' is quite troubling, because feeling cannot serve as a measure of learning. Feeling is super vague, unreliable, and biased psychological construct, which has no validity when it comes to assessing learning outcomes. Second, Clements and Ellerton (1992) interpreted the constructivist claim of being active via the idea of "ownership", but they had not specifically elaborated on how the "ownership" would emerge and be assessed by both the student and the teacher. Third, the authors send a clear message devaluing the significance of very important academic skills, listening and reading, the students need to learn in school.

Given the nature of mathematics and science and their symbolic language to communicate abstract ideas, well-structured and coherent instruction is critical. At the same time, the learning mechanisms, assimilation and accommodation, are "functional aspects of structure-formation" (Piaget, 1970, p. 71), thus cannot be instructed. Since learning results in the learner's cognitive and behavioral change, this change can only be caused by what the learner does him/herself. The effect of teacher instruction is merely the degree to which the teacher can engage and facilitate the learners' activities, cognitive or hands-on, or both. It is the effectiveness and efficiency of instruction that influences the activation of prior and the acquisition of new knowledge and its integration into prior structure. We stress here that probable ineffectiveness of the direct instruction, or any instruction, is nothing more than an outcome of the flaws of methodological design and implementation of the planning into classroom instruction, rather than the idea of direct or explicit instruction itself. We argue that direct instruction can be as effective as any other type of instruction. We do not support the position that students are necessarily passive when listening to a teacher or observing how the teacher is modeling reasoning process, or explaining a complex concept in science and mathematics. Furthermore, actively ‘doing’ something does not guarantee the students' genuine engagement in a cognitive process that will result in learning, either concepts or transferable skills.

Whether one is listening to the teacher, talking, carrying out some practical activity, trying to memorize facts, taking notes, or reading, one is engaged in cognitive and physical actions. When these actions promote a noticeable change in the learner, and this change can be assessed, learning takes place. We assert that learning cannot be explained in terms of active or passive. Learning, if occurs, is always active.

Knowing is an adaptive process involving the organization of an individual’s experiences; there is no independent world outside the mind of the knower

Perhaps one of the revealing signs that a theory has flaws is when the advocates themselves publically declare fundamental concerns. Even the supporters of constructivism recognize the second principle as being rather controversial and worry-some (Lerman, 1989; Quale, 2007; Wheatley, 1991), and a subject to "debate for philosophers" (Lerman, 1989, p. 211).

The concept of knowing as an adaptive process seems a subject of the field of psychology, while the premise about non-existence of the world outside the mind of the knower clearly belongs to philosophical discussion. The disorder with constructivist *'elephant and blind men'*, the assortment of ideas and views from unrelated categories of different fields, e.g., psychology and philosophy, are forcing those who try 'constructing meanings' of the constructivist field to constantly make 'long ways around' comments and detours in order to build coherent arguments, in particular, when it comes to the claim of the "independent world outside the mind of the knower" (Lerman, 1989, p. 211).

In relation to systematic mathematics and science learning, studying "fundamentals of scientific knowledge" (Vygotsky, 1978, p.84) goes beyond what students would experience in their day-to-day interactions with the environment. Mathematics and science, as external to a learner systems of representations (Goldin & Shteingold, 2001, p. 2), have their structures, which throughout their historical development have already been created, revised and refined.

Once a system of external representations is established and structured, then the rules, relationships and other elements of the system are not longer random or arbitrary, yet are subject to further refinement and expansion by scientists. Other words, there exists a ready-made system of mathematics and science, external to the learner's world, within its structure and organization of relationships, to be learned. In the classroom, mathematics and science principles, as a part of the established external system, can be inquired, discovered or revealed and applied when solving problems of all kinds. Cobb, Yackel & Wood (1992) suggested that "overall goal of instruction is to help students construct mental representations that correctly or accurately mirror mathematical relationships located outside the mind in instructional representations" (p. 4). Yet, they referred the idea of "representational view of mind" as "pragmatic considerations" (p. 4). Practically, they suggest that radical constructivism rejects the representational view of mind (p. 6). In general, the claim that the mind represents the world accurately or completely is a subject of the debate about the nature of knowledge, and is a philosophical issue. We don't deny that philosophical beliefs affect our views on psychology and education, in general. However, we maintain that since the objects of study in philosophy, psychology and education are different by nature, they cannot be addressed by the same models of reasoning and methods. Unfortunately, we are constantly facing the problem created by the contemporary constructivist field where philosophy, psychology and education are tangled, viewed and addressed jointly.

Specifically, in mathematics and science classroom, one of the educational goals is to facilitate in students the development of the internal representations of the established external system of representations, which in turn will be manifested by certain competencies. Mathematics and science competences depend on the existence in students the basic symbolic structures or mental images that allow them to respond to the problems or tasks with accuracy and fluency. For example, if a student has developed conceptual understanding of linear equations with one unknown (Panasuk, 2010; Panasuk & Beyranevand, 2011), then the student is able to respond to the problem, *Ann and Tom together have $28. Ann has $10 more than Tom. How much has Tom?* The equation, $x + 10 = 28$, would precisely and objectively (or unbiased) describe the true relationship between the quantities. The process of internalization of the external representations in mathematics and science (e.g., the notions of unknown and variable, formal algebraic notations, Newton's laws, etc.) can be described as building conceptual understanding, rather than constructing meanings. The constructivist idea of constructing meanings seems unfit to mathematics and science education, and even the pairing the words is presumptuous. For instance, the concept of fraction in mathematics has already established conventional meanings. Under some conditions, a fraction (Long & DeTemple, 2000, p. 355) can be used to represent a part of a whole; while under other conditions a fraction can be used to describe a ratio or a quotient. Since the meanings of fractions have already been determined and described, learners are expected to develop conceptual understanding of the concept by connecting and associating the intended meaning with their prior conceptual structures. Thus, the idea of constructing meaning and, associated with it the concept of "interpretation" (von Glasersfeld, 1983a, p. 6), seem blurred.

Do we construct or negotiate, or make sense?

Of course, the internalization of the external representations in mathematics and science by the learner may bring about inadequate internal representation (or as we might call it misconception) of the existing relationship. In attempt to link constructivism with learning, von Glasersfeld (1983b) wrote that despite the "difference between the interpretation of experience and the interpretation of language … [b]oth rely on the use of conceptual material which the interpreter must already have", and he referred to this as making sense, which is the "means [of] finding a way of fitting available conceptual elements into a pattern that is circumscribed by specific constraints" (para13). He further elaborated on this by implying that "if our interpretation of experience allows us to achieve our purpose, we are quite satisfied that we 'know'; and if our interpretation of a communication is not countermanded by anything the communicator says or does, we are quite satisfied that we have understood" (para 13).

This notion is captivated in constructivism writing to mean that making sense of our experience is equivalent to meaning making (Cobb & Steffe, 1983; Hardy & Taylor, 1998; Splitter, 2008; Wheatley, 1991), and is further evident in the following quote, which appears to sum up the constructivist view of learning:

> "learning would be viewed as an active, constructive process in which students attempt to resolve problems that arise as they participate in the mathematical practices of the classroom. Such a view emphasizes that the learning-teaching process is interactive in nature and involves the implicit and explicit negotiation of mathematical meanings" (Cobb, Yakel, & Wood, 1992, p. 10).

The use of the encumbered terms, such as meaning making, negotiation of meaning, and making sense, provides very little help to understand what learning is and how learning outcomes can be revealed and assessed. We wonder, how one can negotiate meanings "interacting with symbolic realities" (Driver, et al 1994, p.7) such as function, equation, second law of thermodynamic, etc. Referencing to the earlier stated definition, we assert that learning mathematics and science cannot be described by the notions of constructing or negotiating of meanings.

Helping students to develop conceptual understanding.

We agree with Fox (2001) and Jenkins (2000) that it is crucial for teachers to be aware of how students make sense of the concepts and relate the new concepts to their prior experiences. It is unlikely that educators would argue that the teacher's role is to design the students' experiences that would motivate and engage them in meaningful cognitive activities resulting in measurable learning outcomes. The issues and disagreements arise when prescriptions and rigid conditions are strongly advised and advocated that if closely abided, would guarantee the best results. Colburn (2000), vigorously promoting constructivist teaching strategies, mainly referred to physical engagement of students into doing something, e.g., group work, hands-on, talk, projects etc., which have been labeled as student-centered. First, all these 'doings' are rather forms of organization of learning, without referencing or connecting to the content, thus the discussion of their effectiveness has no ground and is futile. Second, phraseology, i.e., student-centered environment, seems excessive accentuation of the centrality of the learner in the learning process.

Since, we have already addressed the issue about passive learning as non-existence, here we point out that endorsing so called constructivist activities, which are supposedly grounded in constructivist learning theory, had the damaging effect and raised the problems constructivism had constructed in education. In various appropriate settings and under certain conditions, some forms of learning, e.g., social and individual making sense of a scientific concepts, discovery, hands-on activities, could be useful. However, they were proposed as the most important for meaning making. Moreover, it was even declared that for constructivists the cooperative learning is a primary teaching strategy (Tobin, 1998). A self-respected researcher knows that it is next to impossible to set up a valid study to collect empirical evidence on so called effective strategies due to enormous complexity of design, myriad variables, and inevitable bias about what best strategy really is and its implementation. Any proclamation of such marvel may give to classroom teachers misleading idea and deposit the belief that such strategy exists.

Devaluing direct instructions.

The constructivist claim that knowledge cannot be instructed but can only be constructed, presumably can make sense. However, it seems unjustifiable to assert that what is learned is not influenced by direct explicit instruction. Although, there is a great deal of research showing that, under certain circumstances, people are better at remembering information they create themselves than information they receive by other means (Bobrow & Bower, 1969; Slamecka & Graf, 1978), it does not imply that people do not remember what they are told. Indeed, in other cases people remember as well, or even better information that is provided than information they create (Slamecka & Katsaiti, 1987; Stein & Bransford, 1979). The classical example is the Biederman and Shiffrar's (1987) research study about sexing the eggs, which documented that structured several minute direct instruction brought novices up to the levels of experts.

Direct instruction, as defined by Kirschner, Sweller, and Clark (2006) is "providing information that fully explains the concepts and procedures that students are required to learn as well as learning strategy support that is compatible with human cognitive architecture" (p. 75). They continue saying that the human cognitive architecture is being the "manner in which our cognitive structures are organized" (p. 76).

Kirschner, Sweller, and Clark (2006) further defined learning as "a change in long-term memory" (p. 75), and the long-term memory as the "central dominant structure of human cognition" (p. 76). Then, the aim of an instructional strategy is to create a change in the long-term memory. If there is no change in the long-term memory, then there is no learning. The working-memory is where conscious processing occurs; when processing novel information that had not been stored in the long-term memory, the working memory is limited in duration and capacity.

Not surprisingly, the constructivist approach to instruction has different interpretations. While Mathews (2000) contends that constructivists do not want to be associated with discovery learning, Cobb (1999) affirms that constructivism is reminiscent of the discovery approaches to learning, and says that learners learn best what they discover. Kirschner, Sweller, and Clark (2006) question the constructivist approach that rely on minimal guidance where students are allowed to 'make sense' of information through discovery learning. This is yet another example of the equivocal nature of constructivism in education. In any case, Kirschner, Sweller, and Clark's (2006) concern is that this constructivist approach to instruction proceeds as though the working memory does not exist, or has no limitations when dealing with novel information. Reviewing evidence from controlled experiments obtained from multiple studies, Kirschner, Sweller, and Clark (2006) documented that in science classrooms, where minimal guidance and minimal feedback approaches were employed, students were often lost, confused, or frustrated, and harbored misconceptions, compared to students in classrooms where explicit instructions were given and where learning was evident. Therefore, this indicates that there is a value in direct instruction, and it should not be discarded or labeled with negative connotation as a 'traditional' teaching method.

Conclusion

For several decades, constructivism has been a widespread multifaceted perspective, which struggled to render explanations about learning. Constructivists theorists and researchers developed their ideas and built theories on a set of principles, which rooted in different layers of philosophy and psychology, generating more questions than explanations. Confusion created by constructivism's foot in education as a learning theory is well harvested now, and probably irrevocably. At times, constructivist ideas are merely teaching strategies, upgraded and wrapped into a sophisticated language, which might be perceived as a theory to entice educators to use in order to maximize the learning outcome of every child in the classroom.

The use of grandiloquent language, overwhelmed with new terms and notions that rather confuse than clarify (e.g., learner-centered environment, construction and negotiation of meanings) and claim more than explain, contributed greatly to "the gap between pedagogical rhetoric and the reality of the classroom practice" Jenkins (2000, p. 607). Clearly, one should be able to see that the very foundation of the so-called 'constructivist theory of learning' has been collapsing. Even the advocates of constructivism acknowledge that it is smothered with controversies. It is rather obvious that constructivism, though taking its time, is falling from supremacy because its paradigm is "blurring" (Kuhn, 1970, p. 84). The accumulation of anomalies is impossible to ignore.

It appears that such complex process as learning, cannot be explained exclusively through one or another influential school of thoughts; each has something to offer. In the quest for a theory that would better explain learning, perhaps one might explore the possibility of consider merging cognitive and behavioral perspectives. Re-evaluation of existing learning theories, even marked with limitations and incompleteness, might give a raise to a new paradigm in education and influence the development of a new theory supported by strong empirical and theoretical bases; the theory that will be adequate to take in responsibility to bring about well-established principles of learning, and consequently educational practices to facilitate students' acquisition of knowledge.

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