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Learning and Adaptation in the Theory of Constructivism

Abstract: Learning and adaptation are conceptually distinct and refer to different processes. Both concepts are incorporated in Piaget's *genetic epistemology* and in the more radical constructivist model of cognition that has sprung from it. Misinterpretation of the different roles the two terms play in that theoretical model is one of the reasons why the constructivist approach has often been misunderstood by educators. In this paper I shall lay out the use of the two terms in the constructivist theory and give some indication of its application to learning and the practice of teaching.

THE CONCEPT OF ADAPTATION

In everyday language the difference between the terms learning and adaptation is sometimes blurred because both refer to a fundamental requirement. If we were not adapted to our environment, we would be unable to survive, and if we could not learn, we would die of our mistakes. For the biologist, however, there is an important difference: adaptation refers to the biological make-up, the genetically determined potential with which we are born; and learning is the process that allows us to build up skills in acting and thinking as a result of our own experience.

Another way of bringing out this difference would be to explain that biological adaptation is the result of accidental mutations in the genes that determine possibilities of development, whereas learning can be engaged in deliberately in view of goals that we or others choose. This means that learning is an activity that we, consciously or unconsciously, have to carry out ourselves. In contrast, the basic meaning of adaptation is not an activity of organisms or species. I am here not concerned with the much looser meaning of the word in everyday language, where it may refer also to deliberate modifications (e.g. we adapted our plan to the change in the weather). Adaptation in the technical sense, merely ascribes, to whatever organisms are alive today, the physical and behavioral characteristics that are necessary to survive and have offspring in their present environment.

What further tends to mislead about the biological meaning of the term adaptation, is its definition as the outcome of a process called *natural selection*. This seems to relate the process to the deliberate, goal-directed selecting that is done, for example, by breeders of dogs or horses. Natural selection, in contrast, happens quite aimlessly as the result of changes in the environment which simply wipe out all those that do not have the characteristics necessary for survival. In this context one should emphasize the fact that the characteristics that enable an organism to survive a given environmental change, have to be present in the organism *before* that change occurs; and since the theory of evolution holds that modifications of the genetic make-up must be caused by mutations, the adaptedness of living organisms can be credited only to accidental variations.[1]

Piaget started out as a biologist and began to investigate what he considered to be manifestations of 'intelligence' (using the term in a wider sense than is usual). It began with his early discovery that mollusks of the same species were able to produce offspring that developed different and appropriately shaped shells, if they were transplanted from still to fast-flowing water or vice versa. It was a change of physical structure that did not involve a change in the mollusks' genetic make-up. He saw this as the effect of environmental constraints that foreclosed all but the viable developmental possibilities of the organism. Hence it was a form of *adaptation* that was closer to learning — the natural selection that produced it did not eliminate other potential developmental pathways in the genome, but only in the individual mollusks in question. Their offspring, if placed in another environment, could develop different shells which, relative to the new constraints, were again adapted.

Seen in this way, the concept of adaptation could be incorporated in a theory of learning. In my view, this is the major contribution Jean Piaget has made to our understanding of cognition. Eventually this perspective led him to the conclusion that the function of intelligence was not, as traditional epistemology held, to provide cognitive organisms with 'true' representations of an objective environment. Rather, he began to see cognition as generator of intelligent tools that enable organisms to construct a relative *fit* with the world as they experience it.

Though the notion of 'fit' was borrowed from the biological concept of adaptation, it no longer contained the element of preformation or genetic determination in the cognitive domain. Here it was the product of intelligent construction, of the organism's own making, as the result of trial, error, and the selection of what 'works'.[2] As the presence of various potential patterns of development enabled mollusks to grow shells that were adapted to the constraints of their actual environment, so the conceptual constructs of cognitive organisms could be developed to *fit* experiential requirements. Fit or viability in the cognitive domain is, of course, no longer directly tied to survival but rather to the attainment of goals and the mutual compatibility of constructs.

To make clear and emphasize the instrumental character of knowledge, be it on the level of sensorimotor activities or conceptual operations, I have always preferred the term *viability*. It seems more appropriate because, unlike 'fit', it does not suggest an approximation to the constraints.

During the last two decades of his life, when Piaget had realized that his theory had much in common with the principles formulated by cybernetics,[3] he shifted his focus from the chronology of development in children to the more general question of the cognitive organism's generation and maintenance of *equilibrium*. In this regard, too, room was left for misunderstandings, because the term was not intended to have the same meaning on all levels of cognition. On the biological/physical level, an organism's equilibrium can be said to consist in its capability to resist and neutralize perturbations caused by the environment. On the

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1 This is in no way changed by recent hypotheses that environmental stress or 'pressure' may accelerate the rate of mutations, because the mutations as such are still random events.

2 In principle this is what Campbell (1960) called "blind variation and selective retention"; I would only add that, in the cognitive domain, the blindness is sometimes tempered and partially overcome by analogical thinking.

3 Cf. Cellérier et al., 1968, and Piaget, 1977.

conceptual level, however, the term refers to the compatibility and non-contradictoriness of conceptual structures.

SCHEME THEORY

As a biologist, Piaget was well acquainted with the notion of *reflex* and he investigated the phenomenon in his children. Since infants manifest some such 'fixed action patterns' as soon as they are born, they must be considered the result of genetic determination rather than learning. Whereas most developmental psychologists seemed satisfied with that explanation, Piaget focused on the fact that this genetic determination was likely to be the result of natural selection. In other words, he considered that these action patterns arose through accidental mutations and spread, because they, rather than others, had consequences that were conducive to survival. He therefore saw reflexes not as they are usually depicted in textbooks, *viz.*:

STIMULUS → ACTIVITY (RESPONSE)

but as composed of three rather than two parts. The third part was the result of the activity that was crucial for the perpetuation of the reflex. On the basis of the organism's past experience, this result could be *expected*, and thus open the way to cognitive applications:

1		2		3
PERCEIVED	→	ACTIVITY	→	BENEFICIAL or SITUATION EXPECTED RESULT

This addition was legitimate because, although reflexive action patterns are 'wired in' and remain fixed for a certain time, they can eventually be modified or even dismantled by the organism's experience. Adults, for instance, no longer manifest some of the reflexes that helped them to find the mother's nipple when they were infants.

Piaget thus adopted the three-part sequence of the infant's reflex as the basic structure of goal-directed sensorimotor activity. He called it *action scheme* (*schème*[4]) and built on it, with the help of his concepts of *assimilation* and *accommodation,* a revolutionary learning theory.

The student of Piaget's writings, however, will not find this theory neatly formulated and described in any one place. Its development, presumably, took time and was spread in bits and pieces over a number of different publications (e.g. Piaget, 1937, 1945, 1967). As Bärbel Inhelder, Piaget's constant and most important collaborator, remarked, "the notion of scheme has given and is still giving rise to different interpretations" (Inhelder & de Caprona, 1992, p.41). The interpretation I am presenting here has proven the most useful in our applications.

In the Piagetian action scheme, assimilation can be operative in two places. In part 1 it is involved in the recognition of a perceived situation as the sort with which the particular action is associated. Since no two experiential situations are ever exactly the same, the *recognition* of a situation entails being unaware of certain differences. If another observer — e.g., the psychologist who observes the child — notices such a difference, he or she will say that the child is assimilating the new situation to a specific past experience. From the point of view of the child, however, especially if it is a young child, there *is* no difference. The situation is simply perceived as the situation that led to a successful activity in the past. (As adults, of course, we frequently 'assimilate' deliberately and mostly remain aware of doing it — e.g., when we are using a table knife as screwdriver, knowing full well that it is not a screwdriver and was not intended for that purpose.)

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4 Piaget occasionally used the word *schéma* to designate standardized patterns or simplified representations but never in the same sense as *schème;* hence Piaget's meaning is wholly obscured if the second term is translated as "schema".

The second place of assimilation in an action scheme is in the recognition of part 3 as the result expected of the activity. If that result fits the expectation, that is, if the child remains unaware of any differences, the action scheme will be considered a success and will be strengthened as a repeatable pattern. In contrast, if the result of the activity is such that it cannot be assimilated to the expectation, there will be a discord and thus a *perturbation*. This perturbation may be disappointment or the surprise caused by an interesting novelty. In both cases it may open a path to *learning*.

LEARNING AND TEACHING

The possibility of learning arises when the perturbation is serious enough to direct attention to the situation that triggered the activity. In that case one of the differences that were disregarded owing to the assimilation of the perceived situation, may now be noticed; and this, in turn, may lead to a modification of the perceptual requirements of the scheme or to the formation of a new one. Both would constitute an *accommodation*. Similarly, the failure of the original action scheme may point attention to the activity, which may again lead to a modification and thus to an accommodation.

I want to emphasize that I have so far spoken only of the sensorimotor level. A constructivist exposition of learning on the conceptual level would have to begin with Piaget's theory of *reflective abstraction* (Piaget, 1977a, vols.1 & 2) which I have discussed elsewhere (cf. Glasersfeld, 1991b). In this context, I can merely point out that the three-part model of the action scheme remains a powerful analytical tool in the domain of reflection, but there, obviously, the perceptual situation is replaced by a conceptual one, and the activity by a mental operation; and perturbations are no longer caused by unexpected perceptual results but by relational surprises, such as the breach of an expected regularity or an operational result that is incompatible with other conceptual structures,

The basic principle of the constructivist theory is that cognitive organisms act and operate in order to create and maintain their equilibrium in the face of perturbations generated by conflicts or unexpected novelties arising either from their pursuit of goals in a constraining environment or from the incompatibility of conceptual structures with a more or less established organisation of experience. The urge to know thus becomes the urge to *fit*, on the sensorimotor level as well as in the conceptual domain, and learning and adaptation are seen as complementary phenomena.

If one accepts this principle, one can no longer maintain the traditional idea of knowledge as representing an 'external' reality supposed to be independent of the knower. The concept of knowledge has to be dismantled and reconstructed differently. This is a shocking suggestion, and I have elsewhere laid out the reasons for such a radical step (Glasersfeld, 1985). I have called my position *radical* constructivism to accentuate the changed concept of knowledge and to differentiate myself from those who speak of the construction of knowledge in the framework of a traditional epistemology. I want to emphasize, however, that radical constructivism is intended as a model, not as the description of a real world, let alone a metaphysical proposal. It is intended to be used as a working hypothesis whose value can lie only in its usefulness.

APPLICATIONS AND SUGGESTIONS

In the past ten years the beginnings of a constructivist approach to teaching have been developed and applied in practice (Clement, 1991; Cobb et al., 1992; Confrey, 1990; Désautels & Larochelle, 1989; Dykstra, D.I., 1991; Glasersfeld, Ed., 1991a; Steffe, 1991). Some of these applications are now yielding longitudinal studies with elementary school classes followed over two or three years. The preliminary results are extremely promising in that they show children who are *learning to learn* (cf. Cobb et al., 1992)

The teaching procedures that are based on the constructivist theory do not claim novelty or originality. Good teachers have always known all this and more, but they did not find it in the traditional dogma of instruction. They came to it by intuition or as a result of many trials and failures. Constructivism provides a model of cognition that leads directly to a method of teaching that credits the student with the power to become an active learner. Some tentative directives can be summarized as follows:

1. Training aims at the ability to repeat the performance of a given activity and it must be distinguished from teaching. What we want to call *teaching*, aims at enabling students to generate activities out of the understanding *why* they should be performed and, ultimately, also how one can explain that they lead to the desired result.
2. Knowledge has to be built up by each individual learner, it cannot be packaged and transferred from one person to another.
3. Language is not a conveyor belt or means of transport. The meaning of words, sentences, and texts is always a subjective construction based on the individual's experience.[5] Though language cannot 'convey' the desired constructs to students, it has two important functions: it enables the teacher to orient the students' conceptual construction by means of appropriate constraints; and when students talk to the teacher or among themselves in groups, they are forced to reflect upon what they are thinking and doing.
4. Students' answers and their solutions of problems should always be taken seriously. At the moment they are produced, they mostly make sense to the student even if they are wrong from the teacher's point of view. Ask students how they arrived at their answer. This helps to separate answers given to please the teacher from those that are the result of understanding or misunderstandings.
5. Only a problem the student sees as his or her own problem can focus the student's attention and energy on the genuine search for a solution.
6. Rewards (i.e. the behaviorists' external reinforcements), be they material or social, foster repetition, not understanding.
7. Intellectual motivation is generated by overcoming an obstacle, by eliminating a contradiction, or by developing principles that are both abstract and applicable. Only if students have themselves built up a conceptual model that provides an explanation of a problematic situation or process, can they develop the desire to try their hand at further problems; only success in these attempts can make them aware of their power to shape the world of their experience in a meaningful way.

This sample of constructivist directives is far from complete, but it illustrates the thrust of our effort. Without distorting it too much, one could say that constructivism does not invent a new didactic method, but it shows the teacher what *not* to do, and it suggests an attitude of respect towards the student. If we want to teach thinking, we must have the faith that students are able to think and we must provide them with opportunities to do it. Where this has been practised, it has tended to show that both teachers and students can come to profit from their interactions and at the same time find them enjoyable.

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5 This must not be understood as a negation of the role of social interaction which causes the unceasing 'adaptation' of individual meanings.

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