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Chapter 2

CONSTRUCTIVISM AS EDUCATIONAL THEORY: CONTINGENCY IN LEARNING, AND OPTIMALLY GUIDED INSTRUCTION

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ABSTRACT

Constructivism is a major referent in education, although it has been understood in various ways, including as a learning theory; a philosophical stance on human knowledge; and an approach to social enquiry. In terms of informing teaching, constructivism has variously been seen by different commentators as a basis for progressive, mainstream or failed approaches to pedagogy. This is unfortunate, as the different ways the term has been interpreted have confused debate about the potential of constructivism to contribute to planning effective teaching. This chapter sets out the basis of one version of constructivism: that which is informed by findings from both cognitive science, and from educational studies exploring learners' thinking about curriculum topics and about classroom processes. A key concept here is the way in which new learning is contingent on features of the learner, the learning context and the teaching. This version of constructivism (which has been widely embraced) offers a theoretical basis for designing effective pedagogy that is accessible to classroom teachers.

The chapter will explain that although constructivism understood this way certainly offers the basis for learner-centred teaching, it is far from 'minimally-guided' instruction, as caricatured by some critics. Rather, a feature of this approach is that it does not adopt doctrinaire allegiance to particular levels of teacher input (as can be the case with teaching through discovery learning, or direct instruction) but rather the level of teacher guidance (a) is determined for particular learning activities by considering the learners and the material to be learnt; (b) shifts across sequences of teaching and learning episodes, and includes potential for highly structured guidance, as well as more exploratory activities. When understood in these terms, constructivism provides a sound theoretical basis for informing teaching at all levels, and in all disciplines.

Keywords: Constructivism; learning theory; contingency in learning; designing instruction; evidence-based pedagogy.

INTRODUCTION

This chapter presents the basic tenets of constructivism as a learning theory, and so as a basis for developing pedagogy and designing curriculum and instruction. It is argued that constructivist pedagogy draws upon educational theory informed by research and broad scholarship, and so provides a sound foundation for evidence-based practice.

Unfortunately constructivism has become a widely adopted slogan that has been applied in different ways in various contexts. It is, *inter alia*, used to label qualitative approaches to research, various ways of thinking about learning and cultural reproduction, and approaches to pedagogy. The different associations of constructivism are so diverse, that constructivism in education has been variously seen as progressive, as the basis of current good practice, and as *passé*. Within science education, for example, constructivism has been considered as the accepted paradigm for thinking about learning, as a well-stabished principle now widely taken for granted, and as a philosophically dangerous tendency that undermines science through relativism. Some of those who consider constructivism in education to be progressive describe it as a student-centred approach, and some critics characterise constructivist teaching as 'minimally guided instruction' – although this is certainly not how most educators who consider themselves constructivists would understand their approach.

Given the wide range of different understandings of the term, it would be folly to make a claim for what 'constructivism' actually is: constructivism is clearly many things to many people. However, the present chapter is concerned with *constructivism as the basis of educational theory*, as it is generally understood by those educators who have developed constructivist approaches to thinking about teaching and learning. Constructivism as educational theory comprises of ideas about how human learning occurs, and the factors that tend to channel learning; and ideas about how curriculum and instruction should be designed to best respond to educational purposes, given what is understood about learning.

A CONSTRUCTIVIST PERSPECTIVE ON LEARNING

The constructivist perspective on the nature of learning (Bodner, 1986; Glasersfeld, 1989; Larochelle, Bednarz, and Garrison, 1998; Novak, 1993; Phillips, 2000; Sjøberg, 2010; Taber, 2009b) can be seen as part of a long tradition in educational thought (Egan, 1984), but in its modern form has as its basis how people make sense of their experience. It might be understood in terms of a shift in the location of the meaning of what is found in our environment.

A traditional, commonsense, way of thinking about this is represented in figure 1. This assumes that the learner comes to knowledge by recognising the meaning of what is found in the environment. So the object or event in the environment – this could be anything: a chair, a chemical reaction, a utility bill on the doormat, a sentence read from a novel, the utterance of a teacher in a classroom – is assumed to have some inherent meaning, which the learner is able to identify, and so add to their store of knowledge about the world. Perception is about recognising the inherent meaning of what is experienced.

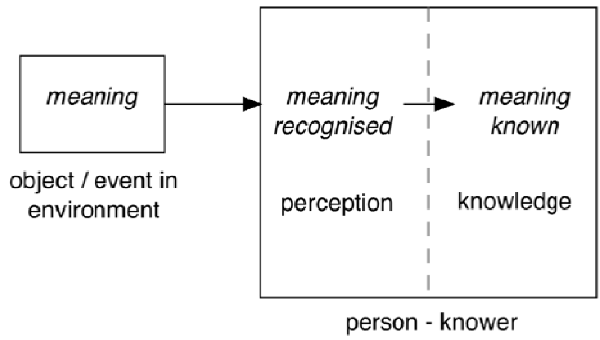

Figure 1. A traditional view of how we come to knowledge.

This perspective makes sense in many situations. After all a chair does have an inherent 'meaning', at least in the sense that it is created with a particular function in mind. Similarly, when the teacher tells the class that 'Paris is the capital of France', the utterance is motivated by the intention to communicate a specific meaning, and pupils need to recognise *that* meaning if they are to acquire the knowledge that is represented in the teacher's words.

In human societies most of the knowledge we acquire is based on what is already part of the pool of available cultural knowledge. A primary rationale for formal education, then, is to allow 'reproduction' of this knowledge. The commonsense view of how schooling works is based on a folk model of learning as based on knowledge transfer, or more accurately knowledge copying from one mind to another (figure 2).

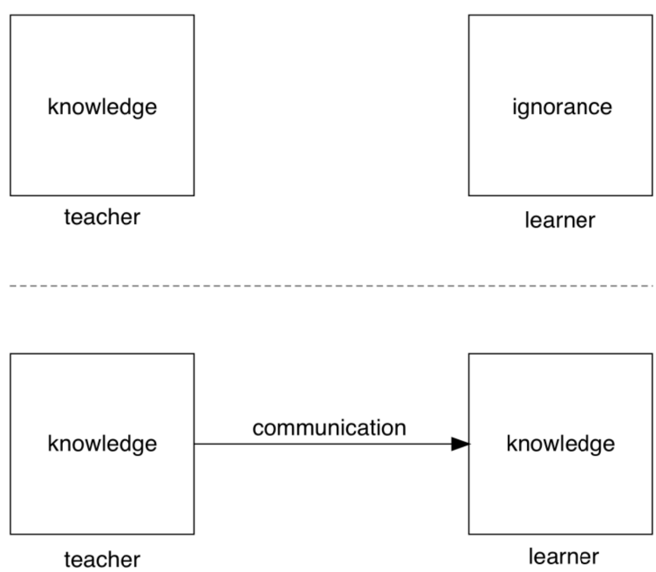

Figure 2. The folk model of teaching is that somehow the teacher's knowledge is copied into the mind of the learner.

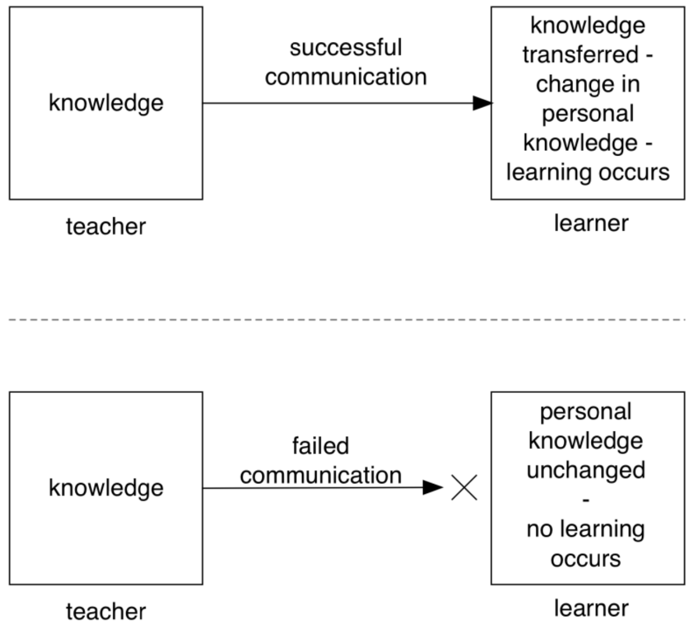

Figure 3. A binary view of teaching – either the teacher's knowledge is copied to the learner's mind, or there is no learning.

At one level this model works well. At one time, a good deal of effort was spent in many classrooms on the teacher drilling learners in repeating information considered to be worth knowing. In this way, pupils can learn multiplication tables, spellings, the dates of major wars, the main economic activities of South American countries, how to say good morning in various foreign languages, and very much more. Humans can learn a wide range of material by rote, at least with sufficient practice and appropriately spaced opportunities to practice. Rote learning has its place. In a performance of a play, where the particular language used is considered an inherent part of the art, it is appropriate for each actor to say the lines as written, rather than to offer the gist in their own vernacular. We say, the actor must 'learn the lines', not that the actor must learn the essence of their meaning. In poetry the precise choice of words is as important as the ideas they represent.

If education was solely concerned with this kind of 'facsimile' reproduction of information, then we could consider teaching effectiveness in binary terms (figure 3): sometimes learning occurs, and sometimes not. Complex (rote) learning can be analysed as a sequence of specific items to be communicated, each of which is either learnt or not.

Meaningful Learning

Yet rote learning is very limited. Learning 'word-perfectly' that the square of the hypotenuse of a right-angled triangle is equal to the sum of the squares of the other two sides, or that when a body A exerts a force on a body B, then the body B exerts a force, equal in magnitude, opposite in direction, and along the same line of action, on body A, is generally considered to be of little value if the ideas represented in the form of words can not be applied, because they have been learnt without understanding. Indeed one of the real issues in assessing students through formal tests and examinations is that it is far easier to judge when to award marks if the criterion is remembering a specific canonical formulation for a law, rule, theorem etc, than to judge whether the students' 'own words' can be considered to reflect an understanding sufficiently close to the canonical meaning (Taber, Forthcoming). Yet if understanding is the aim of much teaching, ability to reproduce given statements and definitions is of limited interest. So although learning by rote is an important phenomenon, much of formal education (and informal learning, for that matter) is about a different kind of learning: what Ausubel (1968, 2000) termed 'meaningful' learning. This brings us back to figure 1, because it soon becomes very clear that even when it may be justified to assume there to be inherent meaning in the objects and events we perceive in the environment (a teacher's explanation; a paragraph in a text book), there is no automatic process of acquiring that meaning.

Rather, we have available what might be termed 'cognitive apparatus' that allows us to interpret what we see in meaningful ways, because we can call upon existing cognitive resources (knowledge elements, interpretative frameworks, discussed further below) from which to make sense of experience (figure 4, cf. figure 1). This cognitive apparatus usually allows us to, for example, recognise a chair, even if it is not quite like any chair we have experienced before. Someone who had never seen a chair might well decide to use it to sit on, just as they might decide to use a convenient boulder as a seat. In general, however, people recognise a chair because they have developed cognitive resources for recognising chairs, based on previous experiences relating to chairs.

Personal Meaning-Making

The nature of human cognition – that we have to actively make sense of our experiences in terms of existing internal analytical resources – helps make our thinking flexible (so we can make sense of a design of chair never seen before), but mitigates against teaching being a binary process where an intended meaning is either communicated unchanged or not at all. Experiences of working in classrooms reinforces this conclusion: sometimes learners seem to acquire intended meanings; sometimes they seem to fail to learn anything; but often something else happens – students learn something which is *different* from that intended. Students often acquire a partial and/or distorted version of what was intended (Gilbert, Osborne, and Fensham, 1982).

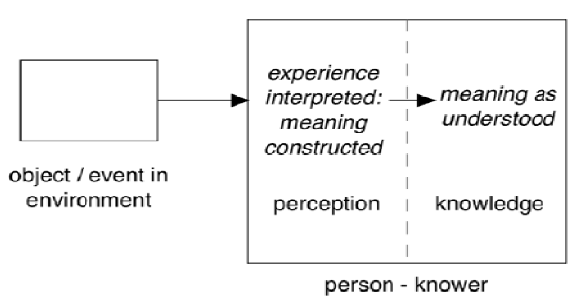

Figure 4. Knowledge constructed by interpreting new experiences in their light of existing conceptual frameworks.

Figure 2 does not describe the general process, at least when what we mean by knowledge requires more than learning by imitation. We know this because it so often becomes clear that learners have acquired a different meaning to that intended by the curriculum developers, the textbook author, or the classroom teacher. If matters were as simple as figure 2 suggests, then learning processes would be binary: successful or null, as in figure 3.

The constructivist view suggests this is because the processes by which we come to experience our surroundings are processes of *interpretation*. So the individual has to actively construct a meaningful interpretation of what is being seen and heard. That is, all meaningful learning is a process of personal meaning making through that individual's current knowledge and understanding. Consequently, each person in a classroom will construct a personal version of what is being taught (see figure 5).

Sometimes most students in a class will construct a similar meaning, and it will closely reflect the teacher's intended meaning. However, often this is far from being the case. This makes sense from a constructivist viewpoint, and indeed the popular uptake among educators of constructivist approaches to thinking about teaching and learning was in part because it made sense of the common finding that in many topics where students experienced learning difficulties, it was not a matter of students not understanding teaching, but rather of them understanding differently to what was intended (Taber, 2009b).

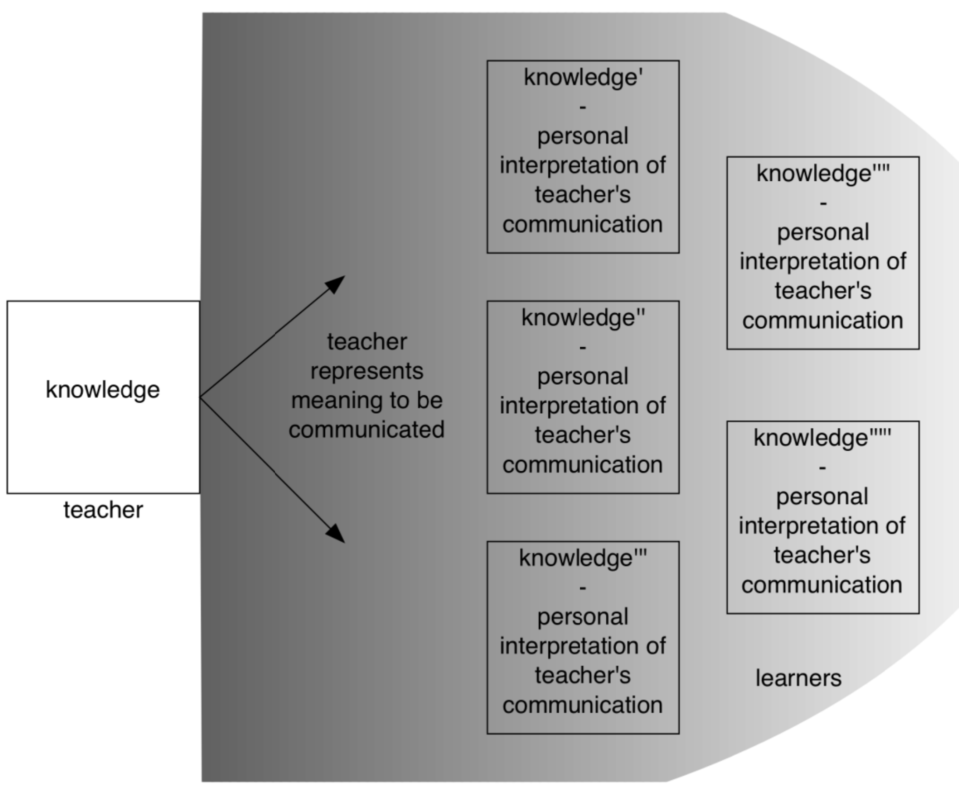

Figure 5. Each learner develops personal knowledge that is a unique reconstruction of the teacher's knowledge, by interpreting the public representation of the teacher's knowledge through available interpretive resources.

ELEMENTS OF A CONSTRUCTIVIST THEORY OF LEARNING

To draw a distinction between the apparatus of human cognition, the 'hardware' if we adopt a familiar metaphor, and the resources available to support cognition (the software and data files if we keep with the metaphor) is not entirely appropriate (Taber, Forthcoming). The substrate supporting cognition is the brain, a highly interconnected network of neurons that can act as tiny switches and signal boosters. Current thinking suggests that there is probably not a strong demarcation between brain processes involved in thinking and storing (memory) – that is, the structures which represent knowledge are active in, *and modified by*, the processing of new information, as well as acting as the basis for recalling information (Fuster, 1995). Often our memories of events (a lesson, a conversation, a concert, etc) are much less *records* of those events, than reconstructions of the experience based on our impressions of all those experiences which we categorise in a similar way. Myriad discrepant witness accounts and strained marital conversations show how often different people's memories of the 'same' event, even when offered totally honestly, show fundamental inconsistencies that illustrate different observers or participants cannot all hold accurate memories. Partly this is about how something is interpreted and experienced at the time, and partly this is about the way human memory works. When we remember something, our consciousness is provided (by the preconscious processing we are not aware of) with the best attempt at a coherent account. Unless the original event was highly salient and 'impressed' itself upon us (i.e. usually this means we were especially alert as a surge of adrenalin was triggered), memory is likely to be at least in part a re*construction*.

Key Constructivist Premises

Constructivism as learning theory can be considered to make claims about the nature of human learning. Two such claims would be:

- Human learning is constrained and channeled by the nature of the cognitive apparatus that inevitably has built-in biases;
- Human learning is contingent upon the cognitive resources that are available to any particular individual to interpret (make sense of) information.

'Information' here can simply mean the electrical signals that enter the brain from the senses: these signals are representations of the external environment (patterns of light falling on the retina; vibrations in the air leading to a resonance with certain sensory neurons in the cochlea) in the form of electrical pulses. From the biological perspective, this seems to be the physical basis of perception and cognition.

The hypothetical example earlier of the individual who was able to recognise a chair that had never been seen before, needs to be understood in these terms. Somehow information from the senses, in the form of electrical pulses, is processed in the brain and interpreted as representing a chair, by drawing on existing cognitive resources developed through prior experiences of (other) chairs.

This however begs the question of how we learnt about chairs in the first place: for *re*-cognition depends, by definition, on having previously had that cognition. So there is an issue of how we can come to know something new. Socrates had an answer to this, in that he assumed that we were born into the world with this knowledge, which just needed to be activated (e.g. by appropriate questions that might help us remember it). Modern constructivists take a different view, which is that knowledge is developed in an iterative process, and built up slowly through life's experiences. This leaves a key question of what the starting point for construction is – what the original building materials are.

The Genetic Element

Clearly this is not the place to explore this issue in any depth, but it is important to understand that human beings are never a complete *tabula rasa*: a blank slate upon which anything can be written. By the time a human being is born, she is already the outcome of an extensive development process. This is not just the individual's pre-natal period, but rather includes a much more extensive evolutionary history. For at conception the new organism carries genetic information that will inform cognitive development, and that information has been shaped by the outcomes of millions of learning experiences of that person's ancestors. Of course, this does not mean that if great Grandmother learnt to play Chopin on the piano, our neonate will come into the world as a pianist. But it does mean that the newborn has biases built into the basic structure of the brain that channel how sensory information will be interpreted. We are all somewhat unique. Throughout human (and pre-human) history our ancestors' brains varied, and so their perceptions of the world varied; as did the extent to which their interpretations of their world supported their ability to have families; and not to starve, or get eaten, or drown, or fall off cliffs and so forth (or at least, not until they had produced some offspring).

The brain of the new born child is already biased to perceive the world in particular ways (Goswami, 2008): not 'the way' the world is; and perhaps not in an optimum way to understand the world; but usually in ways much like the ways that generations of forebears found supported a productive life.

For most of that extensive development period, those forebears were living in a world that is quite significantly different to the cultural, physical and technological environment that our newborn will find: so the new human being might well be better adapted to making sense of a hunter-gather's life on the savannah as part of a community of a few dozen, rather than that of an accounts clerk working in a corporate office in a vast metropolis. One appropriate metaphor might be to suggest that we are the products of extensive market research, but unfortunately carried out in a rather different market place to that in which we are expected to sell our wares!

Pre-Wiring and Pre-Dispositions

Babies come into the world with the apparatus in place to almost immediately recognise faces. That does not mean there is a single gene for face recognition, but rather that the genetic code common to all normal humans leads (due the interaction of various genes and the environment of the embryo) during gestation to the development of a pattern recognition system that very readily recognises faces. The bias is so strong that even as adults we readily 'recognise' faces from the most basic symbols, and indeed in many accidental configurations (craters on the moon, butter melting on toast, etc).

Our genetic inheritance is also thought to predispose us to learning human language (Chomsky, 1999): that is, all human languages follow certain aspects of a common template (a 'universal grammar') that has evolved with us so that we readily pick up the basis of spoken language in the community we experience during a particularly sensitive period. We are not genetically predisposed to learn English, or Mandarin, or Esparanto – but we are genetically predisposed to learn a human language rather than bird or whale song or Klingon.

Similarly, very early in child development, babies appear to show surprise at physically impossible events (e.g. an object that was seen to be placed behind an obstruction not being revealed when the obstruction is moved), and to have a notion of agency: that some types of regularities in their environment are able to deliberately act to bring about events. These types of findings suggest that the human brain has evolved to readily appreciate certain types of pattern in the world, and so to readily interpret what is sensed in particular ways. These biases give the youngster a head (sic) start in making sense of the "great blooming, buzzing confusion" (James, 1890) of early experience, but – being biases – also lead to false positives, that is, the tendency to over-interpret experiences in certain ways.

One example of this might be the tendency of young children to anthropomorphise inanimate objects: to see the sun and moon, and wind and clouds, etc to be sentient actors in the world, acting because of their own reasons. Piaget (1929/1973), for example, reported much of this type of thinking in children. These biases are not readily overcome as we mature – just as adults still tend to see faces when the cues are quite minimal and ambiguous, ☺. The present author has reported how high ability, college students, quite readily assigned wants and needs (and sometimes even emotions like jealousy) to individual atoms as the basis of their attempts to explain chemical phenomena (Taber, 1998; Taber and Watts, 1996).

Cognitive Development

Piaget's (1970/1972) great project (his 'genetic epistemology') was intended to investigate how humans could possibly come to knowledge of the world, given the starting point (in effect a single cell containing only genetic information from the parents). His stage theory is still highly respected in some parts of the world, although many of the details of his model and claims have been widely critiqued (Donaldson, 1978; Sutherland, 1992). Despite the varying credence given to the specifics of his work, Piaget's vision offered an approach to appreciating conceptual development that was viable given philosophical considerations and biological constraints. Piaget saw (i) that the baby was not in a position to construct formal, abstract knowledge of the world, but was able to act in the world, in an intelligent way, because it was able to use its sensori-motor experience to model the world, and then modify that model in the light of further experience; and (ii) that by iterative processes it was possible to move through qualitatively different levels of understanding: Einstein the man was constructed from and *by* Einstein the neonate, through the iterative processes of making sense of the world (constructing internal mental models), acting in the world according to expectations (predictions based upon those models), and comparing new experiences with predictions, so to develop understanding (by modifying the models on the basis of feedback). This is clearly what happens in cognitive development, and Piaget developed the evidence-base to start to understand how and why this development occurs.

Piaget therefore contributed to the viability of a constructivist view of learning, something that had much earlier origins (Glasersfeld, 1989), showing that the individual who enters the world with no knowledge of calculus, or of the causes of the industrial revolution, can construct such abstract formal knowledge of the world because we are genetically endowed with *the potential to construct the apparatus needed for formal thought* by iterative action on the environment. We are not born with innate knowledge of the world in the sense of Socrates, but rather we are endowed with innate knowledge of how to construct a system of personal knowledge about the world, and one which if not exactly 'pre-tuned' by evolution, certainly has some design features that have been extensively pre-tested for us.

Of course, the flip side of this amazing process is that all of our knowledge is *personal construction*, and so work-in-process: the current iterations of our models that best make sense of our experience so far, when interpreted in terms of the inherent biases which got the process underway, and the constant cycling of new perceptions (*interpreted through the current state of knowledge*) being matched against what the current state of knowledge would lead us to expect. No wonder that as humans, we are subject to 'confirmation bias' – we tend to recognise the evidence that supports, rather than challenges, our current thinking. Accepting this means accepting that human knowledge cannot be seen as absolute, in some positivistic sense, but rather our current best fit model to experience (Glasersfeld, 1990), in the pragmatic tradition of thinkers such as John Dewey (Biesta and Burbules, 2003).

Implications for Teaching: Intuitive Theories, and Alternative Conceptual Frameworks

A key point that arises from this perspective, is that teaching is seldom about helping learners build up knowledge from nothing: indeed the constructivist approach suggest that would not be possible, as learning always builds upon, and with, the cognitive and conceptual resources already available. This leads to a number of key constructivist principles for teachers:

- Teaching involves activating relevant ideas already available to learners to help construct new knowledge;
- Students will build their new knowledge upon partial, incorrect, or apparently irrelevant existing knowledge unless carefully guided.

Students often have their own ideas about a topic that they have developed spontaneously (see below), or have acquired from other sources (family, friends, media), and which are seldom a very good match to the canonical version of knowledge presented in a curriculum. This has been explored extensively in the context of science learning, where hundred of examples of 'alternative conceptions', 'preconceptions', 'intuitive theories', and 'alternative conceptual frameworks' that students acquire, and which are inconsistent with school science, have been reported (Duit, 2009; Taber, 2009b).

As what a student will understand of teaching will be contingent upon their existing ideas and ways of thinking about a topic, teachers therefore have to diagnose student thinking effectively, so that they can channel that thinking towards the target knowledge presented in the curriculum (Brock, 2007). Where teaching is not designed to closely build upon a learner's current state of knowledge, a range of things can go wrong – misinterpretations, failures to make expected links, making inappropriate links (Taber, 2001).

When teaching abstract concepts that cannot be directly shown or demonstrated to learners, the teacher needs to find ways to help students make connections with knowledge that could be relevant: using models, analogies and metaphors for example. As this suggests, effective constructivist teaching, whilst 'student centred' in terms of its focus on how knowledge building takes place in the mind of the learner, is very much 'hands-on' teaching where the teacher seeks to guide learning by supporting the knowledge-construction process.

CONCEPT DEVELOPMENT AND TEACHING

Piaget's work has faced various criticisms, and one is that he focused largely (though not exclusively) on the lone epistemic subject interacting with the environment, whereas much human learning is social in nature. Piaget was himself very aware of this, and clearly very few of us rediscover the theorems of geometry, or the causes of the rise and fall of the Roman Empire, from first principles. We learn from family, from peers, from media, from educational experiences such as schooling (for pupils), or professional development opportunities (for their teachers). Piaget's approach may be seen as a sensible move in a research project, what Lakatos might have called following a 'positive heuristic' (Lakatos, 1970): perhaps something along the lines, 'consider the epistemic subject in his environment as the unit of analysis, and leave aside complications of social interactions as detail to be considered at a later stage'.

Piaget's contemporary Vygotsky, however, looked at some of the same basic questions about how humans come to knowledge in a complementary way. If a 'hard core' assumption (i.e. in Lakatosian terms, a central commitment which is taken for granted in the research programme) of the Piagetian programme was the centrality of a individual epistemic subject, then Vygotsky's socio-historical programme included a 'hard core' assumption that the knowledge of a person living in a human community will to a large extent derive from social interactions, through which aspects of the culture are acquired (Vygotsky, 1978).

This perspective goes beyond consideration of the 'content' of thinking, and also relates to the forms of thinking available. Whereas Piaget suggested a model with an invariant sequence of stages of cognitive development that all individuals normally passed through, Vygotsky's socio-cultural perspective suggested that more 'advanced' forms of thinking were themselves culturally mediated. Certainly when his colleague Luria led an expedition to the Soviet Asian republics, he found that illiterate peasants did not engage with standard modes of thought common among those who have been through the formal education system: for example they seemed unable or willing to complete syllogisms, and tended to group objects according to those which could be understood within an imagined narrative, rather than those with similar functions (Luria, 1976). This is somewhat different from suggesting that these individuals did not attain what Piaget would call formal operations, but certainly suggests that modes of thought which people within a specific culture take for granted are not universal human norms. Reading Luria’s examples of informants refusing (for example) to infer the colour of a hypothetical bear, that had reportedly been seen in the North, where the investigator claims all the bears are white, the sense is not of an inability of appreciate logic, but more a failure to appreciate the point of offering a conclusion, based on hear-say evidence, that the investigator could draw for themselves (cf., Smagorinsky, 1995). Commonly the peasants took the reasonable stance that, as they had never been to the North themselves, they had no good grounds for guessing the colour of a bear they had never seen. Schooling, it seems, encultures us into certain ‘language games’ that might seem quite bizarre to the uninitiated.

Two Types of Concepts

Vygotsky suggested that there were two origins for concepts (Vygotsky, 1934/1986), that we construct our own informal concepts spontaneously, without initially being able to operate with them effectively, or having language to talk about them; and that we also learn about ‘scientific’, or ‘academic’ (Vygotsky, 1934/1994), concepts from others. We might think of the former type of concepts as those acquired through the types of action in/on the environment discussed by Piaget, based on the inherent pattern-recognition qualities of the human cognitive apparatus. Piaget’s model would suggest that these spontaneous concepts would have the potential to be developed into formal tools for conscious thought through the iterative processes of cognitive development he studied.

Vygotsky, however, focused on how in normal circumstances the individual exists in a social and cultural context, where the personal concepts of individuals are modified by interactions with others, to allow the development of a somewhat common language, and to some extent at least a sharing of concepts. That is, although each individual has to construct their own conceptual frameworks, these are ‘moderated’ by interactions with others.

Vygotsky had the insight to appreciate that academic concepts presented in formal teaching, for example, whilst pre-packaged in linguistic and logical forms, would not automatically be available to the learner. In other words he seems to have appreciated the notion of rote learning, and realised that concepts cannot be unproblemtatically copied from one mind to another, as meaningful concepts are those that are integrated into existing frameworks of understanding. In Vygotsky’s model, the process of cognitive development is one of the gradual linking of the personal, largely implicit, spontaneous concepts with the formal, but initially isolated and non-functioning academic concept.

Modern Ideas about Concept Development

Vygotsky’s model has much in common with modern thinking about learning. It has been argued that much of our knowledge is built from primitive knowledge elements, that act at preconscious levels of thinking, and which are acquired spontaneously through the inherent pattern recognition mechanisms of the cognitive apparatus (diSessa, 1993; Smith, diSessa, and Roschelle, 1993). During conceptual development it has been suggested that such implicit knowledge elements can pass through several stages of re-representation at successively more explicit levels (i.e. becoming more directly accessible to conscious thought and operation), to the highest level where such concepts can be thought about and manipulated linguistically (Karmiloff-Smith, 1996). This process can be somewhat accelerated when the individual learns about concepts (i.e. Vygotsky's 'academic' concepts) from others through language.

The Zone of Next Development

One of Vygotsky's (1978) best know ideas is the zone of proximal, or next, development (ZPD), which referred to what a learner could not yet do unaided, but could do with support from a more knowledgeable individual (see figure 6).

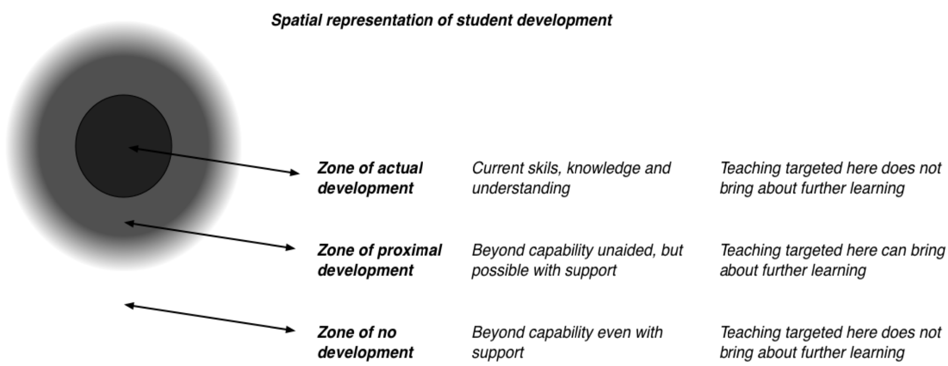

Figure 6. The Zone of proximal development.

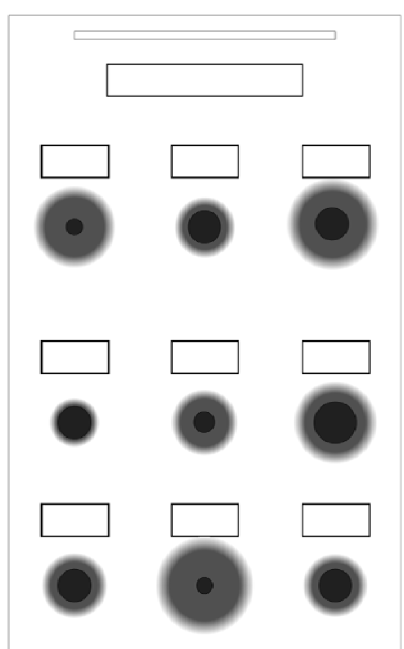

Figure 7. In any class, the teacher is faced by learners with different current levels of development, and different potentials (ZPD) for making progress.

Vygotsky's point went beyond the obvious (it is easier to do something difficult if we are helped by someone who can do it better than us!) to highlight two issues of relevance to teachers, that might provide the basis for two more constructivist claims:

- Meaningful learning only takes place when teaching is pitched beyond what is currently known and understood, but 'within reach' of existing knowledge and understanding;
- Different learners, although apparently having the same starting points, may differ in how far they can 'reach' beyond existing knowledge and understanding, to meaningfully learn new material.

In other words, the ZPD is not a standard-sized 'space' around existing learning, but is an individual characteristic (see figure 7): Vygotsky suggested that given the social context of formal education, it was more useful for a teacher to know about an individual's ZPD than their current state of knowledge, as learning took place in the ZPD.

Scaffolding Learning

This leads to the notion of teaching as scaffolding (Wood, 1988), informed by Vygotsky's work. This is the principle of setting a learner a task that is currently beyond their expertise, but within the ZPD; and then providing support – modelling, guidance, hints, etc., so that the learner can achieve with support. In Vygotsky's thinking, what is achieved first on the inter-personal level can become assimilated into the zone of actual development (ZAD), becoming internalised so that it can then be achieved unaided (Scott, 1998). The teacher's role is to offer support, and then gradually fade this as the learner masters the task, until the ZAD (and so the ZPD around it) has shifted (see figure 8).

Vygotsky's work has clear implication for differentiation of teaching. The same task may be routine for one member of a class, suitable to challenge and potentially develop another, and well beyond what another classmate can achieve even with support. In practice, in the latter case, the outcome is either explicit failure, or an apparent achievement that is so heavily based on input by the teacher or the learner's classmates that it has no value as a learning experience.

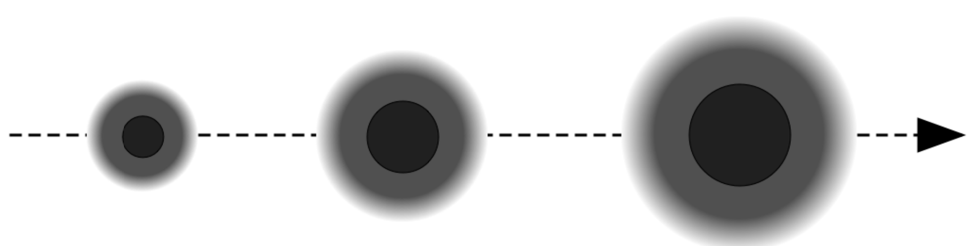

Figure 8. Learner progression involves the expansions of the ZAD, which supports growth in the ZPD around it.

It was also a feature of Vygotsky's work, that the relevance of other learners, and not just the teacher, is recognised as important in the learning process. Students often learn a great deal by working with, and having discussion with peers, who because of the generally similar level of development may inherently pitch their inputs within each other's ZPD.

Conceptual Trajectories and Student-Centred Teaching

A constructivist model of learning as construction of personal knowledge suggests that every student in a class will bring unique conceptual and cognitive resources to bear on a lesson (as well as different levels of motivation, interest, confidence, metacognition etc). A lesson taught as a lecture, presented to a class, will be understood and interpreted in as many different ways as there are students in a class. This is inevitable, but the target knowledge set out in the curriculum applies to all the students. Even if it is recognised as unreasonable that all students should reach the same final knowledge state, it is usually expected that the teacher facilitates all the learners to develop in the same 'direction'.

Yet with each individual pupil's ideas being channeled by the unique current state of their knowledge, each is likely to take a somewhat different trajectory in their learning. The teacher's job is then, to some extent, like that of an educational sheepdog, running between different members of the flock, to help marshal them towards the same end-point.

Constructivism and Approaches to Teaching

This outline, of key thinking about constructivist principles of learning, sets the scene for considering the nature of teaching that might be considered constructivist. This has been a major issue of debate, to the extent that constructivist approaches to teaching have been denounced (Kirschner, Sweller, and Clark, 2006), and metaphorically put on trial (Tobias and Duffy, 2009).

Whilst approaches to pedagogy have always been the subject of much interest, the debate came alive after a paper by Kirschner, Sweller and Clark (2006) arguing that constructivist, discovery, problem-based, experiential, and inquiry-based teaching had all failed. For these authors, these different labels all related to iterations of the same fundamental approach to pedagogy, which had been shown to be ineffective. However, the key phrase used to collectively describe these different teaching approaches adopted by the Kirschner and colleagues was 'minimally guided' instruction. In considering their arguments then, there would seem to be two questions: whether what can reasonably be considered 'minimally guided' instruction is an effective means to support learning; and whether constructivist approaches to teaching can reasonably be considered 'minimally guided'.

The Myth of Minimally Guided Instruction?

Certainly when Kirschner, Sweller and Clark's paper led first to a public debate at the American Educational Research Association (in 2007) and then a book asking whether constructivist instruction was indeed successful or not (Tobias and Duffy, 2009), a key issue was what was meant by minimally guided instruction, and whether recommended approaches to pedagogy could be considered to fit this description. In some of the rhetoric, pedagogy became presented as a choice between ‘direct instruction’ and ‘minimally guided instruction’ (Taber, 2010b).

Direct instruction is at heart a specific, well-tested, approach to designing instruction, and has found to be effective in a number of fields. ‘Minimally guided’ instruction, is a blanket term which has been used to describe a range of approaches that deliberately do not explicitly teach all the content to be learnt to the student. At first sight this looks very much like a ‘no contest’. If the curriculum required student to learn, for example, the capitals of European Union (EU) states: France-Paris; Eire-Dublin; Italy-Rome, and so forth; then we could caricature the two options as: (a) the teacher who has this knowledge, to make it available to the learners by presenting a table, and perhaps a large map with the state and capital city names clearly shown; (b) the teacher to tell pupils that they need to know the names of the EU states and their capital cities, and then retire to a quiet corner of the classroom to enjoy a much-earned cup of coffee.

It seems obvious that students are more likely to learn accurately and quickly in the former situation, than in the latter situation. However, even in this apparently clear-cut example, it may be that the teacher wishes to combine the learning of these simple facts, with some higher level educational aims: learning research skills on the internet; developing skills of self-directed learning and greater metacognitive awareness; ability to cooperate effectively in small group, etc. From this perspective it may not matter if the learning of state capitals is less efficient, especially if the teacher views this as less important than the other goals.

It also becomes clear that if the teacher is looking to develop this broader range of skills, she may not be prepared to ‘tell the answers’, but she is likely to be very busy in the classroom in monitorial and supporting the processes of learning. Her coffee may have to wait. It is also clear that although it would have been much easier for all concerned if the teacher had simply presented the students with the information about states and capitals, it is rather harder to see how she could have explicitly taught them to have greater metacognitive awareness, or to work better in groups, without setting up activities where they had to try things out for themselves.

Of course this example is just a caricature of direct instruction, which is a developed approach that goes beyond just telling learners the answers. Baumann (1984) refers to how the teacher tells/shows/models/demonstrates/teaches skills, and contrasts this with learning from resources such as books or worksheets, where the teacher primarily facilitates the use of the resources rather than directly controls the sequence and pace of focus of the learning. That ‘direct teaching’ in this sense should be more effective than the alternatives is perhaps not surprising: at least, it should not be surprising from a constructivist perspective. Given the individual differences in any class (see figure 7), effective learning is only likely to be possible when there is a constant matching of current learning to learning needs in order to scaffold the next learning activity: and this requires careful monitoring and regulation of the learner at an individual level.

The monitoring or regulation is unlikely to be something that can be programmed into learning resources directly (Taber, 2010a), and will almost certainly need to be carried out by a person with appropriate levels of knowledge and skills. For the most advanced students - academic scholars, autodidacts – this regulation and monitoring will be carried out by the learners themselves, and effective learning from interaction with resources is quite possible. For most students, certainly at school level, considerable input is needed by the teacher to direct learners. Undoubtedly, the greater the learners' motivation, self-efficacy, and - above all – existing metacognitive skills, the easier the teacher's job becomes: thus the development of the learners' metacognition (and such proxies as 'study skills') should have high priority as an educational aim (Taber, 2009a).

The skills and knowledge of the effective classroom teacher should not be underestimated, for effective teaching means operating a series of parallel interactions with individual learners and groups, 'on-line', in real-time. This is the case whether the main mode of instruction is teacher-talk, or the teacher acting as the manager for group or individual activities. Whether 'direct instruction' is more effective here, is surely going to be in part dependent upon the quality of the learning resources, and the teacher's knowledge and understanding of their rationale and design, as well as whether they find teaching as an activity more or less rewarding when teaching in this mode. The point here, though, is not to question the superiority of direct instruction over resource-led teaching, but rather to point out that from a constructivist perspective, effective teaching will depend upon the teacher making on-line decisions informed by their knowledge of subject matter, subject pedagogy, and of the particular learners in the class. So from this constructivist perspective effective learning cannot be considered as 'minimally guided', regardless of whether it is primarily the teacher standing at the front of the class talking to the whole group, or whether the teacher is flitting around a busy room supervising different learners engaged in a range of learning activities.

Discovery Learning and Constructivist Perspectives

The notion of minimally guided teaching fits better with approaches to 'discovery' learning that are open-ended. Here the learner is provided with the potential tools for making discoveries and then left to make those discoveries. Of course, discovery learning takes place within a curriculum context (so there are specific learning goals), and the provision of specific apparatus or resources act as some form of structuring of activity, even if the teacher takes an extreme view about learners needing to find out for themselves. (And in my experience, most teachers' instincts make them more likely to intervene too quickly during activities where students need to take time to think things through, rather than to leave students to their own devices for too long.)

Such an approach might be considered informed by a constructivist perspective drawing uncritically on a Piagetian model, i.e. that people naturally build up increasing complex models of the world by interacting with their environment, so the provision of a specific environment may facilitate the construction of desired knowledge. This would of course, on the Piagetian scheme, require the learner to be at a current level of cognitive development that supports the specific desired learning. So this is not an approach that is likely to allow individuals to make for themselves the discoveries underpinning modern culture, to which a great many gifted individuals contributed over many centuries.

That is not to suggest there is no place for discovery. Indeed the term 'discovery' appears in steps in versions of the learning cycle (Marek, 2009). In one early version the 'preliminary exploration' (which was actually the open-ended familiarisation stage) is followed by 'invention' (where the teacher introduced the concept to be learnt, and its name, drawing upon student familiarity deriving from the previous stage), and then 'discovery' which was actually the stage where students discovered *how to apply* the new concept to new examples. The term 'guided discovery' was used for processes that were considered analogous to (but not strictly identical with) the processes of discovery in science. Later the discovery phase became renamed as 'conceptual expansion' or 'concept application'.

At some level, constructivism implies that the individual has to create knowledge themselves, and clearly the feeling of discovering a pattern oneself rather than just being told, can have considerable motivational value. However, often such discoveries are only going to come about when the environment is carefully set up to make the important patterns discoverable: in other words, the teacher needs to scaffold learning within the learner's ZPD. Certainly in science education it is well recognised that getting students to undertake classroom experiments intended to reveal patterns in nature is a very haphazard way of helping students to discover scientific laws and principles (Driver, 1983).

Often the pattern that seems obvious to the science teacher is completely missed by the student, who instead imposes quite a different pattern on the observations. This is not surprising from a constructivist perspective, as perceptions are channelled through existing conceptual frameworks, and many of the ideas in science are quite counter-intuitive (which is why great scientists like Newton, Curie, Darwin and Einstein are fêted). So, given the iterative nature of learning, discovery approaches are likely to lead to students discovering patterns, but those that are contingent upon *their* existing ways of thinking, rather than those which have currency in the culture, and are privileged in the curriculum. Whilst some genuinely open-ended 'discovery' learning way well be useful to allow students to follow interests and to encourage creativity, effective discovery learning will - from the constructivist perspective - need to occur in carefully engineered situations designed to scaffold desired learning. Discovery learning can be either minimally guided; or it can be supported by constructivist teaching; but *not both*.

Constructivism And Enquiry Learning

Where 'discovery learning' tends to be a phrase that is less commonly used today, as Kirschner and colleagues (Kirschner et al., 2006) recognised, similar thinking has informed the idea of learning by enquiry (or inquiry, sometimes used interchangeably), which is very popular, especially in subjects such as maths and science (Lawson, 2010). As with 'constructivism', the term is widely used without a clear, agreed meaning (Bencze and Alsop, 2009), but it is generally associated with teaching that is based around setting-up student enquiries that mimic the academic research process. This type of teaching is widely advocated in the United States (Alsop and Bowen, 2009). The same considerations apply here as for discovery learning, but it is important to note that the focus on enquiry often means that the rationale for using this approach is somewhat different. It way well be accepted that enquiry learning – setting up enquiries for pupils to undertake, sometimes over extended periods – is not the most effective way of teaching the focal concepts, but this is still preferred because the primary rationale is to teach students the skills and processes of enquiry.

Where this is the aim, it may well be considered acceptable if students do not come to the 'right' answers by themselves, as long as they are learning to pose good questions, and to develop their skills in the methods of enquiry: data collection, analysis, argumentation etc.

Given this, the general point made above still applies. A constructivist teacher might, given these educational goals, allow considerable leeway in how students undertake their enquiries, but will not be allowing students to develop their own methodologies of enquiry in a laissez-faire manner. So effective, constructivist, enquiry teaching will carefully guide the learning about the logic and methods of enquiry, ideally so that each student is working within their ZPD as regards their developing conceptualisation and skills for undertaking enquiry. So there may appear to be minimal guidance in terms of the actual enquiry directions and decisions taken by students, but at a meta-level, the learning is being carefully monitored and scaffolded in terms of the understanding of inquiry processes, and the tools made available to make and execute those decisions. So again, learning by enquiry *could* be minimally guided, but genuinely constructivist enquiry-teaching will need to be carefully scaffolded by the teacher.

CONSTRUCTIVISM AS OPTIMALLY GUIDED INSTRUCTION

The aim of this chapter is to give readers a flavour of constructivist thinking about learning, and of how this can inform pedagogy. The central challenge of the personal constructivist perspective on teaching is to balance two central features of learning:

- Learning is a process of changing the potential for behaviour, by the iterative interaction between an individual's internal mental models and their interpretation of experience;
- As new learning is contingent on current knowledge and understanding, the iterative nature of the process is (in the absence of external guidance) likely to lead to an increasingly idiosyncratic way of understanding the world.

Within a society, the latter tendency is moderated by constant interactions with others, providing specific feedback on our own interpretations of the world that tend to keep them largely in line where there is general consensus – as Piaget himself recognised (Glasersfeld, 1997). Educational institutions formalise this process, by setting up bodies of canonical target knowledge, and charging teachers with the job of offering feedback to channel the student's development. However, the constructivist teacher knows that this channeling process must be designed to provide the 'database' for learning, and to guide, but not swamp the inherent internal processes of reflection upon experience. For only when, at some level, the learner recognises a misfit between expectations and experience, is the intrinsic process of modifying ideas triggered.

The aim of constructivist teaching then is not to provide 'direct' instruction, or 'minimal' instruction, but *optimum* levels of instruction. Constructivist pedagogy therefore involves shifts between periods of teacher presentation and exposition, and periods when students engage with a range of individual and particularly group-work, some of which may seem quite open-ended. However, even during these periods, the teacher's role in monitoring and supporting is fundamental. Constructivism as a learning theory suggests that effective teaching needs to be both student-centred *and* teacher-directed (see figure 9).

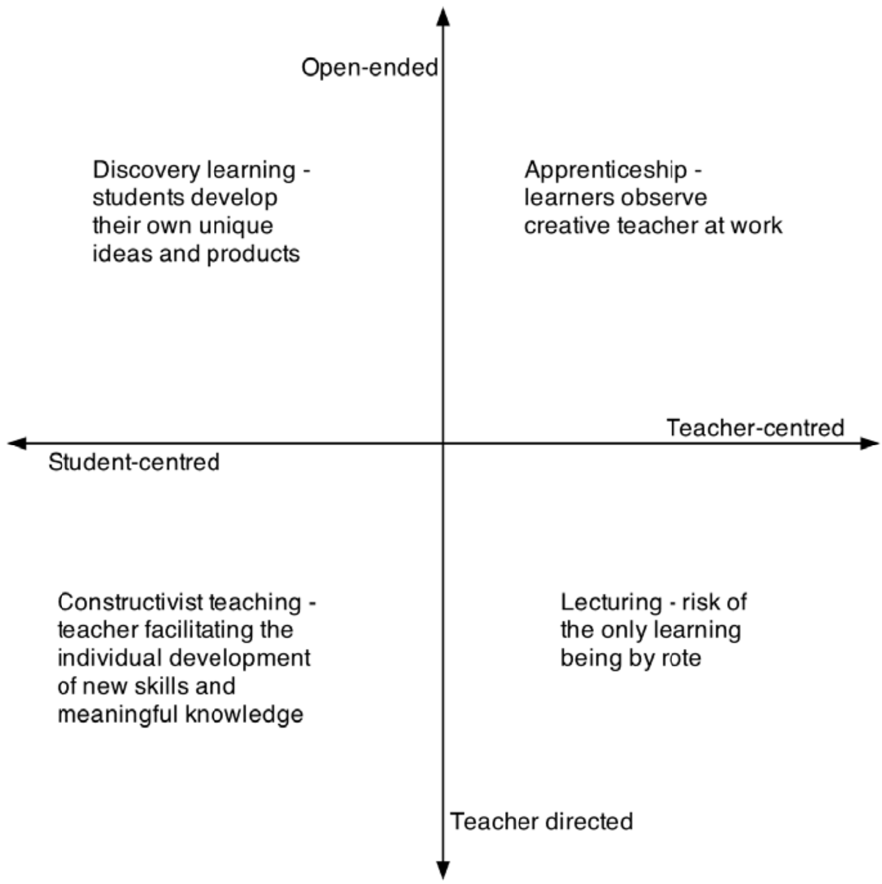

Figure 9. Teaching informed by constructivist theory will be both student-centred, and teacher directed.

So although constructivism is a learner-centred theory of teaching, the constructivist teacher works in the students' ZPD, to monitor and direct learning, from a perspective that understands how learning is contingent upon each individual's existing conceptual structures. Constructivist theory informs the teacher that each learner needs time, space, and suitable experiences, to support the learning processes; but also that minimal guidance during learning is unlikely to lead to the desired outcomes.

Such a teacher recognises that teaching designed to help students learn canonical knowledge is only possible where the teacher has a good understanding of both where the learner is now (the adage of Ausubel, 1968 about the teacher fidning out that the leaner already knows), and where the learner is expected to go to (the importance of the structure of the subject matter, Bruner, 1966; Gagné and Briggs, 1974) as well as of appropriate levels and form of guidance to bring this about (i.e. pedagogic subject knowledge, Gess-Newsome and Lederman, 1999). Constructivism, when understood in these terms, is recommended as the basis for designing pedagogy that is most likely to bring about high levels of desired learning.

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