Chapter 2

Historical developments in the understanding of learning

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Erik de Corte describes a progression in which earlier behaviourism gave way increasingly to cognitive psychology with learning understood as information processing rather than as responding to stimuli. More active concepts of learning took hold (“constructivism”), and with “social constructivism” the terrain is not restricted to what takes place within individual minds but as the interaction between learners and their contextual situation. There has been a parallel move for research to shift from artificial exercises/situations to real-life learning in classrooms and hence to become much more relevant for education. The current understanding of learning, aimed at promoting 21st century or “adaptive” competence, is characterised as “CSSC learning”: “constructive” as learners actively construct their knowledge and skills; “self-regulated” with people actively using strategies to learn; “situated” and best understood in context rather than abstracted from environment; and “collaborative” not a solo activity.
Introduction

The interest in learning and how to influence it have been around throughout history. Already in ancient Greece, Socrates (fifth century B.C.) and in Rome Seneca (first century A.D.) wrote about the nature of learning. At the dawn of the modern era, Juan Luis Vives (1492-1540) and Comenius (1592-1671) formulated influential ideas about learning and teaching (see e.g. Berliner, 2006). In the less distant past, Johann Friedrich Herbart (1776-1841) and his followers can be considered as the precursors of the scientific study of learning and teaching. They stressed, for instance, the important role in learning of prior knowledge consisting of mental states or ideas (Vorstellungen); new ideas are learned by relating them to already existing mental states by a process of “apperception” (see e.g. Bigge, 1971).

The scientific study of learning began in earnest, however, at the beginning of the twentieth century. The first section of this chapter presents an overview of the major concepts and theories of learning over that century in the Western world: behaviourism, Gestalt psychology and the Würzburg School of Denkpsychologie, cognitive psychology, constructivism and socio-constructivism.

The scientific study of learning encouraged high expectations concerning its potential to improve educational practice. However, as argued in the next section, throughout the 20th century the relationship between research and practice has instead been an awkward and not very productive one. The chapter continues with a review of the dominant current perspective on learning in educational settings that can guide the design of innovative learning environments, including as illustration an example for mathematical problem-solving in an upper primary school. I conclude with some final comments and implications of the review for policy.

Major concepts of learning throughout the twentieth century

**Behaviourism**

The behaviourist understanding of learning originated in the United States in the early 1900s, where it came to dominate during the first part of the twentieth century. The basic idea of the behaviourist perspective is that learning consists of a change in behaviour based on the acquisition, strengthening and application of associations between stimuli from the environment (e.g. the presentation of “3 + 3”) and observable responses of the individual (the answer “6”), so-called “S-R bonds” or connections. This view underlies a family of behaviourist learning theories that vary especially in the mechanisms seen to be influential in determining the S-R bonds. For education, the two most important behaviourists were Thorndike and Skinner.
Thorndike’s variant of behaviourism dominated the early decades of the twentieth century and is usually called “connectionism”. For Thorndike, the connections between stimuli and responses are controlled by different laws of learning, the most important being the “law of effect”: a response to a stimulus is strengthened or reinforced when it is followed by a positive rewarding effect, and this occurs automatically without the intervention of any conscious activity. For example: “How much is 16 + 9?” Pete answers: “25”. Reinforcement by the teacher: “That is correct, Pete”. The second major law – S-R connections become stronger by exercise and repetition – is the “law of exercise”. It is not hard to see the direct connection between this view of learning and the so-called “drill-and-practice” programmes. In this era, Thorndike had a substantial impact on education, especially with his 1922 book *The Psychology of Arithmetic*.

Skinner (1953) developed his variant of behaviourism known as “operant conditioning” towards the middle of the century. In contrast to Thorndike, Skinner distinguished between behaviour elicited by external stimuli and operant behaviour initiated by the individual (for instance, spontaneously assuming the right body position to perform a correct serve in tennis): rewarding (the coach says “excellent”) the correct parts (the right body position) of the more complex behaviour taken as a whole (performing a correct serve), reinforces it and makes it more likely to recur. Reinforcers thus control the occurrence of the desired partial behaviours and this is called “operant conditioning”.

Skinner argued that his operant conditioning was immediately applicable to classroom learning even though it was based on experiments with pigeons and other animals. Learning is considered as the stepwise or successive approximation of the intended complex behaviour such as the correct serve in tennis. It is guided by reinforcement of appropriate contributing but partial behaviour produced by the individual or elicited by different situational arrangements organised by the teacher to facilitate their appearance. The best-known application of Skinner’s theory to education is in “programmed instruction”, in which the correct sequence of the partial behaviours to be learned is determined by detailed task analysis.

**Gestalt psychology and the Würzburg School of “Denkpsychologie”**

The European counterparts of the behaviourist theories in the first part of the twentieth century were Gestalt psychology and the Würzburg School of the psychology of thinking. Both schools strongly disagreed with psychology as the science of behaviour, a view which they considered too mechanistic. Although behaviourism was quite well known in Europe, it never became as dominant as in the United States.
The key idea of Gestalt psychology is expressed in the German word *Gestalt* which means a “configuration” – an organised whole as opposed to a collection of parts. Exponents such as Wertheimer and Köhler argued that human behaviour cannot be fully understood by the behaviourist approach of breaking it down into its constituent parts. On the contrary, it has to be studied as a whole (Bigge, 1971). The mind interprets sensory data according to organising principles whereby humans perceive whole forms – “gestalts” – rather than atomistic perceptions (De Corte, Greer and Verschaffel, 1996): the spontaneously-observed whole (e.g. Rembrandt’s painting Night Watch) comes first and is afterwards gradually given structure. The whole is more than the composite parts. For learning and thinking, the major contribution of Gestalt psychology is their study of insight: learning consists of gaining insight, discovering a structure, and hence of acquiring understanding. Insightful learning occurs as the sudden solution to a problem. But because the Gestalt approach to learning remained rather global, it had little to say about instruction (Knoers, 1996).

The Würzburg School led by Külp, focused on the study of thinking, especially problem solving. A basic idea of the Würzburgers was that a problem-solving process is guided by a determining tendency, *i.e.* the thinking process is goal-oriented and controlled by the task (*Aufgabe*). Building on this idea, Selz (1913) studied thinking processes and discovered that good thinking depends on using appropriate solution methods, and that there are specific methods for solving particular problems (see also Frijda and De Groot, 1981).

**Cognitive psychology**

An important development in American psychology was initiated in the late 1950s and has become known as the “cognitive revolution”; this resulted in the shift from behaviourism to cognitive psychology (Gardner, 1985). People are no longer conceived as collections of responses towards external stimuli but essentially as information processors. One reason for this shift was growing dissatisfaction in psychology with the ability of behaviouristic theories to explain complex mental phenomena. But also, according to Simon (1979) who was a pioneer of cognitive psychology, this development was strongly influenced by the ideas of Würzburg and Gestalt psychology, and by the emergence of the computer as an information-processing device that became a metaphor for the human mind.

The so-called “information-processing” approach became increasingly dominant in instructional psychology in the 1970s and, in contrast to behaviourism, strongly influenced European research. Instead of being satisfied with studying externally-observable behaviour, the aim was to analyse and understand the internal mental processes and the knowledge structures that underlie human behaviour. So, the interest for education is, for instance, in
grasping the strategies involved in competent mathematical problem-solving or unravelling the conceptual structure of a students’ knowledge of the French Revolution.

This new perspective was accompanied by a fundamentally different understanding of the nature of human cognition, namely a shift from an atomistic toward a Gestalt view. This considered the organisation of knowledge as the central characteristic of cognition (Greeno, Collins and Resnick, 1996). The behaviouristic, response-strengthening metaphor of learning was replaced by the knowledge-acquisition metaphor (Mayer, 1996; see also Sfard, 1998). Learning is seen as the acquisition of knowledge: the learner is an information-processor who absorbs information, performs cognitive operations on it and stores it in memory. Accordingly, lecturing and reading textbooks are the preferred methods of instruction; at its most extreme, the learner is the passive recipient of knowledge seen as a commodity dispensed by the teacher (Mayer, 1996; Sfard, 1998).

**Constructivism**

To unravel internal mental processes and knowledge structures in their studies of human learning and thinking, cognitive psychologists had to administer more complex assignments than the simple laboratory tasks used by the behaviourists. Out of this research work emerged the idea during the 1970s and 1980s that learners are not passive recipients of information; rather, they actively construct their knowledge and skills through interaction with the environment and through reorganisation of their own mental structures. As argued by Resnick (1989): “Learning occurs not by recording information but by interpreting it” (p. 2). Learners are thus seen as sense-makers. Stated differently, the knowledge-acquisition metaphor had to be replaced by the knowledge-construction metaphor (Mayer, 1996). For instance, De Corte and Verschaffel (1987) found evidence supporting this constructive view of children’s learning even in the simple domain of solving one-step addition and subtraction word problems. Indeed, they observed in first-graders a large variety of solution strategies, many of them not taught in school – in other words, they were constructed by the children themselves. For example, to solve the problem “Pete had some apples; he gave 5 apples to Ann and now he still has 7 apples; how many apples did he have initially?” a number of children estimated the size of the initial amount and checked their guess by reducing it by 5 to see if there were 7 elements left, a kind of trial-and-error approach that they invented themselves. The accumulating evidence in favour of the constructive nature of learning was also in line with and supported by the earlier work of influential scholars like Piaget (1955) (see Annex) and Bruner (1961) (see Annex).
There are many different versions of constructivism (Phillips, 1995; Steffe and Gale, 1995). One of the distinctions relevant for education is between radical and moderate constructivism. Radical constructivists claim that all knowledge is purely an idiosyncratic cognitive construction and not at all the reflection of a reality “out there”. For moderate (or realist) constructivists, learners arrive at cognitive structures that eventually correspond to external realities in the environment, and this construction process can be mediated by instruction. But common to all constructivist perspectives is the learner-centred approach whereby the teacher becomes a cognitive guide of student learning instead of a knowledge transmitter.

Socio-constructivism

In the late 20th century, the constructivist understanding of learning was further amended by the emergence of the “situated cognition and learning” perspective that stresses the important role of context, especially social interaction (Brown, Collins and Duguid, 1989; Greeno, 1989). Strongly influenced by the landmark work of Vygotsky (see Annex) (1978), but also by anthropological and ethnographic research (e.g. Rogoff and Lave, 1984; Nunes, Schliemann and Carraher, 1993), the information-processing constructivist approach to cognition and learning came in for increasing criticism. The major objection was that it considers cognition and learning as processes taking place encapsulated within the mind, with knowledge as something self-sufficient and independent of the situations in which it unfolds. In the new paradigm, cognition and learning are conceived of as interactive activities between the individual and a situation, and knowledge is understood as situated, “being in part a product of the activity, context, and culture in which it is developed and used” (Brown et al., 1989, p. 32).

Cognition is thus considered as a relation involving an interactive agent in a context, rather than as an activity in an individual’s mind (Greeno, 1989). This led to new metaphors for learning as “participation” (Sfard, 1998) and “social negotiation” (Mayer, 1996). One of many examples that illustrate this situated nature of cognition comes from the work of Lave, Murthaugh and de la Rocha (1984); they studied recruits to a Weight Watchers dieting programme carrying out shopping and planning and preparing diet meals. A major outcome of the study was the virtually error-free mathematics problem-solving observed in dieting shoppers in the supermarket whereas they made frequent errors with parallel problems using paper- and-pencil methods in a formal test situation.
The evolving concept of learning

During the twentieth century the concept of learning has thus undergone important developments. For behaviourists, it was conceived of as response-strengthening through reinforcements. The advent of cognitive psychology brought fundamental change by putting the focus on the central role of information processing which led to the view of learning as the acquisition of knowledge in rather passive ways. With the focus on the active role of the learner as a sense-maker came a new metaphor for learning as “knowledge construction”. Near the end of the century this constructivist view was amended by highlighting the important role of the situation in which cognition and learning occur and the socio-constructivist understanding of learning is seen as “participation” or “social negotiation”. The latter constitutes the current dominant view of learning. In this approach the psychological processes evolving in the learner, on the one hand, and the social and situational aspects impacting learning, on the other hand, are considered to be reflexively related, with neither having priority over the other (Cobb and Yackel, 1998). This distinguishes the socio-constructivist standpoint from the socio-cultural approach that accords precedence to the social and cultural processes.

Theories of learning and educational practice: an awkward relationship

The major aim of education is to promote student learning. Therefore, with the emergence of the scientific study of learning, expectations grew that this would yield principles and guidelines to improve classroom practice and learning materials. We can now examine whether and to what degree the different concepts of learning reviewed in the previous section have met these expectations.

De Corte, Verschaffel and Masui (2004) have argued that what has been called an “educational learning theory” (Bereiter, 1990) should involve the following four components:

1. Aspects of competence that need to be acquired.
2. The learning processes required to pursue and attain competence.
3. Principles and guidelines to initiate and support those learning processes.

A condition for any learning theory to be potentially relevant for classroom practice, therefore, is that it should address those components. Thorndike’s connectionism as well as Skinner’s operant conditioning met to a large degree such requirements: they provided a coherent theory with methods for specifying aspects of competence to be learned, a theory of how such learning takes place and methods and conditions for instruction and intervention (Resnick, 1983).
Nevertheless, these behaviourist theories failed to influence educational practices in any substantial way. A large body of research was carried out under both approaches, but mainly in controlled laboratory situations using non-academic, often artificial and even meaningless learning tasks and materials (such as nonsense words or syllables). Consequently, there was a large gap between the tasks and situations covered by the research, on the one hand, and the complex realities of classrooms, on the other. Neither connectionism nor operant conditioning had anything substantial to offer, for instance, about teaching and learning deep conceptual knowledge or thinking and reasoning skills. As observed by Berliner (2006) about connectionism: “Thorndike’s contributions were both monumental and misleading. While he brought rigour to educational research and gained a respected place for educational psychology in the colleges of education of the last century, he led us to irrelevance as well.”

In contrast to behaviourism, Gestalt psychology and the Würzburg School made interesting contributions to better understanding the thinking skills that education should foster in students, as illustrated by the work of Wertheimer (1945) on productive thinking or the studies of Selz (1913) on problem solving. Selz, for instance, focused on unravelling methods that are suitable and efficient for solving particular problems. Once such methods have been uncovered, they can be learned by individuals and teachers can and should help students to acquire such solution methods. But this promising idea has not led to much evaluative research and implementation. This observation applies generally to the application of Gestalt psychology and the Würzburg School to education: major components of an educational learning theory (namely, aspects of competence, effective learning processes, guidelines to support those processes and assessment methods) are largely missing or at best very sketchy, and this holds especially for the learning to facilitate the acquisition of thinking skills and for the intervention methods to initiate and support such learning (Resnick, 1983).

There are parallels with the early days of cognitive psychology in the United States. While in the behaviouristic era the study of learning was prominent in psychological research, the focus shifted with the advent of cognitive psychology. The information-processing approach aimed at understanding the internal processes and knowledge structures underlying human competence and to do this it was necessary to confront people with sufficiently complex tasks so as to elicit the intended information-processing activities. As a consequence, the tasks and problems used in research became more similar to those involved in the subject-matter domains of school curricula (Resnick, 1983). But, due to the primary interest in unpacking mental processes and knowledge structures, the study of the learning needed to acquire competence was pushed into the background (Glaser and Bassok, 1989).

Towards the end of the 20th century, however, this situation began to change. First, with the substantial progress that was made in the 1970s and
In line with these developments, research on learning in education has thus undergone tremendous changes over the past two decades. With the focus on learning and teaching tasks in real classrooms, using a variety of quantitative as well as qualitative research methods, this work has much greater relevance for education compared with behaviourist studies. Indeed, it has substantially contributed to our understanding of student learning in the different subject-matter domains of the school curriculum, as well as of the teaching methods that facilitate productive learning. This is well illustrated and documented in the two volumes of the Handbook of Educational Psychology that were published in 1996 (Berliner and Calfee) and 2006 (Alexander and Winne), as well as in the Cambridge Handbook of the Learning Sciences (Sawyer, 2006). For instance, research on mathematics learning has yielded a great deal of insight into the knowledge and skills involved in successful problem-solving and into students’ difficulties with mathematical problems. This work has resulted in guidelines for designing innovative learning environments for problem solving and for the development of assessment instruments for monitoring learning and teaching (De Corte and Verschaffel, 2006).

These positive developments notwithstanding, complaints about what Berliner (2008) has recently called “the great disconnect” between research and practice are still the order of the day. Leading researchers are themselves very well aware of this situation. For instance, in her 1994 Presidential Address to the Annual Meeting of the American Educational Research Association, the late Ann Brown argued: “Enormous advances have been made in this century in our understanding of learning and development. School practices in the main have not changed to reflect these advances.” (1994, p.4; see also Weinert and De Corte, 1996). And very recently Berliner (2008) stated: “Toward the end of the twentieth century, learning in real-world contexts began to be studied more earnestly (Greeno, Collins and Resnick, 1996), but, sadly, such research still appears not to be affecting practice very much.” (p. 306)

Consistent with these assertions, in our own research we have recently observed that the new insights about learning and teaching mathematical problem-solving are not easily implemented in classroom practice, even when they have been translated into a reform-based textbook (Depaepe, De Corte and Verschaffel, 2007). This should not be considered as a failing on the practitioner side to adapt to and apply our research; bridging the research/
practice gap will require all stakeholders in the school system – researchers, policy makers and practitioners – to work on this as a joint endeavour (see also De Corte, 2000).

What are the causes of this enduring awkward relationship between research and practice? Berliner (2008) provides an enlightening analysis of the “great disconnect”. Looking over the history of education, the general understanding of what constitutes the act of teaching is relatively fixed and stable, making it difficult to change teaching behaviour. Classrooms are diverse and complex settings, making it unlikely that research findings can be translated into teaching “recipes” that fit all classrooms and are generally applicable in practice. William James, one of the founders of educational psychology, already remarked in 1899 that psychology is a science while teaching is an art and that sciences do not generate arts directly out of themselves. As argued much more recently by Eisner (1994), teaching is an art in the sense that it is not dominated by prescriptions and routines, but is influenced and guided by qualities and contingencies that are unanticipated and unfold during the course of action.

But although good teaching is an art in the sense described by Eisner, this does not prevent a well-grounded theory of learning from being relevant for educational practice (National Research Council, 2005). It can provide teachers with a useful framework for analysis of and reflection on the curriculum, textbooks and other materials, and their own practice. While even a good theory cannot yield concrete prescriptions for classroom application, its principles can be used flexibly and creatively by teachers as guidelines in planning and performing their educational practice, taking into account the specific characteristics of their student population and classroom setting.

Bridging the gap between theory/research on learning and educational practice constitutes a major joint challenge for educational researchers and professionals, but also for policy makers who can help create the conditions to reduce this “great disconnect”. This is an important issue and I discuss it further in the final section of this chapter.

Current understandings of learning

Bransford et al. (2006) distinguish between three major strands in research on learning:

• Implicit learning and the brain.
• Informal learning.
• Designs for formal learning and beyond.
In *implicit learning*, information is acquired effortlessly and sometimes without someone being aware of having acquired it — language learning in young children is a good example. *Informal learning* takes place in homes, playgrounds, museums, among peers and in other settings “where a designed and planned educational agenda is not authoritatively sustained over time” (Bransford et al., 2006, p. 216). Examples include the everyday learning in non-Western cultures that lack formal schooling as documented in ethnographic studies (e.g. Luria, 1976), but also in the informal learning of mathematics in Western cultures, for instance, as illustrated by the study of the shopping and cooking activities of dieters referred to above (Lave et al., 1984). *Designs for formal learning and beyond* corresponds largely with learning from teaching in educational settings. According to Bransford et al., this strand involves “the use of knowledge about learning to create designs for formal learning and beyond (where ‘beyond’ includes ideas for school redesign and connections to informal learning activities) and to study the effects of these designs to further inform theoretical development.” (2006, p. 221)

It follows from this perspective on formal learning that: (1) systemising and advancing knowledge about learning is crucial (the main focus of this section); (2) design-based research (see Annex) is an appropriate avenue for advancing this knowledge; and (3) it is important to stimulate synergies between formal and informal learning.

On the latter point, according to the U.S. National Research Council (2000), students spend only 21% of their waking time in school, against 79% in non-school activities where informal learning is taking place in interaction with adults, peers and multiple sources of stimuli and information. Formal schooling is thus far from the only opportunity for and source of learning in our modern society in which ICT and media have become so ubiquitous and influential. No wonder that the motivation of youngsters for school learning has to compete with the seduction to engage in other activities that are often perceived as more interesting. Therefore, it is critically important to enhance cross-fertilisation between formal innovative learning environments and students’ informal learning. One way of doing this is by linking new information to students’ prior formal as well as informal knowledge.

*Adaptive competence as the ultimate goal of education and learning*

Many scholars in the field of education now agree that the ultimate goal of learning and instruction in different subjects consists in acquiring “adaptive expertise” (Hatano and Inagaki, 1986; see also Bransford et al., 2006) or “adaptive competence”, *i.e.* the ability to apply meaningfully-learned knowledge and skills flexibly and creatively in different situations. This is opposed to “routine expertise”, *i.e.* being able to complete typical school tasks quickly and accurately but without understanding.
Building adaptive competence in a domain requires the acquisition of several cognitive, affective and motivational components (De Corte, 2007; De Corte, Verschaffel and Masui, 2004):

1. **A well-organised and flexibly accessible domain-specific knowledge base** involving the facts, symbols, concepts and rules that constitute the contents of a subject-matter field.

2. **Heuristics methods, i.e.** search strategies for problem analysis and transformation (*e.g.* decomposing a problem into sub-goals, making a graphic representation of a problem) which do not guarantee but significantly increase the probability of finding the correct solution through a systematic approach to the task.

3. **Meta-knowledge** involving, on the one hand, knowledge about one’s cognitive functioning or “meta-cognitive knowledge” (*e.g.* believing that one’s cognitive potential can be developed through learning and effort); and, on the other hand, knowledge about one’s motivation and emotions that can be actively used to improve learning (*e.g.* becoming aware of one’s fear of failure in mathematics).

4. **Self-regulatory skills**, regulating one’s cognitive processes/activities (“meta-cognitive skills” or “cognitive self-regulation”; *e.g.* planning and monitoring one’s problem-solving processes); and skills regulating one’s volitional processes/activities (“motivational self-regulation”, *e.g.* maintaining attention and motivation to solve a given problem).

5. **Positive beliefs** about oneself as a learner in general and in a particular subject, about the classroom or other context in which learning take place, and about the more specific content within the domain.

Prioritising adaptive competence does not mean that routine expertise becomes unimportant: it is obvious that mastering certain skills routinely (*e.g.* basic arithmetic, spelling, technical skills) is crucial to efficient functioning in all kinds of different situations. If certain aspects of solving a complex problem can be performed more or less mechanically, it creates room to focus on the higher-order cognitive activities that are needed to reach the solution. People can also learn to use their routine competences more efficiently with passing years.

But adaptive competence is so important because it goes beyond that — it “…involves the willingness and ability to change core competencies and continually expand the breadth and depth of one’s expertise” (Bransford et al., 2006, p. 223). It is fundamental, indeed necessary, to acquiring the ability to transfer one’s knowledge and skills to new learning tasks and contexts (De Corte, 2007; Hatano and Oura, 2003). It follows that adaptive competence is central to lifelong learning.
Considering adaptive competence as such a key goal has important implications for the learning processes to best acquire it. The traditional dominant form of school learning has been teacher-directed or – as termed by Simons, van der Linden and Duffy (2000b) – “guided learning” – “a trainer or teacher takes all the relevant decisions and the learner can and should follow him or her. He decides about the goals of learning, the learning strategies, the way to measure outcomes and he takes care of feedback, judgments, and rewards”. (p. 4)

As an important component of adaptive competence consists of skills in self-regulating one’s own learning and thinking, it is obvious that such teacher-directed or guided learning is certainly not the only appropriate way to achieve it. Simons et al. distinguish in addition two other ways of learning, namely “experiential” and “action learning”. Experiential learning is not controlled by the teacher and has no pre-determined objectives. What is learned is determined by the context, the learner’s motivation, others with whom the learner in contact, discoveries made, etc. What is acquired is a by-product of the activities in which one is involved. Action learning is not a by-product but, unlike guided learning, the learner plays a much more active role in determining the objectives of the learning and it is largely self-organised and self-planned.

In line with Simons et al. (2000b), I argue that novel classroom practices and cultures are needed to create the conditions for a substantial shift from guided learning towards action and experiential learning, resulting in a balanced, integrated use of these three ways of learning in order to support the progressive acquisition of adaptive competence. Such a balance should allow for structure and guidance by the teacher where and when needed and it should create space for substantial self-regulated and self-determined student learning. It should also leave open opportunities for what Eisner (1994) has called “expressive outcomes”, i.e. unanticipated results from incidental learning in a variety of situations such as a museum, a forest, etc.

School learning needs to be more ambitious than was traditionally the case in taking on additional objectives: it should be active/constructive, cumulative, self-regulated, goal-directed, situated, collaborative, and permit individually different processes of meaning construction and knowledge building (De Corte, 1995; 2007). This takes into account Shuell’s (1988) view of good learning (see also Mayer, 2001; National Research Council, 2000).

Simons et al. (2000b) identify an even more extended list: the shift towards action learning, on the one hand, requires more active, more cumulative, more constructive, more goal-directed, more diagnostic and more reflective learning; the shift towards experiential learning, on the other hand, requires more discovery-oriented, more contextual, more problem-oriented, more case-based, more social and more intrinsically-motivated learning. In a booklet in the “Educational Practices Series” of the International Academy
of Education entitled *How Children Learn*, Vosniadou (2001) summarised the empirical evidence which supports most of these characteristics. She presents the research findings as underlying twelve “principles of learning” and argues their relevance for educational practice: (1) active involvement; (2) social participation; (3) meaningful activities; (4) relating new information to prior knowledge; (5) being strategic; (6) engaging in self-regulation and being reflective; (7) restructuring prior knowledge; (8) aiming towards understanding rather than memorisation; (9) helping students learn to transfer; (10) taking time to practice; (11) developmental and individual differences; and (12) creating motivated learners.

**Effective learning: constructive, self-regulated, situated and collaborative (CSSC learning)**

It is not possible to review here all the features and principles to guide and support students in acquiring adaptive competence, and I focus on the four key characteristics, namely that learning is constructive, self-regulated, situated and collaborative. The four vignettes in Box 2.1 describe concrete examples illustrating them.

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**Box 2.1. Four vignettes illustrating characteristics of effective learning**

**Vignette 1**

Solution of a simple subtraction by a primary school pupil: 543-175 = 432. How did this pupil arrive at making this incorrect subtraction?

**Vignette 2**

Someone buys from a 12-year-old street vendor in Recife, Brazil, 10 coconuts at 35 cruzeiros a piece. The boy figures out quickly and accurately the price in the following way: “3 nuts is 105; 3 more makes 210; … I have to add 4. That makes … 315 … It is 350 cruzeiros.”

When the boy had to solve traditional textbook problems in school, he did much less well than while doing his business on the street. In the class he did not use the procedures that he applied so readily on the street, but he tried to apply the formal algorithms learned in school which he did not master very well (From Nunes, Schliemann and Carraher, 1993)
Learning is constructive

The constructivist view of learning has nowadays become more or less common ground among educational psychologists (see e.g. Phillips, 2000; Simons et al., 2000a; Steffe and Gale, 1995). But, what does this mean exactly? There is strong evidence now that learning is in some sense always constructive, even in environments with a predominantly guided learning approach. This is convincingly demonstrated by the research showing the occurrence of misconceptions (such as “multiplication makes bigger”) and defective procedural skills (as illustrated in Vignette 1) among students in
traditional mathematics classrooms. As expressed pithily by Hatano: “it is very unlikely that students have acquired them by being taught” (1996, p. 201).

What is essential in the constructivist perspective is the mindful and effortful involvement of students in the processes of knowledge and skills acquisition in interaction with the environment. This is illustrated nicely by the rather cumbersome but accurate calculation procedure invented by the Brazilian street vendor in Vignette 2, and also by the solution strategy of first graders for one-step word problems mentioned in the earlier short description of constructivism.

There are, however, many versions of constructivism in the literature spanning a wide variety of theoretical and epistemological perspectives, as described by Phillips (1995) in his article *The good, the bad, and the ugly: The many faces of constructivism*. This characterisation still holds true today, so that at present we cannot yet claim to have a fully-fledged, research-based constructivist learning theory. The present state of the art thus calls for continued theoretical and empirical research to give a deeper understanding and a more fine-grained analysis of constructive learning processes that promote the acquisition of worthwhile knowledge, cognitive and self-regulation skills, and the affective components of adaptive competence. We need more research into the role and nature of teaching to foster such learning.

**Learning is self-regulated**

Constructive learning, being about the process rather than the product, is also “self-regulated”. This captures the fact that “individuals are metacognitively, motivationally and behaviourally active participants in their own learning process” (Zimmerman, 1994, p. 3). Although research on self-regulation in education began only about 25 years ago, a substantial amount of empirical and theoretical work has already been carried out with interesting results (for a detailed overview see Boekaerts, Pintrich and Zeidner, 2000; see also National Research Council, 2000; National Research Council, 2005; Simons et al., 2000a).

First, we now know the major characteristics of self-regulated learners: they manage study time well, set higher immediate learning targets than others which they monitor more frequently and accurately, they set a higher standard before they are satisfied, with more self-efficacy and persistence despite obstacles. Second, self-regulation correlates strongly with academic achievement, and this has been found in different subject areas (Zimmerman and Risemberg, 1997). Third, recent meta-analyses of teaching experiments show convincingly that self-regulation can be enhanced through appropriate guidance among primary and secondary school students in the way illustrated in Vignette 3 in Box 2.1 (Dignath and Büttner, 2008; Dignath,
Buettner and Langfeldt, 2008; see also Boekaerts et al., 2000). Important recent research by Anderson (2008) shows that the learning and achievement of disadvantaged students can be improved significantly by teaching self-regulatory skills.

There is still need for continued research in order to gain a better understanding of the key processes involved in effective self-regulation in school learning, tracing the development of students’ regulatory skills, and unravelling how and under what classroom conditions students become self-regulated learners. That is, there is much still to be understood about how students learn to manage and monitor their own capacities of knowledge-building and skill acquisition and about how to enhance the transition from external regulation (by a teacher) to self-regulation.

Learning is situated or contextual

It is also widely held in the educational research community that constructive and self-regulated learning occurs and should preferably be studied in context, i.e. in relation to the social, contextual and cultural environment in which these processes are embedded (for a thorough overview see Kirschner and Whitson, 1997; see also National Research Council, 2000; National Research Council, 2005). In the late 1980s, the importance of context came into focus with the situated cognition and learning paradigm. This, as described above, emerged in reaction to the view of learning and thinking as highly individual and involving purely cognitive processes occurring in the head, and resulting in the construction of encapsulated mental representations (Brown et al., 1989). The situated view rightly stresses that learning is enacted essentially in interaction with, and especially through participation in, the social and cultural context (see also Bruner, 1996; Greeno et al., 1996). This is also well illustrated in Vignette 2 by the calculation procedures invented by the Brazilian street vendor in the real-world context of his business. In mathematics, the situational perspective has stimulated the movement toward more authentic and realistic mathematics education (De Corte et al., 1996).

The “situated cognition” perspective has nevertheless also come in for criticism. It has been criticised for being only “a ‘loosely coupled’ school of thought” (Gruber, Law, Mandl and Renkl, 1995), for making inaccurate and exaggerated claims from which inappropriate educational lessons might be drawn (Anderson, Reder and Simon, 1996) and for downgrading or at least not appropriately addressing the role of knowledge in learning (Vosniadou, 2005; Vosniadou and Vamvakoussi, 2006). There is therefore a need for further theoretical inquiry and empirical research to better integrate the positive aspects of both cognitive psychology and situativity theory (see also Vosniadou, 1996).
Learning is collaborative

The collaborative nature of learning is closely related to the situated perspective that stresses the social character of learning. Effective learning is not a purely solo activity but essentially a distributed one, involving the individual student, others in the learning environment and the resources, technologies and tools that are available (Salomon, 1993). The understanding of learning as a social process is also central to socio-constructivism, and despite the almost idiosyncratic processes of knowledge building, it means that individuals nevertheless acquire shared concepts and skills (Ernest, 1996). Some consider social interaction essential, for instance, for mathematics learning as individual knowledge construction occurs through interaction, negotiation and co-operation (see Wood, Cobb and Yackel, 1991).

The available literature provides substantial evidence supporting the positive effects of collaborative learning on academic achievement (Slavin, this volume; see also Lehtinen, 2003; Salomon, 1993; van der Linden, Erkens, Schmidt and Renshaw, 2000). It suggests that a shift toward more social interaction in classrooms would represent a worthwhile move away from the traditional emphasis on individual learning. It is important to avoid going too far to the opposite extreme, however: the value for learning of collaboration and interaction does not at all exclude that students develop new knowledge individually. Distributed and individual cognitions interact during productive learning (Salomon and Perkins, 1998; see also Sfard, 1998), and there remain numerous unanswered questions relating to collaborative learning in small groups (Webb and Palincsar, 1996). For instance, we need a better understanding of the ways in which small-group activities influence students’ learning and thinking, of the role of individual differences on group work and of the mechanisms at work during group processes (van der Linden et al., 2000).

In addition to the four main characteristics of the CSSC conception of learning, two other aspects can be mentioned briefly: learning is cumulative and individually different. That it is cumulative is implied in it being constructive – students develop and build new knowledge and skills on the basis of what they already know and can do. Ausubel argued already in 1968 that the most important single factor influencing learning is the learner’s prior knowledge. That claim has been vindicated by the studies showing that prior knowledge explains between 30 and 60% of the variance in learning results (Dochy, 1996). The importance of prior knowledge clearly also underscores the value of linking formal to informal learning.

Learning is also individually different, which means that its processes and outcomes vary among students on a variety of pertinent variables. Prior knowledge is one of these variables, but so are ability, students’ conceptions of learning, learning styles and strategies, their interest, motivation,
self-efficacy beliefs and emotions. Encouraging and sustaining effective learning therefore means that school should provide as much as possible adaptive education (Glaser, 1977) to take account of these differences.

**Meeting criticism of constructivist approaches**

The understanding of learning described above is broadly the socio-constructivist view, albeit combining and integrating the acquisition and the participation, *i.e.* the individual and social aspects of learning. However, although the available literature provides fairly good support for CSSC learning (more extensive overviews can be found in Bransford *et al.*, 2006; National Research Council, 2000; 2005), the constructivist perspective has also come in for criticism. Kirschner, Sweller and Clark (2006) argue that approaches based on constructivism rely excessively on discovery learning and provide minimal guidance to students, ignoring the structure of human cognitive architecture and resulting in cognitive overload of working memory. These authors plea for a return to direct instruction.

The critics are correct in concluding that pure discovery does not yield the best learning gains as has been shown by Mayer (2004) in an overview of the literature of the past fifty years. But, they mistakenly equate constructive learning with discovery learning. Learning as an active and constructive process does not at all imply that students’ construction of their knowledge and skills should not be guided and mediated through appropriate modelling, coaching and scaffolding by teachers, peers and educational media (Collins, Brown and Newman, 1989). Indeed, Mayer’s extensive review (2004) shows that guided discovery learning leads to better learning outcomes than direct instruction. He concludes that:

A powerful innovative learning environment is characterised by a good balance between discovery and personal exploration, on the one hand, and systematic instruction and guidance, on the other hand, while being sensitive to individual differences in abilities, needs, and motivations among learners.

The balance between external regulation by the teacher and self-regulation by the learner will vary during the student’s learning history – as competence increases the share of self-regulation can also grow and explicit instructional support correspondingly fall. Following these principles for the design of learning environments will at the same time prevent cognitive overload and induce so-called “germane cognitive load” that facilitates effective learning. (Schmidt, Loyens, van Gog and Paas, 2007)

Box 2.2 presents a brief overview of a learning environment at the classroom level that embeds this CSSC learning concept.
Box 2.2. A CSSC classroom learning environment for mathematics problem solving in a primary school

Goal of the project: design and evaluation of an innovative learning environment to foster CSSC learning processes for adaptive competence in mathematics among fifth graders. The “CLIA model” (Competence; Learning; Intervention; Assessment) (see De Corte et al., 2004) was used as the guiding framework. This project was to design a learning environment (LE) in close collaboration with four participating teachers covering a series of 20 lessons to be taught by those teachers over a four-month period (Competence: the LE focused on the acquisition by students of a self-regulation strategy for solving maths problems. It consisted of five stages: i) build a mental representation of the problem; ii) decide how to solve it; iii) execute the necessary calculations; iv) interpret the outcome and formulate an answer; v) evaluate the solution. A set of eight heuristic strategies (including draw a picture; distinguish relevant from irrelevant data) was embedded in the strategy.

Learning and intervention: to elicit and support CSSC learning processes in all pupils, the learning environment was designed with the following three basic features embodying the CSSC view of learning.

1. A set of carefully-designed situated, complex and open problems were used that differ substantially from traditional textbook tasks as illustrated by the following example.

The teacher told the children about a plan for a school trip to Efteling, a well-known amusement park in the Netherlands; were that to turn out to be too expensive, one of the other amusement parks might be an alternative. Each group of four pupils received copies of folders with entrance prices for the different parks. The lists mentioned distinct prices depending on the period of the year, the age of the visitors and the kind of party (individuals, families, groups). In addition, each group received a copy of a fax from a local bus company addressed to the school principal giving information about the prices for buses.

The first task of the groups was to check whether it was possible to make the school trip to the Efteling given that the maximum price per child was limited to 12.50 euro. After finding out that this was not possible, the groups received a second task: they had to find out which of the other parks could be visited.

2. A learning community was created through the application of a varied set of activating and interactive instructional techniques, especially small-group work and whole-class discussion. Throughout the lessons the teacher encouraged students to reflect on the cognitive and self-regulation activities involved in the five-stage strategy of skilled problem-solving. These instructional supports were gradually faded out as students became more competent and self-regulated in their problem-solving activities.
3. A novel classroom culture was created through the new social norms about learning and teaching problem-solving, such as: discussing about what counts as a good response (e.g. often an estimation is a better answer to a problem than an exact number); reconsidering the role of the teacher and the students in the mathematics classroom (e.g. the class as a whole, under the guidance of the teacher, will decide which of the generated solutions by the small groups is the optimal one after evaluation of the pros and cons of the alternatives).

Assessment: students’ progress toward the goals of the learning environment was assessed summatively using a variety of instruments. Formative assessment was substantially built in, resulting in diagnostic feedback facilitating informed decision-making about further learning and teaching. This was obtained as a result of discussions and reflection on articulated problem-solving strategies in small groups and in the whole class.

Results:

The LE had a significant and stable positive effect on students’ competence in solving maths problems.

In parallel to these improved results was a substantial increase in the spontaneous use of the heuristic strategies taught.

Results on a standardized achievement test covering the entire math curriculum showed a significant transfer effect to other parts of the curriculum such as geometry and measurement.

The low-ability students, and not only those with high and medium ability, also benefited significantly from this LE.

A new CSSC-oriented learning environment, combining a set of complex and realistic problems with highly interactive teaching methods and a new classroom culture, can thus significantly boost students’ competency in solving mathematical problems.

(For a detailed report of the study see Verschaffel, De Corte, Lasure, Van Vaerenbergh, Bogaerts and Ratinckx, 1999)
Concluding remarks and implications for policy

The CSSC learning concept is nowadays well supported by research evidence. It can, as illustrated by the study summarised in Box 2.2, be implemented as the framework for the design of innovative learning environments at all levels of the educational system, and for classrooms as well as for whole schools. This positive conclusion should not lead to complacency among scholars in the field of learning and teaching. It should rather stimulate and challenge the research community to continue its endeavours as even the brief review contained in this chapter reveals the many complex issues remaining to be studied and clarified, the marked progress notwithstanding. The aim should be to elaborate a more thorough explanatory theory of the learning processes that facilitate and enhance the acquisition of adaptive competence.

In view of implementation of the CSSC concept, it is interesting to ask whether teachers’ and students’ ideas and beliefs about learning converge with this approach. Taking as a starting point De Corte’s (1995) concept of effective learning as a constructive, cumulative, self-regulated, goal-oriented, situated and collaborative process of knowledge and meaning building, Berry and Sahlberg (1996) developed an instrument to measure and analyse ideas about learning of 15-year-old students in five schools in England and Finland. A major conclusion of the study was that most students adhere to the knowledge transmission model that is difficult to fit with the CSSC concept. They conclude: “…our pupils’ ideas of learning and schooling reflect the static and closed practices of the school” (p. 33).

Berry and Sahlberg add that this conclusion is mirrored by similar findings from other studies for teachers and adult students. So, we should be concerned that students’ and teachers’ beliefs about learning can be a serious obstacle for the implementation of CSSC learning approaches, the more because, as already mentioned, of the deeply entrenched stability of teaching behaviour (Berliner, 2008). Changing beliefs constitutes in itself a major challenge.

Reducing the “great disconnect” and addressing the awkward relationship between learning research, on the one hand, and educational practices, on the other, with the sustained implementation of innovative CSSC learning environments confronts education professionals, leaders and policy makers with major challenges. First, curricula and textbooks would need to be revised or re-designed. Challenging though this is it is certainly not enough – integrating new ideas in textbooks does not guarantee that they will appropriately be used in practice (Depaepe et al., 2007). Indeed, research shows that teachers interpret the new ideas through their past experiences (Remillard, 2005) and their often traditional beliefs about learning and teaching. This easily results in absorption of the innovating ideas into the existing...
traditional classroom practices. Moreover, as argued by the Cognition and Technology Group at Vanderbilt (1997), the changes implied for teachers are “much too complex to be communicated succinctly in a workshop and then enacted in isolation once the teachers returned to their schools” (p. 116).

There is therefore strong need for intensive professional learning and development of school leaders and teachers, aiming at the “high fidelity” application of innovative learning environments and materials, while focusing on changing predominant perceptions and beliefs about learning. Such changes in teachers can be facilitated by an iterative process in which their current views are challenged by being confronted with successful alternative practices (Timperley, 2008; see also National Research Council, 2000).

Finally, the sustainable implementation of the CSSC learning concept requires that it is appropriately communicated to and supported by the broader community around the school (Stokes, Sato, McLaughlin and Talbert, 1997). This is necessary to avoid what Dewey called already in 1916 “the isolation of the school” but it is of the utmost importance if we are to foster synergies between formal learning in the classroom and informal learning outside the school (National Research Council, 2000).
Annex

The Swiss epistemologist and psychologist Jean Piaget (1896–1980) proposed one of the most influential theories of cognitive development based on his observations of and interviews with children solving intellectual tasks. According to his theory cognitive development has four stages that all people pass through in the same order: sensorimotor (birth to age 2), preoperational (ages 2 to 7), concrete operational (ages 7 to 11) and formal operational (ages 11 to 14). Of special importance in the context of this chapter is Piaget’s recognition that children’s knowledge is not a mere copy of the external reality; on the contrary, children build their knowledge themselves through action on physical, social and conceptual objects (de Ribeupierre and Rieben, 1996).

Jerome Bruner (1915–) is one of the most influential American educational psychologists of the 20th century. He was very instrumental in the move in the USA from behaviourism to cognitive psychology. Influenced by Piaget, he distinguished three modes of thinking: enactive, iconic and symbolic. In contrast to Piaget he did not link each mode to a specific period in children’s development, but considered each mode as present and accessible throughout, but dominant during a developmental stage. His view of knowledge as a constructed entity and his advocacy of discovery learning have contributed to the emergence of constructivism. Later on he became more and more influenced by Vygotsky’s cultural-historical perspective on development resulting in the viewpoint that the full development of the mind’s potential requires the participation in social and cultural activities (Bruner, 1996).

Lev Vygotsky (1896-1934) was a Russian psychologist, a contemporary of Piaget but who died far too prematurely at the age of 38. Since his cultural-historical (also called “socio-historical”) theory became known in the USA and Europe in the 1970s, he has been very influential in Western developmental and educational psychology. The focus of his work was the development of higher psychological processes such as thinking, reasoning and problem-solving. His basic idea is that cognitive development can be understood only in terms of the historical and cultural contexts and settings that children experience and participate in. In contrast to Piaget, he thus attributes an important role in cognitive development to the social environment of the child, especially through face-to-face interactions and language (Vygotsky, 1978).
In contrast to experiments that aim to describe how learning occurs under given conditions of instruction, **design-based research** focuses on designing, implementing and evaluating new instructional interventions. Design-based research aims at contributing to the innovation of school practices and so goes beyond merely developing and testing particular interventions. This approach seeks to contribute to theory-building about learning from instruction and the design of learning environments based on theoretical notions of what the optimal course of a learning process should be to attain a certain educational objective. In a recursive cycle of analysis and theory reformulation, examination of learning activities and student outcomes either support the initial theoretical notions or are used to revise them (De Corte, Verschaffel and Depaepe, in press; The Design-Based Research Collective, 2003).
References


