Modes of Knowing and Modes of Coming to Know
Knowledge Creation and Co-Construction as Socio-Epistemological Engineering in Educational Processes

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Purpose: In the educational field a lack of focus on the process of arriving at a level of profound understanding of a phenomenon can be observed. While classical approaches in education focus on “downloading,” repeating, or sometimes optimizing relatively stable chunks of knowledge (both facts and procedural knowledge), this paper proposes to shift the center of attention towards a more dynamic and constructivist perspective: learning as a process of individual and collective knowledge creation and knowledge construction. The goal of this process is to profoundly understand a phenomenon in its multi-dimensionality and complexity and to reflect on the processes that have lead to this understanding. The issue we want to tackle in this paper is how this profound understanding can be brought about in a technology-enhanced learning environment. Design/Structure: Part 1 of this paper explores strategies of technology-enhanced knowledge sharing/creation in the field of higher education. Part 2 presents a successful blended learning scenario that illustrates the implementation of these learning strategies in a concrete course design. In this case study students are involved in active theory construction processes by conducting virtual experiments with a virtual organism. Part 3 elaborates on the epistemological implications of this case study. Findings: A constructivist framework for modes of knowing and modes of coming to know is developed. It is shown that – in order to reach a profound understanding of a phenomenon – it is essential to take into account the multi-faceted character of knowledge and to use the strategy of double-loop learning. Conclusions: This leads to an understanding of learning/teaching as a process of socio-epistemological engineering. Furthermore, the role of the teacher changes in such a constructivist setting of learning/teaching: Their primary task is to provide a “pedagogically (and technologically) augmented environment.” They are responsible for creating an atmosphere of collective knowledge construction and reflection. Beyond the role of a coach and moderator the teacher has to act as a facilitator or “enabler” for the (individual and collective) processes of double-loop learning. Keywords: Blended learning, collaborative co-construction, collective learning, double-loop learning, eLearning, individual learning, knowledge construction, knowledge creation, organizational learning, socio-epistemological engineering, university teaching.

1. Introduction

Our educational systems are being forced to develop in more and more specialized directions. Due to economic pressure, practical skills and competencies have become more important than general education (vs. “training”; cf. discussion about “Bildung” vs. “Ausbildung”). Many fields in high-tech industries, especially, have very high demand for highly specialized and trained workers. The reaction of our education system is to “produce” well-functioning specialists that exactly fit the required profile.

From cognitive, human, and a long-term perspective, the success and the effectiveness of such an approach is highly questionable. Developing and teaching general cognitive abilities seems to be at least as fundamental as training particular technical skills. That is why a pedagogical model which tries to integrate these two poles will be presented in this paper. The key to this approach is to focus on the operation of understanding. Understanding is the most profound operation of our thinking/cognitive system and, at the same time, the foundation for any reflective and responsible application of a technology or method. How can this operation be supported and developed in an educational setting?

The approach taken in this paper is to develop an understanding of teaching and learning processes which are “knowledge-based,” i.e., where the processes of teaching and learning are re-interpreted in the light of individual and collective knowledge construction and knowledge creation. It reveals that concepts from knowledge management and organizational learning, as well as from constructivism play a central role in this approach.

It will be shown that the strategy of double-loop learning (e.g., Argyris & Schön 1996) is essential for the process of understanding and knowledge construction. It takes into account both the constraints of environmental dynamics and the necessity to reflect on the framework of reference, the goals, the premises, and the methods which are applied to this process of knowledge construction.

Furthermore, we will see that conducting double-loop learning on not only an individual level but also in a group/team environment of cooperative knowledge construction amplifies the effect of the learning
2. Sharing and constructing knowledge in technology-enhanced environments

2.1 Knowledge sharing
What are the elements involved in such a context of educational socio-epistemological engineering? Almost every teaching/learning situation can be seen as a situation of knowledge sharing in one sense or the other. The goal of this process of knowledge sharing is to individually and collectively construct and create (new) knowledge as well as to develop a deeper understanding of the phenomenon under investigation. Figure 1 shows the elements and the processes which are relevant in this knowledge-sharing cycle.

Knowledge sharing always takes place between the poles of (i) individual knowledge (including all the cognitive processes leading to this knowledge), (ii) currently shared/collective knowledge, and (iii) organizational/scientific knowledge. The ultimate goal of knowledge sharing-processes (i) and (ii) is to generate and to create new knowledge. The construction of new knowledge is based on the combination of different sources of individual, collective and organizational knowledge.

The whole cycle is organized as a feedback process where the result of one cycle is the basis for the next round of knowledge creation. As will become evident in the following sections, these types of knowledge sharing determine how teaching and learning processes are organized.
2.2 Strategies of knowledge sharing/ construction

Each of these types of knowledge-sharing can be associated with knowledge-sharing and educational technologies (in a broad sense). These technologies give educational processes particular flavors and favor certain types of learning/teaching strategies and knowledge processes. Sharples (2006) introduces a differentiation relating strategies of knowledge sharing and learning/teaching with specific media (see Table 1).

In the era of mass print literacy, the textbook (and its related form in the domain of eLearning) was the medium of instruction (Table 1, A). This implies an understanding of knowledge transfer and downloading of mental models. Whereas in the knowledge transfer perspective, the goal of the learner is to repeat such knowledge or models, “advanced” learning strategies aim at individual and collective knowledge construction and modeling (see Table 1, B). Learning is a process of “coming to know”: learners, in cooperation with peers and teachers, construct knowledge and models which can be interpreted as transiently stable interpretations of their world (e.g., von Foerster 1972; von Glasersfeld 1984, 1989, 1995; Scott 2001; Sharples 2006). Most of the eLearning technologies that are presently in use support these processes by providing platforms for presenting knowledge, for enabling communication and for virtual collaboration and cooperation.

Going one step further, (Table 1, C) learning is extended “back to its roots”: this mode of learning and knowledge sharing/construction takes into account that each learner is not only embedded in an intellectual framework and in a virtual and artifactual environment, but also in their physical and social context (e.g., Pask 1975, 1976; Scott 2001). Furthermore, this approach respects the fact that they are not only a more or less passive recipient of the knowledge that constructs their mental models, but that the learner is also actively interacting with their environment. In other words, the learner is capable of actively changing environmental dynamics and structures (e.g., by conducting experiments, by creating artifacts). In that sense, learning becomes a kind of conversation/dialogue in context; it is dialogue and conversation on multiple levels: with other learners, with external reality, with external knowledge, etc. In such a context mobile learning technologies become highly interesting and effective tools that support these kinds of situated learning processes. Furthermore, “dialogue” is understood, in this context, to have the specific meaning of D. Bohm’s and others’ concept of dialogue (cf. Bohm 1996; Schein 1993).

Finally, it has to be said that these three modes of learning and knowledge-sharing do not exclude each other. Rather, mode C (“learning as conversation in context”) is based on knowledge-downloading processes – to some extent.

2.3 The concept of “ba”

If learning and knowledge-sharing processes are understood in such a way, we have reached a relatively sophisticated level of knowledge work: namely the domain of knowledge creation. It can be compared to a concept well known in knowledge management, which is referred to as “ba” (cf. Nonaka & Konno 1998; Nonaka & Toyama 2003). It is a physical or virtual collaborative space where participants feel safe to exchange and develop new knowledge. “We define ba as a shared context in motion, in which knowledge is shared, created, and utilized… Ba is a phenomenological time and space where knowledge, as “a stream of meaning” emerges. New knowledge is created out of existing knowledge through the change of meanings and contexts… Ba is an existential place where participants share their contexts and create new meanings through interactions.” (Nonaka & Toyama 2003, p. 6f)

In that sense, the concept of “ba” goes far beyond purely technological or educational issues – it concerns the general question of knowledge construction and knowledge creation; more specifically, the conditions enabling and facilitating these processes. If we start to understand university teaching and educational processes in general in such a way, the character of both the knowledge taught1 and of the learning strategies will change dramatically. In the following sections, the nature of these changes will be developed in more concrete detail.

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<table>
<thead>
<tr>
<th>Strategy of knowledge sharing and learning/teaching</th>
<th>Medium, technology, and context</th>
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<tbody>
<tr>
<td>A • Learning as knowledge transfer</td>
<td>• Print, textbook</td>
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<tr>
<td>• Learning as downloading and repeating of (well-established) mental models</td>
<td>• Download style (e)learning (“first generation eLearning”)</td>
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<td>B • Learning as (individual and collective) knowledge construction, modeling</td>
<td>• eLearning + collaborative aspect (virtual cooperation, communication, etc.)</td>
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<tr>
<td>C • Learning as dialogue/conversation in context</td>
<td>• Being embedded in a (concrete, physical, etc.) context</td>
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<td>• + creating/changing context</td>
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<td>• Embodiment in environment + in social context + in technological context</td>
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<td>• Immediate/direct experience with environment and changing reality</td>
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<td>• Mobile learning (technologies)</td>
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<td>• “Socrates-like learning,” “peripatetic learning”</td>
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<td></td>
<td>• Concept of “Ba”</td>
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Table 1: The relationship between strategies of knowledge sharing (teaching/learning) and the medium applied (adapted from Sharples 2006).
3. Case study: Enabling understanding via a process of collective theory construction in a virtual environment

This section presents a learning/teaching example that illustrates the implementation of learning strategies B and C (Table 1) in a concrete course design. It is based on an existing, well-developed, successful blended learning scenario that was developed as a medium-level course at the University of Vienna.

3.1 Virtual experiments and theory construction

The following example is a sub-project in the course “Internet Seminar on Philosophy of Science.” This seminar has been held with minor changes and adaptations several times since 2002. The target group is students at the end of their bachelor degree (3–4 semesters at the university, average age: 21–23 years). The interesting, and at the same time, challenging feature of the task is the highly interdisciplinary background of the participating students. Most of them come from the fields of educational sciences, psychology, and sociology. About 25–30% are students from the natural sciences (mostly biology and physics); 15% are from the field of computer science. The group size is about 20–25 students with an average of 60–65% female students.

The task of the student project is to develop a theory or model of the behavioral dynamics of a virtual organism: first in a process of individual and, second, of collaborative/cooperative virtual and face-to-face (f2f) knowledge construction. The conceptual and philosophy-of-science background of this task can be outlined as follows: “What are the epistemological characteristics of a theory or model?”; “Which processes are involved in developing and constructing a theory?”; and “Which modes of knowledge and knowledge generation are involved in this process?”

Whenever we observe the behavioral dynamics of an object we are interested in finding an explanation for its behavior, i.e., we observe a black box and try to make it “transparent” (in the sense of Glanville’s “black/white box,” Glanville 1982). Hence, almost every theory tries to offer a mechanism (acting as an “explanation”), which is responsible for generating the externally observable behavior. Epistemologically speaking, the problem is that we do not have direct access to this mechanism in our object of investigation2 in the real world; thus, the goal of almost every scientist is to “look behind this curtain” (Kosso 1992) and to construct a theory or model that “explains” or “predicts” the behavior that has been observed in the investigation of the black box.

The student’s task in this project is to experience what it means to make an experiment from the scratch: starting with observations, then interpreting them, attempts to find some structure and patterns in these observations, construction of hypotheses, development of more and more sophisticated models and predictive mechanisms, testing these predictions and – in case of falsification – starting this circle again. This project is realized as a virtual experiment in which students can interact with a web/cgi-based virtual organism (see Figure 2) by exposing this organism to a stream of input/stimuli. The sequence of the stimuli can be chosen freely by the student (see buttons at the bottom of Figure 2). These inputs are transformed into a pattern of behavioral responses that are displayed on the screen, i.e., every stimulus triggers a behavioral response.

Technically speaking, this virtual organism is realized as a finite automaton that has internal states, which correspond to the externally shown behavior in a homomorphic manner only (i.e., one single externally observable behavior can be realized by two or more different internal states, which are indistinguishable from the outside). This architecture implies that the organism does not follow a simple stimulus–response behavior pattern, but that it has non-linear behavioral dynamics, which leads to some confusion and perplexity in the course of theory construction. If students are not familiar with the concept of an internal state or of a non-trivial machine (von Foerster 1972) this task is the ideal setting for discovering and understanding these notions, which are highly relevant for almost every field in both

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![Virtual Organism](Figure 2: Screenshot of the virtual organism.)
are challenged to making these virtual experiments, students the natural sciences and the humanities. By
learning how to conduct a (virtual) experiment.
Learning to observe by making as few assumptions as possible (problem of theory-ladness).
Learning how to construct regularities in the virtual interactive experiment (in relation to the patterns of chosen inputs).
Individual construction of hypotheses and testing these hypotheses (“single-loop learning”).
Developing an adequate modus of presenting the resulting model in a manner that can be followed and understood by other “scientists” or colleagues.
Virtual presentation of one’s own theory in the group (via communication platform) and confrontation with different or even opposing models and approaches.
Defending and negotiating one’s own theory in the space of a virtual community (social competencies).
Reflecting and reaching an understanding of what it means to construct a theory and of which processes and difficulties are involved in this procedure;
Collective reflection on the process of theory construction leading to a deeper understanding of the process.
Transfer of these experiences into one’s own background and discipline.

The whole project is situated in a blended learning setting on the one hand students have to individually construct their models and theories by conducting online virtual experiments with the artificial organism. We do use a specific platform for the organism — it is programmed especially for that course. On the other hand, students have to discuss their ideas and hypotheses about the organism’s behavioral dynamics with their fellow students via a discussion board (both the open source “Discus” and the “WebCT Vista” discussion board are used). During the phases of presence/f2f, the processes of both theory construction and online discussion are discussed and reflected on. In the final session of the seminar, a presentation of the results and a final reflection on the whole project and its intellectual and social processes is made. This final reflection has turned out to be extremely important because students learn to see and understand differences in approaches, assumptions, and methods from looking at the diversity of results (that is due to the highly interdisciplinary audience).

This final phase is essential for consolidating the results and discourse, as well as for the social structure of the group.

3.2 Experiences, discussion, and reflection
The results and feedback of this blended learning scenario are manifold and it is possible to give details on only a selection of subjects:

Establishing the field as “ba”. Establishing a space of “ba,” as presented above, is a prerequisite for a successful collaborative knowledge-construction process. Students are engaged in examining their own (disciplinary) premises, their mental models, and their ways of constructing knowledge and of understanding a phenomenon. In order to do this, it is necessary to create a socially and intellectually safe environment where they feel free to start these sometimes quite personal explorations. That is why it is necessary to have several f2f sessions before starting that online project. In these sessions, the students have the chance to get to know each other and to develop a level of trust in a uncompetitive atmosphere: an atmosphere of exploration, of jointly searching for explanations and understanding, of listening, mutual respect, and openness was established.

“Experiencing” constructivism. Feedback from students showed that many of them have, for the first time in their university career, hands-on experience of actively developing a scientific theory/model. Above that, they have stated that they have the experience of what “constructivism feels like,” i.e., they experience various modes and stages of knowledge construction in a very concrete and direct way. It is important, however, that this process is accompanied by a theoretical discussion about constructivist issues and by a reflection on the concrete knowledge-construction processes. Leaving behind rather naive and “realistic” beliefs about (scientific)

knowledge is only one of the insights that have been gained in the project.

Understanding fundamental concepts (e.g., concept of internal states)
Although the groups of students are highly heterogeneous (regarding both their disciplinary backgrounds and their study progress) almost all of them have reached an understanding of fundamental concepts such as the role of internal states, the role of the behavioral/stimulus history, network representations, formal methods for structuring the behavioral dynamics, innovative ways of describing the mechanisms which are responsible for generating the observed behavioral dynamics, etc.

Understanding and abstraction. Feedback in the phase of reflection and concrete results (i.e., models and their descriptions) have both shown that this project has had a deep impact on the students’ understanding of the process of knowledge/theory construction and of what it means to develop concepts and hypotheses and to perform operations of abstraction. The construction of a concept is vital to the capacity for abstraction as one has to cognitively move from a singular event or a particular observation to an abstract concept, which has (a) a universal and (b) a constructive character and (c) essentially contributes to understanding the observed phenomenon.
The keys to bringing about profound understanding are manifold: students have to do something practically in a very concrete project; above all, they have to perform an intellectually challenging task that is closely related to problems they are confronted with in their life; and hence, they have to understand the meaning and the goal of this exercise (which is important for their motivation). There is a good balance between the phases of individual research and of cooperative knowledge construction.

Integrating know-how, know-what, and reflective knowledge. Due to its roots in epistemologically-founded knowledge didactics, the focus of this project is on learning to understand; understanding always implies the integration of various forms of knowledge and learning (see also 4). The design of this project forces the students to go through all stages of knowledge construction, in which they are confronted with a range of different
types of knowledge and at the same time have to reflect on these operations.

This strategy ensures that a high level of understanding is reached by integrating various practical activities with intellectual/cognitive tasks, social skills, and with a continuous process of reflection. The simulation of the organism as well as the situation of social simulation of a scientific knowledge-construction process both act as a motivation for performing such a challenging integration.

The collective dimension of understanding and knowledge construction. Introducing the dimension of (social) interaction, communication, and cooperation between the students increases the learning impact of this project. By mutually confronting their results from individual theory construction, students are not only trained to defend their models, but they are also led to deep insights about their own assumptions, premises, theoretical/disciplinary background, and scientific or intellectual cultivation.

Most of these processes happen in peer-to-peer communication and learning: the teacher only has to observe these discussions for a final reflection. It is very important to summarize and reflect the whole process of theory construction, plus the phase of cooperative knowledge construction and negotiation in a face-to-face phase, in order to consolidate the essential points and learning outcomes.

Interdisciplinarity: Integrating approaches from the natural sciences, humanities, and philosophy (of science). One of the most interesting experiences from this project has been the discovery of the richness of solutions and approaches. Due to the heterogeneous background of the participants, the results of this project, as well as of other projects in this seminar, have been highly diverse. What seems to be a weakness has turned out to be an absolute asset of this course: students are confronted with completely divergent and unfamiliar approaches and results from their peers and what is felt as an irritation in the first step facilitates a process of discussion and reflection on exactly the diversity of these results. As an implication, the reasons and the assumptions that lead to these results and their diversity are the focus of this debate. In these discussions, the collective mode of double-loop learning is realized (see 4.2.3 for further details).

Simulating scientific procedures and social competencies. Apart from cognitive competencies, this project focuses on acquiring social skills and insights into the (social dimensions of) cooperative processes of scientific theory construction. It is a kind of social engineering or social simulation in which the participating students are fully challenged in their roles as “scientists.”

4. Modes of knowing and of coming to know

When we learn, we are said to acquire “knowledge.” In CT (conversation theory), as a radical constructivist theory, “having knowledge” is understood as a process of knowing and coming to know. It is not the “storage” of “representation.” (Scott 2001, p 348)

What are the theoretical and epistemological implications of the learning design that has been presented above? What can we learn from and for a constructivist perspective? Apart from trivial statements, such as “knowledge is the result of construction processes,” it is necessary to take a closer look at two points: (i) Which types of knowing/knowledge have to be differentiated in educational and scientific knowledge creation processes (see 4.1)? (ii) Which modes of learning/teaching lead to a profound understanding of a phenomenon and how are these two points related (see 4.2)?

4.1 Modes of knowing

From the example above, it has become evident that knowledge and knowledge construction have to be considered as the heart of educational and knowledge-sharing processes. In order to understand and improve learning/teaching processes more profoundly, we have to take a closer look at the modes of knowing and knowledge that are involved in these processes. Table 2 gives an overview of these modes. This table identifies three domains describing (i) the level of knowledge (in the sense of which realm of the phenomenon/environment this level refers to), (ii) the cognitive activities which are necessary to construct and explore this realm, and (iii) the characterization of the knowledge which is the result of these construction processes.

4.1.1 From observations to causes. Level concerns the “superficial” properties of a phenomenon: our primary observation, perception, and cognitive processes bring about a rather superficial and singular (in the sense of referring to a single concrete object or phenomenon) kind of knowledge at first. This knowledge is realized as a list of observations, description of behaviors or behavioral dynamics, and as a list of data, facts, etc. It is not about the more general and universal properties of the observed phenomenon, but describes this phenomenon on its behavioral level.

Taking this descriptive knowledge as a point of departure and progress in the processes of construction, we reach the level of (emerging) patterns, trends, and relationships: they are not “directly perceivable” by our senses. In order to arrive at that level, more complex and active construction processes are necessary. This is usually the domain of the (natural) sciences, where first relationships are constructed between facts and descriptions, and behavioral patterns begin to emerge, i.e., these patterns are the result of more or less complex inductive and constructive processes (in most cases being realized as statistical procedures). Most so-called (scientific) explanations are situated on this level: they offer cognitive, mental, or even physical mechanisms that make explicit the relationship between hidden (theoretical) structures and observed phenomena.

These mechanisms are assumed to be “responsible” for generating the observed phenomena (cf., for instance, Maturana’s concept of scientific methodology: Maturana & Varela 1980; Maturana 1991). One can also offer an explanation for the constructed patterns and regularities by providing such a pattern-generating mechanism. Hence, the resulting knowledge is mainly concerned with the “how” and the dynamics of the observed phenomena. In many cases it has the form of “recipe-knowledge.”

The cognitive activities leading to this kind of knowledge have strong structural similarities with the processes of theory/hypothesis construction that are well-known from the natural sciences (e.g., Kolb 1984, p. 32; Pesci’s 2001). From a learning perspective, these construction processes can be considered as epistemological optimization aiming at finding the best possible level of functional
fitness (in the constructivist sense; e.g., von Glasersfeld 1984, 1991, 1995): they are realized in a single-loop learning cycle (see also 4.2.2).

On level 3 we go one step further; on this level, more qualitative issues are at stake. While level 2 is mainly concerned with rather quantitative and measurable matters, construction processes on level 3 aim at the realm of a phenomenon that goes beyond its material, measurable, and tangible properties, such as its meaning, finality, etc. Philosophically speaking, this level concerns the exploration and the construction of causes (for instance, in an Aristotelian sense [1989]). It can be reached by applying intellectual tools, such as radically questioning, exploring the meaning, or trying to reach “deep understanding” of a phenomenon. The resulting knowledge, in a way, is the source for a deeper understanding of a phenomenon, i.e., the construction of a kind of “deep knowing/knowledge” (e.g., Schamper 2000, 2001; Senge et al. 2004) or knowing a phenomenon “from within.” From a con-

<table>
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<tr>
<th>Level</th>
<th>Activity</th>
<th>Resulting knowledge</th>
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<tbody>
<tr>
<td>1</td>
<td>Behavioral level</td>
<td>Observing, Detecting &amp; registering, Describing</td>
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<td>Description of the observed object, its behavior (properties), its external and superficial properties (e.g., material, etc.)</td>
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<td></td>
<td></td>
<td>List of observed properties (“data,” “facts,” etc.)</td>
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<tr>
<td>2</td>
<td>Level of (emerging) patterns of behaviors and relationships</td>
<td>Searching for, constructing, and discovering regularities and patterns, Projecting patterns, Quantitative induction, Constructing patterns, Single-loop learning</td>
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<td>“Explanation” of the observed behavior by making use of internal mechanisms (which are postulated and “projected” into the observed behaviors)</td>
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<td>Know-how</td>
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<td>These mechanisms are considered to be responsible for generating the constructed (behavioral) patterns (i.e., the mechanisms that are the “pattern generators”)</td>
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<td>“Recipe knowledge,” skills &amp; algorithmic knowledge</td>
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<td>3</td>
<td>Level of causes and the “source”</td>
<td>Searching for, constructing, and discovering causes, meaning, finality, etc.</td>
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<td></td>
<td>Activity of “radical questioning”</td>
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<td>Constructing the intangible dimensions of the environment</td>
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<td>Constructing the “deeper source,” the “substance”</td>
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<td>Understanding the observed phenomenon</td>
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<td>Understanding its meaning and the “source”/causes which are behind the mechanisms</td>
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<td>Knowledge about the intangible dimension of the observed phenomenon</td>
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<td>Know-what/why</td>
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<td>“Deep knowing/knowledge,” knowledge about the core of a phenomenon</td>
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<td>Knowing “from within”</td>
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<td>“Metaphysical knowledge” (in the sense of knowing the “substance”)</td>
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<td>4</td>
<td>Level of potentiality, change, and design</td>
<td>Exploring and developing the potentials of a phenomenon</td>
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<td>Making use of and bringing “deep knowledge” and the mechanisms to the domain of application</td>
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<td>“Facere” and design</td>
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<td>Changing a phenomenon according to knowledge</td>
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<td>Artifacts, technology</td>
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<td>Changing social, scientific, and cultural realities</td>
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<td>Organizations</td>
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<td>Visions + their realizations</td>
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<tr>
<td>5</td>
<td>Level of reflection (on the causes, source, patterns, processes of knowledge construction, etc.)</td>
<td>Reflecting, reframing, Radical questioning of own mental models, premises, etc.</td>
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<td>Reflecting on the learning and construction process itself</td>
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<td>Reflecting on the design-process itself</td>
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<td>Double-loop learning</td>
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<td></td>
<td>Knowledge about the following questions:</td>
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<td></td>
<td>What are the assumptions/premises behind these causes/source?</td>
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<td></td>
<td></td>
<td>What are the mental models behind the observed behaviors, patterns and their source?</td>
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<td>How can these premises and mental models be changed and what effects would these changes have on the understanding of the whole phenomenon?</td>
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</tbody>
</table>

Table 2: Levels of knowledge, modes of knowing, and the (cognitive) activities necessary for developing these modes.
radical constructivism

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Chapter 4: Constructivist Epistemology

4.1.2 Creating realities, innovation, and reflection.

It is that level of deep knowing which also reveals another dimension of a phenomenon, namely, its potentiality with regard to change, i.e., each phenomenon is in a certain state at every point in time and that state can change over time. Hence, there exists a space of potential change at every moment: a space of possible changes which can happen or which can be induced to that phenomenon. As a simple example, think of a stone that is given a new form by an artist: a process of transformation into a sculpture according to the artist’s plan or knowledge. This sculpture is one possible instantiation in the space of potentiality of that stone. Only if one has a profound knowledge (level 3) about an object, a phenomenon, etc., is it possible to explore, construct, and develop the full potential of that phenomenon, i.e., on level 4 we change our perspective from the mode of (constructive) perception and “contemplation” to the mode of externalization and “facere”/doing. Both modes are construction processes (internal and external). The interesting point is that this level of knowledge not only explores the space of potentiality, but also realizes (some of) these possibilities. In other words, we do not remain in the space of intentionality/knowledge by constructing only new knowledge; rather new physical realities are created or existing (physical) realities are changed as a result of applying knowledge from levels 1–3 and by externalizing or instantiating this new knowledge in/to reality.

In a way it is a “materialized constructivism” where artifacts, design, technology, etc. are a product of this level-4 knowledge process in the same way as is creating cultural, scientific, social, etc. phenomena. This mode of knowledge is the key for most processes of knowledge creation, of innovation, and of finding and instantiating a vision.

Finally, level 5 knowledge brings in a completely new quality to the process of knowledge construction: the dimension of reflection. This step has the potential of fundamentally questioning the knowledge that has been constructed so far by reflecting on the knowledge, its premises, and on the construction and learning processes that have led to that knowledge. The cognitive activities, methods, and epistemological technologies that are applied in that process include processes of deep reflection and questioning, systematic reframing, questioning the premises and ideologies, the construction processes, uncovering mental models and hidden assumptions, etc. This level of knowing introduces a completely new dynamic into the whole process of knowledge construction and knowledge creation, because it is situated on a meta-level and it can bring up completely unexpected results and new perspectives which have not been considered so far (cf. also case study in section 3). As will be shown in section 4.2.3, this mode of knowing and knowledge acquisition can be realized in the double-loop learning strategy – it is especially powerful when it is performed in a collective setting.

Rogers (2001) gives a good overview of the role of reflection in higher education: the author shows the importance of this concept for the levels of knowledge that have been developed above.

4.1.3 Profound understanding: Complementarity of know-how and know-what.

Most approaches of teaching/learning aim at level 2 (and 3), i.e., skills, know-how and competencies (even at the university level). From an epistemological perspective it can be shown that these approaches do not really aim at the peak of human cognitive capacities: generally speaking, skills concern rather superficial knowledge on the level of functionalities, algorithms, “know-how,” techniques, “systems,” “recipes,” guidelines, methods, etc. Yet the human mind is “designed” to penetrate much deeper into the phenomenon of interest. Our intellect is not satisfied with being able to grasp the functional aspects of a phenomenon (e.g., the dynamics of a particular system) or to predict certain aspects. Rather, both our cognition and most complex tasks in almost every field (of science, economics, technology, etc.) call for a profound understanding of the object under investigation first. Only then can one start making serious decisions, predictions, or take action (in a responsible manner).

So, what do we mean by the term to “profoundly and deeply understand” a phenomenon? In fact, this question is as old as philosophy and has a wide spectrum of possible answers. In general, one can summarize that our intellect is interested in the meaning and the deeper sense of a phenomenon (cf. level 3, 4, 5 in Table 2). All of our intellectual efforts aim at achieving and constructing a profound answer concerning the understanding of the “what” (and the “why?”) of a chosen phenomenon of interest (Pask 1975, 1976; Resch 1977; Scott 2001). Above that, we are capable of reflecting both on the understanding of the phenomenon itself and on the (construction) processes that have led us to that understanding. Only when we have reached this level of operation we can claim to have come to a kind of profound judgment on a particular aspect of a phenomenon.

From a constructivist perspective, it is clear that the aspect of the “how?” or functioning of a phenomenon is an important contribution to the process of understanding it (in the sense of functional fitness). However, as has been well known since ancient philosophy and metaphysics (e.g., Aristotle 1989; Philippe 1991), there is (intellectual) primacy of meaning of and understanding a phenomenon (e.g., “causa formalis”) over having some idea about its functioning. One can only fully understand the functioning of a phenomenon if one has reached or constructed some understanding of its meaning, of its “what,” and/or its finality. Remaining on the level of functioning means that one has not penetrated very deep into the phenomenon: one has just arrived at...
some understanding of the dynamics and behavioral patterns (cf. level 2 of Table 2) of the phenomenon under investigation without having a profound understanding of its meaning.

This focus on the process of (constructing) understanding (in its most profound sense) is a point that has almost been forgotten in most educational approaches nowadays. Only if one takes into consideration issues from epistemology, the deficiencies of such a reduction to the functional aspects become evident. Hence, a profound pedagogical approach also has to be based on concepts from epistemology and theory of knowledge, as well as from cognitive science (e.g., Peschl 2003). As is shown by, for instance, Pask (1975, 1976), Scott (2001), Rodgers (2002), Rogers (2001) and many others, these modes of knowing are complementary: it is their combination that leads to a profound understanding of a phenomenon. Reducing knowledge to only one or two of these levels perhaps leads to highly specialized and efficient “optimizers” and well adapted “recipe applicators,” but surely will not bring forth persons with a highly open attitude, with exceptional potential for innovation and developing radically new perspectives, and with a high level of reflection.

4.2 Modes of coming to know – from downloading to reflected knowledge construction

Apart from types of knowing the world, we have to take a closer look at the modes of how these types of knowing come about. This question concerns the domain of strategies of knowledge construction/creation and learning.

4.2.1 Mapping instead of construction. From a rather naïve and unreflective perspective, learning is considered to be a process of downloading or mapping knowledge from a source: one aspect of a phenomenon is transferred into the student’s memory/knowledge in a linear process of mapping. The teacher plays the role of transferring prefabricated items of knowledge from “their brain into the student’s brain.” This approach is based on a rather straightforward concept of learning, knowledge, and cognition. It has its roots in the GOFAI approach (“Good old fashioned artificial intelligence”) in cognitive science (e.g., Boden 1990): knowledge is represented in symbols that have a fixed and externally determined meaning.

Classical fact learning (“drill-and-practice”) is a realization of this mode of learning. It is not really efficient from an intellectual perspective, as the level of understanding is not necessarily very high. This is due to the focus on syntactical structures rather than on the semantic dimension. An aspect of the environment is mapped passively to the learner’s knowledge structure via “borrowed chunks of knowledge” (since they are the result of the teacher’s or another person’s/researcher's cognitive processes). The learners themselves do not have a chance to learn the deeper meaning of these chunks unless they try to establish some kind of personal semantics that relate the content to their experience. The process of learning is rather passive and externally driven and, hence, not very satisfying and long lasting.

Epistemologically speaking, this approach to learning/teaching is implicitly based on a realistic perspective following a rather static notion of knowledge that is based on the following (implicit) assumptions: (a) knowledge is dealt with as an object that has a stable and “objective” meaning; (b) the origin of this meaning is not really clear; (c) the origin is more or less independent of its (cognitive) carrier and their experiences; (d) in the learning process this object is transferred from A to B like a parcel; (e) above all, it is reduced to linguistic structures in most cases.

4.2.2 First-order constructivist learning. Downloading knowledge does not guarantee a process of deep understanding, because the focus of this learning process – if it can be considered “learning” at all – is on reproducing syntactical structures or abstract patterns. Whereas the focus of linear learning is on mapping more or less static and prefabricated chunks of knowledge from one brain to another brain, the alternative approach of single-loop learning aims at emphasizing the process of actively constructing, creating, and developing knowledge. Knowledge is not predetermined, but has to be constructed in an active process of personal/individual and collective construction. This first-order constructivist mode of learning has its roots in Piaget’s learning models (learning and knowledge as adaptive functions) or in Kolb’s (1984) experiential learning.

As is shown in the inner loop of Figure 3, learning is embedded into a circular process: this epistemological loop is realized as a process of continuous interaction and feedback between the dynamics of the cognitive system’s knowledge and cognitive structures and its external and internal environment. The goal is to construct structures of knowledge in such a way that they fit into the environmental dynamics. This is realized in a circular feedback process of adaptation and construction. Via processes of perception and primary construction knowledge, structures are built up in the cognitive system. In a particular context, this knowledge is externalized in the form of behavior that fits more or less into the environmental constraints, i.e., at this point of externalization it becomes evident whether the internal model/knowledge has been successful or not. In other words, if the behavior fits into the environmental dynamics or not, if the predicted phenomenon takes place or not, if a particular desired effect of the behavioral action is achieved or not…

The learner’s knowledge has to be changed and adapted according to the success/failure and (mis-)match between the expected/desired results and the real environmental dynamics. This epistemological pattern is well known from the classical approach to knowledge construction in the natural sciences. It has been described by Popper (as “the process of falsification”; Popper 1962) or in the area of constructivist philosophy of science (e.g., von Glasersfeld 1984, 1995; Maturana & Varela 1980; Peschl 2001). Abstractly speaking, this procedure can be interpreted as a kind of “epistemological optimization and adaptation process.” The goal is to continually adapt the structures of knowledge in a feedback loop until an “epistemological homeostasis” (fit between knowledge, externalized behavior, and environmental dynamics) has been reached (cf. also von Glasersfeld’s concept of functional fitness, von Glasersfeld 1989, 1995). While linear learning is driven by an external teacher and their pre-fabricated knowledge, single-loop learning is an internally driven and self-controlled learning process.

From these considerations it is clear that the structures of knowledge that are developed in such a loop are the result of an active interaction with the environmental dynamics and, thus, are highly dynamic. Contrary to the
This second (outer) feedback loop takes into consideration that any kind of knowledge is always based on assumptions, premises, or a paradigm (Kuhn 1970). In general, knowledge always has to be seen as being embedded in and pre-structured by a particular framework of reference. Knowledge receives its meaning and structures from this framework of reference. Thus, understanding of a phenomenon can only be reached if this framework is taken into account because it provides the context and the “semantic infrastructure/background.” This framework of reference plays a key role in the process of learning as it determines the structure of the space of potential knowledge and gives meaning to its basic dimensions. The role of the framework of reference is never made explicit in the context of single-loop learning. It seems that this framework of reference is stable; due to this seeming constancy it is a kind of “blind spot” in our thinking, perception, and understanding. This implies that we do not normally have a conscious experience of these premises, assumptions, etc. on which our thinking is implicitly based. Taking a closer look reveals, however, that this framework of reference is not as stable as it seems.

The double-loop learning strategy takes this potential for changes in the framework of reference into consideration by introducing a second feedback loop (see Figure 3; cf. “why-loop”; e.g., Rescher 1977; Scott 2001). This is implies that a completely new dynamic becomes possible in the whole process of learning and knowledge creation: each modification in the set of premises or in the framework of reference causes a radical change in the structure, dimensions, dynamics, etc. of the space of knowledge. By that process, a new space of knowledge opens up so that completely new and different theories, knowledge, interpretation patterns, perspectives, etc. about the phenomenon under investigation become possible. In the context of science, this process can be compared to what Kuhn refers to as a scientific revolution (Kuhn 1970).

The role of reflection. The method applied to this process is basically the technique of reflection (e.g., Bohm 1996; Depraz, Varela et al. 2003; Rodgers 2002; Rogers 2001; Scharmer 2002; and many others). It is a process of radically questioning and changing the premises and studying their implications.
for the body and the dynamics of knowledge. Double-loop learning has its roots in cybernetics, learning theory, cognitive science, and the domain of organizational learning (e.g., Senge 1990; Argyris & Schön 1996). What are the goals and some of the basic implications of the mode of double-loop learning?

- Blind spots, ideologies, unconscious and perhaps unwanted assumptions, prejudices, or biases are uncovered and become evident in such a process of radical questioning and reflecting.
- Due to changes in the realm of premises, the number of possible knowledge spaces and knowledge dynamics explodes exponentially.
- Reflection is used as a “weapon” against single-minded and mono-disciplinary approaches and learning processes.
- Double-loop learning and reflection not only encourages inter-/transdisciplinary, but makes a multi-disciplinary approach a necessity.
- The profound and deep understanding of a phenomenon is supported in this process. By systematically taking different positions and by reflecting on these positions, the “what” and “why” of a phenomenon is revealed in a radical manner (cf. also Pask 1975, 1976; Argyris & Schön 1996). The learner is forced to go beyond pure functional descriptions and penetrate into deeper layers of that phenomenon.
- Focusing on and sharpening the cognitive capacity of perception and observation. Due to a rigorous process of questioning and reflecting, the capacity of one’s perception is constantly trained as well. One is forced to take new perspectives on the same phenomenon: by that multi-perspective approach, blind spots are uncovered and, what counts even more, new dimensions and new categories are discovered that include not only categories concerning the particular phenomenon under investigation, but also new categories concerning the processes of how to observe, perceive, and interpret in general! This is extremely important for almost every process of knowledge management/sharing, as multiple perspectives and their reflected consolidation are the foundation for every successful process of sharing meaning and understanding.

- Meta-learning. Double-loop learning forces reflection on the learning process itself and, hence, allows a critical perspective on the learner’s own processes, assumptions, and habits of knowledge construction and knowledge acquisition. The mode of double-loop learning unfolds its full effectiveness if it is performed in the milieu of a group or a team (under the assumption that the members of the group are ready and motivated to listen and learn from each other). Findings from organizational learning (e.g., Argyris & Schön 1996, Senge 1990, etc.) show that collective reflection is one of the most powerful instruments in the process of achieving both an individual and a mutually-shared understanding of a phenomenon or of a problem. Apart from the double feedback loops of this learning procedure, an additional feedback loop is introduced between individual and collective learning and knowledge processes. This additional feedback loop enables an even more radical process of questioning premises, as the space of possible perspectives and frameworks of reference is not limited to an individual, but to the variety of the participants’ knowledge backgrounds. Apart from the readiness of the group’s participants to listen to each other and to share knowledge, an atmosphere of mutual trust is a “conditio sine qua non” for the success of such a collective reflective setting. The “social technology” of Dialogue has turned out to be a highly effective tool for supporting these processes of collective reflection and breaking up each others premises (e.g., Bohn 1996; Schein 1993).

5 Concluding remarks

Looking back on the concept of “ba” that was introduced in section 2.2, one can see that collective double-loop learning is the core strategy for this kind of space-of-knowledge creation. “Good ba enables actors to detach themselves from day-to-day routines, externalize their personal knowledge, and to view a given phenomenon from various points simultaneously. In short, ba enables a dialectic process among actors... One way to achieve synthesis in ba is to have dialectical dialogues among participants who bring in various viewpoints based on various backgrounds. Dialectical dialogue is content-based... Questions such as “What is the essence of this thing/event?” or “Why do we do this?” let participants of ba see things and themselves from viewpoints that are rooted deep in their own beliefs and values, and from other’s viewpoints at the same time.” (Nonaka & Toyama 2003, p. 8)
As has been shown in the case study in section 3, mutually revealing one’s knowledge and premises to each other induces a completely new dynamic to the knowledge creation and learning process. It opens new aspects and, sometimes, dimensions in thinking and cooperative knowledge construction. One of the main conditions for such an emergent process is an atmosphere of openness and trust in the group of participants. It is the responsibility of the teacher or moderator to establish such an atmosphere, which facilitates these processes of developing shared understanding, shared meaning, and perhaps shared vision.

One of the implications of double-loop learning concerns the role of the teacher, which radically changes in such a constructivist setting of learning/teaching. Their primary task is to provide a “pedagogically augmented environment.” They are responsible for creating an atmosphere of collective construction and reflection (e.g., by drawing attention to the importance of openness and trust). Beyond the role of a coach and moderator, the teacher has to act as a facilitator or “enabler” for the (individual and collective) processes of double-loop learning.

Coming back to our original questions concerning the modes of knowing and of coming to know in section 4.1f, it appears that collective double-loop learning not only takes into account a wide range of levels of knowledge (see Table 2); above that, it is a highly efficient strategy both for achieving a high quality of profound understanding and for knowledge creation. In the course of this process, knowledge is generated that not only covers the functional aspects of a phenomenon, but that also includes its meaning and reflective aspects (see Table 2).

Applying these insights to educational processes is still not an accepted perception of learning and teaching. This paper has tried to develop a knowledge-oriented and constructivist perspective, shifting the focus from downloading stable chunks of knowledge towards understanding learning/teaching as a highly dynamic process of individual and collective knowledge construction and knowledge creation.

Notes
1. In fact, we will no longer be able to speak of “knowledge taught”; rather, the notion of “learning as conversation context” suggests the use of cooperative knowledge-construction processes.
2. This does not only apply to objects investigated by the natural sciences (e.g., animals or human behaviors), but also to the domain of the humanities. Think, for instance, of a piece of literature which is studied by a scientist. They are interested in what is “behind” this text, the meaning, the possible intentions of the author, the historical context, etc. These are questions whose answers are not explicitly present in the text (= the “empirical material”), but which have to be actively constructed by the scientist.
3. In the sense of not only “hard functional fitness,” i.e., not only functional fitness which is measured by direct success of behavioral externalization, but functional fitness in the sense of being an adequate intellectual instrument for achieving a better understanding.
4. Of course, this does not imply that this knowledge is final – rather, due to the inaccessibility of reality, the process of constructing knowledge and understanding is never-ending (cf. von Glasersfeld 1995; Pieper 2003).

References

Link
An example movie can be downloaded from http://www.univie.ac.at/constructivism/journal/data/1.3.peschl/


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