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Spielraum and Teaching

Wolff-Michael Roth & Daniel Lawless

University of Victoria

Domenico Masciotra

Massachusetts Institute of Technology & Université du Québec à Montréal

All correspondence concerning this paper should be addressed to Wolff-Michael Roth, Lansdowne Professor, Applied Cognitive, MacLaurin Building A548, University of Victoria, PO Box 3100 Station CSC, Victoria, BC, Canada V8W 3N4.

E-mail: mroth@uvic.ca.

Tel: 1-250-721-7885

FAX: 1-250-721-7767

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Spielraum and Teaching

Abstract

In recent years, reflection-in-action has been a major concept for taking account of the craft and practical aspects of teaching. Yet in the everyday teaching praxis, reflection is largely absent for most of the time. In this paper, we argue that this absence is due to the fact that reflection requires objects of thought which have to be constructed. Both the construction and manipulation of these objects requires “time-out” from acting in real time. Taking time-out is frequently impossible in the praxis of teaching, unless we want to miss the “teachable moments.” We propose *Spielraum*, room to maneuver, as a concept that describes the reality of teaching much better than reflection-in-action especially when there is no time-out for reflection. We use two extended classroom episodes to exemplify situations that are better described by the notion of *Spielraum* than by reflection-in-action.

In the past, epistemologies of practice have been elaborated on the assumption that any setting of action is constituted by objective properties at hand, that is, to the practitioner, in the same way that they are available to the analyst. But these epistemologies have largely failed to capture the essence of the teaching experience (van Manen 1994). The failure of such epistemologies lies in the fact that they do not describe the lived experience of teachers, nor the reality in and toward which their actions are directed. In turn, a popular response has been to adopt a reflective stance particularly as outlined in the work Schön (1983, 1987).

One of the benefits of Schön's work is that it provides us with a new rhetoric with which to discuss the practical activities of teaching (Fensternmacher 1988). Inevitably, however, each new paradigm evokes the need for clarification and continuing development. In this paper we focus on one concept within Schön's framework of reflective practice, namely, *reflection-in-action* which concerns itself with the ability of the immediacy of the relationship between thought and action to redirect a problematic situation. We suggest that given the temporal constraints of teaching, the immediacy of the demands of classroom transactions, the concept *reflection-in-action* is incomplete. In particular, we contend that when expert teachers are "surprised" there is no time for reflection as we understand it. Rather they develop and use *Spielraum*, room to maneuver, to explore and develop students' understanding within the immediacy of classroom transactions.

Theoretical Commitments

Reflective Practice

Pedagogical development is grounded in a reflective stance towards one's thoughts and actions. However, descriptions of reflective practice are often confounded by a lack of conceptual clarity about the nature of reflection itself. For example, van Manen (1995) suggests that we have little understanding about the differences between retrospective, anticipatory or contemporaneous reflection. Without developing a full treatise on the nature of reflection we offer a general working definition that allows us to deal with the central issue of the temporal constraints of teaching as well as the problematic of *reflection-in-action*. We suggest that reflection is a pragmatic (goal driven) action that attempts to objectify, conceptualize or thematize a problematic phenomenal experience. In this, reflective thinking is fundamentally purposeful and involves an initiating perplexity (Dewey 1933).

Given our understanding of reflection, we hold that the concept of *reflection-in-action* is confounded by the failure to distinguish between reflection as an individual cognitive event and emergent transactional events involving and embedding students and teachers. It is in the latter events that a widely construed concept of *reflection-in-action* becomes problematic and begins to break down.

Reflection-in-Action: A Temporal Problematic

Central to the development of reflective teaching is the concept of *reflection-in-action* or the logic of on-the-spot experimentation (Schön 1987). Recently, however, the limitations of the concept of *reflection-in-action* have been outlined and its usefulness for understanding pedagogical transactions questioned (Eraut 1995, van Manen 1995). Much of this criticism focuses on the temporal constraints of enacting reflective practice within a classroom environment. For example, if *reflection-in-action* is to include any element of reflection as we generally understand reflection to mean, then it must also involve a degree of detachment, because reflection necessitates an object (a representation of the world) to be operated on. Yet, representing and reflecting are processes that take time, which does not exist in the experience of ongoing action. Nevertheless, expert teachers are still capable of acting appropriately even without having the luxury of time-out for reflection.

Given the constraints of the immediacy of classroom transactions, the examples used by Schön (1983, 1987) are simply not analogous to the lived experience of working in a classroom with 25-30 active students. Take for instance the example of building a garden gate, which Schön (1987) uses to illustrate an action context framed in terms of *reflection-in-action*. First, he made a drawing. Next, he began to make the structure from pickets but stopped to think about how to make it square before continuing to nail the pieces to complete the gate. Of particular concern is the temporal characteristic of his actions, namely, his account is full of descriptions of time-out. Schön continuously stopped to think about his next move. Meanwhile, the gate in progress waited patiently, all pieces staying in place until Schön decided what to do next. Yet, from our experiences, teaching cannot be likened to the action of nailing a gate together.

Students, conversations, and activities do not wait; they continuously act and unfold. In real classrooms, teachers would be out of synch as soon as they engaged in such a process of continuous time-out. Unlike Schön, teachers have to act, without extended periods of time for representing (objectifying) students, conversational topics, and classroom. Teaching is a continuously unfolding event, and teachers must engage in the right action, at the right instance, even when the context has changed in unforeseeable ways. In each situation and moment, an action is required even if that action is non-action. More importantly, we suggest that experts relate to the setting in a non-thematic, non-self-referential awareness. There is no longer a subject that experiences itself in an objectified world—there is only enacting performance that constitutes an event. Experts are so involved in the activity that they do not experience themselves as separate from the activity. This absorbed oneness, Heidegger (1977) called *Dasein*.

Teachers' Dasein: Being-in-the-Classroom

Novice teachers often feel that despite their subject matter knowledge, teaching skills and understanding of educational theories, they remain unprepared for life in the classroom. They experience a gap between *theories* of teaching (classroom management, learning, and curriculum) and the *praxis* of teaching: a gap between what is being said about teaching, and what they experience as actually happening in the classroom. We submit that if theorizing of teaching is based on *Dasein*, we will be able to describe practice in ways which teachers can relate to their own experience.

Heidegger (1977) postulated *Dasein* (literally "being-there") as the fundamental mode of human existence. According to Heidegger, we always and already find (and therefore understand) ourselves as being at some place and some point in time. "In understanding, a particular Dasein takes a stand on itself in a *local situation* by appropriating a for-the-sake-of-which and some in-order-tos from *the world*" (Dreyfus 1991, p. 192). *Dasein* combines Self and world into a single irreducible entity: being-in-the-world. As *Dasein*, we are always somewhere, for some purpose, at some time, and absorbed in some activity. As teachers, our experience is one of being-in-*this*-classroom to teach *this* subject matter to *these* children. The classroom is not some removed entity which can be given in terms of its objective (shared) properties, but is an experienced world in and toward which we act by investing ourselves and introducing possibilities. Thus, it is because *being-in-the-world* and participatory belonging precede any subject-object relation (Ricœur 1990, 1991) that we find ourselves *first of all* in a world to which we belong, physically and socially, and in which we cannot but participate. Only *subsequently* are we able to set up objects (including the signs on which reflection is based) in opposition to ourselves, objects that we reclaim as objectively knowable. That is, only subsequently do we explain and theorize our teaching.

Teacher development, that is, the evolution of being-in-the-world involves a concomitant transformation of being, world, and the relation signified by “in.” The world is comprehensible, immediately imbued with sense (always and already shot through with meaning) because Self has the capacity to be present outside of itself (that is, as an other to Another) and in the world, and to be modified by the world as it is exposed to its regularities (Bourdieu 1997, Ricœur 1990). Having acquired a system of dispositions appropriate to these regularities, the *body* (mind and senses) is apt in practically anticipating these regularities leading to an em-*bodied* knowing, a practical comprehension of the world which is completely different from the conscious reading of the world that one ordinarily takes as understanding. *Dasein* is primarily constituted by possibility—a developing *Dasein* increases its possibilities for acting in its constructed world, its reality. These possibilities do not arise from a particular skill, but arise from the readiness for action correlative to the current situation and without cogitating next moves in a detached way. Readiness for appropriate action, whatever the unfolding events, means that the agent has *Spielraum*, the room to maneuver appropriately in the current situation. This *Spielraum* “is a version of originary transcendence” (Dreyfus 1991, p. 191). The trajectory of increasing mastery is therefore characterized by an enlarged system of (virtual) possibilities of integrated and simultaneously available action and an increased readiness for enacting these possibilities (Masciotra et al. in press, Roth et al. 1999, Roth and Masciotra 1999).

Spielraum

Dreyfus (1991) articulates what we consider the difference between *reflection-in-action* (Schön, 1987) and what we conceive of as possibilities in the *Spielraum* of the agent. The individual agent has *Spielraum*, room to maneuver in the current situation as the range of possibilities she knows *without* reflection. Schön did not operate in this *Spielraum* when he built his garden gate but stopped and reflected. Such contemporaneous reflection in situations, however, allows for a “stop and think” kind of action that may differ markedly from the more immediate action required in classroom interactions.

Classrooms, as complex settings, can be described and structured in many different ways. One’s positioning within (and the particularities of) the setting change what is salient. Master teachers, therefore, position themselves to increase their possibilities for acting without having to frame the setting in conceptual terms. Familiarity expands the reality, and with it, the *Spielraum* and therefore the possibilities for acting. “The range of possibilities that Dasein ‘knows’ without reflection, sets up *the room for maneuver* in the current situation” (Dreyfus 1991, p. 190). Thus, the possibilities open in any *particular* situation can be thought of as a subset of the *general* possibilities making up what is significant to the agent. These possibilities reveal what constitutes appropriate action in a specific situation. *Spielraum*, therefore, contributes to classroom interactions in two distinct ways. First, the teacher’s readiness for action allows an unfolding of a realm of appropriate possibilities within the immediacy of the student-teacher transaction. Second, this realm of possibilities, in turn, allows the teacher a point of entry to unfold the reality of the students’ understanding.

Theories of teaching need to account for the ongoing evolution of events in order to explicate the actual experience of teaching. To understand the *Spielraum* of a teacher, we need to understand her common sense, the taken-for-granted world; in situations of breakdown, we need to understand the salient elements that constitute her world. To demonstrate how the concept of *Spielraum* operates in a classroom situation we offer two illustrations in which a master teacher uses his *Spielraum* to develop and reveal the students’ conceptual understanding of a given problem.

Unfolding Conversations, Unfolding Realities

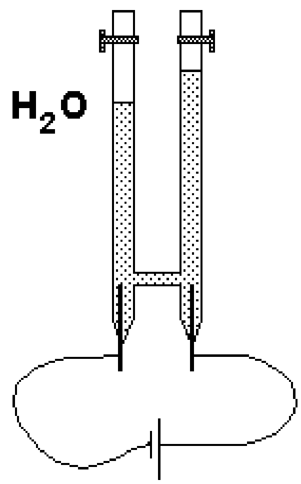
In this section, we provide two detailed vignettes of student-teacher transactions. We illustrate how unfolding conversations reveal and develop the realities of the participants. To be a master teacher means to be able to act at the right moment and in an appropriate manner. This requires considerable *Spielraum*, room to maneuver, in the face of all the contingencies real-time interactions pose to the participants involved.

Both episodes are taken from an ongoing study in a local middle school where Roth coteaches with teachers and interns. They are taken from one part of a larger ongoing research agenda designed to understand the reality of teaching science from the teacher's perspective, especially the enacted mastery in teacher-student transactions involving questioning sequences (Roth 1993, 1995, 1996a, 1996b, 1998a, 1998b, Roth et al. 1998, Roth and Boyd 1999, Roth et al. 1999, Roth and Roychoudhury 1994). Roth co-taught with several teachers in the same school; consequently, there were many opportunities to reflect on commonly experienced teaching events with colleagues at different levels of professional development. All collaborations between Roth and the teachers were constructed under the auspices of professional development using a participatory action research design (Eldon and Levin 1991), which in turn, led to the conceptualization of teaching developed in this article.

Episode One: Challenging Mickey Mouse Models

Teachers who use demonstrations as opportunities to explore ways of describing and explaining scientific phenomena, find that whole-class discussions can be full of surprises. Teacher-student conversations represent "good" teaching when they respect students' cognitive and emotive needs, follow an internal dynamic which unfolds in an intelligible manner for all participants, and reach specified curricular goals. Good teaching also demands that the teacher remains a presence and enacts a poise and effectiveness that enables her to achieve a close relationship with the students. With this presence comes a readiness for action which, because there is no time-out, precludes reflection. Master teaching is characterized by this readiness for action, which is a highly developed improvisation and the bipolar opposite of "winging it." Such readiness for action is exhibited in the following episode.

The following excerpt takes place in a grade 7 classroom where students are engaged in a 4-month unit on water designed to explore its physical and chemical properties. During a previous lesson, one of the two teachers in the class (Roth) had elicited students' hypotheses about the nature of the bubbles that are visible when water is boiled; these hypotheses included the four substances vapor, oxygen, hydrogen, and air. To construct a context that might allow students to eliminate two of these hypotheses (oxygen, hydrogen), Roth set up an apparatus (see figure in transcript) that produced oxygen and hydrogen. The purpose was to demonstrate characteristic reactions when a glowing and burning splint are brought to each, respectively (oxygen makes the glowing splint burst into flames; hydrogen, when lit, results in a small explosion). He prepared the experiment in such a way that, from the students' perspective, hydrogen would be produced in the left column corresponding to the position in the chemical formula from the reader's perspective (H_2O). An additional environmental clue to the nature of the gases could have been the fact that there was twice as much of the gas in the left column as in the right column (see figure in transcript).[1] Before starting his tests of the two gases, the teacher had decided to ascertain that students clearly understood the nature of the gases.[2]



01 Roth: These POINTS-TO[columns] contain different gases. Which one do you think is hydrogen, and which one is oxygen, given that you already know that this POINTS-TO[H_2O] is the chemical formula of water?

02 Tony: Hydrogen is right, oxygen is left.

03 Roth: Why would you say that this POINTS-

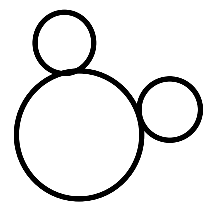
[1] The figure in the transcript shows an electrolysis apparatus as presented in the class. The chemical formula was written on the chalkboard so that the environmental cue (H_2 on the left side of the formula) would be consistent with the nature of the gas to the left, hydrogen (H_2). The current from the battery splits the water molecules to result in hydrogen and oxygen, which are seen as bubbles rising in the two columns; that is, in chemical terms, two molecules of H_2O change into two molecules of H_2 and one molecule of O_2. The chemical equation describing this reaction is $2\ H_2O \longrightarrow 2\ H_2 + O_2$.

[2] In this article, the following, common transcription conventions are used:
(3.2) -- Pauses in seconds, one-tenth of a second accuracy;
= -- Equal sign indicates "latching," i.e., the normal period of silence between the end of one speaking turn and the beginning of the next does not exist;
that -- italics indicate a greater emphasis on a word or syllable;
POINTS-TO[structure] — Physical actions whose objects are enclosed in square parentheses;
[-- square bracket to indicate overlap of speakers and activities with respect to ongoing talk;
?!. -- Punctuation marks speech patterns such as questions, exclamations, stops, and full stops, rather than grammatical units.

		TO[right column] is hydrogen?
04	Tony:	Because there is less hydrogen and more [oxygen in a water molecule]
05	Roth:	[POINTS-TO[“2” in H_2O]]
06		Does everyone agree with that?
07	Stan:	Yeah.
08	Jon:	Yeah.

To the teacher, Tony’s answer (line 02) was unexpected since, in his 15 years of teaching science, he had never heard students make the claim that the smaller amount of gas should be hydrogen. He had set up the electrolysis apparatus and written the chemical formula for water in such a way that, from the students’ location in the room, the hydrogen and oxygen columns and the order of these atoms in the formula were both the same. For the students in this situation, however, the physical arrangement (that brought the larger amount of gas and the H_2 in the formula into respective proximity) did not constitute an environmental cue. For Roth, this was a novel situation, an unexpected twist. Before he could proceed with demonstrating how hydrogen and oxygen reacted in the presence of glowing and burning splints, he needed to be sure that students identified the gases correctly. Rather than switching to a telling science mode, the situation became a moment of exploration. Above all, the teacher needed to understand the students’ understanding. That is, he needed to know what they understood, how they understood, and the nature of the reality in which they operated: As much as possible, he needed to know the world through the students’ eyes. The most appropriate teaching move, therefore, would be to elicit what salient perceptual elements led students to such a claim. At the same time, in his experience of the moment, he did not reflect. Questioning simply unfolded as a matter of course and without objectifying distance. Despite the unexpected nature of Tony’s response, his next question (line 03) elicited an explanation for the earlier response. Whereas the “2” in the chemical formula H_2O could have meant that there was more hydrogen, Tony’s response suggested that he thought the opposite. The teacher’s immediate action was to ask whether other students agreed with this answer which seemed so inconsistent with Roth’s own understanding. Nevertheless, other students agreed with Tony (lines 07-08).

09	Roth:	Where did you get the information from that there is more oxygen than hydrogen in the water?
10	Tony:	There is two little ones and one [big one, and one big oxygen.]
11	Roth:	[POINTS-TO[H_2 in H_2O]]
12	Stan:	The little Mickey,
13	Jon:	With the ears
14	Stan:	The little Mickey Mouse
15		[(5.3)
16	Tony:	WALKS[blackboard] DRAWS[Mickey model]]
17		This two POINTS-TO[small circles] are the hydrogen and this POINTS-TO[large circle] is the oxygen



The teacher's subsequent discursive move (line 09) effectively invited students to further elaborate on their response. Tony, Stan, and Jon then collectively disclosed the source on which their argument was based. As they had seen drawn by the intern teacher in the class, Tony drew a Mickey Mouse-like figure (see lines 15-16 in transcript) and identified the big circle as oxygen, and the two smaller circles as hydrogen. Here, students reasonably inferred that if there are size differences in the atoms, there should be differences in the volume these gases take up. However, from the scientific worldview that constituted Roth's reality, this inference was inappropriate, since gases, in their molecular form, take up the same amount of space irrespective of the size of individual molecules (and atoms). Furthermore, as the Mickey Mouse model of water had not been a part of his own reality before, he did not expect this image to be used as an argumentative resource. At this point, the teacher was in a delicate situation from which he had to get out, *then* and *there* (rather than at his desk analyzing teaching), without the time-out required to reflect (deliberate) on possible actions or evaluating the relative benefits of each action. At the same time, he had to continue to explore, *then and there*, the children's reality, their understanding, the conceptual structure of their reasoning, and the concomitant elements of the world as they saw it. All the while he remained committed to the development of the conversation. Our research with a preservice teacher who did her internship with Roth showed, that the most difficult aspect of becoming a teacher lay exactly in acting appropriately in the "here and now," to do the right thing at the right moment without having time-out for reflection (Roth and Boyd 1999).

When Roth questioned whether students generally agreed (line 06) with Tony's proposition, several "yes" answers made it necessary to find out more about the nature of the students' understanding. If there had been a "no" answer, the students could have been asked to elaborate on the opposite positions. However, since this was not the case a unique situation emerged as a result of the conflict between the students' conceptions and the teacher's. Nobody expected this situation even though everybody contributed to its emergence; however, only Roth could seize its pedagogical properties. His next action (line 09) positioned him so that he was able to elicit students' descriptions in order to develop a better understanding of their reality: The question elicited the nature of the resource on which students' argument were based. The subsequent exchanges brought forth just that. After Tony had drawn the Mickey Mouse model, and the three boys had constructed their explanation in the public space of the whole-class conversation, the teacher was able to enter the students' reality and position himself such as to retain his *Spielraum*. Thus, his subsequent questioning continued the conversation, engaged students in further inferences, elaboration, and explanations, and disclosed further aspects of the students' reality.

Roth's experience of this event can be described as analogous to the improvisation work of a jazz musician working off the play of other musicians while at the same time projecting her own presence, all the while moving the musical piece forward. Throughout the sequence, questioning was immediate and excluded time for reflection. Rather, Roth enacted within a large set of possible questions that were *present-to-hand*.[3] Emergent questioning was constituted by an appropriate next move, which not only

[3] Heidegger's (1977) notion of present-to-hand expresses that something is available without reflection such as this keyboard with which we write this article. It is present-to-hand, available and taken for granted and therefore permitting us to write, without having to reflect on its nature as a keyboard. It has become *transparent* to our activity of writing research.

allowed the teacher to understand the reality of the children but also engaged students in widening their horizon and therefore enlarging their reality. In the process of enlarging, new aspects of students' reality came to be known, including unexpected elements, which provided a new playing field on which to enact further questioning.

In this short episode, Roth was able to create new possibilities for action through effective questioning and listening. In essence, he created a *Spielraum*, room to maneuver, using the range of possibilities available in his currently salient world. At the same time, he did so without consciously reflecting prior to each move.

Episode Two: Building Models

The following episode describes an interaction between Roth and three students exploring the role of molecular models in explaining the states of matter (solid, liquid, and gas). For Roth, the central point of the unit was the nature of models as explanatory resources. Prior to this episode, the intern teacher had displayed an overhead transparency with drawings of the particulate models of solids, liquids, and, gases along with a definition of each. In the post-lesson debriefing, Roth suggested that students probably copied the drawings into their notebooks without actually understanding the role of models in explaining the three states of water.[4] He then proposed a small-group activity: Students would first build models in separate groups, followed by a whole-class discussion where students could explain why they built the models in the way they did, as well as describe how the models account for the observable physical properties of matter. This lesson could then lead into another one that allowed students to develop understanding of solid-liquid and liquid-gas phase transitions (melting <—> freezing; and boiling <—> condensing) by constructing explanations based on their previously constructed models.[5]

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[4] It is likely that in students' experience, the drawings are simply drawings rather than models that have, in the work of scientists, a reality of their own, their own properties and behaviors.

[5] There are different scientific ways to frame the phenomena at hand. The one to be developed with the students here focuses on the strength of the bonds between molecules. If bonds are strong, they are also rigid leading to a solid at the macroscopic level. If the bonds are weaker, the molecules begin to move with respect to each other, but are held together by the tension at the surface of the substance leading to a liquid. Finally, if the bonds are very weak or absent, the molecules can dissipate therefore explaining the gaseous state. Scientifically correct models that explain the different states ice, water, and vapor should therefore have stiff, loose, and no bonds between the models of the molecules (here the small and large marshmallows).

On the day of the model building lessons, Roth and the intern teacher provided students with a variety of materials from which they could freely choose components for their models. Both teachers then moved about the classroom to interact with students in their small groups. As Roth approached one of these groups, the following conversation ensued.

01	Roth:	So you are building a solid? (0.6)
02	Dan:	No, a liquid.
03	Bill:	Liquid.
04	Roth:	Why is that? POINTS-TO[string/marshmallow model] (FIGURE 1.a)
05	Sara:	I don't know, ask them POINTS-TO[boys]
06	Roth:	You explain it to me. (1.9)
07	Sara:	I don't know, maybe they should go together, see. POINTS-TO[Fig. 1.d]
08	Bill:	In the book. POINTS-TO[Fig. 1.d]
09	Dan:	In the book. (1.8)
10	Bill:	It's here in the book.
11	Roth:	But I want *you* to explain it to me. (2.2)
12	Sara:	They'd be moving around more, so they'd be a little farther apart.
13		GESTURES[slack between marshmallows on string] (Fig. 1.a)
14	Dan:	I go by what the book says.
15	Roth:	GETS[beaker with water, beaker with ice] (Fig. 1c)

At the start of the conversation the students have already built their models. However, when asked about various aspects of the structure they are not certain about why they actually build their models in the way they did other than they correspond to the drawings provided earlier by the intern teacher (lines 05, 07-10, 14). To move on the conversation, Roth went to get two beakers containing the two substances to be modeled, ice and water (line 15). This served to produce a *Spielraum* adapted to children by facilitating their reflection upon the relationship between the models they were building and their referents in the phenomenal world.

Insert Figure 1 about here

16	Roth:	What is the difference between the ice and the water here?
17	Bill:	This is closer POINTS-TO[water] and this POINTS-TO[ice] is farther apart.
18	Roth:	Do you see that?
19	Bill:	Yeap.
20	Sara:	There's gaps right there. POINTS-TO[ice]
21	Bill:	YES! See it is immersed.
22	Roth:	So there are gaps, what does that mean for the water?
23	Sara:	It is supposed to be together.

Here, Roth holds up the two beakers and asks students to identify differences between the two substances. Bill suggested that something is closer in water than in ice (line 17). Since the conversation was initially about the model, one could interpret his suggestion as a statement about the state described by the model in which molecules are closer in water than in ice. But the statement could also refer to the macro-state where the ice cubes have gaps between them. Roth (line 18), who evidently interpreted Bill's suggestion in the first way, asked the student if he could see the difference in the distances. The student laconically responded with "Yeap," which was elaborated by Sara who pointed out the gaps between the ice cubes. (She actually pointed to the beaker in general rather than to a specific gap.) Roth followed up on the description of the gaps by asking students what could be concluded about water (line 22). Sara suggested that water "is supposed to be together" (line 23). Although this may not have been salient to all students, or even Sara herself, she had provided a starting point for the description of liquids, namely that they fill a container without leaving spaces.

24	Dan:	No, it POINTS-TO[ice] is like one lump of salt. That is really all close together.

		Here GRABS[beaker w/ water] they are spread apart. See here, in my diagram. POINTS-TO[diagram of solid] They are close together. (3.4)
25	Bill:	Liquid.
26	Roth:	So, can you tell me what the water does that the ice doesn’t do?
27	Sara:	It moves more.
28	Bill:	It moves more, closer together.
29	Dan:	The molecules are closer together.
30	Sara:	Because the water is more compacted.
31	Roth:	OK, so the water is kind of compact. So, if you said, is one of them taking the shape of the container? (0.9)

We can see here how the students draw on the resources provided elsewhere (and by another teacher) to the situation at hand. They associate the spaces between the ice cubes in the beaker with the spaces between molecules in their notebook drawings. While there are spaces in both cases, the cases really are of different logical type and therefore cannot be compared within the standard scientific discourse. The challenge for the teacher is to help students move from where they are and from what they see, to a different way of describing, and therefore perceiving, and explaining the phenomena at hand, without doing violence to their current (but scientifically incorrect) perceptions. A good teacher does this in the then-and-there of the unfolding events and without taking time-out for reflecting. His task, therefore, is to enter the students’ world and by interacting with develop understanding; that is, he has to enable them to construct new avenues of perceiving, describing, and explaining what physics takes as its fundamental objects.

Not wanting to do violence to children’s observations and description imposes at least two important constraints on the teacher. First, he cannot simply impose his vision. His prior research had shown that students often see the same event in incommensurable ways (e.g., Roth et al. 1997). Second, in order to enter the reality of students, he has to listen empathetically and congruently. Therefore, he is obliged to use his questions as tools to help explore and understand their ontology, their experienced world and their explanations. But to do this, he has to remain open to their responses, and therefore ready for action in situations where he cannot know the specific descriptions and explanations students will produce in the next instance.

If Bill's description and explanation (line 17) referred to the particulate model of water, he would be incorrect.[6] However, rather than suggesting that his statement did not conform to standard science, Roth asked whether Bill could see these distances (line 18). This question, although it had unfolded from the ongoing events rather than from lengthy reflection, comes from the *Spielraum* available to the teacher, which opened up at least two possibilities. First, the student might refer to the gaps between the ice cubes, so that his description was a phenomenal one; or second, he might describe (in a scientifically incorrect way) the particulate model of water, his perception already informed by theory. Roth's move (line 18) opens the conversation up for clarifying this point, which in turn allows Roth to enter the reality of Bill, his ways of perceiving the materials and models (drawn and built) before him. The question has practical significance, in that it takes the inquiry further, as well as epistemic qualities, in that it changes what and how the teacher knows about the situation.

Bill's laconic answer, "Yeap" (line 20), does not allow inference about how he perceived the situation, but Sara's comment clearly identified the gaps between the ice cubes with respect to which the water was more compact. This came up again in the interaction following Roth's question about "what water does that the ice did not" (line 26). Sara and Bill suggested that water moves more (again we do not know which aspect they describe, but they may have referred to their experiences of water as fluid and ice as solid). Bill subsequently explained that this makes the molecules move closer together (line 28), and Sara added, that the water was more compacted (line 30).

In general, such a description of solid and liquid states would be inappropriate since molecular distances are smaller in solids than in liquids. In water, however, the situation is reversed. The molecular arrangements in ice (and the hydrogen bonding mechanism between molecules) actually make the distances larger (leading to a higher volume of a specified mass of the substance, therefore to a lower density, and to

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[6] We wrote "if Bill's description and explanation referred to…" because of the inherent under-determination of referents by signs (Eco 1984). Methodologically, we follow the ethnomethodological advise and take interacting individuals' own sense—available from their actions—as a starting point for understanding just what they meant. We begin our analysis with the presupposition that a shared view and understanding is a special case, which in many cases cannot be assumed (e.g., Roth et al. 1997).

the fact that ice floats on water). One of the descriptions students had not yet provided was then introduced by the teacher (line 31) namely that the water takes the shape of the container. The scientific theory indicates that the bonds between water molecules are weaker, and therefore allow for free movement of the molecules relative to each other. Thus the students' model, if they were to reflect the observation that liquids "fill" a container completely, needed to reflect the weak and flexible bonding between molecules. On the other hand, the observation that solids are inflexible should be reflected at the molecular level by rigid bonds (e.g., skewers, tooth picks) in students' model.

In fact, students' diagrams in their notebooks reflected models of solids and liquids in general but were inappropriate descriptions for ice and water. This conflict needed to be resolved without simply telling the students how Roth saw the events commensurable with his own disciplinary understanding. If the teacher wanted to be successful at all, he had to simultaneously facilitate the conversation to take certain turns and help students individuate aspects of the situation that lend themselves to a scientific description and explanation. At the same time, the teacher's actions needed to recognize that students' perceptions were likely to be different from his own. Thus, to be successful, the teacher needed to enter the reality of the students and engage students on their ground such that they could develop perceptions, descriptions, and appropriate explanations. Although Dan's (line 24) description and explanation appears commensurable with a scientific description, the teacher could not assume that all students or even Dan would be consistent in scientific ways across other aspects of the theorization of ice and water. In fact, Dan provided a scientifically incorrect description because he used the notes copied during the previous science lesson as explanatory resources: In his diagram, the particles in the solid were closer together than those in the liquid. What Roth's question (line 26) about the properties of ice and water did was deflect any possible impact of Dan's statement (line 24) and shifted the focal point away from the drawings to the properties. Basing himself in the drawings, Dan's regard was already theoretically informed. He perceived the water as a substance where the particles are farther apart than in the solid.

If he had not shifted the direction of the conversation, Roth would have been in the impossible situation where students explained water and ice in terms of a scientifically inappropriate model or could have confronted them with the fact that the drawings are incorrect, at least for the water. Another option was to defer such a discussion and refocus the present conversation to the nature of the bonding, leaving unanswered the questions about the relative distances between the particles in solids and liquids. At this point then, Roth introduced his description of water, as a substance that takes the shape of the container (line 31). This was not a move that resulted from reflection, for there was no time-out to objectify the conversation and its topics; therefore, there was no time to reflect upon possible conversational moves Roth might have instigated to change the evolution of the conversation. If he had done so, the point of attachment of his speaking turn to a particular previous student turn would have passed. Rather, Roth's comment refocused the conversation upon the properties of water and ice as evidenced in Sara's rejoinder (line 32).

32	Sara:	That one POINTS-TO[beaker w/ water]
33	Roth:	Why is that one taking the shape of the container?
34	Sara:	Because.
35	Roth:	Think about your model here, your water here POINTS-TO[model], does it take the shape of a container? FORMS[container with hands]? See, I have a weird container, can you put it in here?
36	Sara:	PLACES[molecules in hands]
37	Roth:	Does your model take the shape of the container?
38	Dan:	Not really.
39	Bill:	They are more compact, they need to be closer together.
40	Sara:	They need to be pushed together.
41	Bill:	To form the shape of the.
42	Sara:	Just push them closer together?

Roth developed this aspect of the topic by asking for an explanation (line 33). Thus, after the "taking shape of container" was salient in the case of the water, Roth refocused again shifting to the students' models. Here, "is one of them taking the shape of the container?" (line 31) is not like giving a correct answer to students, because this fact is already part of the students' lifeworld. Roth's question, which also sought confirmation for a matter of fact, made this scientific fact salient within the students' reality.

From a scientific (detached) perspective, this is an important move, for the models are used to explain the phenomenal properties of the world. To Roth, the nature of models as explanatory resources was the central point of this part of the unit. Rather than letting the descriptions unfold anew, Roth shaped the context of Sara's answer by asking her to think in terms of the drawing. Roth literally formed an odd-shaped container with his hands, and asked Sara to place her model into it. He followed through by asking whether the model took the shape of the container. Rather than focusing on the fact that the marshmallow molecules rested wherever they fell in the cupped hands, the students' descriptions made salient the remaining gaps. Dan, Bill, and Sara (lines 38-42) pointed out that the model molecules needed to be closer together if they were to appropriately represent the water.

Again, there was a conflict between the possibilities of models and the phenomenal observations made, interfering in fact with the teaching of the scientific di/vision of the phenomena. The problem here was that the model showed spaces within and between the models that were unfilled. The water in the beaker, however, did not have such gaps. Within the students' reality, this was a conflict which could only be resolved by pushing the model molecules together until the same gap-less continuity could be observed in the model as was observed in the phenomenon (water) to be explained. Roth's next move again had the potential to further enter students' reality (line 43).

43	Roth:	But if you were looking very close POINTS-TO[water], what do you think you would be seeing?
44	Dan:	Bubbles.
45	Bill:	Movement [water] less POINTS-TO[ice] movement. (2.5)
46	Roth:	LOOKS[intently at water, ice] Movement of what?
47	Bill:	Molecules.
48	Dan:	Water.
49	Bill:	Because, it takes the shape of the container. (2.1)

50 Dan: Ours GESTURES[marshmallows on string] are moving VIBRATES[string], like water in a container.

51 Roth: Yours are moving?

52 Dan: Like water in a can. VIBRATES[model] This is vibrating like water in a container. And it goes all around.

Specifically, his question ("…what do you think you would be seeing?" line 43) encouraged students to construct in public space possible descriptions of hypothetical close-up observations. Such moves are not designed in a reflective sense, for in the teacher's lived experience, there was only instantaneous (but deliberate) action without reflection (qua deliberation). Explanations of expertise in teaching need to account for this experience rather than simply dismiss it because it does not fit into structural descriptions.

Sometimes, the teacher did not use questions to redirect the movement of the conversation, but simply asked students to elaborate and explain previous utterances. For example, students' responses (line 44-45, 47-50) were constituted by laconic, short utterances. Roth responded with equally laconic questions that repeated student utterances (line 46, 51) resulting in further students' elaborations. Here, Dan and Bill provide the descriptor "movement" of water / molecules at the phenomenal level and movement of their two models (Figures 1.b, 1.c). Roth, when no more answers appeared to be forthcoming from the group, picked up on the last comment by putting into question the last student comment, "Movement of what?" (line 46). In the subsequent exchange, students then elaborated parallel descriptions at the model and phenomenal levels. For example, Bill suggested that the model takes the shape of the container (lines 47, 49) and Dan explicitly connected this to his own model. In this model, water molecules were stringed and suspended in a shoe box which vibrated like water in a container or can, and which "goes all around" in the box in the way water at the macroscopic level would (lines 48, 50, 52). From a scientific perspective, this model had tremendous power, for it showed both the relations between the molecules thought to exist at the microscopic level, and the phenomenal properties of water at the macroscopic level. (This likeness was later further explored and demonstrated when Dan [line 56] actually pushed the molecules closer together so that they could no longer move with respect to each other.)

In these excerpts, the teacher's questions had a double function, one pragmatic the other epistemic. On the one hand, his questions scaffolded the talk of students who were encouraged to express themselves about the ice, water, and the model for a liquid in front of them. On the other hand, by listening to the students' responses he entered the reality of the students, including their ways of perceiving and explaining certain topical elements. That is, the questions afforded the disclosure of students' current understandings. Therefore, while each question contributed to the unfolding shape of the conversation, the unfolding conversation, in turn, shaped students' understandings of the current topic and the teacher's understanding of students' relation to this topic.

Teachers interested in right answers or beginning teachers might have halted the conversation at this point or told students that they were correct and had achieved the lesson objectives. Roth, however, expanded the conversation so that the water model would be contrasted to solid (and later again, to a gas). (Our research shows that such extensions contribute tremendously to students' development of discursive competence [Roth 1996b].)

53	Roth:	How would you make a solid?
54	Dan:	A solid? You'd like, put them all really close together.
55	Roth:	And why would you do that?
56	Dan:	Because we learned that (2.8). Like these MOVES[marshmallows close together on string] have to stick together
57	Sara:	When they are close together, they don't move. But when they are separate, they are spread apart, and then occasionally, they move closer together.

After Dan had so vividly demonstrated the properties of water and of the model to explain these, students were now facing a new reality with a question that asked them how the model of the solid should be made. This question contrasted with the immediately preceding explanation of the liquid model so that the answers formed a textual contrast to the previous answers. Here, Dan at first suggested moving the molecules in the model closer together (line 54), but Roth encouraged him to elaborate on his design move by asking for an explanation. In his rejoinder, Dan did not really provide an explanation other than deferring to the authority of his regular teacher ("because we learned that") but insisted that the molecules had to stick together. Sara provided a description of the model that is commensurable with a scientific description: There is more movement when the molecules are "spread apart."

Here then we have a move where the question changed the situation, and in doing so, provided students with *Spielraum* to expand their reality and to perceive and explain the differences that they experienced. Although Roth did not reflect on the move, its effect was to bring about the students' reflection on situating their model and their task in the context of other models and tasks. A posteriori, one might suggest that Roth's next move could have been to ask students again to explicitly address the relationship between the model and phenomenon. Roth, however, continued to expand the context anew and asked how a model of gas would be different from the models for a solid and liquid they had elaborated thus far.

58	Roth:	And how is gas different then?
59	Dan:	It goes wheeee.
60	Sara:	It goes apart, spreads out GESTURES[into the air], and when it moves, it is all independent.
61	Roth:	So if you were to model a gas, would you model it with a string? POINTS-TO[string model]
62	Sara:	Gas?
63	Roth:	Yes. How would you model a gas?
64	Dan:	I don't know, you'd have to.
65	Jon:	Like we have the water molecules, but really far apart.
66	Sara:	Like I know, you would put the marshmallows into a bottle or a box, and you would put the water molecules on the toothpick. When they, maybe, you can have them in there.
67	Roth:	And how far can they move apart?

68 Dan: The water vapor would leave the container.

69 Bill: Very far, until they hit the walls of the container.

70 Roth: But if you don’t have a closed container?

71 Dan: They would go into the clouds.

72 Bill: They would go into the atmosphere, and then come back with the rain.

73 Sara: But they wouldn’t be able to leave the room because of the ceiling.

74 ((Intern stops the activity and has students clean up.))

In this last segment, Roth’s questions encouraged students to design and explore the model of a gas. In response to the question how gas would be different from the other two states, Dan and Sara provided phenomenal descriptions of gas, but neither one addressed the nature of the model. Roth’s question (lines 61 and 63) raised this as the issue. Jon brought the distance into the conversation—which has to be large—and Sara suggested that the model molecules had to be detached from each other. The episode concluded with a scientifically appropriate description of what the model for water in its gaseous state would have to look like.

This end has to be considered temporary, for it is only during subsequent lessons that the teacher can find out if students’ language remains consistently scientific across a variety of situations. We cannot ever know whether students were aware at this point of the differences between water and other substances, or what *exactly* they were thinking independently from what they express. Aware of these dilemmas, Roth engaged students during the fo0llowing lesson in conversations about the anomaly of water in terms of the relation between interatomic distances and state of matter. Nevertheless, our research showed that these students changed their concept of the water molecule and models of water in its three different states. These students clearly demonstrated these developing understandings on quizzes and unit tests. We therefore assume that *these* interactions with the teacher have led to important student learning.

Discussion

In our previous work (e.g. Roth 1993) which was conceptualized in terms of Schön's (1987) *reflection-in-action*, we have missed an important aspect of understanding the immediacy of classroom events. In order to develop this understanding we have adopted a phenomenological framework that begins with the concept of being-in-the-classroom (Roth et al. 1999). We suggest that to understand the *Spielraum* of a teacher, we need to understand her common sense, the taken-for-granted world. In situations of breakdown we need to understand the salient elements that constitute her world. In this paper we have used two episodes to help unfold that understanding.

In the first episode where students suggested that the gas with the greater volume should be oxygen (because Mickey's head portrays oxygen as a much larger atom) Roth was in an unexpected situation. The new element was a description never heard before. Consequently, he positioned himself such as to uncover the source of the unexpected answer, and thereby, create new possibilities and a greater *Spielraum* for action. Questions that elicited students' perceptions permitted him to see the world through their eyes as well as allow students to reconstruct their own perspectives. Similarly, in the second episode, students perceptions of ice and water included elements that were not entirely expected such as the fact that students saw spaces in ice (a posteriori we know they saw spaces between the ice cubes). Rather than saying that there were no spaces in ice, Roth's moves created *Spielraum* for developing the conversation with students, which in turn disclosed students' perceptions. From there he could then contribute to the conversation and help students reframe their descriptions of the phenomena and reorient their perception.

In each instance, the teacher exhibited a readiness for appropriate action although he could not know in detail what students would contribute to the conversation. At the same time, we note that his knowing-in-action was actualized in his being-in-the-classroom. The practitioner knows the world, but in terms of lived knowledge that is not external to a knowing consciousness. Paraphrasing Bourdieu (1997) we may say that the practitioner knows his world too well, without objectifying distance, precisely because he is part of it and inhabits the world as he does his habit (costume) or his habitat. In the reality of teaching, the teacher as practitioner inhabits the classroom. His fundamental mode of existence is that of being-in-a-classroom. Here, there is no time-out, no time to reflect on and consider alternative actions. In the reality of teaching, we seldom stop and deliberate our next moves. As experienced practitioners, we enact good questioning and live our subject matter knowledge. This was also true in the present episodes as evidenced in the following comment (expressed during one of our recorded debriefing sessions) on the teaching episodes presented earlier.

> [Roth:] In this situation, I was not thinking about wait time, or productive questioning. These are ways of describing teacher knowledge but they do not describe my reality of teaching. In this situation, I was simply ready to seize the moment. When I think about teaching, my declared intentions are to increase the discursive competencies of students. I want to reach this through the engagement in conversations. As the conversation unfolds, I ask questions that appear to be the most appropriate at this moment. My universe is this group, the materials water and ice, the models students had constructed. I am also aware of what I want, approximately, models which have some explanatory pedagogical power.

Thus, in the episodes presented here, the conversations unfolded. Roth did not have time to reflect, but had to do his part for the conversation to unfold. He could not go and look up some information, re-represent the situation in terms of some symbol or sign, then figure out a solution which he could implement in his questioning. Such reflection would have been prohibitive in terms of time and energy as well as lead to a loss of synchronicity within the unfolding conversation. If the teacher was to be successful in his questioning, he had to enact questioning on the spot, without time-out for reflection. As an experienced practitioner with over 20 years of teaching physical science, Roth had developed an extended capacity for creating *Spielraum,* which enabled him to unfold the students' realities.

Unfolding Students' Realities

Phenomenological (and constructivist) presuppositions hold that our realities differ because the experiential horizons that frame our perception and interpretation differ. Roth, with extensive experience and training in physics has his own "reality of physics"; but his students' experiences are different and so is their reality. His questions opened up students' reality, but at the same time expanded the boundaries that determine students' current interpretive and perceptual horizons. In this sense, the questions guided or scaffold students because they always tested the outer edge of students' current reality. The questions therefore can neither be completely in Roth's reality of physics, nor completely internal to students' reality, but always along the interface of the two. Students required opportunities to explore their own horizon on the basis of the world that is currently familiar to them. But simultaneously, the conversation had to engage them in a journey that took them beyond what they already know and without the understanding of where this will get them.

For the teacher to do an appropriate job, he needs to find out what the reality is like, in which reality students are operating, how they situate themselves and the subject matter in it, and where their horizons are positioned. Masterful questions which come from the *Spielraum* available in the then-and-there of the unfolding classroom events have the double purpose of unfolding the existing reality of the student as well as expanding the boundaries of the horizon that constitutes this reality. The movement, though instigated by the teacher, has to come from the students. They are the builders of their own reality. The teacher can encourage students, provide scaffolds, or stop someone from taking a blind alley (e.g., Roth 1994), but only students themselves can enlarge their own reality.

In the present episodes, students made diverse connections and observations that did not fit into the teacher's questioning scheme. For example, they suggested that there was more oxygen than hydrogen in water, or they proposed that there was more space between the molecules in a solid than in a liquid. In the Mickey Mouse world this was a correct inference. Nevertheless, students thereby made salient elements that are not relevant, and even run counter, to the conceptual aspects of the subject matter children are to learn according to the curriculum guidelines. Here, the students made salient that water presented itself in a closed form, whereas there were gaps between the ice cubes. This was an unexpected comment, and, if the situation was to lead to learning for the student, if their descriptions were to change to become commensurable with current scientific standards, Roth needed to contribute to the discourse in ways that allowed such a change to occur. It would not have helped if he had provided students with a description and explanation in his own physics reality, for it is highly probable that the students would not have been able to perceive or understand what he said (e.g., Roth et al. 1997, Roth and Tobin 1996).[7] Yet despite

[7] Extensive studies of lectures at different levels of schooling showed that a majority of students perceived the demonstrations considerably different from the teacher. Thus, the teachers' explanations and theoretical developments made little sense and ultimately led to scientifically incorrect understandings.

the unexpected nature of particular student responses, the teacher was not unprepared and still had *Spielraum* available for developing the lesson.

Thus, when we try to understand what a teacher does, and when we try to understand how a student learns and constructs her new world, we need to understand their reality *then-and-there*, at the moment of the interaction between them. It makes little sense to describe teachers, students, and context in terms of an objective reality. Instead, we need to understand the salient elements that constitute their contemporaneous worlds, for these are the experienced worlds in which they act and react in an absorbed manner and without objectifying and representing the situation.

Implications for Teacher Education

Novice teachers often feel cheated because what they learn in university classrooms does not seem to apply to their practice as teachers. This was also the case for the novice teacher who co-taught with Roth a 4-month unit on water (Roth and Boyd 1999, Roth et al. 1999). Her trouble was not that she was ill-prepared. She had been a successful student in her classes and had acquired a stock of discursive resources on which to draw for implementing discipline. That is, she could talk about the necessary forms of teacher knowledge as well as the need to reflect on her teaching in general. In conversations outside the classroom, her pedagogical discourse was quite elaborate and she had many resources to bring to discussions. Yet, however hard she tried, she found it impossible to "implement" the knowledge which she had acquired in her university courses. (The problem lies, of course, with the notion of 'implementation' and the epistemology underlying the teacher training that she underwent [e.g., Roth et al. in press]. Adherents of this epistemology presume that one can acquire a practice such as teaching in the form of propositional knowledge which, during practicum like situation, can than be converted into practical knowledge.) When it came time to enact a curriculum in the *here and now* of the classroom, she felt at a loss—and ultimately cheated by her university teachers. In the end, after all else had failed, she began to enact, in a trial and error fashion, a search for appropriate responses in a *here and now* fashion (Roth et al. 1999). That is, the intern teacher had to find ways in which she found herself acting in *this* classroom with *these* students at *this* time. This kind of knowledge is not always transportable, because, as robot designers have learned the long and hard way (cf. Wheeler 1996), *robust* knowledge is always situated and situating. But this too is consistent with the realities of teaching, and many a teacher has found herself in a situation where, whatever she had done and tried in the past, does not seem to help with this class, at this time, and in this context (e.g., Roth and Tobin 1999).

Rather than focusing on the teacher and blaming her for not being competent, nor focusing on these students and blaming them for being a “bad” class, our focus should be on the relations of *this* teacher in the reality of *this* class. We need to ask, “What do we need to do to develop the relationship in the most appropriate way?” We suggest that there is a need to think about and theorize teaching in a non-rationalist way. Because some aspects of teaching are akin to a craft (Grimmett and MacKinnon 1992), as practice without theory, it therefore requires a different pedagogy. Teaching requires a pedagogy that differs from that suited reproduce explicit procedural and propositional knowledge, which only produces teachers who talk well *about* practice yet are unsuccessful *enacting* practice. Much of what is to be communicated about teaching exists as a *modus operandi,* a mode of production (and reproduction) that presupposes a mode of perception and set of principles of di/vision. Furthermore, one of the best ways to appropriate it is in practical operation, by coparticipating with a more experienced other (Roth 1998b). This allows novice teachers to experience how teaching operates in the face of practical choices without necessarily explicating them in the form of formal precepts.

If teaching is so embodied and tied to our experience of being-in-the-world of the classroom, it comes as no surprise that learning to teach requires the personal experience of teaching in classrooms. By coteaching, novice teachers can observe and begin to emulate the more seasoned peer—how he walks about the classroom, calls on students, waits, feels confident, deals with a difficult situation then and there and generally expose themselves to the knowing-in-action that lies at the heart of Schön’s work.

Conclusion

We began this paper by noting that past epistemologies of practice have failed to capture the essence of the teaching experience. That is, it lies in the nature of theoretical knowledge that codified social scientific facts, moral philosophy, and teaching methods generally cannot tell a teacher what to do in particular circumstances. All practical, real-life situations are so complex that any single theory is undermined by the facts at hand, the world as experienced by the participating individuals. It lies in the nature of theories and generalizations that they are too universal so that potentially many of them can befit the same situation. What a teacher then would have to do is try finding that which is most appropriate in the situation. When she does this, she is almost always in trouble, for she has to take time-out to reflect, select, plan a course of action, reconnect with the situation at hand and hope that she has not too much out of touch with the students' reality.

There is therefore a gap between the objective truth of the world and the lived truth of who we are and what we do in the world. This gap is thematized and topicalized in those instances when the subjects of research oppose objectivist and objectivizing analysis by saying, "This is not the way things are." We contend that *Spielraum* is closer to what we actually experience during teaching. When we have little *Spielraum*, we feel classroom events to get out of hand and out of control. We begin to feel to have done something different and wish to be able to redo a lesson. As experienced teachers, we are intuitively aware of our *Spielraum*. However classroom events unfold, we position ourselves such as to turn them into "teachable moments."

However, it is difficult if not impossible to describe the ineffable aspects of the teaching experience associated with *Spielraum*. Most research in teaching is engaged in technical descriptions of the explicit. But it has been noted (though without description of specific cases) that the elements which make expertise what it is do not lend themselves to description (Dreyfus and Dreyfus 1986). Our difficulty therefore rests in trying to communicate something that is ineffable, that is, constructing credible accounts of our dispositions and experiential knowledge. We suspect that is it out of this same struggle that much of the controversy over descriptions of teachers' knowledge including Schön's *reflection-in-action* is born as well as gives birth to other concepts such as *Spielraum*. Nevertheless, our descriptions cannot be like those that are constructed within the frames of a technical rationality. Understanding dispositions is a process that requires both the lived experience and the reflective practice objectifying this experience. Only in this double move of bringing together lived experience and rational reflection can we come to understand texts and actions (Ricœur 1991). Explication is concerned with the structuralist identification of fields of forces and *positions*, the distribution of socially efficient resources that define the external constraints bearing on interactions and representations. Understanding is concerned with the immediate, lived experience of agents in order to explicate the categories of perceptions and *dispositions* (appreciations) that structure their action within their horizon.

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References

Bourdieu, P. 1997. *Méditations pascaliennes* [Pascalian meditations]. Paris: Seuil.

Dewey, J. 1933. *How we think: A restatement of the relation of reflective thinking to the educative process.* Boston: D.C. Heath and Company.

Dreyfus, H. L. 1991. *Being-in-the-world: A commentary on Heidegger's 'Being and Time,' division I.* Cambridge, Mass: MIT.

Dreyfus, H. L., and S. E. Dreyfus. 1986. *Mind over machine: The power of human intuition and expertise in the era of the computer*. New York: The Free Press.

Eco, U. 1984. *Semiotics and the philosophy of language*. Bloomington: Indiana University Press.

Eldon, M., and M. Levin. 1991. Cogenerative learning: Bringing participation into action research. In *Participative action research,* ed. W. F. Whyte, 127-142. Newbury Park, CA: Sage.

Eraut, M. 1995. Schön schock: a case for reframing reflection-in-action? *Teachers and teaching: theory and practice, 1*, 9-22.

Fensternmacher, G. D. 1988. The place of science and epistemology in Schön's conception of reflective practice? In *Reflection in teacher education,* eds. P. P. Grimmett & G. L. Erickson, 39-46. Vancouver, BC: Pacific Educational Press.

Grimmett, P. P., and A. M. MacKinnon. 1992. Craft knowledge and the education of teachers. *Review of Research in Education* 18, 385-456.

Heidegger, M. 1977. *Sein und Zeit* [Being and time]. Tübingen, Germany: Max Niemeyer. Engl. version consulted was translated by J. Macquarrie and E. Robinson New York: Harper and Row, 1962.

Masciotra, D., E. Ackerman, and W.-M. Roth. in press. "Maai": The art of distancing in karate-do mutual attunement in close encounters. *Journal of Adult Development* **, ***-***.

Ricœur, P. 1990. *Soi-même comme un autre* [Oneself as another]. Paris: Seuil. (Translation consulted by Chicago University Press 1992.)

Ricœur, P. 1991. *From text to action: Essays in hermeneutics, II*. Evanston, IL: Northwestern University Press.

Roth, W.-M. 1993. Metaphors and conversational analysis as tools in reflection on teaching practice: Two perspectives on teacher-student interactions in open-inquiry science. *Science Education* 77, 351-373.

Roth, W.-M. 1994. Experimenting in a constructivist high school physics laboratory. *Journal of Research in Science Teaching* 31, 197-223.

Roth, W.-M. 1995. Affordances of computers in teacher-student interactions: The case of Interactive Physics™. *Journal of Research in Science Teaching* 32, 329-347.

Roth, W.-M. 1996a. Teacher questioning in an open-inquiry learning environment: Interactions of context, content, and student responses. *Journal of Research in Science Teaching* 33, 709-736.

Roth, W.-M. 1996b. Thinking with hands, eyes, and signs: Multimodal science talk in a grade 6/7 unit on simple machines. *Interactive Learning Environments* 4, 170-187.

Roth, W.-M. 1998a. Science teaching as knowledgeability: a case study of knowing and learning during coteaching. *Science Education* 82, 357-377.

Roth, W.-M. 1998b. Teaching and learning as everyday activity. In *International handbook of science education, eds.* K. Tobin and B. Fraser, 169-181. Dordrecht, Netherlands: Kluwer Academic Publishing.

Roth, W.-M., G. M. Bowen, N. Boyd, and S. Boutonné. 1998. Coparticipation as mode for learning to teach science. In *CONNECTIONS '98,* ed. J. Anderson, 80-88, Victoria, BC.

Roth, W.-M., and N. Boyd. 1999. Coteaching, as colearning, in practice. *Research in Science Education* 29, 51-67.

Roth, W.-M., D. Lawless, and K. Tobin. in press. Time to teach: Towards a praxeology of teaching. *Canadian Journal of Education*.

Roth, W.-M., and D. Masciotra. 1999. Relationality as an alternative to reflectivity. *Submitted*.

Roth, W.-M., D. Masciotra, and N. Boyd. 1999. Becoming-in-the-classroom: A case study of teacher development through coteaching. *Teaching and Teacher Education* 15, 771-784.

Roth, W.-M., C. McRobbie, K. B. Lucas, and S. Boutonné. 1997. Why do students fail to learn from demonstrations? A social practice perspective on learning in physics. *Journal of Research in Science Teaching* 34, 509-533.

Roth, W.-M., and A. Roychoudhury. 1994. Science discourse through collaborative concept mapping: New perspectives for the science teacher. *International Journal for Science Education* 16, 437-455.

Roth, W.-M., and K. Tobin. 1996. Aristotle and natural observation versus Galileo and scientific experiment: An analysis of lectures in physics for elementary teachers in terms of discourse and inscriptions. *Journal of Research in Science Teaching* 33, 135-157.

Roth, W.-M., and K. Tobin. 1999. Toward an epistemology of teaching as practice. *Submitted*.

Schön, D. A. 1983. *The reflective practitioner. How professionals think in action.* New York: Basic Books.

Schön, D. A. 1987. *Educating the reflective practitioner*. San Francisco: Jossey-Bass.

van Manen, M. 1994. Pedagogy, virtue and narrative identity in teaching. *Curriculum Inquiry* 24, 135-170.

van Manen, M. 1995. On the epistemology of reflective practice. *Teachers and Teaching: Theory and Practice* 1, 33-50.

Wheeler, M. 1996. From robots to Rothko: The bringing forth of worlds. In *The philosophy of artificial life*, ed. M. Boden, 209-236. Oxford: Oxford University Press.

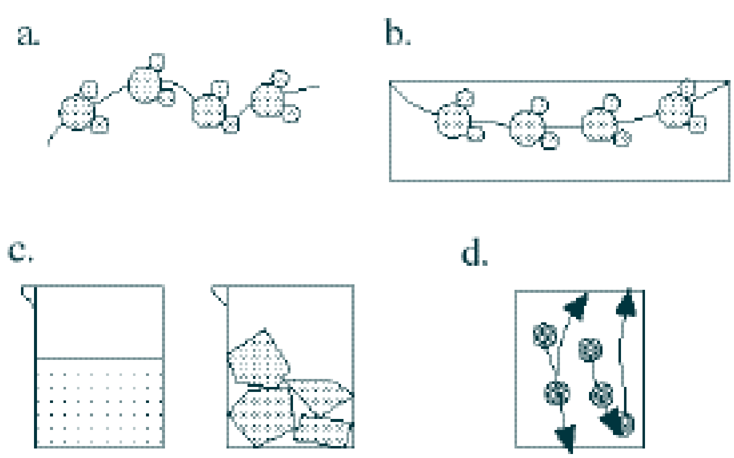

Figure 1. a. Sara's string-based model of a liquid. **b.** Dan's string-model mounted into a shoe carton. **c.** Beaker with water and ice used by Roth for engaging students in comparisons between models and physical materials. **d.** Model of liquid state of water in Bill's notebook.