Chapter 13

Conceptions and Characterization An Explanation for the Theory-Practice Gap in Conceptual Change Theory

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There is nothing more practical than a good theory.
–Lewin 1952, p. 169

For more than 2 decades now, conceptual change theory has been lauded as a powerful framework for improving science teaching and learning. This has resulted in an increasingly sophisticated theory building, yielding, among other things, a comprehensive documentation of students' (mis-, alternative, naïve, etc.) conceptions across most science domains. This increasing sophistication is required to address increasingly adequate the complex phenomena of teaching and learning science. Yet, despite this sophistication, the theory is not yet practical for the practice of teaching. On the contrary, with an increasing sophistication, the gap between research output and that what is finally put into practice by teachers has increased as well. In other words, "there is the paradox that in order to adequately address teaching and learning processes research alienates the teachers and hence widens the 'theory-practice' gap" (Duit and Treagust 2003, p. 683).

In this chapter I explain the origin of this paradox. I start with an exemplary case of two students who jointly interpret a particular graph. Drawing on conceptual change theory, it can be said that they articulate "their conceptions" and that conceptual change is occurring. Departing from this case, I briefly rearticulate the current state of conceptual change theory and I illustrate that a key aspect of theory building in conceptual change, that is, the attribution of conceptions to individuals, is justified by the characterization of the individual by the practices in which they engage. To better understand this process of characterization and the way in which it is used as a rationale for the attribution of conceptions to individuals, I approach it through the lens of hermeneutic phenomenology. This investigation reveals a number of methodological problems that account for the theory-practice gap.

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I conclude this chapter by discussing the implications of this understanding of the origin of the paradox that, to address teaching-learning processes, research yields an increasingly sophisticated teacher-alienating output.

The Case: Logging the Heart with Microcomputer-Based Labs

The exemplary case is part of a larger design study in biology education, called *Logging the Heart with Microcomputer-Based Labs* (van Eijck 2006). The aim of this study was to improve the teaching of quantitative concepts by using Microcomputer-Based Laboratories. This study was rooted in a framework that overlaps theoretically with conceptual change theory to the extent that conceptions are understood as distinguishable entities that can be attributed to individuals. However, it adopts also a situated cognition perspective by analyzing how individuals' conceptions are grounded in the situations at hand. As such, this study aimed at overcoming a so-called cognitive-situative divide that plays a role in conceptual change theory as well (e.g., Vosniadou 2007).

The case features a situation in which two students (Ashley and Becky) have just measured, for a first time, the carotid pulse with a heart rate sensor (see Figure 13.1). To allow readers to understand what is happening in the situation, I illustrate first the specific artifacts and the way in which they are used.

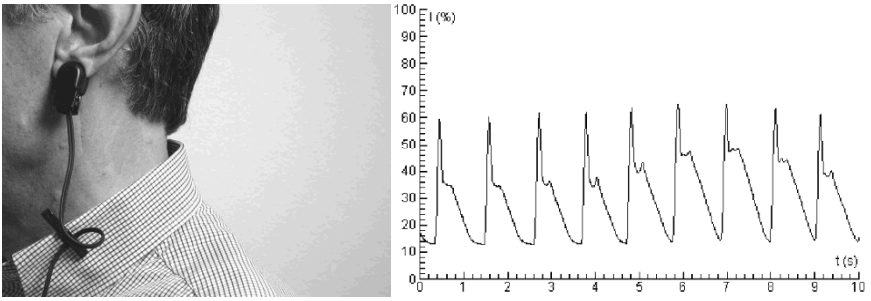

Figure 13.1. Heart Rate sensor attached to the ear lobe (*left*) and a typical outcome of students' measurement of the carotid pulse (*right*).

The heart rate sensor holds an ear clip, which consists of a light emitting diode (LED), and a photoelectric cell in between which the earlobe can be placed. The quantity depicted on the vertical axis in the graph is the relative light intensity (*I* in %) that is the relation between the light emitted by the LED and the light received by the photoelectric cell. The more the earlobe is saturated with blood, the less light is transmitted through the ear lobe. The signal of the photoelectric cell is amplified and inverted. The output signal of the heartbeat sensor is a measure for the blood saturation of the blood vessels of the ear lobe and varies with the frequency of the heartbeat. In Figure 13.1, a typical example of students' outcome of the measurement of the carotid pulse is observable. The carotid pulse is

ultimately caused by the contraction of the ventricles of the heart and hence the heartbeat frequency can be derived easily from the graph. In the exemplary graph, the measurement took 10 s and nine carotid pulses are observable. The carotid pulse in the ear lobe is proportional to the blood pressure in the aorta. Consequently, the quantitative concepts—observable in the graph as typical spikes—can be explained by featuring processes taking place in the aorta during a heartbeat.

Besides the MBL equipment, the students use a hand-out with a manual that illustrates step-by-step the measurement setup, after which the students do assignments that have to do with the measurement outcomes, such as deriving the heart beat frequency. With the transcript below, we enter the conversation after Ashley and Becky have measured the carotid pulse and are working on the assignments. Ashley utters a specific question about the graph asked in one of the assignments, after which a short discussion unfolds:

1	Ashley	[Speaking out aloud the question written in teaching materials] What is the relation between what you have measured and the streaming of blood in the ear lobe?
2	Becky	When the blood pressure is higher … When the blood pressure is higher … It is streaming … It is streaming … It is streaming faster through the ear!
3	Ashley	[Observing the notes of another student]
4	Becky	Hey! [Becky attracting attention of Ashley]
5	Ashley	[Turning towards Becky]
6	Becky	[Pointing to screen] If the percentage is higher …
7	Ashley	More blood is let through
8	Becky	Yes!
		[Silence. Becky is looking in the direction of the screen for more than 5 seconds]
9	Becky	No, more blood is in the ear lobe, isn't it?

By featuring this case, I do not pretend to present solid evidence for the occurrence of conceptual change or the appearance of particular conceptions. Rather, for the purpose of my argument, I exemplify some features of theory building on conceptions and conceptual change in order to point out my position.

Conceptual Change Theory

Conceptual change theory draws on the distinction of "conceptions" which are attributed to individuals, such as students and teachers. It is said that individuals have particular "mental structures" (Vosniadou 2007) on which they draw when articulating their conceptions. For instance, in the featured case we might attribute several conceptions to Ashley and Becky. Both Becky (lines 4–6) and Ashley (line 11) express the first conception, describable as "the heart rate sensor measured the

speed of blood in the ear." Only Becky (line 15) expresses the second conception, which can be described as "the heart rate sensor measured the amount of blood in the ear."

An important aspect of conceptual change theory is to compare students' (mis-, alternative, naïve, etc.) conceptions with accepted scientific conceptions. For instance, we might classify the first conception expressed by both Becky (lines 4–6) and Ashley (line 11) as "inappropriate" when compared to accepted scientific conceptions. In other words, both Ashley and Becky have particular "mental structures" by which they "inappropriately" interpret or "misconceive" the graph and maintain that "the heart rate sensor measured the speed of blood in the ear."

The term "conceptual change" is used to characterize a learning process that may occur when the new information to be learned comes in conflict with the learners' prior knowledge usually acquired on the basis of everyday experiences. It is claimed that in these situations, a reorganization of prior knowledge is required—a conceptual change. For instance, conceptual change is said to be required when the scientific concept of force comes in conflict with the everyday concept of force as a property of physical objects (Chi et al. 1994) and understanding the Copernican view of the solar system comes in conflict with the geocentric view (Vosniadou and Brewer 1992). The particular case featured in this paper does not deal with common problematic big issues featured in conceptual change theory such as the concept of force and views of the solar system. Yet, it is comparable to examples in the literature of conceptual change that deal with students' confusion between distance and its derivative, velocity, while interpreting distance-time graphs and which are featured in cases in which microcomputers are used for remedial teaching (Zietsman and Hewson 1986). In these examples, settings in which students interpreted time versus distance graphs were specifically designed by "using conceptual change strategies with the aim of helping the students to change to an acceptable conception" (p. 30). In this case, the situation is more or less comparable in the sense that there is some confusion between the amount of blood and its derivative, the streaming speed of blood, while students interpret an amount of blood versus time graph.

According to classical conceptual change theory (Posner et al. 1982), it is assumed that the learner is a rational being and will thus respond to logical and factual information. For instance, confronted with the graph in line 13–14, we could maintain that Becky's current conceptions are inadequate to allow her to grasp the phenomenon successfully. Then, in line 15, she has replaced or reorganized her central conceptions, which allowed her to accommodate the scientific conception that the heart rate sensor measured the amount of blood in the ear. Hence a conceptual change would have occurred.

Since 1982, classical conceptual change theory has undergone multiple criticisms. Specifically, the assumption that individuals respond rationally to situations fails to take into consideration the contextual components of the paths that lead to knowing and understanding and that have to do with, among other things, worldviews, artifacts, and other sociocultural aspects of the setting at hand (Saljö 1999). For instance, in the above excerpt, we might object the strictly cognitive perspective

and maintain that the conception "the heart rate sensor measured the speed of blood in the ear" is due to the question posed in the teaching materials, which emphasizes the streaming rather than the amount of blood. As well, research has shown that artifacts in the setting such as graphs can induce students' misconceptions (Roth et al. 2005). In this case, for example, the confusion between streaming and speed of blood may be due to a lack of resources that is required for appropriate interpretation of the graph. If the vertical axis of the graph in Figure 13.1 had referred to the amount of blood rather than the relative light intensity *I*, the students might not have articulated a misconception. In response to such criticism conceptual change theory has matured. There is now a more detailed account of what actually changes in conceptual change theory and recent theory building takes in consideration so-called situative perspectives according to which conceptions are flexible, malleable, and distributed and situated in the sociocultural setting.

With regard to the current mature state of conceptual change theory, the issue of the theory-practice gap is even more pertinent. Indeed, the inclusion of situative frameworks in conceptual change theory should allow a more detailed, sophisticated understanding of conceptions in the setting due to which the practice of teaching and learning is addressed in more detail. For instance, conceptual change theory should allow us to frame the case of Ashley and Becky such that we understand why and how they come to articulate the conceptions in the very setting in which they engage. This should yield a better understanding of the practice of teaching and learning, and, consequently, its improvement. In the current practice of theory building on conceptual change, however, the resulting increased detail alienates practitioners, which frustrates the improvement of teaching and learning practices. There is thus the paradox that a better understanding (theory-building) of teaching and learning practices widens rather than closes the theory-practice gap. The aim of this paper is to understand the origin of this paradox.

Conceptions and Practice

As a first exploration of the theory-practice gap, we might ask the question how teaching and learning practices are approached in conceptual change theory building. That is, what do researchers do with these practices when a conception is attributed to the individual? Conceptual change theory, to begin with, always describes the practice in which speakers make conceptions available. In the case of Ashley and Becky, for instance, I describe the practice I monitored by means of the video camera during my research, such as specific artifacts (graphs, heart rate sensor, MBL) and the speakers' utterances and bodily positioning in the conversation. As well, interview studies, which are frequent in the field of conceptual change research, describe in detail the questioning practices as a result of which students provide specific answers that are accounts of conceptions. Even in questionnaire-based research on conceptual change, there is a detailed account of the practices in which the conceptions are supposed to emerge, namely the practices of providing

a specific answer to a specific question of the questionnaire. Irrespective of the method of data collection, research rooted in conceptual change theory describes (in part) the practices in which a conception is supposed to emerge (or not).

Conceptual change theory, however, does not focus on practice in its entirety—practice is not the unit of analysis. Rather, in distinguishing conceptions, the focus is on the individual who makes the conception available in a way that allows its registration in a suitable medium (usually written text). Conceptual change theory "takes as a unit of analysis the individual in a constructive interaction with the world through a variety of mediated symbolic structures, some internal and some external, in rich sociocultural settings" (Vosniadou 2007, p. 55). Accordingly, a conception, the thing thought by the individual, is considered to reside in some form in the memory system and as such perceived as being part of the core of the individual's personality, in the form of a mental structure. Conceptual change theory describes the practice in which conceptions are supposed to emerge to the extent that the external mediating symbolic structures (speech, writing, gestures, and images) are intelligible for the reader in science journals; the reader must be enabled to resituate these symbols in the practice in which the individual engages at the moment on which s/he is making the conception available. Thus, the individual remains the link between conceptions and practices: the individual is characterized by describing the practices in which s/he engages and this is in turn a rationale for attributing a conception to the individual. This attribution of conceptions justified by characterizing the practice in which the individual engages is irrespective of the method of data collection. Even in questionnaire studies, the attribution of the conception to the individual is justified by characterizing the individual in a specific practice, namely the practice of writing down a specific answer to a specific question of the questionnaire.

In short, through a characterization of the individual by the practices in which s/he engages, a key aspect of theory building in conceptual change is justified, namely the attribution of the conception to the individual. Hence, to better understand the origin of the theory–practice gap, I focus in more detail on this characterization of the individual. The lens of hermeneutic phenomenology precisely makes this focus possible.

Characterization and Identity

The characterization of the individual is a key issue in hermeneutic phenomenology, specifically in regard to the question of the nature of identity (Ricoeur 1992). Ricœur attempts to solve the problem how individuals remain one and the same throughout all physical and psychological changes they undergo. For instance, in the case of Ashley and Becky, we might ask the question how we can determine whether the individual articulating the words described in lines 4–6 is the same as the individual articulating the words in line 15, based on the practice at hand. In both situations the individual is articulating different sounds and is behaving

differently, based on which we can attribute different conceptions to these individuals and assume a number of physical and psychological changes that have occurred in between the two situations. Nevertheless, I recognize that the two individuals in each of the situations actually belong to one and the same Self denoted by the name Becky.

The solution to the question of the nature of identity and its seemingly paradoxical inferences starts with a notion of self as duality. As such, self presupposes two notions of identity that induce confusion once reflectively conflated. One mode of identity, which is referred to as idem-identity (sameness): "Identity in the sense of idem unfolds an entire hierarchy of significations, in which permanence in time constitutes the highest order" (Ricoeur 1992, p. 2). For instance, a number of physical similarities can be distinguished between the situations referred to in lines 4–6 and line 15 respectively. Based on these similarities—permanence in time, one may conclude that in both situations the same individual is present, namely Becky. More generally, we can say that who Becky is and was is part of a biography—a narrative featuring the same person (character), Becky, with both constant and changing character traits in the course of the teaching-learning case, which highlights a fragment of her life (a plot).

However, idem-identity does not give answer to the question who Becky is, as she is changing over time. For instance, the similarities we have distinguished previously in two situations and based on which we have concluded that Becky is present in each of two situations, might not be present in other situations occurring later. This is a fundamental aspect of identity: When Becky is moving from situation to situation in her daily life, she is someone different with respect to the others surrounding her. The question who Becky is, can thus only be answered by adopting the notion of an identity that is opposed to idem-identity, namely ipse-identity (selfhood), which "implies no assertion concerning some unchanging core of the personality" (p. 2). Ipse-identity gives the self its unique ability to initiate something new and attributable to itself. Thus, in contrast to idem-identity, ipse-identity is not dependent on something permanent for its existence. That is, while Becky changes both psychologically (different conceptions) and physically (producing different sounds) between lines 4 and 15, we can still identify her as Becky.

There are therefore at least two aspects to identity. On the one hand, a person appears to have an idem-identity, which undergoes developments that are articulated in autobiographical narratives of self. In this perspective, events in the lives of individuals may provide resources to understand these individuals differently, leading to changes in their biographies. Second, in contrast to the contention of identity as a (relatively) stable phenomenon that is constructed in biographical narratives, ipse-identity is the experience of the different ways in which individuals relate to others in the varying contexts of everyday life and which entails the individual to be perceived as something that continuously changes. The difference between the two aspects of identity—ipse-identity and idem-identity—is thus precisely how we can conceive characterization: character is "the set of distinctive marks which permit the re-identification of a human being as the same. By the descriptive features that will be given, the individual compounds numerical and

qualitative identity, uninterrupted continuity and permanence in time" (Ricoeur 1992, p. 119). Hence, idem-identity emerges out of ipse-identity due to characterization. For instance, in order to re-identify Becky, who articulates sound in line 15, as actually being the same as Becky, who articulates sounds in line 4, we narratively sketch Becky's character by descriptive features, based on which we can conclude that she remains the same. Note that these descriptive features are physical. This is why characterizing Becky makes her spatiotemporally permanent in the resulting narrative.

The fact that idem-identity is narratively sketched also reveals an important role of language in understanding identity: We understand identity by means of interpreting signs as accounts of human action. Language can thus be seen as one of the available sets of descriptive features by means of which we understand identity and hence narratively construct idem-identity. Indeed, in the case of Ashley and Becky, an excerpt of their discourse is presented as a resource for narratively constructing both Ashley's and Becky's idem-identity. Yet, despite the resources provided, the Becky that is thus permanent in time, the idem-identity, is not the real Becky, that is, Becky herself. Without both idem-identity and an ipse-identity, we cannot explain self. Self therefore has both sorts of identity—it is constituted by two irreducible orders of causality, namely the physical (idem) and the intentional (ipse) orders. Any comprehensive account of human action must express the way it is related to both of these orders. Therefore, any causal explanation for what Becky is doing what she does and saying what she says, has to do with both her intentions and the spatiotemporal setting of which she is part. But, as intentions are realized through embodiment, a self actually produces its spatiotemporal setting and as such its idem-identity will emerge from ipse-identity. Ipse-identity therefore consists of the realization of possibilities through human action while idem-identity emerges out of ipse-identity by characterization of the possibilities that are realized by human action.

Revisiting the Theory-Practice Gap

Given the attribution of conceptions to the individual by characterization, how does the theory–practice gap emerge in conceptual change theory building? In order to illustrate this, I return to the case of Ashley and Becky. In the beginning of this chapter, I approach this case through a conceptual change perspective and I attribute two conceptions to Becky that I justify by describing Becky's actions. Let me consider in detail the first conception, which can be described as "the heart rate sensor measured the speed of blood in the ear." In conceptual change theory, the rationale for the attribution of this conception follows from characterization: By means of a description of physical features, I narratively sketch a biography that constitutes in part Becky's idem-identity. For instance, I present the text of the excerpt (lines 4–6 in particular) to account for the sounds Becky is making, a photograph representing artifacts she is handling, a graph representing another

artifact, and so on. All of these physical features characterize Becky's actions by means of which I justify that I attribute to her idem-identity the conception "the heart rate sensor measured the speed of blood in the ear." In hermeneutic phenomenological sense, I let Becky's idem-identity emerge out of ipse-identity by characterizing her spatiotemporally, which is the justification for the attribution of a conception to Becky.

This analysis of the attribution of conceptions in terms of the two types of identity reveals thus an important feature of conceptual change theory building: the attribution of conceptions is justified by narratively constructing idem-identities. Learning in conceptual change theory, that is, the change from one conception to another is thus illustrated by presenting two different idem-identities to which conceptions are narratively attributed. To the one idem-identity we attribute a scientifically unacceptable conception, such as "the heart rate sensor measured the speed of blood in the ear" (lines 4–6). To the other idem-identity we attribute the scientifically acceptable conception "the heart rate sensor measured the amount of blood in the ear" (line 15). The change in conceptual change is thus illustrated by characterizing two different idem-identities. Herewith, we can make another important inference about how conceptual change theory builds theory from the collected data. The causal explanation for what Becky is doing what she does and saying what she says, is usually constituted by a physical order of causality only.

However, as Becky's self is constituted by two irreducible orders of causality (physical and intentional—idem and ipse), a comprehensive account of her actions must express the way it is related to both of these orders. Because idem-identity has emerged out of ipse-identity by characterization, there is a relation between the physical order of causality and Becky's actions. Such a relation has not yet been established for the intentional order of causality, because we cannot describe this by characterization. It is related to ipse-identity, which is the realization of possibilities embodied in action by Becky. Therefore, the attribution of the conception "the heart rate sensor measured the speed of blood in the ear" to Becky expresses a way of relating the account of her actions to the intentional order of causality, which is thus instantly made plausible for it realizes her actions to be comprehensible. Thus, by reframing Becky's ipse-identity as a conception, we propose intentions for what she is doing, which is immediately plausible because it makes the characterization of her actions, the changes between the subsequent idem-identities, comprehensible.

This improved understanding of what researchers *do* do with practices when conceptions are attributed to individuals reveals a number of methodological limitations in the way conceptual change theory addresses teaching-learning practices. To begin with, by reframing Becky's ipse-identity as a conception, part of her self becomes an unchanging core of the personality. Thus, we introduce a Cartesian dualism to explain the intentional order of causality, which makes our account of Becky's actions comprehensible. Conceptions in conceptual change theory, then, can be conceived as manifestations of *cogito ergo sum* ("I think, therefore I am"). However, this induced Cartesian dualism is a methodological limitation because it overlooks the way in which individuals transact with the natural world around

them, that is, through embodied action with which they produce rather than only experience practice.

Moreover, whereas the attribution of a conception to Becky makes what we observe through characterization of her actions comprehensible, this is no reason to assume that the conception actually exists. Indeed, following the Duhem-Quine thesis, the hypothesized conception is by itself incapable of making predictions about human action, that is, about what Becky is doing. Hence the conceptions that are attributed to Becky are ontologically problematic in this case. Related to this issue is that Becky's idem-identity has been constructed by a particular characterization of her actions. There is thus the problem that there is simply no way to test the assumption that this characterization is a valid and reliable account of the conceptions that we are observing. On the contrary, it is likely that the account of her actions as the observer characterizes it is inherently colored by the conceptions s/he wants to observe and which is made hence plausible by characterization. (On researching and observing, see especially chapter 14.) This is another reason to believe that the conceptions that are attributed to Becky are methodologically problematic.

These methodological issues likely play a role in the theory–practice gap that appears in addressing teaching learning practices through conceptual change theory, that is, when conceptions are attributed to individuals to explain their actions. This gap is not yet experienced when we initially build the theory, that is, when we attribute a conception for the first time and justify it by characterization (i.e., the creation of idem-identity out of ipse-identity). It rather becomes emergent whenever these justified conceptions are applied to address new teaching and learning practices in which individuals other than the ones in the previous situation play a role. The reattribution of conceptions to individuals in new teaching learning practices must then be validated by the re-characterization of the previously "justifying" idem-identities out of ipse-identity. This, however, is exactly what is methodologically problematic. Ipse-identity, as stated previously, is that what implies no assertion concerning some unchanging core of the personality. Moreover, in new teaching and learning settings, different individuals set the stage, which implies that the previously justifying idem-identities must emerge by characterization from different ipse-identities. The resulting characterization of individuals, by which the previously justifying idem-identities are narratively reconstructed and by which conceptions are justified, are constructed such that the individuals' actions are comprehensible in regard to a predetermined intentional order of causality, namely the conception by means of which teaching and learning processes are addressed. However, such a characterization does not warrant a valid and reliable narratively constructed understanding of the individuals' actions in terms of both the physical and intentional orders of causality. On the contrary, the validity and reliability of the resulting account of the individuals' actions are questionable both with respect to the physical and intentional orders of causality. In regard to the intentional order of causality, I point out above that the validity and reliability of the resulting characterization is questionable on forehand. With respect to the physical order of causality, the resulting characterization rather serves to make the

resulting account of the individuals' actions comprehensible. The theory–practice gap thus emerges as the difference between a true account of the individuals' actions (i.e., an account that is by definition valid and reliable in terms of both the physical and intentional orders of causality) and the account of the individuals' actions resulting from a conceptual change view (the validity and reliability of which are questionable in terms of both the physical and intentional orders of causality).

This analysis of the theory–practice gap explains why conceptions are usually only observed in teaching and learning practices that are highly conditional and experimental (clinical) settings and therewith closely resemble the practices in which conceptions are identified for the first time. These conditions ensure that, to a limited but crucial extent, the previously justifying idem-identities can be narratively reconstructed. To practitioners, however, it is difficult to realize or to observe such previously justifying idem-identities, not at least because of the methodological limitations pointed out previously. Moreover, practitioners, through their embodied actions in the practices in which they engage, continuously characterize their own and students' identities. These idem-identities may be crucial for addressing these teaching and learning practices but also may be completely different from the ones characterized as a result of addressing teaching and learning practices through the perspective of conceptual change. In addition, because of the methodological reasons pointed out previously, there is no reason to assume that such idem-identities are similar to the idem-identities that are the result of characterizations by conceptual change theory. On the contrary, it is likely that practitioners have difficulty to recognize the idem-identities that are the yield of conceptual change theory. This is why the theory–practice gap widens despite the sophistication of the conceptual change theory and what thus accounts for the origin of the paradox I explain in this chapter.

Coda

The aim of this chapter is to articulate the origin of the paradox that theory building on conceptual change yields an increasingly sophisticated teacher-alienating output. Given its origin, the question remains how to overcome this paradox and therewith to close the theory-practice gap. The solution may be to abandon the idea of conceptions as an unchanging core of the personality residing in individuals as mental structures. Therewith, one can overcome the requirement of attributing conceptions to individuals and the inherent narrative construction of idem-identities by characterization that justify such attributions. One way to do this is to perceive conceptions as consisting of a dialectical unit of all relevant (meaning-making) semiotic resources publicly made available by a speaker in a situation such as talk, gesture, and context (Givry and Roth 2006). Here, the situation rather than the individual is the unit of analysis, which conforms to a contemporary notion of knowledge as a distributed and situated entity. Indeed, such a notion

allows us to construct a narrative identity of the speaker that makes a conception available which is valid and reliable with respect to both the physical and intentional orders of causality. That is, in such an approach there is no need to reduce the intentional order of causality to a particular conception. Rather, a conception is the result of the transaction between the speaker who is publicly making it available and the practice in which s/he is engaging, which accounts for both the intentional and physical orders of causality. This approach thus overcomes the Cartesian dualism and therewith the methodological limitations that occur when attributing conceptions to individuals and therewith failing to take into account how individuals simultaneously experience and produce practice through embodied actions. Then we can understand and explain why Ashley and Becky say what they say and do what they do in situations as explicated in the case in the beginning of this paper. For instance, by abandoning conceptions as individual entities, it would become logical that Becky articulates two times "It is streaming … It is streaming …" (line 5), for this utterance realizes the transaction between Becky and the practice in which s/he is engaging. Moreover, rather than assuming that Becky thinks that "the heart rate sensor measured the speed of blood in the ear," we come understand why she says subsequently that "It is streaming faster through the ear!" Indeed, she thereby makes publicly available the scientifically unacceptable conception that "the heart rate sensor measured the speed of blood in the ear." But this is, after all, an acceptable answer to the confusingly posed question encountered in the complicated teaching learning practice in which she is engaging at that moment.

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