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CONCEPTUAL CHANGE AND CONTEXTUALIZATION

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A common way of understanding the difficulties students encounter in trying to understand a scientific concept is to regard the problem as being one of *conceptual change* (e.g Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992; for a review of the field see Duit this volume). According to this view, understanding the scientific way of describing the world is associated with relinquishing old, naive, inconsistent and vague conceptions about the surrounding world and adopting instead precise, potent and otherwise scientifically accepted ways of conceptualizing the world. In this respect, this line of reasoning is similar to that of Piaget or of science historians who, having knowledge of the end result, attempt to describe the pathway that would lead to that result.

Quite another way of conceptualizing the problem is offered by Resnick and Säljö (this volume). For them, the problem is not how to bring about a conceptual change, but rather to know what characterizes the situation in which the students entertain their commonsense descriptions and explanations; consequently, the educational problem is how to create a situation where the appropriate scientific ideas will come into play. If we do not talk about "knowledge" but only about "knowing" (Resnick) and if concepts "create objects" and are discursive in nature (Säljö), then we are no longer able to say that students hold conceptions and that these conceptions can be changed; there are only situations that can be arranged in such a way so that students act in accordance with certain principles, for example, the scientifically accepted rules for investigating and discussing a specific phenomenon.

However, if we retain the propositions that students act within the medium of language and that the actions are context dependent, then we need not abandon the claim that students do in fact hold conceptions, and that context is a central factor in explaining why they tend to maintain their conceptions. To show this I will use the intentionalist model of action suggested by von Wright. The questions von Wright adresses when talking about intentionality relate to classic philosophical problems concerning the meaningfulness of behaviour, the explanation of action, and problems regarding reasons and causes. However, the model is also interesting in a pedagogical context because it relates cognitive factors to behaviour and the individual to his or her culture. In that sense the intentional perspective can be regarded as a pedagogical perspective.

In his analysis of action, von Wright (1971 and 1979) distinguishes among different aspects and different antecendents of action. To begin with, one aspect of action is its intentionality. In order to understand a sequence of behaviour as an action and not merely as a reflex or a series of muscular movements, we have to ascribe meaning to the behaviour. We do this, according to von Wright, by looking upon the behaviour as having been performed intentionally. The intention gives meaning to the behaviour. The intention is what the agent means by doing something, or what an outside observer understands that action to mean.

The intentionalist model of action conforms, according to von Wright, to a practical syllogim. The syllogism can be formulated in different ways; the following can serve as an illustration:

> A person P intends to do *x* (where *x* is a verb or a verb-phrase).
> P believes that he cannot do *x* unless he does *y* (where *y* is a verb or a verb-phrase).
> Thus, P does *y*.

Thus, to construe an intentional explanation is to look upon behavioural sequences as forming intentional actions or to look upon a single action as being one in a sequence of actions forming a larger whole, and this larger whole is an action in itself.

> Behavior gets its intentional character from being *seen* by the agent himself or by an outside observer in a wider perspective, from being *set* in a context of aims and cognitions. This is what happens when we construe a practical inference to match it, as premises match a given conclusion. (von Wright, 1971, p.115)

von Wright's notion of intentionality is similar in some respects to Searle's concept of *intention in action* as opposed to *prior intention* (Searle, 1983). Intention (in action) in this sense is part of the action itself (or "the action utterence", to use Searle's term), whereas prior intentions stand in a causal relationship to actions. As for the notion of causal antecendents, von Wright differentiates between internal determinants such as wants, beliefs, and abilities, and external determinants which constitute duties and opportunities for acting. These determinants of action can be illustrated in a figure (Figure 1).

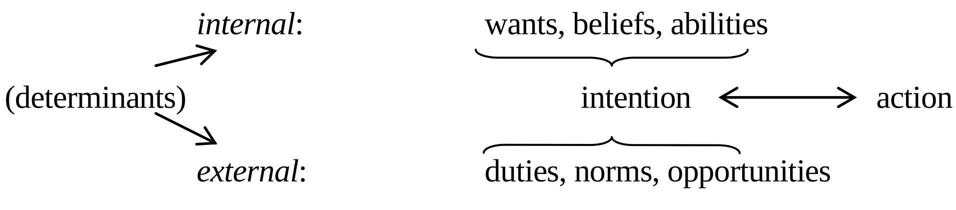

Figure 1. Determinants of action based on von Wright (1971 och 1979).

Using this model of action and its determinants, I propose a third way to conceptualize students' difficulties in aquiring new conceptions, and that is to regard the problem as one of contextualization. As indicated by the figure, there are different kinds of contexts. Broadly speaking, there is the *cognitive context*, which comprises cognitive abilities and cognitive structure and, leaving theories of moral and value aside, the cognitive aspects of wants. Then there is the actual setting for an action that form the *cultural context*, which refers to aspects of the interaction between the individual and the situation and to norms and patterns of behaviour in the society. It goes without saying that these different kinds of contexts are in play simultaneously or, to put it another way, they constitute separate aspects of the context as a whole.

Here, I will talk about contextualization in three respects: first, the contextualization of explanations, i.e. as pertaining to the relevance of different forms of explanation in different situations; second, the contextualization of a concept within a more embracing conceptual framework; and third, the contextualization of descriptions or explanations within a given speech genre. It is my view that there has been far too much emphasis on *conceptual change* and not enough on the process of *concept formation*. A great deal of stress has been put on "cognitive conflict" or "dissatisfaction with existing conceptions" (Strike and Posner 1982), whereas the role of "intelligibility" and "plausibility" (ibid.) has not been discussed enough. With reference to the three forms of contextualization outlined above, we can say that not enough attention has been paid to contextualization of new concepts in the act of explaining something, i.e. the applied or semantic side of the matter; the contextualization of new concepts within the framework of more embracing ideas, i.e. the psychological or cognitive side of the matter; and the contextualization of new concepts in the narrative forms used in everyday life, i.e. the cultural side of the matter.

FORMS OF CONCEPTUAL CHANGE

The concentration on conceptual change can perhaps be explained by a failure to distinguish between the various ways an individual can incorporate new conceptions. In a learning setting conceptual change can signify at least three different processes. *First*, in some contexts the process is in fact one of abandoning an old conception and replacing it with a new one, as in cognitive development. A case in point is the child who, up to the age of five or six, believes that the sun and the moon follow him, but who, at about the age of eleven, knows that they only *appear* to do so (Piaget, 1973). *Second*, in other contexts the process is one of acquiring an entirely new conception, in which case there is in fact no conceptual change at all, but rather the emergence of a quite new conception. This was exemplified in a study by Silvia Caravita on how pupils in elementary school organize the concept of organism. A reasonable conclusion from the study was that both the concept of organism and a conceptual framework for this concept were created during the course of the instruction (Caravita & Halldén, 1994, with references). *Third*, in still other contexts, conceptual change may entail acquiring a new way of conceptualizing the world, not in order to replace the conceptions one already entertains, but rather to enrich one's repertoire of conceptualizations of a particular phenomenon (see e.g. Caravita & Halldén, 1994; Wistedt, 1994).

These different processes in the acquisition of new conceptions actualize different kinds of questions. First of all, there is the *normative* question of what kinds of acquisitions we want our students to make. It is not always the case that we want our students to abandon their old conceptions and replace them with new ones; or, to quote Joan Solomon: "It would indeed be a poor return for our science lessons if they /the pupils/ could no longer comprehend remarks like 'wool is warm' or 'we are using up all our energy'" (Solomon, 1983, p.50). Then, there is the *logical* question of what kind of acquisition *can* in fact take place: Is there already an alternative conception that can be altered or are we trying to get the students to construct an entirely new framework? And then there is the *empirical* question of what is actually taking place: How do students cope with conceptions introduced in the instruction and what is the end result of the instruction?

My remarks here on contextualization relate primarily to this last question. By drawing on some examples I will try to point at some of the difficulties students encounter in coping with scientific conceptions and explanations and show that these difficulties need not be regarded as arising from the failure to bring about a conceptual change, but rather can be regarded as difficulties students encounter in finding adequate contexts in which to put the questions that confront them.

THE APPLICABILITY OF SCIENTIFIC THEORIES AND MODELS TO EVERYDAY PROBLEMS

If we ask students direct questions pertaining to theoretical principles, we risk getting responses that mirror verbatim learning only. If, on the other hand, we ask real-world questions, we are in fact testing much more than the students' knowledge of theoretical principles. We are also testing their ability to contextualize problems in the realm of the appropriate scientific field as well as their ability to identify a problem as a case in which a specific scientific principle is to be applied. Kahneman and Tversky (1982), in studying how judgements are made under conditions of uncertainty, speak about *errors of comprehension* and *errors of application*. This dichotomy makes it difficult to know at first glance the reason for a student's failure in problem solving. It may be that the student has not acquired a particular conception or scientific rule that is necessary for solving the problem or that, having acquired the conception or rule, has failed to apply it correctly.

In their investigation of statistical intuition, Kahneman and Tversky presented subjects in one of their studies with the following personality sketch:

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. (Kahneman & Tversky 1982, p.496).

Respondents were then asked which of the following two statements about Linda was the more probable one: a) Linda is a bank teller; or b) Linda is a bank teller who is active in the feminist movement. In terms of probability theory, of course, statement a) is the correct answer; the conjunction rule states that the probability of a conjunction A & B cannot exceed the probability of either A or B alone. This means that the more predicates we attribute to an entity, the greater is the risk of fallacy. However, Kahneman and Tversky found that 86% of the undergraduate students and 50% of the graduate students in psychology chose statement b) - i.e., that Linda is a bank teller who is active in the feminist movement - as being the more probable one.

Even after extensive discussion, the "statistically naive" students, i.e. those who had not had former training in statistics, stuck to their initial choice. Kahneman and Tversky concluded that these students did not have a solid grasp of the conjunction rule, resorting to a heuristic of representativeness instead; that is to say, the students based their judgements on the extent to which the characteristics of an element, in this case Linda, matched archetypical characteristics of a particular class, in this case the class of anti-nuclear demonstrators who major in philosophy.

But do we in fact know anything about how the students who chose statement b) understood the conjunction rule? I have amused myself by presenting a group of about 50 of my students, most of them women, with the same personality sketch as that used by Kahneman and Tversky, with the addition that I also asked them to give their reasons for their choice. Then, after giving the students the correct answer according to probability theory, I asked them to comment once again on their initial answer, after which we had an open discussion. The results of the exercise were very similar to those of Kahneman and Tversky with regard to the quantitative distribution of responses between the two alternatives. The interesting result, however, was to be found in the students' comments regarding their choices.

One student gave an apt description of the dilemma in choosing an alternative:

> First I thought a), according to the rules for determining the probability of a true statement, but then I thought that I was supposed to draw <u>conclusions</u> from the text describing Linda and thus I chose b). Now, however, I realize I was wrong!

This student is talking about two different methods for solving the problem: one is to apply probability theory and the other is to "draw conclusions". What is meant here by "drawing conclusions" is not entirely clear, however. A possible interpretation is that it refers to a kind of causal reasoning or to the construction of a good reason assay: if certain characteristics can be attributed to a person, or if it can be assumed that he or she embraces certain beliefs and attitudes, then that person can be expected to behave in a particular way. This kind of reasoning is illustrated in the comment made by another student:

> Since Linda had been involved so much in issues of discrimination and social equality while at school, I thought she'd be inclined to carry on the "struggle" later on in her working life.

Still another student chose statement b), on the basis of "social grounds": Linda "... shows commitment to a variety of social issues and, besides, she has a lot of time because she's single".

One of the students who chose statement a) seems to have made a deliberate choice of method in relation to the nature oftask confronting the student:

> I chose a) because that way I'm neither assuming too much nor too little. A safer judgement. The risk of being prejudiced or making generalisations determined my choice of a). ... Maybe it wouldn't have been wrong to say that she belonged to the feminist movement, but it might not have been right either, so I left it out.

Here, the student seems to have made a deliberate effort to avoid using causal reasoning or a good reason assay analysis in solving the problem. The reluctance to make what could be a prejudiced judgement in the face of insufficient information led this student to use probability theory instead.

In the first comment presented above, the student concluded by saying that s/he realized s/he was wrong. This conclusion can be compared with the initial comment made by another student:

> "An academic grade in philosophy does not land you a job in a bank, the feminist movement speaks for b)."

After the statistical solution was presented, this student continued:

> "From now on I'll have to take everything's probability into account, but in this case I don't intend to change my mind."

This cursory dispatching of the method of statistical analysis was also exemplified in the open discussions carried out at the conclusion of the exercise. Some of the students said that they were quite clear about the the principles of probability theory, but that they nevertheless were of the opinion that alternative b), i.e., that Linda was both a bank teller and active in the feminist movement, was the more probable one.

I will argue that these students can make a good case for their standpoint. If my analysis here is correct, the students were in fact choosing between two quite different methods for solving the problem: one method entails applying causal reasoning or making a good reason assay analysis, the other method entails applying the principles of probability theory. Furthermore, we cannot in fact know with any degree of certainty that the students who chose statement b) failed to grasp the conjunction rule and thus had committed an error of comprehension, or that they had committed an error of application. In order to do so, we would have to be able to argue that the information given in the task clearly indicates the superiority of the one method over the other, which means that we will have weighed that information in the face of what we know about human behaviour. This information would also have to be weighed in relation to the goal for the activity, in this case reaching a decision about Linda. That is, what is the reason for decide if Linda is a bank teller and/or active in the feminist movement? If Paul Cobb is right in saying that the overall goal of everyday reasoning is "to act so that the individual can achieve his or her particular goals in a specific situation" (Cobb, 1986, p.3), it may well be the case that the students who rejected the use of probability theory for solving the problem in the exercise were quite right to do so.

It may be that how we function in everyday life is facilitated by the guesses we make about causal relationships and stereotypes. Thus, a good reason assay analysis may be a more functional approach in handling our relations with other people than is the statistical analysis of human actions and characteristics. It is only when situated in the context of academic reasoning about judgement under uncertainty that this kind of reasoning is disregarded; in fact, the students simply "failed to play the academic reasoning game", as Cobb phrased it (ibid., p.3).

To conclude so far, the outcome of this exercise supports the view that students tend to see problem-solving tasks in the context of everyday life and consequently apply the problem-solving strategies that they use in everyday life (cf. also Wistedt, 1994). In our example here, this means that many of the students did not choose the methods of probability theory to solve the problem, but rather clung instead to a kind of causal reasoning or good reason assay analysis, not because they did not understand or were unable to apply probability theory, but because they did not find it meaningful to do so in this particular case.

CONTEXTUALIZATION WITHIN MORE EMBRACING IDEAS

To contextualize a problem can mean to relate it to a specific physical situation, but it can also mean to relate the problem to other ideas. In the former case we are talking about situational contexts and in the latter about cognitive contexts. "Concepts are embedded within larger theoretical structures that constrain them", as Vosniadou has phrased it (1994, p.63); and Tiberghien (1994) has argued that "in physics, interpretation and prediction imply a modeling process which consists of three levels: theory, model and experimental field of reference" (p.74), and that there is constant interaction between these levels. Theory is concerned with questions about explanation, paradigms, laws etc.; the level of model is concerned with relations between physical quantities and qualitative aspects associated with observable phenomena; and the experimental field of reference is concerned with measurement, facts and experimental devices.

Tiberghien restricted her discussion to the field of physics. However, this kind of reasoning is applicable to most academic subjects, even though it may not always be possible to make such clear distinctions between these different levels as it is possible to do in physics. In relation to learning in history I have differentiated between alternative frameworks at different levels, the empirical, the conceptual and the theoretical (Halldén, 1993), and I have used the same distinctions in studies on learning biology (Halldén,

1990) and further, together with Caravita, in a discussion of conceptual change (Carravita & Halldén, 1994).

Examples of difficulties with this kind of contextualization can be found when students are presented with a problem whose solution is counter intuitive. A colleague of mine, Lars-Johan Norrby, at that time at Stockholm University, presented freshmen in chemistry the following problem as a diagnostic test (Norrby, 1982): a pad of commercial steel wool was suspended in an old-fashioned two-armed balance and then tared. The students were asked what they thought would happen if a lighted match was held under the pad of steel wool. What does happen is that a coating of Fe_3O_4 is formed, making the sample heavier. Before carrying out the experiment, about half of the students believed that the steel wool would become lighter and the other half that it would become heavier. After the heat was applied, everyone was able to see that the steel wool had indeed become heavier, the problem now was to explain why.

Some of the students gave fully acceptable explanations, others gave no explanation at all to what they had seen, or they made no mention of weight in their explanations; still others, according to Lars-Johan Norrby (personal communication), quite simply denied that the steel wool had become heavier.

This would appear to be a case in which the embracing conceptual structure in which the problem is contextualized is one of common sense. The students know that in everyday life we consume energy, judging at least from the information on our electricity bills; we also burn things, whether it be wood burned in the fireplace or rubbish thrown into the incinerator.

But it is not only that we sometimes contextualize problems in terms of a common sense framework, even though they were intended to be put into a scientific framework. It is also that we cannot always be sure of to which scientific framework a problem actually belongs (cf. Linder, 1993). In an ongoing study on conceptions of evolution in biology at the university level, we asked students a question previously used by Margaret Brumby (1984). The question was intended to actualize evolutionary reasoning.

> Scientists have warned doctors of the danger of their increasing use of antibiotics (e.g. penicillin) for treating minor infections. What is the main reason for their concern?

Comparable groups of students answered the question before and after a five-week introductory course in biology (Halldén, Hansson, & Skoog, 1994). The results were somewhat puzzling in some respects. There was an increase in answers mentioning the adaptation of bacteria to antibiotics after the course compared with before the course. But, although there were good Darwinistic descriptions in the answers students gave to another question which referred more directly to natural selection, there was a predominance of answers mentioning only "adaptation" in the explanations the students gave to the antibiotics question. About half of the students who appeared to have a profound insight into the concept of evolution, judging from their answers to the direct question on natural selection, gave strictly adaptational answers to the antibiotics question.

One interpretation of this result is, of course, that the students had probably learned the formula of natural selection verbatim but that they were unable to apply it in a practical case, and this would thus be an example of an error of application. However, there was some evidence against such an interpretation. Most of the students in this group also referred in their answers to recent findings in biology pertaining to heredity in bacteria such as the existence of mobile segments of the DNA, i.e. transposons, and the possibility of genes moving from one chromosome to another and even from one species to another. With that knowledge in mind it is no longer obvious that the neo-Darwinian principles of evolution can be used to explain adaptation with regard to bacteria; that is, the theoretical context for the problem is no longer self-evident. In passing, it can be mentioned that when the results from this study were presented before an audience in which several of those present had an extensive academic background in biology, an animated debate broke out concerning the evolution of bacteria and the relevance of Darwinian reasoning in relation to this. For the debaters the theoretical framework in which the problem ought to be contextualized seemed not to have been self-evident.

After completing the introductory course in biology, some of the students in our study went on to specialize in molecular biology, geo-sciences or chemistry. Preliminary results from further testing seem to indicate that the ability of these students to use evolutionary reasoning when presented with a question on natural selection tended to decline despite additional study in related fields. That is to say, the answers they gave to questions on evolution directly after the introductory course in biology were more profound than the answers they gave further on in their academic career when their studies had become more specialized. In particular, the mention of the factor "struggle for life" in these students' explanations of natural selection occured much less frequently. The inclusion of this factor was regarded as one of the most significant learning results of the introductory course. But further on in their studies the students seemed inclined to try their hand at applying models from the molecular level in biology, from chemistry, and so on, in solving problems of natural selection. Assuming these results hold after closer inspection we can see how students contextualize problems within other theoretical frameworks than those that were intended.

The discussion so far has concerned the contextualization of a problem in everyday contexts and within various theoretical frameworks. I have referred to these as situational contexts and cognitive contexts, respectively. But there is still another kind of context which can be mentioned here, the cultural context or speech genre.

SPEECH GENRE AS A FORM OF CONTEXTUALIZATION

In our study of students' conceptions in biology, a group of students were given the following question on a written examination. The question was formulated by the examining lecturer.

> The elm tree disease can wipe out the whole elm tree species (Ulmus gla'bra). How does this happen? And what can be done to protect the *Ceratosystis* fungus which carries the disease?

This question can be regarded as having to do with natural selection and the survival of the fittest - perhaps not so closely as one might think at first glance, but that need not concern us here. Actually, the question consists of two parts: first, there is the question of why the fungus can eradicate elm trees; and second, there is the question of how to save the fungus from extinction. It is the second question that is of interest here.

It is, of course, a provocative question. Why save the *Ceratosystis* fungus if it destroys the beautiful elms? But the question the students were to answer was how to save the fungus from extinction; if the fungus wipes out the elm tree and the elm tree is its only possible host, the fungus will as a consequence destroy itself.

The analysis of the study is still in progress, so the following figures are preliminary. However, they are accurate enough for the point I want to make here.

Of the 49 students taking the examination four made no attempt to answer the question at all. Of the remaining 45 students, 34 gave some sort of answer to the question while the other eleven tried by one means or another to circumvent the question. It is these eleven students who are our concern here.

Some of these eleven students restated the problem: it became a question of saving the elms, not in order to save the fungus, but as a goal in itself.

> The fungus is sensitive to pollutants, and so its life conditions have deteriorated. The fungus dies and as a consequence the ability of the elm tree to take up nutrition is impaired. ... Maybe there is a fungus that is more resistant than Ceratosystis and could be made to coexist with the elm tree.

Here the fungus does not constitute a threat to itself. It is threatened by other factors, which in turn constitutes a threat to the elm. For this student, the only reason for saving the fungus seems to be in order to save the elms, and to reach that goal the student is prepared to replace the Ceratosystis - i.e., the species that was to be saved from extinction - with another fungus.

Other students did not seem to realize what was the nature of the problem. They concerned themselves with the problem of saving the fungus without relating this goal to the problem of the extinction of the elms. One student suggested that:

> ...you can make sure poisonous chemicals (to the fungus) are not spread around. You can take better care of the elm tree forests so that there are always new trees to replenish the old. If the trees grow closer together and are not spread out, the life conditions of the fungus will also be improved.

Apparently, this student's only concern was how to take care of the Ceratosystis. Then there were students who did not accept the project of saving the fungus as being worthwhile:

> I must have missed something here altogether. What do you mean elm tree disease? Why would anyone want to protect a fungus that causes the disease?

A common characteristic of the answers given by these eleven students is that the conflict actualized by the question - how to save one species without bringing about the extinction of the other - is circumvented in one way or another. The fact that there is a conflict here is either disregarded by the students altogether or made short work of it because of their concern with the preservation of the elm.

The failure to realize the nature of the question or to simply reinterpret the problem as one of how to save the elms can be understood as a contextualization of the problem in terms of popular ways of talking about nature today: pollution, saving the whales and the coala bear, and so forth. In this sense it can be regarded as an example of a speech genre or an orchestrated dialogue where the non-biological society has the louder voice (Bakhtin, 1986). The question, as it was formulated on the written examination, lay outside the framework of popular ways of describing problems pertaining to the extinction of endangered species and environmental pollution common to the age in which we live.

The answers given by the 34 students who addressed the question of how to save the fungus indicated that the students were aware of the conflict between the fungus and elm trees. In the case of 23 of the students, the nature of the conflict was explicitly stated. The students not only tried to answer the question, they also clearly stated what was the nature of the conflict. This can perhaps be regarded as one means of drowning out the public voice so that the voice of biology can be heard; that is, to find the appropriate disciplinary context.

CONCLUSIONS

According to Goodwin and Duranti (1992), a context is a frame "that surrounds the event being examined and provides resources for its appropriate interpretation" (p.3). Thus, embedded in a context is a focal event. Here, I have tried to show how different kinds of problems can be understood as focal events seen from a variety of contexts and how this can explain the students' ways of solving the problems.

First, we looked at contextualization in everyday settings, or the *situational context*. When scientific concepts compete with commonsense thinking in explaining everyday problems, it is not self-evident that the scientific concepts will prevail. This means that the students are not always on the wrong track when they apply everyday thinking rather than the conceptions accepted in the sciences. As I have tried to show, many of the students who used everyday reasoning in answering the probability question, did so as a deliberate choice. Furthermore, it is my view that in many instances what kind of reasoning would be the most fruitful one is an open question. Perhaps this is often the form of contextualization confronting us when students give "wrong" answers to applied everyday problems, from which we conclude that "conceptual change" has not occurred. The students have situated the problem in an everyday setting and there they find the scientific explanation inappropriate.

Second, we looked at contextualization within more embracing ideas, or the *cognitive context*. In disputes among scholars, the question of how a phenomenon ought to be contextualized can be a vitally important one, as the example on the adaption of bacteria shows. In such discourses, however, the problem of context is often explicitly stated and discussed. In learning situations, on the other hand, the contextualization is often tacit or implicit; it is not immediately apparent to which conceptual framework a student relates a focal event. However, in learning situations this kind of contextualization is probably the most important one and the most difficult one to deal with (cf. Wistedt, in press). The problem relates to the so-called learning paradox. Plato formulated it in the dialogue *Menon* where Menon says to Socrates that if we know what justice is we need not make any study of it but, on the other hand, if we do not know what justice is, how do we know when we have found it? Thus, in order to understand lower order concepts it is necessary to already possess a higher order concept that forms the context for the lower order concepts, and a condition for possessing that higher order concept is that the lower order concepts are already understood. It is this paradox we are trying to solve when we introduce our students to a new subject matter field.

Third and lastly, we looked at contextualization in a speech genre, or the *cultural context*. Perhaps it is in this direction we should look for a solution to the learning paradox. To become an expert within a field can be regarded as being socialized into a specific view of the world. Fred Davis (1974) talked about how to recognize a good sociological story. He said that even if many students can tell good and quite truthful stories about the data they have acquired, often the data belong to genres other than sociology, often an ideological, psychological or religious genre. It is not always easy to distinguish a good sociological story from other kinds of stories. In order to be able to make that distinction, the novice sociologist must acquire "a sound knowledge of and abiding love for his discipline" (p.316). Further, in *Towards a Theory of Instruction*, Bruner (1966) argued that when students are to study a particular discipline, they should be introduced into the way of talking and joking - with the jargon - common to that discipline. These recommendations seem to me to be a plea for introducing the students into a specific speech genre. Such a speech genre might then become part of a higher order conception which could help students to structure focal events, even if only vaguely.

The overall aim of this chapter has been to question the fruitfulness of looking upon the difficulty students encounter in understanding scientific concepts solely as a problem of conceptual change. The problem might be better understood as a problem of contextualization. The implications of this view for both research and instruction then, are that more attention should be given to the various forms of contextualization that are in play when students make an effort to understand a particular phenomenon, concept, situation or event.

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