FROM PHENOMENON TO CONCEPT: DESIGNING PHENOMENOLOGICAL SCIENCE EDUCATION

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Abstract

One important challenge of today's science education is to relate scientific concepts, often experienced as alienated by students, to the lifeworld of the students. Phenomenological science education has the potential of bridging the gap between the experienced lifeworld of the students and that of the scientific concepts. In this paper we present and discuss four steps connecting lifeworld phenomena and scientific concepts: developing a rich picture of the observed phenomenon; choosing some of the everyday concepts from the rich picture as points of entrance for moving towards scientific concepts; introducing scientific concepts, and; using the introduced concepts for a deepened understanding of the investigated phenomenon. In order to guide this transformation process the teacher needs what we define as phenomenological competencies of teaching. This is marked by: the ability to let the phenomenon 'speak' on its own terms; the skill of careful observation of the students; the skill of combining these two abilities by seeing and promoting the student's inner activity in investigating the phenomena, and; the teacher skill of curriculum design. Finally, we discuss the training of such phenomenological competencies of teaching in the education of science teachers.

Key words: lifeworld, phenomenology, science education, teacher competencies.

Introduction

In a study inspired by Martin Wagenschein, the German science educator in physics and mathematics, a physics teacher and a class of 4th grade students were together investigating the phenomena of sound and sound production (Thiel, 1990). After they have found out how a sound is produced, by hitting a tambourine, the teacher proceeds by asking them how it is possible that Toni, one of the students, can hear the sound although the teacher hits the tambourine and they stand far apart from each other:

Rainer: We have ears, that should be enough.

Teacher: Yes, of course, that's the correct answer to my somewhat clumsy question. But how is it, how can we imagine that the sound comes from me to Toni?

Rainer: This is how it is. When you are talking, with your mouth, then there's a sound, and the sound, it goes into my ear and makes the eardrum vibrate.

Ralf: But how does it get to Toni's ear? That is not at all easy.

Stephan: First you open the mouth and blow the sound out. You notice this when it touches the hand, the sound.

Wolfgang: Well, the sound is nothing else than air.

Ralf: No, the air only carries the sound.

Rainer: The air, it pushes the sound. The mouth, it produces the sound, and the air pushes the sound to Toni.

Wolfgang: The air doesn't have to push. When Mr. Thiel shouts, then he blows out the sound, and it comes by itself to Toni. And the sound makes the eardrum vibrate.

Teacher: (...) OK, the question is not that easy to answer, whether the sound itself is the air or the air only carries the sound. Now, we have to find a way to ask nature how it is. (*ibid.*, pp. 136–137; our transl.)

In this excerpt of a science lesson we find *students on their way to science*: a phenomenon from nature is investigated and at the same time the phenomenon of students' own way of deepening their understanding is made explicit. The students' searching for concepts and explanations are taken seriously by the teacher. Their pondering, asking and answering are leading the way from the investigated phenomenon of sound to possible scientific concepts, as for instance frequency or decibel. The teacher is both a teacher of physics in the sense of having the responsibility for bridging experience to concept, and a facilitator for the students' learning process. These are also the two foci of this article: the stepwise transformation of everyday phenomenal experience into an understanding of the same phenomenon structured by scientific concepts, and the teacher competencies required for this transformation.

Science teachers meet the current crisis in science teaching in two forms: the inability of many or most students to achieve correct understandings of scientific concepts (Carré, 1993), and students' increasing disinterest in science subjects (Hannover & Kessel, 2004). Students often regard science as too theoretical and too abstract. It is not experienced as integrated in children's and young peoples' lives (Beach, 1999). As Wagenschein states, in science lessons, 'the phenomena of nature are hardly touched upon as the teacher hurries on and goes further into the instrumental, the abstract, the laboratorial, the technical, and the mathematical, so that the children no longer can participate with their eyes, ears and hands.' (Wagenschein, 1983, pp. 108–109; our transl.).

Since 2006 a new curriculum has been established in Norway in order to meet some of the challenges described above. 'The Knowledge Promotion' is the latest reform in the 10-year compulsory school and in upper secondary education and training in Norway. It introduces certain changes in substance, structure and organization from the first grade in the 10-year compulsory school to the last grade in upper secondary education and training (UD, 2007). In the new science curriculum there are formulated explicit learning goals related to 'The young scientist' and students' development of a curious mind and of research methods. That this new curriculum also has consequences for the teacher education program will be elaborated on in the last section.

In this paper the following research question will be addressed: How are scientific concepts put in a meaningful relation to phenomena of the students' lifeworld? Which teacher competencies are required in order to design this transformation process? And how are these competencies trained in the teaching of science teacher students? The discussion is based on nearly 8 years of experience with phenomenology as part of the teacher training program at the Norwegian University of Life Sciences.

Phenomenology, lifeworld, and science education

In order to discuss the design of phenomenological based science education, we need to go more thoroughly into the concept of lifeworld. Further, we try to throw some light on the potentials of connecting phenomenology and science education.

Lifeworld ontology and the ontological reversal

The notion of lifeworld is primarily defined in the phenomenology of Edmund Husserl. In his posthumously published work *Crisis in the European Sciences* (1970), Husserl maintained that the scientific culture of Europe has 'fallen' into an uncritical acceptance of Cartesian dualism and its consequent objectivistic and naturalistic views of knowledge. This 'fall' means that science is unable to consider how the subjectivity of the researcher participates in the constitution of scientific knowledge. In this work Husserl also introduced the concept of the lifeworld which has been of central importance for the application of phenomenology in the social sciences. What he actually meant by this concept has been the subject of long debates, but, with the risk of oversimplification, it could be said to mean 'the world of everyday experience'. Husserl's point was that the natural sciences has lost contact with the lifeworld, or more exactly: they no longer realize how scientific knowledge is related to everyday experience and that it in fact always *presupposes* this experience as its ontological foundation (Dahlin, 2001).

In his account of Husserl's critique, Harvey (1989) describes Husserl's argument as pointing to an 'ontological reversal', meaning that abstract scientific models are taken as more real than our everyday reality, since the abstract, often mathematical models are seen as the *real causes* behind everyday experiences. Here, the purpose of science is to reveal the reality which lies behind what we experience through our senses. Therefore, a scientific study of nature cannot pay too much attention to sense experience. It cannot stay or dwell upon the richness and variety of such experience. It must move on to what lies 'behind' it, in the realm

of mathematical algebraisations, i. e., the 'real' world. As Galileo said, the language of nature is mathematics. Whatever other languages nature seems to speak to our senses – languages of colour, form, sound, smell and taste – exist only in subjective consciousness and is ultimately illusory (cf. Dahlin, 2001). We argue that in order to place science education on firm feet, the ontological reversal described above has to be *reversed back*. It means giving ontological priority to the lifeworld of our common human experience, not to algebraic and other conceptual abstractions (Dahlin, Hugo, & Østergaard, 2005).

Phenomenology and science education

Phenomenological critique of current science education points to the problem that many students in science lessons find themselves faced with a mere abstract and cognitive world, separated from their everyday life experiences. An illustrative example of this is found in Rittelmeyer (2006) who tells a story from a chemistry class where the students are comparing evaporation of water and liquid nitrogen. First they are asked to observe water boiling and note at which temperature water turns to steam. Then a bottle of fluid nitrogen is opened to demonstrate evaporation at room temperature.

What do you see?, the teacher asks.

A student answers: It crackles in a totally other manner than water.

The teacher: That might be so. But what do you see? (*ibid.*, p. 41)

In this dialogue essentially two important aspects are addressed: Firstly, that chemical substances show their qualities through different sense phenomena and that students use different senses in order to grasp the phenomena. In this case, nitrogen articulates itself *acoustically*. Secondly, that an education appealing to all senses is crucial for supporting the learning process. Here, the teacher ignores the phenomenologically interesting observation, that nitrogen *sounds*, and therefore also the student's experience is ignored. The student's observation is most probably neglected because the observation does not fit into the teacher's pre-established concept of how nitrogen evaporates. However, in order to encourage meaningful understanding, the task of the teacher is to integrate sense experience and coherent understanding of scientific knowledge. Or, in the case that science itself does not incorporate all possible experiences of a phenomenon, the advantages as well as the disadvantages of this reduction should be pointed out by the teacher.

Different applications of phenomenology to the field of science education have been developed (Østergaard, Dahlin, & Hugo, 2007). Common for these applications is the intention of 'returning to the things themselves' (Husserl, 1973), meaning things as given in experience when all knowledge and presuppositions about reality is kept at bay. This means that phenomenology is something you must *do*, and it is the reason why Husserl said that one could not really understand his philosophy by merely reading it. Phenomenology is, as Lukenchuk (2006) notes, a way to connect the theory and the practice of science education.

Bridging the gap between lifeworld and scientific concepts

One effort in doing phenomenology is what could be called the 'didactification' of phenomenology. This implies the investigation and identification of different stages of the learning process, between phenomenon, as embedded in students' lifeworld(s), and scientific concepts, as introduced in science lessons. The gap between phenomenon and concept is experienced differently by teacher and student: The science teacher tends to see an immediate connection, or even to regard lifeworld phenomena as mere examples of scientific concepts, whereas the student experiences the gap as much wider. The process of bridging phenomena and new scientific concepts can be described in four stages (figure 1).

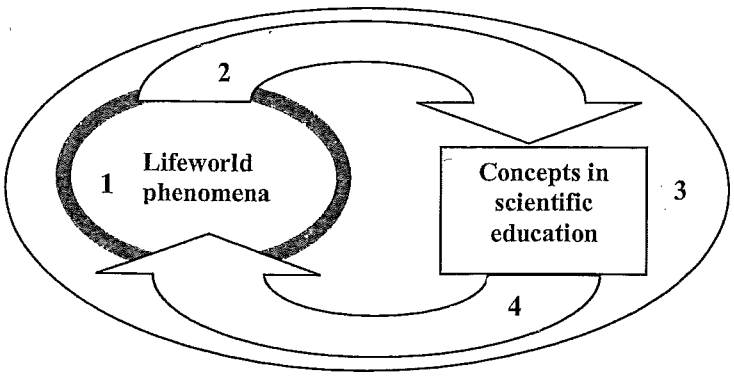

Figure 1. Four stages of bridging scientific concepts and lifeworld phenomena.

1. Developing a rich picture and building a living image of the observed phenomenon. The teacher chooses a phenomenon of which the students can formulate many different appearances ('returning to the things themselves').

2. Choosing some of the students' everyday concepts from these rich descriptions to move towards the scientific concepts. The chosen concepts of the students are related to the appearances of the observed phenomenon, but have at the same time a potential link with science-based knowledge.

3. Introducing scientific concepts and/or models. These concepts / models, often experienced as 'abstracts' of phenomenon by students, are explained as a continuation of, and *not* as a contradiction to, the students' everyday concepts.

4. Using the introduced concepts for a deepened understanding of the phenomenon. By returning to the observed phenomenon, the scientific concepts/models are put in a meaningful context developed by the students themselves.

This model can be regarded as the stepwise approach to deepened understanding of lifeworld phenomena. The aim of designing phenomenological science education is threefold: improved understanding of the investigated phenomenon (by means of scientific concepts); improved understanding of scientific concepts and their interconnectedness with one another; and deepened confidence in one's own ability of making sense of lifeworld experiences (by means of scientific methods and processes).

The learning cycle described above has its starting point and endpoint in lifeworld phenomena. Obviously, an important first step is intentionally to choose and recognize the phenomenon as suitable for learning. Main challenges in this cycle seem to be those of observing the phenomenon thoroughly and of treating students' experiences strictly phenomenologically. Several research works, especially those influenced by Goethe's phenomenology of nature, has emphasised the importance of the schooling of the senses (Hugo, 2006; Østergaard *et al.*, 2007). However, a deepened understanding of the phenomenon does not arise merely out of thorough sense experiences. Experiences need to be transformed into concepts. As Freudenthal (1993) notes, in a study dealing with physics,

> If it is true – and who can deny it? – that in mechanics instruction body experience interferes inconveniently with scientific ideas, then it is of paramount importance, instead of suppressing them, to have the learning processes started just there, and the learner, under guidance, transform them into what we consider scientific. (*ibid.*, p.71)

This principle for teaching and learning is in accordance with phenomenology in that it strives to 'ground' abstract scientific concepts in concrete lifeworld experience. Freudenthal's approach has a parallel with the 'epistemology of physics' presented by diSessa (1993). According to diSessa, children's learning of physics ought to start from what he calls 'phenomenological primitives', or 'p-prims'. P-prims are loosely connected ideas about the world, linked to and cued by concrete experiences and observations of phenomena. They are not general and abstract as scientific concepts, but in spite of their limited applications they seem self-evident and unproblematic. diSessa's point is that learning science means the *refinement* of such p-prims, not their abolishment or replacement. For this to happen, the p-prims have to be carefully taken up and developed in the teaching process, not neglected, denied or declared meaningless and untrue. This conclusion is supported by Arons (1982) who points out the pedagogical possibilities inherent in a phenomenological approach to some physical phenomena having to do with electricity and magnetism.

Szybek (2002) discusses the interactions between what he calls 'the two stages' in science teaching and learning: the stage of scientific knowledge and that of everyday human experience. His analysis ends up in a model of curriculum work involving translations between these two stages. As for students, one overriding theme seems to be the question of how to develop connections to science across contexts that can integrate different aspects of their lifeworld(s) (Kozoll & Osborne, 2004).

Competencies of phenomenological teaching

If the important aspect of teaching science is to promote students' ability to transform their own experiences into what we consider scientific understanding, then it becomes crucial to identify the competencies required in order to guide this transformation.

In the excerpt of the science lesson described in the introduction, the students are allowed to use their own words for describing the phenomenon of sound and sound production (Thiel, 1990). The teacher has attention in two directions at the same time: towards the students and towards the phenomena of sound and sound production. In this science lesson we are allowed to have a glance into their 'childish' but highly crea-

tive attempt at understanding and explaining the world. Stephan, impulsively answering the teacher's question of how the sound comes from one person to another, exclaims: 'First you open your mouth, and then you blow the tone out'. This is not an answer which one will find in a text book or which the teacher would have presented as a correct description. The answer is, however, intuitively grasping the connection between the three related phenomena of sound, the activity of making sound, and the air. This statement is also a result of the teacher's encouraging the student to sense carefully the phenomenon of how a tone is produced in the body. Such statements are 'invitations for experimentation and interpretation of wonders in the nature that cannot be reduced to short formulas' (Flitner, 1990, p.4; our transl.).

Here we find what could be defined as 'phenomenological competencies of teaching'. These competencies, however, all presuppose a genuine interest in the phenomenon observed, and at the same time, a genuine interest in the student. We distinguish between four 'phenomenological competencies of teaching':

I: The competency of careful observation of nature phenomena. This allows the phenomena to unfold themselves, to let them 'speak' on their own terms.

II: The competency of careful observation of the students. This acknowledges students' own way of experiencing and explaining phenomena in nature.

III: The competency of combining these two abilities by seeing and promoting the student's inner activity in investigating the phenomena. Performing this competency implies shaping interplay between the learning process and discovery activity of students and the unfolding of the phenomena.

IV: The competency of curriculum design. This comprises the ability to choose a relevant and interesting phenomenon for teaching, decide ways to present the phenomenon, and plan the amount of time for the students to develop the bridge between phenomenon and concept(s)/model(s).

The first competency is documented in numerous works inspired by Goethe's phenomenology (Østergaard *et al.,* 2007). In the case of sound and sound production, Mackensen (1987) has developed a phenomenological based curriculum for the Steiner Waldorf schools. The second and third competencies are essentially connected to skill of treating both student and phenomenon strictly phenomenologically. Here again, we find the basic intention of phenomenology; to let 'things themselves' speak. In science education we might speak of the *teacher's double focus* in the learning situation: The attention is on the one hand directed towards the subject itself, or the phenomena in nature, on the other hand towards the students (Østergaard, 2003/2006). The fourth competency is that of designing the actual science lesson. It is thus connected to the 'didactification' of phenomenology (Hugo, 2006).

In the lesson about investigating the phenomena of sound, the teacher participates in a twofold dialogue: the teacher is having a dialogue with the student, and at the same time addressing the phenomenon itself as a 'dialogue partner'. The excerpt ends by the teacher asking: 'Now, we have to find a way to ask nature how it is', indicating that nature can be asked and that nature herself can reveal the correct answers. This resembles Martin Buber's (1983) description of the two archetypal forms of dialogue between man and world: the I-you-relation and the I-it-relation. In this lesson the teacher is dialoguing in an I-you-relation *both* with the students and the phenomenon of sound. By asking 'nature how it is', the phenomenon becomes more than a mere object or scientific 'fact'; it becomes a 'dialogue partner' with whom a learning process can take place.

Concluding remarks regarding teacher training

This model of bridging the lifeworld of students and the scientific world of concepts and models has some important consequences for the training of teachers. In the Norwegian teacher education curriculum, five competencies are defined: subject competency, didactical competency, social competency, change- and developmental competency, and ethical competency (UFD, 2003). Another set of teacher competencies are defined in the European DeSeCo-project, reported by Knain (2001): individual competencies, for example subject competency or the ability to think critically, and relational competencies, for example social competency or the ability to design group work. What we have coined as phenomenological competencies of teaching cover all these key competencies. The phenomenological competencies are, however, more specifically oriented towards the challenges facing science teachers. As an attempt to balance the predominant emphasis on abstract understanding and explanation in science education, these competencies have a stronger emphasis on *sensing* as presupposed to understanding. Rehm (2006) notes that understanding of science and scientific concepts also must be regarded as a competence of action. We argue that the understanding of concepts presupposes competences of sensing (cf. Merleau-Ponty, 1962). The concept of frequency can be theoretically understood, but the sound itself must be *heard.*

The teacher training programme at the Norwegian University of Life Sciences has developed two main guidelines. The first, 'the phenomenon first', emphasizes lifeworld phenomena as entrances into understanding science and gaining meaningful science knowledge (Østergaard, 2003/2006). This principle goes for natural phenomena as well as for human and social phenomena (observation exercises focusing on the children and on the dynamics of social interaction and identity formation). The second guideline, 'activity before cognition', emphasizes teaching and learning as activities in which a range of professional and personal skills and competencies are developed (Østergaard & Krogh, 2004).

The competencies described above are trained during education through practicing the skills of observation, reflection, participation and communication. The skills are best trained in real life, in the context of a good learning situation, a setting where the teacher student can identify and develop these skills independently and practice them simultaneously (*ibid.*). Thereby, the mere conceptual understanding, often predominant in science education, is complemented by developing skills of observation, communication and reflection-in-action. Practicing and developing an individual style in these multiple skills enables the student to meet the world consciously as a teacher, and integrating cognitive skills with lived experience.

In his phenomenological approach to science education, Wagenschein claims that the main problem in current physics teaching is that it is planned from the *end*: Starting with the basic concepts and the mathematical structures of physics to be learned, the teacher is aiming at making it understandable for the learner, adding experiments, as mere illustrations. Wagenschein has the opposite point of departure, using experienced phenomena as points of entrance into the world of scientific knowledge. He even goes one step further, pointing at the value of letting the concepts of physics also be challenged through the encounter with phenomena of nature (Wagenschein, 1990). Phenomenology is an attempt to restore the value of direct experience of things. This includes both natural phenomena and students and their approaches to understanding the world.

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