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**Bo Dahlin, 2002: »Science is heavy». Aspects of Pre-Service Science Teachers' Conceptions of Science /Den tunga vetenskapen Aspekter av blivande NALärares föreställningar om naturvetenskap/. Pedagogisk Forskning i Sverige, Vol 7, No 2, pp 81–98. Stockholm. ISSN 1401-6788**

In 1887 the second edition of Nietzsche's *Gay Science* appeared, extended with an appendix called »Lieder des Prinzen Vogelfrei». Nietzsche's intention was to make science more poetic, playful and artistic, thereby giving expression to the undetermined and/or non-determinable ultimate nature of reality. Nietzsche's vision of a poetic science remained neglected for almost a century. However, towards the end of the previous century, it was resurrected in postmodernist ways of thinking. Postmodernism spread in academic circles, primarily within the human and social sciences. In the US it has led to a »Science War» between human and social sciences on the one side, and natural science on the other (cf. the Sokal-affair). But these debates have hardly had any serious impact on the way research in natural science is conducted. Present-day »Big Science» is a very serious business, being strongly connected with technological and economical interests and developments.

An important source of inspiration behind Nietzsche's thinking was J.W. Goethe. Mostly recognised for his poetry, Goethe was however also a serious student of natural phenomena. Present-day philosophers have identified Goethe's approach to natural studies as hermeneutic-phenomenological in character. Goethe always stressed the importance of attentive sense-perceptual observation of phenomena and of resisting the tendency to premature abstract theorising. In the realm of optics, he argued intensely against Newton's theory of the nature of prismatic colours, and his notion of light as consisting of seven basic colours.

Goethe's own formulation of a theory of colour is a good candidate for a gay science in Nietzsche's sense, being much more poetic than Newton's. Put very simply, Goethe differs from Newton in seeing colour as the result of dynamic interactions between light and darkness. He came to this conclusion by performing many observational experiments, which included looking through a prism with one's naked eye at contrasts between various white and black figures. However, the frames of this paper do not permit a more thorough presentation of Goethe's theory of colour.

The conflict between Newton's and Goethe's theories of colour was taken as a starting point for an empirical study of conceptions of science among pre-service science teachers. Understanding the nature of science has long been considered an aspect of science literacy and therefore taken as an overriding aim of science teaching. The question of the nature of science has important

social and political aspects, which have been particularly pointed out within feminist theories of science. If a line of thinking and research is not considered scientific it cannot partake of the economic resources distributed by State institutions and it loses a lot of its possible impact on social and cultural development. Science teaching is an important factor in establishing socially dominant views of what is science and what is not.

In this study, the conflict between Goethe and Newton was to encourage student teachers to express basic assumptions and conceptions of the nature of science. Some of Goethe's central observational experiments with a prism were conducted and the difference between Goethe's and Newton's theories was explained to the participating students (altogether 23 individuals). The students were then divided into smaller groups of 3–6 and asked to discuss among themselves whether Goethe's theory could be considered scientific or not. The group discussions were taped, transcribed and analysed both in terms of form and of thematic contents. Due to lack of space, only a part of the thematic contents is presented in this paper.

The participants were generally reluctant to admit that Goethe's theory of colour could be regarded as a science. In summary, three main reasons were expressed against the claim that Goethe's theory was scientific: it does not explain phenomena by going »behind» them into invisible entities of a mathematical nature; it builds upon purely subjective sensory experience; and it lacks »gravity» or »substance». The three arguments are connected and can be construed as a complex whole. They build to a large extent on unreflected views of science as a product, i.e. on conceptions of what characterises already established scientific theories. In contrast, the arguments expressed for accepting Goethe's theory as a science seemed to be based on views of science as primarily a process of inquiry. The systematic and open-minded way in which Goethe went about studying colour phenomena were seen as an important characteristic of scientific research.

The fact that Goethe's theory was generally considered not to be scientific did not necessarily entail that Newton's theory was regarded as truer. Newton's theory just happens to be the one used and proclaimed in schools, as one student expressed it. Nevertheless there was a strong tendency to belittle or even deny the significance of sense perception in scientific research, compared to the importance of the abstract mathematical models of conventional science.

Two metaphorical expressions for the nature of science appeared as particularly useful in catching the predominant views of science among the participants (the metaphors were actually used by two different students): science as »heavy» and as »peeled-off». The »heavy» character of science refers to its mathematical complexity and its complicated laboratory instruments. Other heavy aspects are the thick textbooks in which science is often presented and the difficulties in comprehending their contents. (One could add the vast economic resources that go into financing modern Big Science, but the students did not mention this.) The »peeled-off» character of science refers to its impersonal, objectivistic nature. Science must not contain anything of a personal, let alone emotional nature. Everything »merely subjec-

tive» has to be left outside the laboratory doors, as it were. The two metaphors of heaviness and peeled-off-ness can be seen as complementary and belonging together, in that it is the striving for impersonality and objectivity that leads to the development of technical instruments of measurement and mathematical formulations. In contrast to the heavy and peeled-off character of conventional science, Goethe's theory appeared as too »light» and non-substantial to be scientific.

Applying C.S. Peirce's view of cognitive-semiotic processes to these notions, it is possible to give a more analytic explanation of what lies behind the resistance to accepting Goethe's colour theory as science. According to Peirce, there is a triadic and dynamic relation between a sign, its referent and its interpretant. The »interpretant» is the interpreting element in meaning constitution, but it is not identical with the conventional notion of a particular individual subject. It can also be a regular or habitual response of a collective or cultural character. If »heavy and peeled-off» is the interpretant commonly produced by the signs »science» and »scientific», it is understandable that Goethe's colour theory cannot become a referent to these signs, since it is rather seen as »light», non-substantial and subjective.

Introducing Goethe's theory of colour and his general approach to the study of nature into science teacher education and school science would challenge the ideology of consensus that characterise much of the science curriculum today. Science is generally presented as a homogenous, non-contestable body of knowledge with few, if any, inherent controversies or conflicts. It would also create a variation in instructional contents on two levels: on the phenomenal level and on the paradigmatic level. On the phenomenal level, the possibility to understand colours in two different ways would be uncovered. On the paradigmatic level, the possibility of other ways of doing science would appear.

It is commonly known that the character of a thing is more clearly apprehended if it is contrasted with another (similar) thing. Thus, understanding Goethe's way of doing science also deepens the understanding of the nature of conventional science and contributes to science literacy. It would also point out the possible significance of sense perception in science teaching and learning. For Goethe, the human being with well-cultivated senses was the supreme instrument of research into nature. If science teachers belittle or even neglect the significance of sense perception in understanding natural phenomena, it may contribute to alienating their students both from nature and from science. Science would continue to be a heavy, non-human affair, in spite of postmodernist clamours.

**Erik Wallin, 2002: School development: An issue of lifting yourself by the hair – or what? /Att utveckla skolan: En fråga om att lyfta sig själv i håret – eller vad?/. Pedagogisk Forskning i Sverige, Vol 7, No 2, pp 99–129. Stockholm. ISSN 1401-6788**

Behind this article are my experiences of helping to establish a new local school, Håbo School, in a process of change spanning across the total educational system of the local community. The changes were not initiated at the school level, but rather at the local community level. The changes were also radical. They have their roots in political decisions with pedagogical consequences and in a fundamental respect may be better conceived of as representing a reform rather than a local innovation or development. Through the changes initiated the students are organised in working teams with their own rooms and staff and they have considerable autonomy.

Håbo School is still developing, but experiences thus far are very positive. This positive outcome stands in some opposition to the proposition that no change is possible if not initiated by the school itself (lately expressed among others by Ingrid Carlgren and Berit Hörnqvist, 1999). In the present article this proposition is tested against the experiences from the changes initiated and accomplished at Håbo School.

Swedish research concerning school innovation and development is discussed initially. Perspectives and theoretical frameworks within this research have varied, but it is possible to find a common perspective that is almost of institutional character. The concept *institution* is important in the article and this concept is presented and then related to other concepts like *tradition*, *culture*, *autonomy* and *relative autonomy*. At Håbo School the school staff members do not have full autonomy, but they do have a relative autonomy vis-à-vis curricula and other government directives.

The concept of institution is discussed in relation to different authorities and examples are given of how Håbo School was anchored in the local community and among the school staff. Institutional theories are discussed in relation to the work of Douglass North (1993) and Mary Douglas (1986). The former points out that institutional norms concerning predictability and safeness in relations are important within institutions while the latter, as an anthropologist, takes notice of how categories of thoughts and shared values are formed in institutions as communities. Together the two theories suggest something of the difficulty of change processes when the force for change is exerted from the outside so to speak. However, communicative theories (Säljö 2000) are also important when we consider institutions and institutional change. In these theories words and the conversations that tear away the veil of the self-evident and give everyday trivialities and routines a reflective meaning are important. These theories suggest that change brought about by pressure from the outside is possible, depending on how the change is initiated. Håbo School is an example.

The cardinal proposition of change expressed in the article is that we exist in our words and in our memories and that this means that it is neither probable

nor sufficient that ideas about and an initial impetus for change emanates from within an institution. Institutions cannot, at least not by their own power, lift themselves by their hair.