

SCIENCE EDUCATION RESEARCH IN THE KNOWLEDGE-BASED SOCIETY

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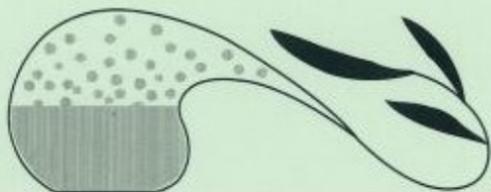


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ON THE METHODOLOGY OF 'PHENOMENOGRAPHY' AS A SCIENCE EDUCATION RESEARCH TOOL

Keywords: Phenomenography, Systems Theory, Constructivism, Research Methodology, van-Hiele-levels, Learning, Experience, Understanding, Concept formation

ABSTRACT

The contributors to this symposium have performed phenomenographic research in different projects. Their epistemology as well as their philosophy of science did more or less differ. It was the scope of this symposium to discuss whether this can be an obstacle or may lead to fruitful debates. After brief descriptions on the methodology of the research performed, 3 questions were discussed: (a) Is it appropriate to "borrow" and use phenomenography methods in non-phenomenological research contexts? (b) Is it justifiable to substitute the term 'experience' used in phenomenography by 'understanding', or 'conception'? (c) How can we secure validity of phenomenographic research?

1. INTRODUCTION, RATIONALE

For teaching concepts in which the *quality* of understanding natural phenomena as well as the understanding of (normal) scientific thought is important to the international science education community. The focus may be on coherent, contiguous and personal insight or on a system of results of Normal Science. If it is accepted that individuals produce personal insight¹, then methods of educational research are needed that trace back and describe such ways of individual understanding. For this purpose, *phenomenography* can be taken as an accepted research method. It was developed in Sweden in the late 1970s out of a Husserlian philosophical background in the context of psychological research, more precisely in a context of learning as coming to experience the world, or aspects of the world, in particular ways (cf. Marton & Booth, 1997). Researchers in other countries have independently developed similar research approaches (ten Voorde 1977, Buck 1993, 1996).

Phenomenography should actually not be regarded as an independent method but rather as being embedded either in psychology (learning theory) or in pedagogy

¹ More about the pedagogical issues in this connection cf. the preceding contribution in this book (Buck et al, 2002)

(educational philosophy). It can be (and is) "borrowed" from outside the underlying phenomenological philosophy, for instance within a constructivist research design. Both the existence of similar methods and its use outside phenomenological research settings give rise to methodological questions. It was the purpose of the symposium from which this paper was drawn, to focus on methodological questions related to a) how data were collected and interpreted, b) how generalizations have been validated, and c) whether or not terms such as 'conception' or 'understanding' can be substituted for Marton's term 'experience'.

In the discussion Marton & Booth's description of the idea of phenomenography (Marton & Booth, 1997, chapter 6) was taken as a referent. All individual contributions during the symposium, either delivered as oral contributions from the panel or as statements from the symposium audience during the symposium, were anchored in this idea.

2. OBJECTIVES, DATA COLLECTION AND VALIDATION²:

Phenomenographers typically take a given phenomenon as a starting point and seek to find out how a person experiences this phenomenon. A current way to do this, as described by Marton & Booth (1997), is to conduct a two-phase interview. In the first phase the phenomenon is introduced in an "open and concrete way", usually by asking the interviewee to perform a certain material task. The second phase is then devoted to letting the interviewee formulate and reflect on his experiences. Marton stresses that the interview is a learning situation, both for the researcher (who learns how other people interpret the phenomenon) and for the interviewed person who is possibly expressing his experience in new ways. This situation is structurally similar to the situation the van Hiele used to promote a level change (van Hiele-Geldof, 1957, van Hiele 1986).

Wolter Kaper and *Martin Goedhart's* research was based on van Hiele's level-theory of concept formation in mathematics. It was adapted by ten Voorde and collaborators in three projects 'understanding chemical substance at secondary schools' (ten Voorde, 1977), 'understanding ionic crystals' (Joling, 1993) and 'understanding energy' (Kaper, 1997). Both phenomenographers, as well as "van Hiele-level" researchers, are looking for a small number of qualitatively different ways – ways of experiencing in the case of phenomenography, ways of using words (geometrical or chemical or physical) in the case of van Hiele level research. They might possibly be looking from different perspectives at more or less the same thing.

Michiel Vogelzang reported on a case study of a pupil learning geometry in the context of "level raising education" by van Hiele and then proceeded to chemical education on melting and solidifying. In the classroom situation presented, the students were forming a certain conception of melting and freezing points. He

² For the synopses of the contributions discussed here cf. symposia 5, 6 and paper session 30 in Psillos et al. (2001)

described how the *teacher* was learning what he can expect the students' own experiences to be at this moment of their learning biography. He used this instance as a close-up picture of what phenomenographic researchers do: They look carefully (i.e. they apply hermeneutic procedures) upon the underlying conceptions and ask questions based on their awareness of the way in which learning progresses and what is constitutive in a given notion of a given phenomenon. Accordingly, it is the hermeneutic skill of the researcher that makes the results valid.

Cedric Linder and *Delia Marshall's* study dealt with tutors' approaches to encourage introductory physics students at the University of Western Cape, South Africa to widen their 'experience of variation' as part of their learning to solve problems. The study covered 5 groups of students working in a "physics co-operative learning setting" (Heller & Hollabaugh, 1992) of 3-5 students on introductory Newtonian mechanics tutorial problems.. The groups of students met regularly in a venue wired with high optical resolution and magnification video cameras.

The study had two consecutive parts. Both parts involved 2 tutors working with 4 groups of students (the same groups of students). For the first 4 weeks of the course the tutors basically responded to student questions. After this (part 2) the tutors were shown how to use Schön's three coaching models as intervention strategies to introduce variation into the students' learning experiences.

The recordings were done at both the macro level (group interaction level) and the micro level (what individuals in the group wrote down and discussed what they wrote). The tapes were then analysed for evidence (1) that the tutors had recognisably begun using Schön's coaching models (cf. Schön 1988, Buck et al, 2002) as a way to encourage the students to search for variation as they struggled to make sense of why and what to do and (2) that discernible learning then began to take place by making use of systems of variation. It is mainly this second concern that is of interest in the context of phenomenographic research: Physics tutors will have to use a combination of approaches when they intervene in group work situations. The kind of intervention which they decide to adopt will be determined by how well they are able to judge where the students are in terms of making sense of a problem and what their difficulties are. It is the researcher's crucial skill that is required by phenomenography.

Hannelore Schwedes and *Lydia Murrmann's* study dealt with the ways in which 10-years-olds' understand light, shadow and vision. They interviewed children and videotaped classroom lessons and complemented their data collection with pre- and post-intervention paper & pencil tests. The detailed analysis of the transcripts of the interviews and lessons started with the reconstruction of meaning of individual statements and actions. For each child, then, lists of reconstructed meaning (understanding) were formulated that refer to coherent interview passages. The categories were refined and finally revised until they covered the whole variety of reconstructed ideas expressed in this research setting.

Vassiliki Spiliotopoulou's research, as far as the *perspective of phenomenography* is involved, aims to describe the essence of all the ways in which the phenomena can be experienced and searches for the appropriate descriptive tools.

Some 280 children, aged 6 to 16 years, in 8 schools in the Merseyside area in England were asked to express their thinking as produced not only from their immediate experience in particular instances but also from their *overall* experience of the world, through their actions, imagination, speculations, theorisation and inferences. The main tool in her study was a questionnaire-grid, in which students had to answer fundamental questions about 22 entities, such as spoon, earth, sugar, man, stars, space, atoms, water, universe etc. In addition she asked questions that solicit children's experience of different phenomena, like life's duration, movement, existence of forces. The question-entity pairs create different situations about which children were asked to state their ways of experiencing it.

A detailed and refined consideration of the children's answers was followed by a synthetic approach through the use of systemic network analysis (Bliss, Monk & Ogborn, 1983). The answers to every question for all entities and for all children were studied, thus leading to a very large number of possible combinations expressed in the triplets: "entity – question - aspect of response". The study proceeded by constructing a network based on the abstraction of the triplets and by recontextualising the produced categories. This procedure was repeated until a certain degree of certainty was reached that the decontextualised categories of the network are good descriptions of all existing triplets for each question and for all entities.

Marton's phenomenographic perspective (1981) suggests that "we would deal with both the conceptual and the experiential, as well with what is thought of as that which is lived". This objective requires consideration of the wholeness of the system. Not only the notion of elements should be considered, but also of modes of connection, the structure and organisation, the levels of structure and the control and function of the system. This is quite a complicated task and there is no way for a study to approach *integrally* all the aspects involved. Spiliotopoulou pointed to the synergy produced by combining the phenomenographic and the systems' theory approach.

Tom Koballa and *Wolfgang Grüber* carried out two studies to understand how prospective teachers conceptualise science teaching as part of their university experience. One study was conducted in the US and the other in Germany, the first one using phenomenography as a research method to construct a structure of categories of student conceptions of science teaching and the second, described as "partially" phenomenographic, involved a "search for predetermined categories" (Ashworth & Lucas, 1998, p. 420). The phenomenographic research involved 7 students who were interviewed in a semi-structured format to elicit descriptions of their conceptions of science teaching and learning. The interview transcripts from these participants were treated as a whole. From these transcripts, 53 utterances were identified as revealing understandings related to science teaching. These utterances were then coded independently by two researchers into 12 and 17 categories, respectively. Examples of the coding categories generated by the two include "linking class activities," "covering content," "considering students' misconceptions," "using hands-on activities," and "making content interesting."

These categories were then discussed by the two and revised by eliminating and merging categories and by grouping other categories based on perceived linkages. This sequence was repeated until a set of categories that both researchers agreed represent the data was constructed. Throughout the data analysis process, the two researchers worked independently to examine the transcripts and construct categories and jointly to discuss the categories and negotiate their re-construction. The outcome of the process was the proposal of a categorical system with qualitatively distinct, conceptual categories. It was by this partially independent and partially negotiated research procedure that Koballa & Gräber undertook to secure some validity of their phenomenographic research. The conceptions generated are nevertheless "provisional descriptions" (Entwistle, 1997).

Nektarios Tsagliotis, – in an attempt to view conceptual change *within* Marton & Booth's Theory of Awareness (1997), elicited and compared children's conceptions on mechanical energy. Within a *second-order perspective* (Marton & Booth, 1997, p. 117-121) focusing on the descriptions of phenomena as they appear to the person, 13 children were interviewed before and after a teaching intervention on mechanical energy. The Interview-About-Instances technique was used (Gilbert, et al., 1985). The same set of eight depicted instances was presented and discussed with the children in both cases. These instances pictured everyday activities (like a man pushing a heavy box, children playing on the seesaw, swinging, going down the slide) or natural phenomena (like a stone rolling down a hill slope) etc. The interviews were analysed on two levels. At the first level the *Pre-Intervention Interviews* and the *Post-Intervention Interviews* were analysed separately in order to elicit a variety of qualitatively different conceptions about each picture before and after the teaching intervention. At the second level the elicited conceptions were compared within the context of each picture in order to identify differences in discernment, simultaneity and variation at deeper layers of awareness. This is an attempt to reveal the dynamics of conceptual change. Within a dynamic approach to conceptual change, children appear to experience and discern some varied features of energy, in terms of characteristics and aspects that come to the fore and remain in focus within the particular context of the depicted instances of the interview cards. As Marton (1990) has argued, "*within the internal dynamics of a conception of something, a restructuring is taking place and one meaning develops into another*" and this appears to be a gradual and on-going procedure. In this sense, if a person's awareness is the experienced world and learning can be seen as a change in the structure of awareness, then conceptual change can be seen as a change in the ways of experiencing various phenomena in terms of changes in discernment, simultaneity and variation of deeper or more advanced layers of understanding these phenomena, within a person-world relationship.

Peter Buck, in an attempt to come to objective phenomenographic descriptions, developed a method which he called "chaining of [non-]understanding". It makes use of non-understanding situations of someone's understanding (i.e. his explanation). Once we can describe what is *not* understood and why, we may understand, what else *has* been understood.

Thus by chaining non-understanding to understanding and thereby gaining insights about the ambiguity of the situation (i.e. reaching meta-understanding, in other words by nesting three explication-demanding situations one into the other) we may reach enhanced interpersonal understanding of the whole. This is accomplished by creating plausibility (viability) of every step of understanding. In a formalized scheme (cf. fig. 1) he depicted his general understanding of what is taking place in phenomenographic research and applied it to case studies on the phenomena of floating and sinking and of distillation.

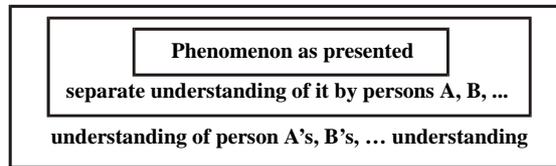


Fig 1.

3. MARTON'S IDEA OF PHENOMENOGRAPHY AS DEPICTED BY BUCK

During the symposium Buck produced the following depiction of Marton's procedure of phenomenography (fig. 2): Marton & Booth state: "The main task.. for our researcher/learner is to discern the internal structure and the intertwined meaning of the object of research [i.e. understanding of the {phenomenon} dealt with by the researcher R or the Testee T_{1...n}] " (1997, p. 133); this is depicted by double arrows in the ovals of fig. 2. It is the *experience* of T that is compared to the *experience* of R, the latter being molded by his/her professional training. The experience is expressed in words; this *shift of quality* being depicted by rectangles.

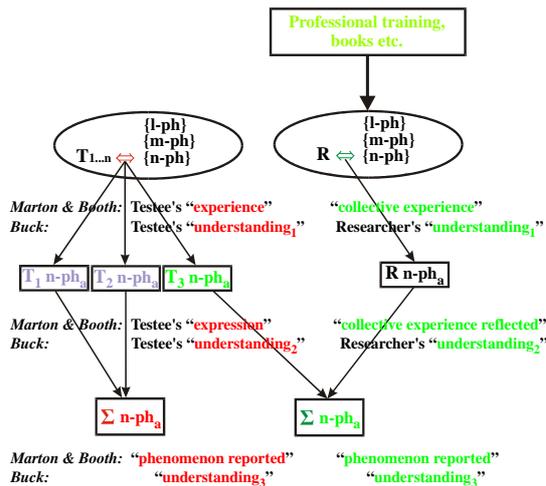


Fig. 2 The procedure of phenomenography as understood by Buck

Buck saw some need for terminological revisions (bearing their origins in his underlying concern of educational philosophy, cf. Buck & al, 2002). He insisted on a distinction between '*experience*' which is inaccessible, and '*understanding*' which is the essence of any dialogue, be it a dialogue between human beings or be it the "dialogue" between a person and a phenomenon (also here the person puts questions and the phenomenon "answers"). In this general dialogue situation there are three qualitatively different "stages" of understanding, indexed with 1, 2 or 3: 'Understanding₁' in Buck's terminology is synonymous to Marton's 'experience', whereas 'understanding₂' is of different quality. It is a relationship (" \Leftrightarrow ") between persons or a person and a phenomenon. 'Understanding₃' is again of a different quality. It is *generalized* understanding, thus abstracted from the persons that have been maintaining their understanding₂. It is a "thought phenomenon" now.

4. DISCUSSION

The question of sample taking, data collection and data processing was not really a matter of dispute. The discussion, instead, focused on science philosophy implications: The compatibility of Systems Theory and Phenomenography was at stake in Spiliotopoulou's contribution. Both seem to complement each other in a favourable way. The research methods developed by the van Hiele and ten Voorde and Buck seem to have structural commonalities with Marton's Phenomenography. The differences lie in the appraisal of the nature of the phenomenon described: "experience" or "text" or "conception"? Mainly three questions were discussed during and after the symposium:

1. Is it appropriate to "borrow" phenomenography in non-phenomenological research contexts?
2. Does it matter if we substitute Marton's term 'experience' by 'understanding' (Buck) or 'conception' (Tsagliotis, Koballa & Gräber)?
3. How can we secure validity of phenomenographic research?

The answers have to be quoted individually: *Wolter Kaper* insisted that he did not exactly borrow the research method of phenomenography. The van Hiele's independently devised their method of distinguishing qualitatively different ways of using subject-related language. Only after careful study we can conclude that both methods have much in common and are perhaps based on equivalent assumptions. Secondly, on the basis of van Hiele-level research he argued that a change in students' use of language shows the emergence of new objects-of-experience (like 'chemical substance'), therefore of new ways of experiencing. Therefore a change in 'conceptions' has been related to a change in students' experience. However, that does not mean that both terms share the same meaning.

Hannelore Schwedes' research context is the analysis of learning processes in physics education. Her basic epistemological assumption is the paradigm of constructivism. To her constructivistic research is compatible with phenomenography although they are based on different philosophies. Both in her

research and that of Marton's are the way that learners experience phenomena they are asked to deal with in physics instruction the central element of analysis. The use of phenomenography gives a special new turn to constructivist approaches: The idea of preconceptions in students minds can be given up and there is no need for postulates about the structure of the brain. Learning, in this context, amounts to a change in the experience of phenomena, related to the physics curriculum.

The power of Marton's term "experience" lies in its wholeness of this conception. It describes a process that unites perception, cognition and emotion in doing something. Therefore it cannot be substituted by the term conception or understanding. Understanding is part of the process of experiencing, and conceptions may be constructed during this process.

The objects of study in phenomenography are experiences. To experience implies mentally to discern the object from its context, i. e. constitute a phenomenon. This means it is experienced as something particular and distinct. By this discrimination on the one hand the context is constituted as context or "outer horizon" and on the other hand the intentional object or the "inner horizon". The conceptions outer and inner horizon (terms from phenomenology) indicate parts of the structure of experience and are at the same time elements of the concrete experiences.

Tom Koballa joins in here: It is acceptable to borrow the research method of phenomenology for use in a non-phenomenological research context because the essential character of the research is to "question the way we experience the world" (van Manen, 1990, p. 5). The focus of phenomenography is on particular phenomena, such as science teaching or learning, and how they are experienced. Different from psychology, the focus is not on remembering, problem-solving or decision making. Phenomenography and phenomenology both share human experience with phenomena as the object of research. However, they have different purposes. Phenomenology focuses on how people experience the world. In contrast, phenomenography tends to focus on ways that people experience the world that enable them to cope with it more or less efficiently (Marton & Booth, 1997). This extended purpose helps to distinguish phenomenography from phenomenology, but does not preclude the use of the methods of description, interpretation, and critical analysis that have long been associated with phenomenological approaches to research.

Further supporting the use of phenomenography is that it combines the explanatory power of both individual and social constructivism. Rather than focusing on the learner's active role in the construction of knowledge or the influence of culture on knowledge development, phenomenography "transcend[s] the person-world dualism imposed" by the two respective schools of individual and social constructivism and considers the person and world as one (Marton & Booth, 1997, p. 12). This enables exploration of the world that people experience.

Conceptions, on the other hand, *Nektarios Tsagliotis* continues, can be viewed as systems or categories of explanation or as "categories of description", which are not seen as individual qualities, but can be used in facilitating the "grasp of concrete

cases of human functioning”, in a person-world relationship. As Marton had mentioned during the symposium, the 1981 paper on *phenomenography* was subtitled “describing *conceptions* of the world around us” (emphasis added) just as Tsagliotis had argued in the synopsis of his paper (cf. Psillos et al, 2001, p. 121): “This approach depicts *conceptions* as being characterisations of categories of description”. Thus, he agrees with Marton that we ought not to make a distinction between immediate experience and reflected conceptual thought, since they both may carry different meanings and understandings [or non-understandings] of a certain phenomenon. He also agrees with Koballa’s view that “people construct conceptions and come to understanding based on their own lived experiences”. Tsagliotis also argued that “the notion of multiple conceptions can be seen as a challenge to a theory of conceptual change, which assumes conceptual stability and does not focus on the dynamics of awareness (Pong, 1999). If multiple, varied conceptions are context dependent, it appears more important to be able to recognise a context, discerning some of its features into focal awareness, and in this sense evoke an *appropriate* conception, in terms of *conceptual appreciation*, delimited by the particular context (cf. Linder, 1993).”

Vassiliki Spiliotopoulou bringing the systems theory approach and phenomenography together argues: The term “experience” is used in a meaningful way in the phenomenographic context and it turns to be a distinctive way of arguing about human learning. Marton & Booth (1997, p.122), by claiming, that experience is neither a mental, nor a psychological, nor a physical entity, but rather “an internal relationship between the subject and the world” and that “an experience is of its essence nondualistic”, draw a line between the analytical approaches in phenomenographic research and traditional constructivist ones

It does not seem that any conflict exists between the epistemological foundations of phenomenography and the *use* of terms like 'understanding', 'thinking' or 'conception'. Because, when we say “we can experience something as something thanks to the two basic capabilities: (a) we can discern entities and aspects, and (b) we can be focally aware of a few entities and aspects simultaneously” (Marton & Booth, 1997, p.123), do we not refer to the human capability of thinking or to the human need to understand? The essence of the point is that the focus chosen for the analysis and the discernment of aspects in the data for producing categories of experiences are of a different nature from the ones produced from non-phenomenological research contexts, which are usually of psychological or mental nature.

Peter Buck argues against these positions (and *Wolter Kaper* agrees to it): Although experience (understanding) is in the focus of phenomenography, it is not accessible as such but only after it has gone through the metamorphosis of becoming a *script*, i.e. it is *language* that we do research on. Making phenomenographic descriptions is hermeneutics almost like philology: it is interpreting texts. It *matters*, if we change the term: by using 'understanding' we state more precisely what we are dealing with. As to the validity of phenomenographic research: we are facing exactly the same problems hermeneutic research is facing. Whether or not to “borrowing” a phenomenological method by, say, a constructivistic approach: As it

is the primary starting point of any research enterprise that matters, in such cases phenomenographic results are turned into constructs, so they are swallowed by the underlying and dominating epistemology.

5. CONCLUSIONS

A one and a half hour symposium of course cannot lead to a more elaborate discussion, nor can it lead to recommendations for future and further research. What the discussion boils down to is the question of what the object of research is. For example take the case where the object of research is what different meanings of various phenomena learners might develop and how these meanings are developed. Given that this is the object of research we might use similar research methods and come up with – at least partially similar – results, the interpretations of which might differ at a deeper level. This is certainly true as far as the question is concerned, what different meanings of a certain phenomenon might learners develop. The very same findings may originate from a constructivist or from a phenomenographic perspective, however the accounts of the results may differ.

If our focus is "differing meanings" it seems legitimate not to make distinctions between immediate experience and reflected conceptual thought, for instance, as both may – or may not – carry the same meaning of a certain phenomenon.

In order to secure validity we have to identify recognisable "critical features" which discriminate between different meanings of a certain phenomenon in an intersubjectively reliable way and we have to demonstrate that "the critical features" are not only critical when it comes to distinguishing between different categories of meanings, but *are also pedagogically relevant* in the sense of being powerful tools for understanding the difference between more and less successful cases of learning.

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