Stream: Student Learning

Paper Title: Learning physics with simulations. Reflections on phenomenographic work and methodology for research on student learning

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Abstract:
The focus of phenomenographic research has been the experience of learning (Marton & Säljö, 1976a; Marton & Säljö, 1976b; Säljö, 1979; Marton et al., 1984/1997; Booth, 1997; Marton & Booth, 1997; Pang, 2003). Drawing on our recent research into the process of learning in higher education physics contexts, we present a discussion of the experience and process of learning, and perspectives from which it can be analysed and understood that emerge from the phenomenographic tradition. First we will relate our empirical work, then elaborate on it as an example of a study of learning. Then we will enter into a reflection on phenomenography as a research approach for the 21st century, in the delimited field of researching learning and teaching practices in higher education, and make an argument that phenomenography has a role to play in the transformative processes demanded by a changing society.

Keywords
Student learning, physics, computer simulations, higher education, phenomenography, methodology

Learning physics with simulations. Reflections on phenomenographic work and methodology for research on student learning

Recently, we have worked in a group that has taken three different approaches to analysing empirical data gathered in a pedagogical situation where pairs of students engaged with a simulation of the Bohr model of the atom: The goal has been to grasp aspects of the ways in which they experience their learning and their process of learning from a phenomenographic perspective. In contrast to most traditional phenomenography, student conversations were collected and analysed as well as interviews.

The students worked in pairs with a simulation of Bohr's model of the hydrogen atom, taken from *ActivPhysics* by van Heuvelen and D'Alessandris (1999). From a university physics teacher perspective, we judged this simulation to be pedagogically promising, with its multiple representations of the Bohr model, its simplicity and ease of use, its structure as a learning sequence, and its use of complementary visuals and text. The simulation consists of three linked representations (see Figure 1):

1. a diagram of the *electron orbits* (top left), with an electron moving around the proton in one of the orbits (only six orbits are represented);
2. a diagram of the corresponding *energy levels* (top right), with the energy of each level indicated in electron volts (eV); and
3. a diagram of the *spectral lines* that result from the electron transitions (bottom left), with the wavelength of the corresponding photon, indicated in nanometers (nm), and its color.

The simulation allows the user to move the electron between the orbits (top left) by clicking on the orbital or quantum numbers (middle right). The transition is indicated in the energy level diagram (top left) by an arrow. The corresponding line in the spectral line diagram (bottom left), with its true colour, starts blinking.

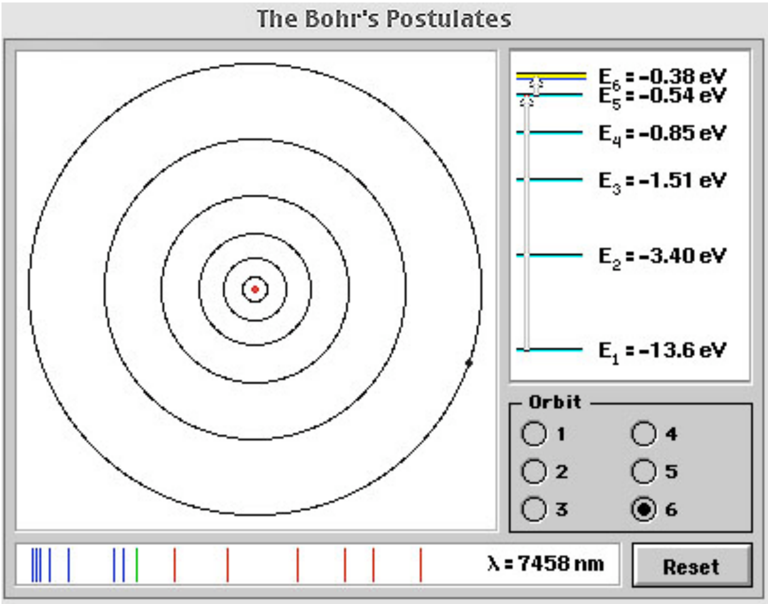

Figure 1. A screen dump of the simulation showing the three forms of representation of the Bohr model of the atom (see text for details)

Table 1 shows three forms of representation of the Bohr model – energy level diagram, spectral pattern and orbital diagram – and how three aspects of each representation – number of levels, discreteness and spacing – are shown in the simulation. The simulation and its representations of the model are as they are, but they could be otherwise, and can be imagined to be otherwise by the student. All three representations have discrete values, though the spectral pattern can be contrasted to the alternative of a continuous spectrum. The number of levels is the same for the orbits and the energy levels, and the number of lines in the spectral patterns is different but related[1], though in all three cases there is the potential for other choices – these numbers are in principal unlimited, though always related in the same way. The distances between lines in the three representations are very clearly different from one another, and can be thought of as deliberate or as a stylistic invention. Thus in using the simulation, there are a number of assumptions that might or might not be made explicit to and by the learner.

Representation in simulation	**Aspects of the representations in the simulation**		
	Number of levels	*Discreteness*	*Spacing*
Energy level diagram	6	Yes	Increasing
Spectral pattern	15	Yes	No obvious pattern
Orbital diagram	6	Yes	Decreasing

Table 1. *The relation between three aspects of the Bohr model and the three representations in the simulation.*

The students were asked to respond to six predictive tutorial questions that accompanied the simulation. When they had finished, roughly after half an hour, the pair of students was joined by one of the researchers for a discussion of varying duration in which they were encouraged to ask questions and seek to clarify anything they had been trying to make sense of during the simulation. The discussions were, in research terms, open ended interviews, exploring students' experience of the tutorial, their learning around specific aspects of Bohr's model and, in particular, their experience of the relationship between the simulation, physics and "the world". Students were commonly referring back to discussions and thoughts they had had while working with the tutorial.

Study 1

The first analysis we want to tell of (Ingerman et al., 2007) concerned the "focus of awareness". Our research question was: "In what ways are the students aware of the simulation in the tutorial situation?" which refers to how elements of the simulation are intertwined in the students' experience and what the simulation's function is taken to be in the pedagogical situation. Being a phenomenographic study, we made the phenomenographic assumption that a small number of qualitatively distinct ways of experiencing the simulation could be analysed and described which, together, would cover the whole of the students' ways of experiencing it[2]. Four such ways were identified after lengthy periods of analysing both the discussions in pairs and the follow-up interviews. We presented the analysis in the form of the four categories, with their salient features of implications for the nature of physics knowledge and the view of learning physics, Table 2.

In category A, focus is on the tutorial task and using the simulation in a purely instrumental way, to complete the task. In B focus is rather on the simulation, examining how the representations can change simultaneously, for example. In C and D the physics phenomenon is brought to the focus of awareness, C within the confines of the task, D going outside the task through analogy with and relevance to other physics phenomena.

[1] The number of possible transitions between six energy levels is 6x5/2 = 15

[2] A "way of experiencing" is the unit of analysis in a phenomenographic study, and can equally be expressed as a way of seeing, or a way of understanding, depending on the circumstances. The basic result of a phenomenographic study is an outcome space of qualitatively distinct ways of experiencing, arranged in an ordered space so that what makes one distinct from its neighbour is apparent.

	Focus of awareness	Nature of physics knowledge	View of learning
A	*Doing the Assignment,* concerned mainly with the constraints and features of the situation as an assignment that has to be completed	Physics is not really present, neither the simulation nor the phenomenon it represents come into focus	Fulfilling the demands of imposed tasks
B	*Observing the Presentation,* where focus is on the simulation and how it works	Physics phenomenon to be seen and explained, as if the simulation were a video or demonstration, and possibly understood	Learning is accomplished by watching and having someone explain
C	*Manipulating the Parameters,* where the simulation is used actively to understand the underlying physics phenomenon	Physics phenomenon to be understood, but delimited by the limits of the parameters given in the simulation	Learning by engaging in the given task and understanding within given limits
D	*Exploring the Physics* acknowledges the representative nature of the simulation and its limits when it comes to physics in the real world	Physics phenomenon is more extensive and more embedded in the world than the simulation can allow for	Learning by explorative creation of a body of knowledge, reaching away from the given

Table 2. The outcome space of the first study, showing the delimitations between categories of different focus –of awareness in terms of the two analytically implied aspects "view of the nature of physics knowledge" and "view of learning physics"

Study 2

The second analysis we made concerns the experienced agency of the computer simulation (Booth et al., in progress); or differently put, an analysis of the students' understanding of the primary (pedagogical or intellectual) tool shaping their learning experience. Our overriding research question can be expressed as "What is the role of a computer simulation as agent for reasoning about a physics phenomenon by students engaged in studying physics?" The analysis revealed, again, four qualitatively different categories, and a further analysis indicated four distinct aspects of each category. Table 3 shows the categories and the aspects, agency, quality of reasoning, structure and the experienced question.

Here A and B can be grouped as seeing the simulation as an instrumental agent for solving a given tutorial task, though while in A it is directed to finding the answer to the question, in B clues of relevance are being sought. In C and D, in contrast, the simulation is seen as a tool for finding insights into the physics involved, C within the confines of the given task and D outside, in the domain of physics – in striking similarity to categories C and D of Study 1.

The analysis of "structure" in terms of parts and wholes and the relations between them (Table 3) is the link between the two outcome spaces. In each case, A has, as its whole, the assignment, related to the parts of the simulations – the representations of the model; the representations can thus have no use or significance outside the assignment. In B, the whole is still the assigned task, but the parts are now the representations and their aspects (energy level, orbit, spectrum) seen in different local relationships to the whole. In C, the whole now embraces physics, and the parts are related locally to the physics that the simulation is intended to lend insights into. In D, the whole is still physics, but in a global sense, to the extent of the student's body of physics knowledge.

In phenomenography and variation theory, learning is seen as becoming able to see something in new and more powerful ways, becoming able to discern salient features of a phenomenon, as it emerges from a situation, whether from a physics text-book problem or real-life situation. The outcome spaces, then, indicate the levels of becoming capable of using the simulation in more powerful ways, more powerful for learning.

		Experienced agency of the computer simulation	*Quality of reasoning*	*Structure*	*Experienced question*
A	*Medium for providing answers to the question*	To answer facts as directly available from the parts of the simulation	No real reasoning. Isolated claims in sequence, according to the letter of the question	Parts in isolation	About the simulation. Fragmented, Direct questions, Isolated, Unrelated
B	*Tool for providing clues about the question*	To be able to address the whole of the question and draw conclusions	Unidirectional reasoning, basically inductive, from simple observations to appropriate conclusions	Parts in local relation	About the simulation. Fragmented but leading to one another in sequence.
C	*Tool for making sense of physics in the question*	Offering opportunities for puzzling out and verifying	Bidirectional reasoning, abductive reasoning, iterative, making observations back and forth, relating to other knowledge in the simulation	Wholes and parts in relation to physics	About physics
D	*Springboard for addressing physics knowledge*	A+B+C = starting point for consideration in physics	Explorative and analogical reasoning. Taking observation as starting points for a sequence of reasoning pointing to physics.	Wholes and wholes, structure of the whole in relation to physics	About physics. "Springboard" to consideration of physics

Table 3. The outcome space of the second study, showing the delimitations between categories and analysed into four distinct aspects.

Study 3

These first two studies have resulted in two sets of qualitatively distinct ways of experiencing two specific aspects of the pedagogical situation – and this is *variation as seen by the researcher*. The third analysis (Ingerman et al., in press) follows the dynamics of interaction between students, simulation, physics phenomenon and teacher, and here we were looking for *variation as experienced by the learner*. Theoretical notions from phenomenography (principally *variation*, *object of learning* and *ways of seeing*) were used to analyse the data on a micro-level for the emergence of ways in which the students themselves experienced variation, depicted in terms of "threads of learning". The analysis was carried out by seeking episodes in the discussions where students paid attention to what we, the researchers, could identify as variation around some aspect or aspects of one or more representation. This we regard as indicating new ways of seeing– characterised as an expanded and more structurally differentiated awareness, seeing in a qualitatively new way, which is in line with the phenomenographic characterisation of learning, as above. This is, then, an exploration of the process of learning over time, carefully following what is a small event in the whole scope of the students' education.

The development of this capability of seeing something in a new way – learning – can be described in two main stages, namely

- The learner discerns variation with respect to one or more aspects of the phenomenon, opening a dimension of variation – what was earlier taken for granted is now open to other ways of seeing.
- The learner recognises a meaning of this variation that is experienced as relevant in their body of physics knowledge and of the Bohr model of the atom.

The learner recognises the meaning of the variation as being relevant within their framework of knowledge of physics in general and the Bohr model of the atom in particular. The experience of variation – that things can be other than what was taken as given – implies that the constituting parts of the whole of the phenomenon and the relations between them change in some way, thereby changing the constitution of the whole. In the case of this simulation, it can take the form of a pattern or other structure of relevance, within a representation or across aspects of different representations. Relating the variation to the phenomenon and its context through relevance lends stability to the way of experiencing the phenomenon, and leads to a capability for seeing the phenomenon in a new way that overarches different contexts.

Building on this we were able to describe the kinds of variation that the students experienced in connection with what we could identify as successful threads of learning, in terms of what was present to the students in the phenomenon and its representation. We classified the experienced variation in two categories, shown and exemplified in Table 4.

	Category	*Example*
A	Variation *within* an aspect of the phenomenon of the simulation of the Bohr model of the atom	Seeing that there can be unlimited numbers of energy levels, when formerly it was assumed that the limit was 4, as illustrated in a text book
B	Variation *across* aspects of the phenomenon of simulation of the Bohr model of the atom	Seeing the three representations in terms of inverse energy-wavelength relationships

Table 4. Examples of two distinct kinds of variation in the empirical data.

The three representations and their three aspects, as shown in Table 1, were all to hand for the potential of seeing variation of these types.

Reflections on learning in this situation

When we bring these three studies together we see that there lacks a coherent picture of learning. To say that learning involves a shift to a more complete way of seeing, as in conceptual change work, has been pointed out by Linder to be inadequate in the complexity we find here (Linder, 1993), even though the complexity has been reduced here to analytical descriptions of the salient features of learning about the Bohr model of the atom with the given simulation and the given assignments. Marton and Pong have demonstrated that during an interview, conceptual shifts could take place when contextual factors drove a change of the students' experience of the economics phenomenon of price (Marton & Pong, 2005).

What we seek is a description of learning in time, one that will allow the tutor, or the student herself, to become aware of the instant and capture it. What we see is that learning is associated with the learner relating an experienced structure of variation to a meaning within the task or the wider field of physics. The experienced structure and the meaning of the phenomenon are inseparably intertwined, but in different given contexts they can be focused on in different ways, thus bring about variation. Booth and Hultén (2003) have shown how dimensions of variation can be opened in the flow of a discussion when contradictory or contrasting remarks are made and brought to the attention of the participants in the context of a complex design problem, thus unlocking variation in a similar manner to this.

The simulation of the Bohr model of the atom is a method for making concrete that which is in theoretical terms highly abstract, complex and incomplete, but which is at the same time highly applicable in practical terms in most of the domain of physics. It lifts out certain critical features of the model and offers the user/learner simple manipulations to explore and reflect on their significance and the relations between them. To learn, then, has a number of layers. One can learn what to focus on, shifting attention from the assignment to its underlying meaning, or pedagogical intention, and thence to the wider domain of physics (Study 1). One can learn what a simulation can be used to achieve in solving text-book tasks, shifting from an instrumental use, which though undoubtedly powerful neglects the opportunity to explore and extend to physics as a whole (Study 2). And one can learn how to spot potential variation and relate that variation across representations of the phenomenon and between aspects of the representations (Study 3).

Further it is also clear that learning is not a readily delimited and instantaneous process directed towards a single object of learning – neither on the level of the dynamics of the process, nor on the more overarching level of focus of awareness or simulation agency. It is rather a process directed to a series of evolving and interconnected objects of learning, constituted by the experience of variation of aspects seen as critical within a particular structure of relevance. In this way, our discussion may contribute theoretically to future phenomenographic analyses of learning and more generally to the discussion on student learning in higher education, and offer tools for investigating the process of learning locally and over time.

Methodological reflections

The first two studies are more or less classical phenomenographic studies – they differ from the standard through using naturalistic conversation as data but the analysis sought to reveal and describe qualitatively distinct ways in which students related to the simulation and the pedagogical situation in which it was embedded. The outcome spaces thus arrived at were then analysed further to reveal salient features of the categories, and to indicate critical aspects of experiencing the phenomena – what differentiates one category from the next. The third, however, is less classical in that it attempts to analyse the ongoing discussions of the students in terms of what constitutes learning, and draws on the variation theory that has been derived from a large number of empirical studies (Marton & Booth, 1997). We will now try to relate some of the features of phenomenographic analysis and theory of learning to the challenge posed by Law and Urry (2004), as cited by Haggis in her "thinkpiece" prior to this conference (Haggis, 2008). This challenge posits, among other things, research approaches that can capture the fleeting, the distributed, the multiple and the non-causal, or as they put it so beautifully

> "Current methods do not resonate well with important reality enactments. They deal, for instance, poorly with the fleeting – that which is here today and gone tomorrow, only to reappear the day after tomorrow. They deal poorly with the distributed – that which is to be found here and there but not in between – or that which slips and slides between one place and another. They deal poorly with the multiple – that which takes different shapes in different places. They deal poorly with the non-causal, the chaotic, the complex" (p 403)

Admittedly, the work we have presented is hardly applicable as a research approach across the whole of the social sciences! We modestly delimit it to one of the themes of this conference, namely student learning in higher education. And though it might be hard to convey to the reader, this quote resonates strongly with our attempts to analyse and understand the learning that goes on in such complex learning situations as the one we are taking as our starting point here.

The first two studies can be seen as offering aggregated but static pictures of the experience of learning with a particular simulation in a particular pedagogical setting; for each there are four specific qualitative categories of ways of experiencing which cover the field of students and the field over time, each of which has a different implication for the learning outcome, and which can be seen as related through a parts-whole analysis. The unit of analysis here is a specific way of experiencing the phenomenon, and they tend to impose order on the complexity they address. The third study, in contrast, deals with snapshots in time, dealing with the unit of analysis of specific instances of learning within episodes in the use of the simulation. Instances have been identified with the theory of variation of experience as starting point, and have been analysed into two categories that also have implications for learning and teaching. This is a dynamic picture of learning where one instance follows another, insights can come and go fleetingly, and where instances are found in different places at different times. The study results are non-causal – they illustrate what *constitutes* learning rather what *leads to* learning as other approaches try to show – and they deal with data that at first sight are chaotic, being natural conversation in difficult learning situations, or open interviews intended to expand the horizons of the phenomena in question of both interviewee and interviewer. These are three of the features of the social world – a world of dynamic, fleeting and non-causal phenomena – that Law and Urry declare to be poorly dealt with in social science research methods.

A further feature that they point to is dealing with the multiple, "that which takes different shapes in different places", which can arguably be met from phenomenography, as exemplified by the constructs of deep and surface approaches to learning, two empirically derived constructs that have been very effective in developing teachers' sense of what drives students to particular kinds of learning practices, but which have to be re-described in specific subject areas and learning situations (Marton & Booth, 1996).

Deep and surface approaches to learning have too often been confused, on the one hand, with "deep and surface learning" and "deep and surface knowledge", which we take to mean profound learning or knowledge as opposed to superficial learning or knowledge. On the contrary, an "approach" is essentially a way of going about one's learning, or making sense of a situation, and not the outcome. A deep approach refers to going beyond the task at hand to the knowledge it implies, in the first of our examples, this is going beyond the tutorial question which is central to the first three "focuses", and the first two of the "agencies", to making sense of the physics involved. The surface approaches are characterised by attention sticking at the task or its external trappings.

On the other hand, the approaches have been misrepresented as a categorisation of students and their ways of going about studying, and related to their cultural background. On the contrary, the approaches are not categorisations of people but categorisations of "how people experience a particular phenomenon" – over a number of contexts. It is often the case that a single person gives voice to a range of approaches, some categorised as deep, others as surface, in one and the same interview. Thus deep and surface approaches differ in detailed description from one learning task to another and from one subject area to another, and a single student working with the phenomenon can be seen as indicating one or the other, as driven by contextual factors.

In the studies we have related, deep and surface approaches to learning can be seen in both the first two studies. In Study 1, categories A and B can be clearly seen as surface approaches, while C is a deep approach with respect to learning to exploit the simulation and D is a deep approach with respect to learning physics. In Study 2, A is a surface approach while B can be seen as surface with respect to physics, but deep with respect to the use of the simulation in the given context. Categories C and D describe deep approaches with respect to learning physics. These are not categorisations of students, but categorisations of instances of expression of one or another approach, offering order in the fleeting, the distributed and the multiple.

A third point to make here is that not only different learning tasks but even different subjects of learning demand distinctly different empirically derived analyses of what constitutes a deep and a surface approach. If we compare the results we have presented for learning with a simulation with the founding work of phenomenography (Marton & Säljö, 1976a; 1976b), on learning from texts, it is seen that the simulation presented here introduces a third level of attention – not only the text and its message now, but the screen picture, the manipulable simulation and the underlying physics message, so learning physics can be seen as intertwined with learning the simulation, and deep and surface approaches become more inter-related, reflected in the outcome spaces with four categories. Similarly, work on approaches to learning to program (Booth, 1992) finds four levels, two referring to the programme that is being written for the computer to execute and two referring to the problem to be solved, and one of each of these pairs focusing on the text and the other interpreting the message.

Phenomenographic reflections

There are five particular features of this research approach of phenomenography that we wish to draw attention to. First, the categories do not refer to collections of individuals – on the contrary, as in our study, they describe sets of relations that can emerge from any student interacting with a simulation in a particular situation. On the one hand, taken together they describe an analysed view of the overall ways in which the students have been experiencing the phenomenon in question. Taken one by one, on the other hand, they describe specific idealised ways of experiencing a phenomenon, which can tell of potential structures and meanings that are present to the students in a learning situation. The qualitative differences between categories can tell teachers and designers of teaching situations about the critical aspects of the phenomenon they have to deal with, and can act as a pedagogical device for ensuring that productive variation is encountered by students in learning situations. These critical aspects, in their turn, indicate what have come to be called dimensions of variation, differentiating what has in some respect been taken for granted from its – potentially more powerful – alternatives.

Secondly, phenomenographic research is not located at the macro level of social science research; there have been no phenomenographic studies of institutions and institutional cohorts of students. This is because an assumption of phenomenography is that learning is always learning *something*, and that that *something* has to be retained in the research study. Further, there is always a context for learning that is assumed to be pretty uniform across the population being studied, which limits studies to certain rather homogeneous groups in terms of subject and/or cohort, though not in terms of background or intentions. Thus the largest sort of research population is the class or subject cohort, or possibly students exposed to a certain sort of learning situation. Most studies can be characterised as lying at this meso-level, which is to say that the learning in classes of students is in focus, usually, as said, with a common subject content of learning or exposure to a common approach to teaching for learning. The first two studies can be thought of as meso-level, but the third is definitely micro-level. Here we were looking at individuals, not as much for what they did or said as individuals per se, but rather as examples of what individuals might do or say in the given circumstances.

A third feature of phenomenographic research, which is on line with the second, is that it is necessary for teachers of higher education to take part in phenomenographic studies of learning in higher education. Both subject expertise and teaching experience is essential in designing studies that deal with central concepts and teaching approaches, and in analysing the data collected. Thus, almost from the outset, phenomenography has been a part of what is now known as the Scholarship of Teaching and Learning movement, where teachers actively research their own teaching practices and their students' learning practices. And in that sense phenomenography is a *performative research methodology*, drawing on the definition of *performativity* offered by Law and Urry (2004): such research *has an effect* in the social domain in which it is situated; it *makes a difference* in the ways learners are met by their teachers in an epistemological sense; the *reality of learning* is enacted both in the participation of teachers in the research in terms of their own learning as well as the enhanced potential for their students to learn; what is discovered in such a study is *brought into being*, in teaching design and enactment.

A fourth feature is that over the years in which phenomenography has been being developed, a body of empirical research has grown up which has allowed grounded theoretical developments, both of methodology and of learning as a phenomenon, to emerge. The third of our studies made extensive use of such theoretical understanding of learning in its search for instances of learning. The theory of *learning and awareness* (Marton & Booth, 1997) has in its turn led to *variation theory* (Marton & Tsui, 2004), which directly informs teachers of ways in which they can be supporting students' learning through considering the productive use of variation in their teaching. This variation is far from the cognitive psychologist's variation of teaching modes and timing patterns, of learning styles and forms of intelligence, but it points, much more significantly, directly to the relation between students and subject knowledge in terms of *experienced* variation of the phenomena that constitute the knowledge situation.

The last, but not least of the features is that phenomenography and variation theory are derived from and attend to issues that are pedagogical, strictly related to ways of experiencing and understanding that have to do with learning, whether formal or informal. This is in contrast to research approaches in education that derive from psychology on the one hand, with its individual and largely cognitive interest, and sociology on the other hand, with its large-scale and society-oriented interest. This is in keeping with the specific discipline of pedagogy, which emerged in Sweden some eighty years ago, breaking off from psychology which had itself broken off from philosophy, and separate from the emerging field of sociology.

Thus we want to defend phenomenographic research from accusations of belonging to the 19th century, as Law and Urry, and by implication Haggis in her thinkpiece, accuse most social science of being. On the contrary, it belongs firmly with the current 21st century issues of massification of higher education, life-long learning and internationalisation. Why? Because all three of these changes mean that the student population of today is much more heterogeneous in several dimensions than was the population from which most of their teachers have come, in particular in terms of preparation and of intention. Thus teachers need to understand, much more profoundly than in terms of school curriculum and examination results, how their students go about learning and what sort of qualitative outcomes they are achieving. They need research tools that are performative, that feed directly back into their teaching, and which are supported by a theory of learning.

Let us direct our argument, finally towards the South African situation today. We believe that such micro- and meso-levels of analysis of learning, related through multi-disciplinary educator-educationalist groups to the institutional levels of higher education can support the South African project of transformation. "Transformation" as a stand-alone concept begs the question of, transformation of what, to what, and with what purpose. In the South African situation, transformation ultimately means the transformation of society from the previously undemocratic, unjust and unfair structures that characterised the apartheid era to a democratic, just and fair society with a goal, as far as higher education is concerned, of offering open access to a system of higher education which itself supports the transformative processes. While society and its organs can determine what they want higher education to transform – transformation of society *through* higher education – and government can legislate what the transformative institution of higher education should be and do – transformation *of* higher education through economic and legislative measures – it is the internal processes and practices of teaching and learning – transformation within higher education – that will, in the end, determine the success of higher education in achieving the grounds and the skills for transformation among the educated population.

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