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A Tentative Approach towards a Consensus between Theories about Science Education and Practices in Comprehensive Schools

A Comparative Study of Five Post-millennial Dissertations

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Abstract

A comparative study has been undertaken of five post-millennial dissertations in Science Education in order to discuss the possible implications of their theoretical perspectives on practices in comprehensive schools. These theories include individual constructivism, sociocultural constructivism, social constructivism, theory of variations and combinations of these theoretical approaches. Even if these theories mainly are focused on learning, they might render tentative hints on acts of teaching. The theory of variations shows how questions might open up for activities which are not directly apparent for a teacher and the theory points out that it is fruitful to present the content of the subject matter in different ways. The sociocultural constructivistic theory focuses on communication between participants and shows how utilization of artefacts might create possibilities for enhancement of learning. The theory for individual constructivism sheds light upon processes of intrapersonal learning. Three different paradigms, emanating from these dissertations, are discussed in relation to school context, they are: acquisition, participation and constitution. It might thus be fruitful for teachers in comprehensive schools to study the contents of these dissertations and to reflect upon how these aspects of didactics could shed light upon teaching and for example to be able to take into account the differences between first and second order perspectives. The future development of didactics seems to lead towards hybrids of these Grand Theories in which for example a change from a dualistic towards a non-dualistic perspective on the relation between subject and object might be fruitful to take into account.

Contents

1. Background

In order to try to explore the development of Science Education it is instructive to try to get an overview of the frontier in this field of didactics by studying the contents in recent dissertations.
The aim of this paper is thus to study aspects on science education as presented in five postmillennial dissertations:
What do these dissertations tell about the contemporary research, learning and teaching paradigms?

An analytical tool, emanating from the conceptual matrix for studies in science education, as presented at a conference in Riga (Ott, 2001) and published in the Baltic Journal for Science Education (Ott, 2002), is utilized in this study.
This matrix consists of three aspects on science education: ***philosophical***, ***operational*** and ***interactive***.
The ***philosophical*** aspect starts with the element *metaphysics*. This is a point of view from which values and views emanate. The second element is *epistemology,* theory of knowledge. The third element is *ontology,* theory about the content of the world.
The ***operational*** *aspect* has its origin in the element *content.* This element is surrounded by the elements *praxis, which* denotes the physical performance in the classroom, and *theory.*
The ***interactive*** *aspect.* This aspect has as its uppermost point the element *preconception or common senses,* which denotes the experiences, preconceptions and everyday knowledge, which a student has. The other factors included in this aspect are *teaching* and *learning.*

In the dissertations, different aspects on theory and practice in science education are regarded.

Schoultz, J. (2000): ***Att samtala om/i naturvetenskap.*** *Kommunikation, kontext och artefakt.*
Schoultz utilizes, in his study, the *sociocultural* theory for interpretation of his results. The importance of utilizing *artifacts* when examining the students´ knowledge is pointed out. Schultz utilizes as methodology a communicative interview when studying students´ conceptualization of physical concepts.
"The purpose of this work is to scrutinize from a sociocultural perspective some of the findings in this area. The background is an interest in communication and learning and the way students meet and use concepts in science in dialogues and in paper- and -pencile tests".

"The cognitive tradition has for a long time consistently maintained that by using questions in interviews and paper-and-pencile-tests you can map a person´s understanding of a scientific phenomenon. Those claims are discussed in this work. What does it mean when a student gives an incorrect answer to a question in a paper-and pencile test or in an interview? Does that prove that the student has insufficient science knowledge, or does it mean that the student has difficulties to define and interprete the question?"

This dissertation expresses a stand against the traditional Piagetian way of interpreting results. Schoultz draws also attention to the importance that the teacher and the student should communicate about the content of the question, within the same discourse.

Dimenäs, J. (2001): *Innehåll och interaction.* *Om elevers lärande i naturvetenskaplig undervisning.*
This dissertation is founded partly on the *phenomenographical* theory and partly on the *sociocultural* theory.

Dimenäs studies learning processes about chemical reactions of six students using interviews, observation and recordings made on videotape. The research question is:
"How to describe and understand students´ learning when directed to natural science phenomena?"
"Phenomena" is seen as the science phenomena experienced by students and teachers and not as a phenomena defined by the natural science tradition."

This dissertation implies a shift from study of phenomena in the world, as performed and interpreted by natural sciences, towards phenomena as they may be experienced, discerned, interpreted and understood by students.

Bach, F. (2001): *Om ljuset i tillvaron.* *Ett undervisningsexperiment inom optik.*
This dissertations is founded on the theory of *individual constructivism*. Bach introduced an experimental way of teaching optics, based on educational research in students learning in optics. He interviewed teachers and tested students about the outcome of this method.
"The main purposes were to study the students´ learning outcome and the teachers´ responses to a proposed new way of teaching based on research in science education, in the field of optics."
This dissertation takes its starting point in research in science education and in students learning. This is in marked contrast to the common method of "indoctrinating" students into traditional ways of regarding science. To what extend do authors of textbooks in science care about results from research in the field of science education?

Emanuelsson, J. (2001): *En fråga om frågor.* *Hur lärares frågor i klassrummet gör det möjligt att få reda på elevers sätt att förstå det som undervisningen behandlar i matematik och naturvetenskap*.
The empirical results in this study are discussed in the light of a rather ortodox variant of the *phenomenographical* theory. Emanuelsson writes as follows:
"This thesis reports results from a study that focuses on how teachers can learn about their students´ learning in mathematics and science."

The empirical material was generated from audio taped classroom interactions and follow-up interviews. With the aid of concrete exemples, teachers were probed on their understandings of selected parts of the interactions, which were observed. The aim of Emanuelssons study was to try to describe variations in the ways in which teachers´questions in the classroom open up possibilities for them to see, understand or experience their students ways of understanding the subject matter areas in mathematics and science. The classroom is regarded as a place for learning not only for the student, but also for the teacher. This is in contrast to classroom studies, which in general focus upon how teachers form their practice.

Eskilsson, O. (2001): *En longitudinell studie av 10 – 12-åringars förståelse av materiens förändringar*.
The empirical results in this dissertation are interpreted using a modified *constructivistic* theory. Eskilsson studied pupils´ abilities to use scientific knowledge in the field of transformations of matter.

"The aims of this project are to study young people´s ability to use science knowledge when talking about and explaining everyday phenomena involving transformations of matter. The development of pupils´explanations is studied on macroscopic and particle levels. Pupils´conceptions are studied from two different perspectives."
A main point in this dissertation is to study how explanations of phenomena in science, by the students, are affected by clarifying questions, which are formulated by the interviewer.

The authors of the dissertations utilized different theoretical frameworks in their methodological approaches and in their interpretations of the results of their studies.

Schultz, who utilized a sociocultural approach in his study claims that childrens understanding may not be regarded as an overt expression of underlying mental models that might deviate from scientifically acceptable ones.
Childrens responses in interviews were, by Schoultz, instead regarded as situated and relative to the premises for communication, which were, by the interviewer, created for the child and which were the tools available as resources for the reasoning of the children.
Schoultz argues that childrens responses to questions should be treated as situated in communicative practices. They should not be taken automatically as indicative of underlying mental structures, which according to the sociocultural theory, may not be studied explicitely or be accounted for. This theory points out that it is a difference between what a person thinks and what he expresses verbally.
Schoultz points also out that studies of conceptual development and conceptual change traditionally choose to study thinking without the support of those culturally meaningsful artifacts that always are present in society and that children are used to encounter in their everyday world. In order to understand this development of thinking about knower and known, one has to retrack the history of human sciences back to Cartesian dualism in the 17 th century, when the psyche of man became separated from the body as well as from social action in concrete and cultural settings. This frame of thinking paved the way for an abstract conception of cognition, in which thinking became an autonomous domain of inquiry. This cognitive domain became regarded as accessible as such outside social or cultural practices.

Schoulz argues however that he, in his dissertation, reunites body and mind in a cultural setting. He means that his study might illustrate the continuity between cognition, discourse and cultural artifacts. The Cartesian mistake might be removed after many centuries.

Dimenäs who utilized a sociocultural and a phenomenographical theoretical framework when interpreting his results writes:
"This study is carried out within a non-dualistic framework inspired from phenomenological ontology. As its standpoints the study has phenomenographic and socio-cultural perspectives of learning and teaching. I have chosen these two aspects because the phenomenographic tradition focuses on content and the socio-cultural focuses on communication."
Dimenäs thus marks, in the interpretative framework, of his dissertation a step towards an *eclectical* approach to theories when he combines the phenomenographic and the sociocultural theories.

Bach who utilized an individualistic cognitive framework writes:
"The theoretical frameworks for this work draw on Piaget and his genetic epistemology. According to this knowledge cannot be regarded as an object possible to acquire or to posess in a static sense. Neither can knowledge be transformed from books to a person or from one person to another. Instead knowledge is seen as something constructed by the subject in an

indissociable subject-object relation and when studying learning it is therefore impossible to think about knowledge as something outside or inside a person."

Bach´s arguments are founded on the interpretation of Piaget´s theory as expressed by Furth (1969, p.19):
"His (Piaget´s) biological notion of an organism in constant interaction with its milieu is a rather commonplace notion, one would think; but this view has for Piaget the special implication that development and evolution are seen as intrinsic characteristics of the biological knowing process and not as events outside that process.
On the level of the theory of knowledge, this notion corresponds with the thesis that knowledge is neither solely in the subject, nor in a supposedly independent object, but is constructed by the subject as a indissociable subject-object relation."
"Most importantly, through interlocking mutual coordinations of actions the child reaches the stage of the first basic invariant of knowledge, that is, the formation of the object, of a thing "out there", independent in existence from his own action. At this point of development, we witness the beginning of a clear separation between the known thing, namely the object, and the knowing person. Knowledge, in the full sense of its human meaning, is found right between these two terms; for knowledge is about our way of expressing the mutual relation of the knower to the known."

This theoretical plattform together with the extensive research on pupils´ ideas in the field of optics, serves as the starting point for the new way of teaching optics, which Bach studies in his dissertation.

Eskilsson who utilized a combination of a cognitive and a sociocultural framework argues:
"The framework for learning in this study contains both pupils´ individual learning and their learning in a social context."
"In the project pupils will discuss everyday phenomena with their peers and with the teacher. The role of the discourse will also be studied in the interviews as well as pupils´ use of parallell models of explanations."
"During the interviews pupils often refer to everyday experiences. These comments can be of different quality from details to overall patterns. An analysis of this can give information about the development of pupils´ understanding as well as about how they use science knowledge when talking about everyday phenomena."

Just like Dimenäs, Eskilsson uses an eclectical approach, combining parts of the individualistic constructivistic theory with parts of the sociocultural theory.

Emanuelsson who utilized a rather pure phenomenographical framework discusses current perspectives on learning, which may be positioned in terms of the acquisition and the participation metaphor, according to Sfard (1998). He proposes a third metaphor, the constitutive metaphor, as an alternative for the discussion of the results in the study.
The results are described in terms of variant and invariant aspects of possible learning objects for the teacher. Attention is payed to what the student possibly focuses upon, and how they deal with the focused content in different zones - the topical, the conceptual and the procedural zone. The outcome of the study is discussed in relation to teachers´ knowledge.

2. Links between dissertations

A comparative study of these different dissertations shows, in a tentative way, how these studies might be regarded as being linked to each other in the form of pearls, which are strung on to a string. See figure.
On one end of the string we find Emanuelssons dissertation, which as an ortodox phenomenographic presentation is will act as a startingpoint..
This study is linked to the dissertation written by Dimenäs, who, beside the phenomenographical approach also utilizes a sociocultural approach.
The study by Dimenäs is via the sociocultural approach linked to the study made by Schultz who uses an ortodox sociocultural approach.
This sociocultural link leads further towards Eskilsson who uses a sociocultural approach but also an individualistic cognitive constructionistic approach. This eclectical variant of learning theory is called the socialkonstructivistic theory. It implies that knowledge is mediated socially but learned individually.
This constructivistic link leads further on to Bach who uses a rather ortodox individualistic constructivistic approach. At the same time, Bach is however pronouncing the parallells, which may be found between the mentalistic cognitive theory and the phenomenographic theory as expressed by Furth who pointed out the constitutive nature of knowledge in the theory of Piaget.

This implies that a link between Bach and Emanuelsson may be constructed as both regard knowledge as a relation, which is constituted between knower and known.
Bach also points out that knowledge may be regarded as being mediated socially but constructed mentally as Eskilsson also did.. This point of view may also be regarded to be close to a sociocultural approach to learning as postulated by Vygotsky.

Vygotsky mentions in his theory the two phases of learning: the interpersonal phase and the intrapersonal phase. This renders also links from Bach´s dissertation to the ortodox sociocultural theory as it is interpreted by Schoultz and to the combination of these theories as they are expressed by Dimenäs.

This means that it seems that a network of theories is wowen by their utilization in the interpretation of the empirical results in these dissertations. This is in contrast to just using separated and discrete theoretical approaches to interprete the empirical results.

3. Discussion

If an analyse is made according to the ***cognitive matrix*** it is for short necessary to rename the three theories used: the Piagetian constructivistic theory will for short be called **pg.**
The socio cultural theory, which originates in the work by Vygotsky is called **vg.**
The phenomenographic theory is called **fg.**

Preconceptions
When starting with the uppermost factor in the matrix, the preconceptions of the students, then all of the theories, **pg, vg** and **fg** take into account what the students have brought with them in their minds to the classroom. The experiences, which a student has made in his everyday life will in a unique way determine what he will be able to discern and experience in interaction with the teacher, with other students and with content within the context and process of learning.

It is important to notice that what is studied in the dissertations are the mental conceptions, which the student has about the world before and after a teaching or learning session. This is in **fg** called a second order perspective. The first order perspective is called upon, when for exemple a physisist directly studies phenomena in the natural world. At the same time, when a researcher studies the process of learning within the classroom this may be regarded as being done from a first order perspective. If she however studies the conception within the minds of the student then these studies may be regarded as occurring from a second order perspective.

Within teaching activities in classrooms in school it is however important to be clear about the fact that teachers are working with a second order perspective when they are studying how the students have created their concepts about the world. It is not the world in itself, which is studied, but the students´ experiences of that world and the conceptualizations in their minds of the phenomena in that world. This implies also that the concepts, which a student has in her mind are not static, but change as the student becomes more aware about the contents of these concepts. In this way, conceptual or discursive knowledge developes during the whole lifetime of a learner.

This implies that it is important to illustrate the content of a concept in as many ways as possible so as to create as many linkings as possible of that concept into the mental schems of the learner. As Wittgenstein said:”The words get their meaning through their use in the language”. It is thus important to notice the dynamic dimension of a concept and not to regard it as a static factor to be learned.

Interactive aspect: Interaction teacher – learner.
On the next level the interaction between the teacher and the student is studied. In **fg** the teacher is trying to describe for himself the different conceptualizations which the student makes of the world. The teacher tries to ask questions which aims at opening up different ways for the student to constitute knowledge about the world. This concept of opening up is not found in the other theories under discussion.

In **vg** the teacher is a partner in the discussions and tries to negotiate the meaning of the concepts with the students. The concept ZPD, *Zone of Proximal Development,* is utilized and scaffolding and fading are concepts, which also are used.

In **pg** the role of the teacher is to act as some sort of a coach. The teacher should also try to contribute in the creation of an environment in which the student may by herself be actively studying. The student thus may be regarded to act as a mini scientist and learn mostly by himself. In a way there might be found a positivistic and empiristic aspect in this interaction.

Interactive aspect: Learning.
In **fg** learning is viewed as the creation of more perspectives and ways of regarding an object.

In **vg** learning is postulated to occur in two stages, first at a social level and secondly at a personal level. This means also that a linguistic discourse about the object has to be developed. Learning may be regarded as being a process, which has a direction from the outside and in. The mechanism is participation in discursive interaction.

In **pg** learning is regarded as if the learner himself constructs his own mental structures. The mechanism implies using the processes of assimilation and ackomodation. There is an intention of the subject to reach a state of equilibrium between the outer environment and the inner structures within her mind. The learner is active and curiosity is the driving force.

Interactive aspect: Teaching.
In **fg** the teacher should try to present the content from as many perspectives as possible and try to open up new ways for the student to regard phenomena. In **vg** the teacher should try to enculturate the student into science using language as a tool. In **pg** the teacher should try to create a learning environment for the student to perform his studies in. It is however important to notice that the theories discussed are theories for learning and that there do not exit any theories of the same dignity about teaching. Teaching may however benefit from the learning theories. At least so far as not to counteract the processes for learning as they are proposed in the learning theories.

The theoretical aspect.
This aspect is manifested in the theories discussed above.

The philosophical aspect:

First and second order perspectives.
From the philosophical aspect, different metaphysical starting points are presented in the dissertations. Dimenäs as well as Emanuelsson discusses a relation between the subject and the world, which differs from the presentations in the other dissertations. They explicitely claim that the only world that exists is the world as understood or experienced by people. Descriptions are thus, in these dissertations, preferentially being done from *a second order perspective.* This means that the researcher focuses on aspects of the world as they are experienced by other people in contrast to descriptions of aspects of the natural world, as for example in physics. This is a *non-dualistic* perspective on relation between man and world. In the philosophical frameworks of the dissertations, the metaphysical questions were to some extend viewed. This was mainly done by discussing the ontological backgrounds to the different studied. A dividing line between a dualistic and a non-dualistic ontological worldview could be observed were Dimenäs and Emanuelsson expressed a non-dualistic

approach to ontology. The other dissertations showed aspects of non-dualistic as well as of a dualistic perspective of learning.

The philosophical aspect: Metaphysics:
All three theoretical frameworks, **fg, vg** and **pg** are materialistic in their natures. Natural science presupposes the existens of its object of study, the natural world. As reference all the publications in science could be mentioned.

The philosophical aspect: Ontology.
In **fg** the ontological point of view is a non - dualistic world – subject relation.
In **vg** and **pg** this is not that clearcut. Both, a dualistic and a non – dualistic point of view may be regarded. At a primitive level for example **pg** talks about an interaction directly with the environment. **Pg** is modelled upon the interaction between a biological creature and the biological environment. On the higher level something from the outside is however coming into the inside.

In **vg** there are claims about nonexistense between outside and inside. At the same time a discussion is made about interpersonal and intrapersonal processes.

The philosophical aspect: Epistemology.
In **fg** knowledge is *constituted* in an act were the mind interacts with the world.
Knowledge is a relational entity between the subject and the world.
In **vg,** knowledge is created by social interaction between learners. Knowledge is to be found in the culture. Knowledge is also to be found in artefacts. The world is preinterpreted by others.
In **pg** knowledge is created by individual construction of the learner. The world acts via constrains.

Philosophers have trough history discussed if knowledge is to be found outside the mind. This is an empiristic way or regarding creation of knowledge. Another way of regarding knowledge is to look at it as if knowledge resides within the mind. This is a rationalistic perspective. In **pg** as in **fg** a third way is expressed as these theoretical approaches tries to unify the empirical and the rationalistic way. In **fg** by constituting knowledge and in **pg** by constructing knowledge.

Justification of knowledge.
All of these theoretical approaches seem to have a starting point in the discussion by Kant about "*das ding an sich*" and "*das ding an mich"*. This means also that we may never fully know the object we study. In **fg** we have a possibility to reach better and better knowledge about the object by viewing the object from more and more aspects. The true knowledge is the sum of a multitude of aspects. But all the same we will never reach full understanding.

In **vg** scientific knowledge may be criticized as just being talk without justification. Vygotsky is however talking about the difference between spontaneous or everyday conceptions and formal scientific concepts, which are learnt in school.

In **pg** the learner enters the learning process with his everyday preconceptions. One method of teaching is that the teacher challenges these preconceptions and tries to create a conceptual change. The new concepts have to be fruitful, intelligent and plausible, (Posner et al. 1982). It turns however out that preconception are very resistive to changes. One other way is to regard

acquisition of knowledge as getting a new perspective of regarding the world, without changing the old.

In our days with a large information flow it is necessary to pay attention to the justification of different pieces of information.

The practical level.
On this level the content of knowledge in interaction withnthe processes in the classroom is discussed.
According to **fg** the questions a teacher poses opens up for the the students to regard an object from different perspectives. According to **vg** the teacher should organize the class so that verbal interaction between the students is optimized. In **pg** the classroom should be organized as a laboratory in which the student may study himself.

In practice it turns out that in everyday interaction with students no ortodox model for teaching is used. In the process of teaching the three different approaches are mixed and are emphasized differentlu during a lesson.

Ways into the future.
According to **fg** the mind of a learner interacts with the world and in this interaction knowledge is constituted. In **fg** an ambition is also to try to study the world from as many aspects as possible. This means that teachers should try to give their students as much experience of the world in which we live as possible.

The different subjects in school are however artificial constructions. Subjects like physics, chemistry, biology and history are just discreet and isolated aspects of the world. This means that subject knowledge implies a reductionistic approach to knowledge about the natural world. A more holistic approach to interaction with nature emerges if instead of studying the world as interdivided into subjects, regard try to regard as many different aspects of the world as possible.

According to **vg** and **fg** language is important and talking about science might be as important as empirical studies. This may imply that laboratory work may diminish. From a first order perspective this development is however not to be regarded as a fruitful development. As a teacher we however study the conceptions, that the students have, from asecond order perspective.

According to **pg** the learners construct their knowledge and might have less obligation to try to learn the difficult theoretical ideas in science. This approach might however not lead to understanding of established theoretical knowledge in science. There has thus to be a certain possibility for transfer of knowledge and not only own constrution of knowledge. Students own construction of knowledge is not apt to reach the heights of for example the theories about dhe dynamics of motion in which mathematical as well as physical entities of a very abstract character are to be found. A theory about cognitive adaptation is not enough to explain the newtonian mechanical laws. This systematic approach to explanations in the natural world has to be transferred and implemented into the mental structures of the student. These mental schemes will not be reached by the sociocultural theory either via talkong about science or negotiation about students preconceptions. Not even in phenomenography will these theories be approchable as a founding subject in phenomenography is “the observed phenomenon” and not the abstract theories behind the phenomena. Maybe this is the reason

that science entered the world first in the seventeenth century after an incubation period of about two thousand years, as started by the ancient Greeks who initiated questions to Nature which were outside magical thought.

4. Reflections about implementations and practice in upper secondary schools

The results from the dissertations might be implemented in different ways in upper secondary schools:

1. As an inspiration for research. Quite a lot of research has been done in primary and secondary schools but there is a lack of research in upper secondary schools along the lines drawn up in the dissertations discussed. As part of this study an investigation, which was inspired by Bachs study in optics was undertaken. The results indicated that the students had received a good insight into the topic. The scientific model for seeing was documented to be qualitatively better developed in the higher classes. The students thus had a good understanding for how seeing occurs and how colours appear.

2. As an implementation of the theoretical frameworks in the dissertations for teaching in science education.

3. As a soundingboard for theoretical considerations about utilization of theoretical approaches for teaching.

A small study has been undertaken at Lerums Gymnasieskola, which is an ordinary upper secondary school just outside Gothenburg. The aim was to investigate the students' thoughts about how they can see something around them. This research project was inspired by Frank Bach's dissertation which is mentioned above.

The students were asked the questiones as follows:

Outside the school building there is a big fur tree. How come that you can see it and why does it look green?

Frank Bach's study told that 20-30 % of the pupils in secondary schools would think of reflection of light as an explanation.
How would pupils think in upper secondary schools?

The pupils participating in this peoject attended the natural science program.
The first graders had not yet studied Physics and among them around 50 % explained the phenomena by references to reflection.
Many of the students had additional explanations regarding signals from the eyes to the brain (some 50 %) or to properties of the tree (30 %).

The second graders had just finished the exams in the Physics A course including optics. More than 95 % of these students referred to reflection in their answers and only some 20 % added a reference to interaction between the eye and the brain.

Among the third graders some 80 % explained the phenomenon by reference to reflection. 30 % of these students made mentiones to the eye and brain.

Some 15 % of the students expressed philosophical thoughts like: *I cannot tell why, because I don't know whether it exists or if it is something my brain has found out.*

The first question was, a few weeks late, followed by a similar second question, which however now was presented under different conditions

The second question was:
In front of you there is a red tulip. How come you can see it with its different colours?

The first graders were divided into groups of 3-4 pupils and cooperated in formulating an answer to the question.
After discussion and negotiations within the group, they reached to a unique answer.
In this case 70 % of the students referred to reflection as an explanation.

The second graders were presented the question from their teacher in biology instead of from the teacher in physics.
Yet there was no significant difference in the answers when compared with the first question.
The third graders were asked if they thought they would give different answers depending upon who asked.
What answer would then be given to:

the physics teacher
the biology teacher
the best friend
the five-year-old child
the grandfather?

The dominating answer involved references to reflection.
The biology teacher would, according to the students, get a more references to interactions between the eye and brain and also to properties of the flower, than the others would get.
The child would give avoiding answers like "*It is hard to explain.*" or "*You must not know everything when you are five."* (30 %).

The main result of this study was that the answer which is given to a simple question depends upon the situation, in which the question is being asked. This influende might be explanined by reference to the sociocultural theory.
In this study no significant difference between the answers given by boys' or girls' was to be noted.
The differences might be explained by how well the pupils are encultered into science and how they have identified themselves as students in natural science. This might be explained by influences from the sociocultural theory.
The study indicates that when the students leave school they have have adopted a multitude of perspectives on how to look upon physical questions. This indicates might be explained with reference to the phenomenographical theory.

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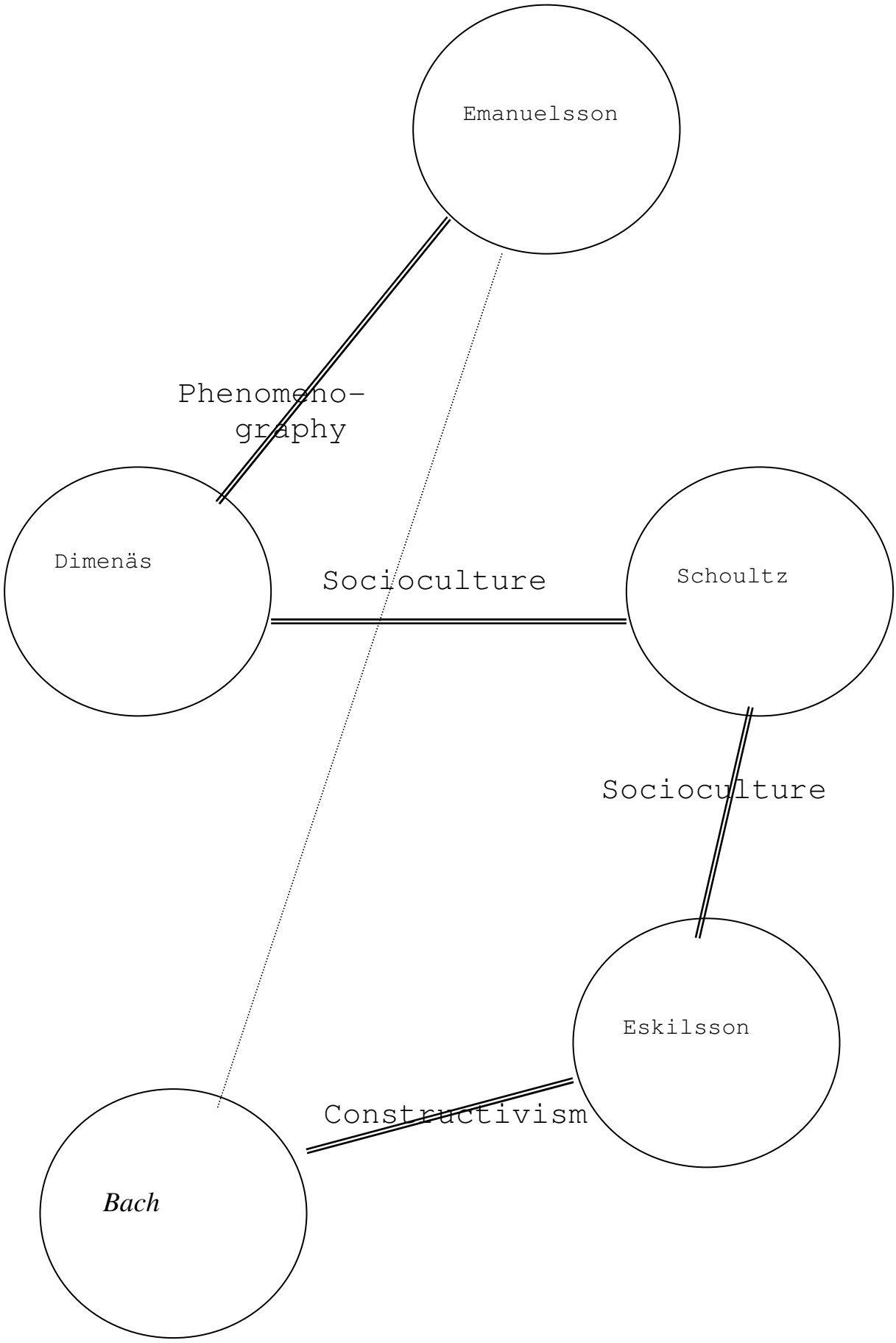
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Eskilsson
Constructivism
Bach