

# **Developing and Implementing Case Studies for Teaching Science with the Help of History and Philosophy**

## ***Framework and Critical Perspectives on “HIPST” - a European Approach for the Inclusion of History and Philosophy in Science Teaching***

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## **1. Abstract**

Despite the fact that many curricula all over the world demand for an inclusion of history and philosophy of science (HPS), the actual degree of implementation is rather low. Central problems are a lack of effective and suitable material for teaching and learning, teachers' beliefs that HPS is only an add-on to science education, and an absence of didactical knowledge on how to teach HPS. Student-centered methods like inquiry learning, experiments with replicas, open-ended discussions or role-play activities are far from being implemented widely. The EU funded project HIPST (History and Philosophy in Science Teaching) aims at a contribution to close the gap between curricular objectives and actual practice of science teaching. Ten partners from all over Europe collaborate in order to develop and refine case studies for teaching and learning with and about HPS. Project outcomes will provide an enriched basis for an effective implementation of HPS. The developmental process is characterized by a symbiotic strategy where researchers, science teachers and experts from science museums join to several international and national conferences as well as thematic working groups. Each of the groups brings their special expertise, knowledge, and resources into the developmental process. Case studies developed within these groups are tested, evaluated in practice and modified respectively afterwards. The paper describes the framework and guiding ideas of HIPST.

## **2. Introduction**

Science educators and researchers have argued for the implementation of history and philosophy of science (HPS) in science teaching (e.g. Matthews, 1994) for a long time. The main arguments have been

- to foster a better understanding of scientific concepts and methods
- to understand how science is embedded in culture and that scientific content and method is not given but manmade
- to develop an adequate understanding of the nature of science (NOS)
- to counteract scientism, dogmatism and simplified descriptions of scientific processes and to understand the philosophical underpinnings of science and doing science

– to develop a critical reflective position science and its applications.

Although, these benefits for teaching and learning science and about science have been pointed out, the status of its implementation is poor. Moreover, teachers' attitudes towards implementing HPS into their teaching is far from being sufficient. Wang (2002) e.g. found out in a study that elementary science teachers doubt the usefulness of the inclusion of history of science into their teaching. Several studies have indicated that teaching about NOS is not a relevant objective of science teachers' practice (Abd-El-Khalick, Bell & Lederman 1998, Reyer, Trendel & Fischer 2004). Furthermore, a common topic in the discussion about teacher education is their lack of knowledge about epistemology and history of science (Abell & Smith, 1992; Aguirre, Haggerty & Lindner, 1990; Höttecke & Rieß, 2007; Irez, 2006; King, 1991, Koulaidis & Ogborn, 1989; Lakin & Wellington, 1994; Palmquist & Finley, 1997). At least on an explicit level their understanding of NOS has been indicated as weak (Craven, Hand, & Prain, 2002) including their understanding of creativity in science. The latter has recently been shown in a study with primary school student teachers (Newton & Newton, 2009).

On the other hand it is not clear to date, if and how teachers' epistemological beliefs shape their teaching practice. A few studies indicate a connection (Brickhouse, 1989, 1990, Kang & Wallace, 2005; Tsai, 2007) while most of the studies at least doubt a simple relation of teachers' epistemological beliefs and their classroom-practice (Lederman & Druger, 1985; Lederman & Zeidler, 1987; Lederman, 1995; Mellado, 1997; Waters-Adams, 2006). It is hardly surprising that their teaching practice is usually neither informed by epistemology nor by history of science (Martins, 2007; Wang & Marsh, 2002). Actually their teaching practice does not take into account NOS aspects even if they are informed about NOS (Lederman, 1999). Views about NOS often seem to be conveyed to the students through "backdoors" like teachers' language (Zeidler & Lederman, 1989).

All these results fit very well with findings of studies outlining the general attitudes of science teachers. Research based on video taped physics lessons in Germany showed that teaching patterns usually are traditional and inflexible (Seidel et al. 2002, Fischler & Schröder 2003, Reyer, Trendel & Fischer 2004, Tesch & Duit 2004).

In short: from a science teachers' perspective HPS usually does not matter, which is a conclusion that also holds for many science textbooks portraying science and its epistemology often in a distorted and insufficient manner (e.g. Abd-el-Khalick, Waters, &

Le, 2008, Guisasola, Almudi, & Zubimendi, 2005, Irez, 2008, Leite, 2002, Pagliarini & Silva, 2007).

Monk and Osborne (1997) certificate the state of implementation of HPS in science teaching as weak. They state that attempts to put history and philosophy of science in the center of teaching have merely enjoyed marginal success. They conclude that efforts for implementing this content in school science teaching should not ignore the perspectives of science teachers themselves, their beliefs about teaching and learning, their major goals and ideas on science teaching, their epistemological understanding, and their doubts about the relevance of HPS. But, this deficient view on science teachers should be balanced by taking into account that teachers are also a source for didactical creativity towards a more effective implementation of HPS. The project outlined in this paper called HIPST might be a small step towards the ambitious objective to overcome limiting factors and boundary conditions of an implementation of HPS (Höttecke, in print). HIPST roughly spoken follows the strategy to develop and disseminate well-approved materials for teaching and learning science with HPST. The project integrates the perspectives and potentials of science teachers into its developmental model.

### **3. Objectives and guiding ideas of the HIPST project**

HIPST is a European project focusing more effective strategies of implementation of HPS into science teaching. The obstacles mentioned above will be taken into account as far as possible. There are 10 partners from 8 European countries:

Germany: Dietmar Höttecke, University of Bremen and Kaiserslautern (scientific lead of HIPST), Falk Riess, University of Oldenburg, Ekkehardt Lang, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in Berlin (project management and coordination)

Great Britain: John Oversby, University of Reading

Greece: Fanny Seroglou, University of Thessaloniki and Dimitris Koliopoulos, University of Patras

Hungary: Gábor Á. Zemplén

Israel: Igal Galili, Hebrew University of Jerusalem

Italy: Paolo Brenni, Istituto Tecnico Toscano e Fondazione Scienza e Tecnica

Poland: Jozefina Turlo, University of Torun

Portugal: Ricardo Coelho, University of Lisbon

An international advisory board of scholars from Brazil (Cibelle C. Silva/University of Sao Paulo), Germany (Thomas Bethge/Department for the Formation of Public Schools in Bremen, Georg Trendel/Ministry for School and Further Education of North Rhine-Westphalia, Anneliese Wellensiek/University of Hamburg), Norway (Marianne Ødegaard/Norwegian Centre for Science Education) and USA (Douglas Allchin/University of Minnesota) supervises plans, procedures and results of HIPST.

The project specifically aims at the development of teaching and learning material for learning scientific content as well as about epistemology, processes and contexts of science. Moreover, science teachers are systematically integrated into the developmental work in order to advance their attitudes, beliefs, competences and general professional development. Therefore, our project aims as well at an operationalization of the high level objectives to learn with and about HPS as well as NOS.

### **General objectives**

Partners collaborate in order to achieve the following general aims of the project:

- To increase the inclusion of history and philosophy of science in science teaching for the benefit of scientific literacy.
- To improve strategies for the development and implementation of domain-relevant materials, teaching and learning strategies into educational practice.
- To strengthen the cooperation and establish a permanent infrastructure of sustainable networking of involved stakeholders in the field of scientific literacy and public understanding of science (schools, museums, universities).

### **Development of case studies for teaching and learning**

Best practice examples for teaching and learning with historical case studies will be collected and newly developed. The concept of teaching and learning with case studies considers science in a detailed, but exemplary manner in order to highlight general aspects of science, epistemology, scientific content and the nature of science. A case study should be confined with a clear beginning and end. It can be exemplified within a narrative approach focusing on a storyline along a central idea (Stinner, McMillan, Metz, Jilek, & Klassen, 2003). Furthermore, the concept of case study stresses the active role of

the learner, which is indicated by the expression “study”. General aspects of learning and motivation like conceptual change, students’ epistemological beliefs, their interests and general attitudes towards science and science learning (Hodge, 2006, Hoffmann, Häußler, & Lehrke, 1998; Osborne & Collins, 2001; Osborne, 2003) therefore have to be taken into account during the design of case studies.

### **Increasing the availability of materials for teaching and learning with HPS**

A major goal of the project is to increase the availability of HPS related teaching and learning material all over Europe and beyond. Therefore, outstanding case studies collected and developed in each country will be translated into English and into the national languages of the participating countries afterwards. Finally, the case studies will be published widely on different media. Empirical evaluation about the efficacy of the material will ensure their high quality regarding the learning goals related to HPS (see Seroglou and others in these proceedings). The project aims at a broad availability of best-practice case studies on how to teach and learn science as well as about NOS, as researchers have asked for (Bartholomew, Osborne, & Ratcliffe, 2004; Akerson & Abd-El-Khalick, 2003).

### **Considering learners’ perspectives**

There is some evidence for positive effects on HPS on students’ interests in science (Galili, & Hazan, 2001, Howe, & Rudge, 2005, Irwin, 2000, Lin, & Chen, 2002, Lin, Hung, & Hung, 2002, Mamlok-Naaman, Ben-Zvi, Hofstein, Menis, & Erduran, 2005, Olson, Clough, Bruxvoort, & Vanderlinden, 2005, Solbes, & Traver, 2003). On the other hand, on the basis of research results about students’ interests, activities for students have been recommended like experimenting, making observations and discussing. Low interests are observed during activities like listening to talks and reading texts (for an overview see Merzyn, 2008). For an HPS approach to science teaching this is obviously a challenge. Historical narratives are often presented in talks of teachers while historical sources are presented in primary source texts. The HIPST-approach therefore strongly focuses on the development of student-centered activities like experimenting, making observations, discussing, and role-playing. Thus, a greater variety of creative and open-ended methods of teaching and learning science will be established. Examples are presented elsewhere (Henke, Höttecke, Rieß, & Engels within these proceedings). Fostering these activities will develop the culture of physics teaching in general as well

as weaken the dominant role of teacher-centered activities. The students' interest in discussions fits very well with a further goal of the project, namely that ideas and procedures of making and evaluating scientific evidence should be discussed and negotiated among the students in the classroom.

### **The role of student-centered activities**

Student-centered activities for HIPST are based on the mediation of two approaches, which both have been advised for teaching and learning about NOS by science educators: Teaching HPS with historical replicas (Heering, 2000, 2003; Höttecke, 2000; Rieß, 2000) and guided inquiry learning (Schwartz, & Crawford, 2004; Lederman, 2004). Within our understanding inquiry learning is regarded as a guided approach, since research has indicated that emphasizing guidance is superior to approaches relying on minimal guidance (Kirschner, Sweller, & Clark, 2006). Moreover, we do not expect inquiry learning alone to be a method which necessarily improves students' understanding of NOS. Instead, activities for explicit reflecting on NOS are regarded as central means for an enhancement of students' understanding (Khishfe, & Abd-El-Khalick, 2002; Lederman, 2004).

Typical activities within the framework of guided inquiry are: Posing questions, developing ideas, formulating hypotheses, designing experiments, analyzing data, using evidence, finding conclusions, criticizing scientific practices, and building communities of practice (e.g. Center for Science, Mathematics and Engineering Education, National Research Council, 2000). Inquiry learning therefore is a method to allow students a high degree of control over planning and executing an experiment. We expect to achieve a greater extent of ownership, relevance and autonomy as central learning dimensions in science.

Typical activities for an HPS approach enriched with replicated experiments from the history of science are: Recapitulating the scientific practices (including experiments), ideas and explanations of scientists of the past, reconsidering arguments, learning about the context of science, criticizing scientific practices of past scientists, learning about the material cultures of the past and considering and developing ideas and conceptions.

These two approaches, learning with replicated experiments on the one hand and inquiry learning on the other, will be mediated as follows: Since we consider the role of experiments for history of science in science teaching as crucial, students have to make their own experimental experiences. But as we are working within an HPS framework,

students have to relate and compare their own experiences with those described by past scientist. The ideas of scientists of the past can also be used as guidelines for the design of learning activities or as guidelines for students own inquiry activities.

Another important student centered activity is role-play. The method is used to develop a better comprehension of NOS in general (BouJaoude, Sowwan, & Abd-El-Kahlick, 2003). Students explore conflicts among scientists and find out more about the reasons for scientific controversies and ways how to settle them. Moreover, the method enables students' empathy with scientists of the past (Ødegaard , 2003; Duveen & Solomon, 1994).

#### **4. Symbiotic strategy for developing case studies on HPS**

##### **A symbiotic strategy of development and implementation**

Our work is based on a developmental model inspired by participative action research (Eilks, Parchmann, Gräsel, & Ralle, 2004) and action research models (Altrichter, & Posch, 1998, McKernan, 2006). These models consider curricular innovations to be explored and developed within circles of retrospective understanding and future action. Ideas, concepts and strategies of teaching are planned, evaluated and reworked in circles. A strong participation of teachers is characteristic for action research models. They explore and solve the problems they previously have identified. The model of Eilks and his colleagues (2004) at the same time stresses the integration of different kinds of expertise into the developmental process in order to overcome differences of norms, rewards and working arrangements, which separate the communities of teachers and researchers from each other (Huberman, 1993). This strategy is called symbiotic (Gräsel & Parchmann, 2004) in order to delineate traditional top-down strategies of implementation. Top-down strategies are characterized by a high degree of adaptation of curricular innovation to the objectives of curriculum developers and researchers. Innovations in this case usually are shaped by results from research and development. But, the problem of top-down strategies is often a low degree of acceptance among practitioners. Thus, top-down approaches share the expectation of a high degree of fidelity. They presuppose that values and commitments implicit in the curricular innovation match the belief-systems of communities of practitioners in schools (Snyder, Bolin, & Jungmann, 1992). But, professional teaching skills and content specific

didactical knowledge are needed to teach an innovation successfully. Strong long-term beliefs about epistemology, general attitudes towards science and general beliefs about teaching and learning may be in conflict with a curricular innovation. As has been shown in the introduction, this is generally the case for HPS. A low degree of implementation is a consequence.

Within a symbiotic approach instead the level of support of practitioners is supposed to be high. Moreover, the level of professional development of practitioners which they achieve during the development and exploration of the curricular innovation, increases. The integration of teachers into the symbiotic developmental model from the very beginning ensures a high degree of acceptance of the outcome in their professional field.

Researchers and teachers share ideas and perspectives. Both shape the developmental processes with their different kinds of expertise, knowledge and skills. Researchers contribute with their knowledge about history and philosophy of science and their knowledge about research findings regarding HPS for science teaching or students' preconceptions. They are responsible for structuring the developmental processes and for defining the key issues of meetings. They organize accompanying research for evaluation and revision of the developed material.

Teachers on the other hand contribute with their general didactic creativity, knowledge and skills based on their own teaching practice. They develop ideas and methods for teaching and learning, provide resources for evaluation and participate in accompanying research cooperatively. Furthermore, the model ensures that teachers develop ownership of new teaching practices (Eilks, Parchmann, Gräsel, & Ralle, 2004), which are not yet part of the current culture of science teaching: they have to moderate discussions and negotiations among students, they guide open-ended inquiry activities (Valk, & Jong, 2009) and instruct students for several kinds of role-play activities.

## A double-cycle developmental model

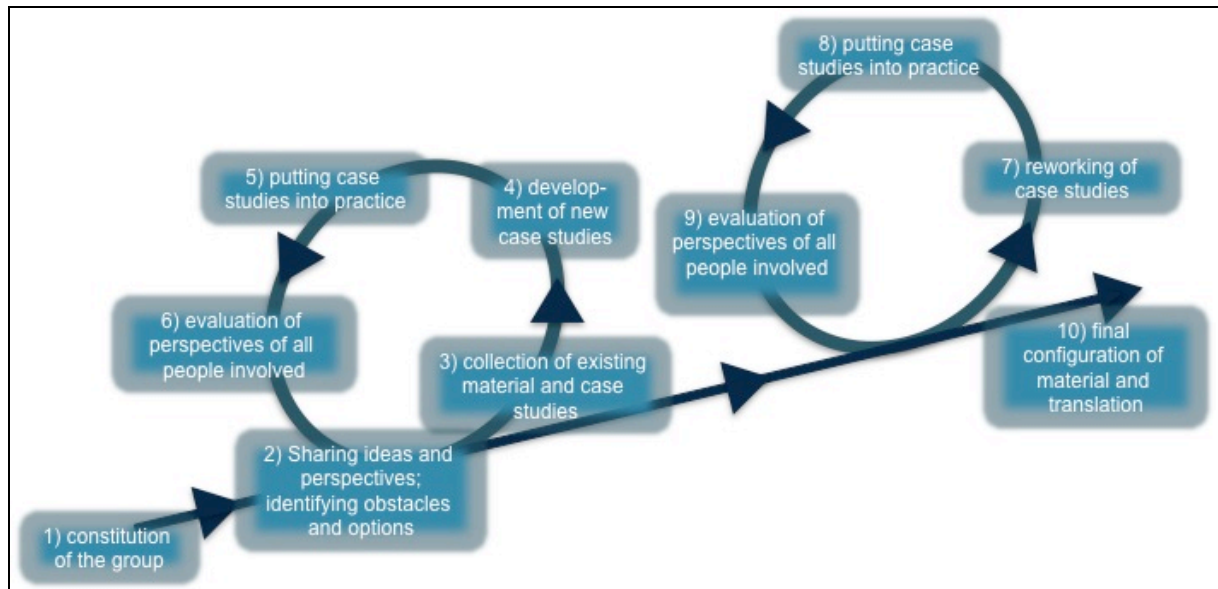


Figure 1: Developmental model of HIPST

For HIPST a double-cycle model has been chosen. It comprises the following systematic steps (Fig. 1):

A group of researchers and practitioners in the related field is constituted. In the very beginning they share their ideas and perspectives with each other. Researchers for instance follow the idea of developing case studies for teaching and learning about NOS with HPS. They place great emphasis on avoiding to fall into the trap of a whiggish approach of history (e.g. Butterfield, 1931; Klein, 1972; Cunningham, 1988; Allchin, 2004). This means that “history” is accused to interpret the past in terms of ideas of the present. One-dimensional stories of scientific success may be a consequence. Therefore, researchers in the project emphasize portraying science as a human endeavor bearing controversial and multifaceted ideas, concepts, theories and experimental cultures of science.

On the other hand science teachers ensure their lessons to be effective and fun for their students at the same time. They define the scientific content, which has to be taught with the HIPST-case studies, as well as the amount of time for teaching available. During this phase researchers and practitioners together start identifying obstacles, boundary conditions, but also options and potentials of the developmental process. Based on this preparatory work the group decides for materials and case studies to be developed and explored in the future.

Subsequently a first phase of development of the case study follows. During this phase historical and epistemological issues have to be discussed as well as didactical and methodological aspects of teaching and learning (for details of the German group see Henke, Höttecke, Riess, & Engels in these proceedings).

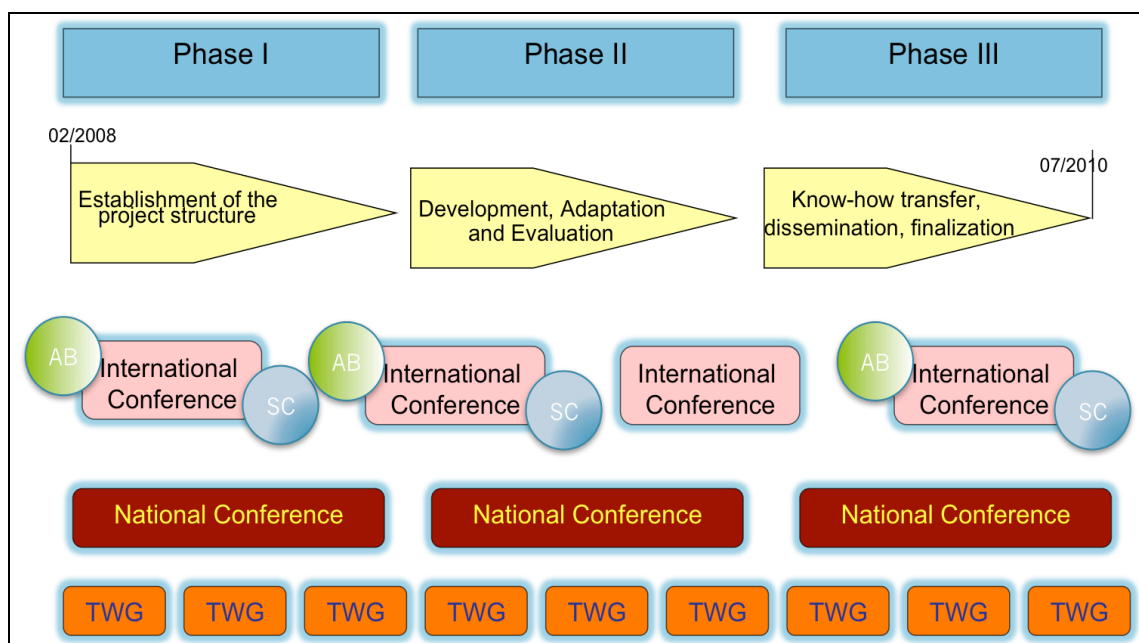
A first test of the case study including an evaluation follows. The tools of evaluation have to be adapted to the questions the whole group or the researchers have defined before. Interviews of groups of students or single students, field notes taken from observations during lessons, interviews with teachers who taught the case study as well as video- or audiotapes are possible instruments next to others (Altrichter, & Posch, 1998, McKernan, 2006).

Based on a discussion of the results of the evaluation a reworking phase follows. After a second test and evaluation the development of the case study will be terminated. During this second phase of test and evaluation it is highly desirable to invite further practitioners to test the materials. This procedure accounts for the fact that practitioners who have been involved in the first phases have developed professional skills and specific didactical knowledge for using the case studies properly. Inviting further teachers from outside the project enables the group to learn more about how teachers use the materials offered to them. This procedure ensures that the material will finally be adapted in a way to support regular teachers who have not been involved into HIPST. Obviously, the developmental process will be the more refined the more cycles the developmental model comprises. But, due to the restricted run-time of the HIPST project of two years a two-cycle model is a manageable maximum.

The process ends with a final configuration of the material and its translation into English afterwards. All of the case studies collected or developed within the HIPST project will be shared among the partners. All partners subsequently translate and publish a choice of materials in their national languages. In order to coordinate the process of exchange and translation and to make it run smoothly the partners have agreed on a common exchange format for the case studies. Finally HIPST will provide a wide range of different case studies based on a HPS approach available in 8 different languages.

## 5. Structure and management of HIPST

The HIPST project is divided into three major phases (see Fig. 2). The first phase is concerned with the establishment of the project infrastructure on international and on national levels. The second phase mainly encompasses the developmental work described above. It also entails an additional empirical in-depth evaluation of case studies in order to learn more about the effects of the case studies produced. Data will be recorded and analyzed about the effects of a selection of case studies on students' views on NOS, their science related attitudes and values, their interests and motivations as well as their self-concept in science learning (see the paper of Seroglou, Vleioras, & Panagiotis in these proceedings). During a concluding phase all necessary steps for an effective dissemination of project results and experiences will be made.



*Figure 2: The structure of the HIPST-project*

*(AB: advisory board, SC: steering committee, TWG: thematic working group)*

Several international conferences ensure an efficient communication and network building among the partners involved. The members of HIPST provide different expertise to the project in order to support a high level of knowledge and skill transfer. The advisory board members attend most of the international meetings. Steering

committee meetings of the project define project goals, make decisions on the course of the project and decide on changes regarding its management if necessary.

During three national conferences held in each country the local situation regarding an implementation of HPS in science teaching in general and project results in particular is analyzed and supported. Among science teachers and experts from teacher education and vocational training, experts from museums and science centers as well as from school science administration are explicitly invited to contribute to the project.

The central working units of HIPST are thematic working groups installed in each country. They make decisions in close cooperation with the national conferences in each country on which branch of science, which professional field and which kind of case study their efforts focus on. The German group for instance comprises 4 researchers from the Universities of Bremen, Oldenburg and Kaiserslautern next to 6 secondary school physics teachers and meets about once a month.

Since HIPST is not restricted to the educational field of school science, but also includes science museums, the thematic groups can also be concerned with the development of case studies for teaching and learning in museums. This is explicitly the case for the Italian group at the *Istituto Tecnico Toscano e Fondazione Scienza e Tecnica* in Florence.

## **6. Perspectives for HIPST and beyond**

HIPST will terminate in July 2010. We expect to have contributed to a more efficient implementation of HPS on several levels. A wide range of case studies for teaching and learning science with HPS will be developed and available in several languages. HIPST also aims at a strong orientation of case studies on the perspectives of learners as well as teachers and researchers in the related educational field. Therefore, HIPST contributes to a higher degree of acceptance of HPS as a way of learning and understanding science among practitioners.

On the other hand we are also aware of some limits of our approach. More research has to be done on implementation regarding HPS in order to understand the boundary conditions and limiting factors better, which hamper at least science teachers to accept HPS as a way of understanding, teaching and learning science. We also have to learn more about the transformative processes which HPS case studies undergo. Like all

curricular innovations they are exposed to changes on their way from a curriculum planned and designed in a workshop to a curriculum carried out and studied in a classroom.

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