Report

S-TEAM

Baseline Report and Indicators Review for Science Teaching Methods and Attitudes in the Context of S-Team

April 2010

The S-Team project has received funding from the European Community's Seventh Framework Programme [FP7/2007-2013] under grant agreement n°234870.

S-TEAM

Baseline Report and Indicators Review for Science Teaching Methods and Attitudes in the Context of S-TEAM

Alexander Gröschner, Jana Heinz, Katrin Lipowski & Tina Seidel

TUM School of Education, Munich, Germany

EU-Project:

Science-Teacher Advanced Methods (S-TEAM)

ISBN: 978-82-93118-06-0

Contact information:

TUM School of Education
Friedl Schöller Professorship of Teaching and Learning
Schellingstr. 33
80799 München
Germany
Mail:
alexander.groeschner@tum.de
jana.heinz@tum.de
katrin.lipowski@tum.de
tina.seidel@tum.de

The S-Team project has received funding from the European Community's Seventh Framework Programme [FP7/2007-2013] under grant agreement n°234870

Contents-Part A

Contents-Part B

Part A
Measures and Indicators for Inquiry-Based Science Teaching as Published from 2005-2009: A Research Review

Alexander Gröschner, Jana Heinz, Katrin Lipowski & Tina Seidel

TUM School of Education, Munich, Germany

EU-Project:

Science-Teacher Advanced Methods (S-TEAM)

Citation:

Gröschner, A., Heinz, J. Lipowski, K. & Seidel, T. (2010): *Measures and Indicators for Inquiry-Based Science Teaching as Published from 2005-2009: A Research Review.* Munich: TUM.

Contact information:

TUM School of Education
Friedl Schöller Professorship of Teaching and Learning
Schellingstr. 33
80799 München
Germany
Mail:
alexander.groeschner@tum.de
jana.heinz@tum.de
katrin.lipowski@tum.de
tina.seidel@tum.de

Contents-Part A

1. Introduction

In the last decade conceptualizations and the development of adequate measures are increasingly becoming important for teacher education and teachers' professional development (Desimone, 2009). In science education recent research findings on students' science competencies (e.g. PISA 2006) point to the importance of reforms to improve science teaching and learning (Bybee & McCrae, 2009; Seidel & Prenzel, 2006a; Prenzel, Seidel, & Kobarg, in press; Prenzel & Seidel, 2009). Reforms in science education are mostly centered on changes in science curriculum and instruction (Abell, 2000). But, as research on teacher professional development shows (Supovitz, Mayer, & Kahle, 2000), any curriculum or systematic reform needs to take teachers' attitudes and capacities into account for enhancing opportunities to adopt reforms and to bring them into the classroom. Abell (2000), therefore, emphasizes: "Reformers have realized that new curriculum or innovative instructional techniques need teachers to carry them out. Thus focusing on reform in science teacher education will be crucial to the success of other science education reforms" (Abell, 2000, p. 3).

The mentioned aspects point to the following assumptions:

(1) Science teacher education needs the enhancement of innovative methods.

(2) The implementation of innovative methods has to be accompanied by defining and developing strategies to disseminate them to teachers and teacher educators.

Before describing the aim of the following review we want to clarify what we have to understand as "innovative methods" in instruction, particularly when targeting the field of science education.

A lot of innovative methods in science teacher education and science education refer to the approach of inquiry-based science teaching (IBST) (Furtak, Seidel, Iverson, & Briggs, in prep.; Duschl, 2003). Characteristics of IBST are defined along the process of teaching and learning science. A broad definition, for instance, is suggested in the report on National Science Education Standards by the National Research Council (1996):

> "Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations" (National Research Council, 1996, p. 23).

With regard to instructional processes in school Supovitz and colleagues (2000) define inquiry as follows:

> "Inquiry-based instruction is a student-centered pedagogy that uses purposeful extended investigations set in the context of real-life problems as both a means for increasing student capacities and as a feedback loop for increasing teachers' insights into student thought processes" (Supovitz, Mayer, & Kahle, 2000, p. 332).

Thus, students should be supported by the teacher to build "evidence-based explanations" (Krajcik, Blumenfeld, Marx, & Soloway, 2000; Beyer, Delgado, Davis, & Krajcik, 2009), to develop knowledge and understanding of scientific ideas (Foy, Marissa Feldman, & Mahoney, 2006) as well as discursive argumentation and communication skills (see Jorde, Moberg, Prenzel, Rönnebeck, & Stadler, 2010) and to understand how scientists study the natural world (Akerson & Hanuscin, 2007; Budnitz, 2001).

IBST as an innovative approach requires interest and methods to increase the level of student motivation and cognitive involvement in the learning process (Cunningham, McNear, Pearlman, & Kern, 2006). The teacher's role, therefore, is to skillfully guide learners to discover ideas on their own, rather than perceiving them as passively receivers of facts and concepts (Goebel, Umoja, & DeHaan, 2009; Seidel & Prenzel, 2006b).

According to these basic understandings of IBST, the focus on the enhancement of student-centered activities in science classrooms does not necessarily lead to a total loss of teacher-directed inquiry. In fact, the levels of inquiry can be differentiated by the relative amount of teacher-directed versus student-directed behaviors during the activity (Bell, Smetana, & Binns, 2005; National Research Council, 2000).

Table 1

Four-level model of inquiry (Bell, Smetana, & Binns, 2005)

Level of inquiry	**Question**	**Methods**	**Solution**
1 (confirmation)	X	X	X
2 (structured)	X	X	
3 (guided)	X		
4 (open)			

The X marks what is provided by the teacher

Bell and colleagues (2005) describe in their simple model four inquiry categories varying in the amount of information provided by the teacher. Beginning with the most strongly teacher-directed inquiry in which the student is provided the most information, the four levels of inquiry are: confirmation inquiry, structured inquiry, guided inquiry and open inquiry (Table 1). At the teacher-directed end of the continuum – called "confirmation inquiry" – students know the expected outcome in advance and teachers provide the question and the procedure. This is a low level of inquiry and is very often called as "chalk-loaded" demonstration lessons (see Seidel & Prenzel, 2006b). At the student-directed end of the continuum – "open inquiry" – students formulate the research question, methods and solution on their own. The model indicates that varying levels of inquiry in the classroom are possible depending on the degree of student-centered and teacher-centered learning that occurs within the activity.

As Gengarelly and Abrams (2009) emphasize, also the level of inquiry in the classroom has to be distinguished from scientific inquiry practiced by scientists in the field. According to our research we refer to a school-based and teacher-related inquiry which points to the development of inquiry-based skills, asking and answering questions about the natural world, enhancing a positive attitude towards science and an understanding of the nature of science (Gengarelly & Abrams, 2009, p. 74).

Regarding the definitions of IBST our study is based on the following assumptions (see also Section 2). Therefore, IBST is characterized by activities that engage students in:

- authentic, problem-based learning activities where there may not be a correct answer;
- a certain amount of experimental procedures, experiments and "hands on" activities, including searching for information;
- self-regulated learning sequences where student autonomy is emphasized;
- discursive argumentation and communication with peers ('talking science') (Jorde et al., 2010, p. 3).

Despite the fact that IBST and its definitions are strongly oriented towards teaching and learning activities within the classroom, researchers and practitioners also agree that the implementation of reform can only be successful if the educational system as a whole and stakeholders involved in the system are addressed (Desimone, 2009). Up to date, however, reform activities are usually targeting single groups or system levels (e.g. teachers, teacher educators, etc.). Reform projects addressing educational systems on multiple levels are rarely implemented (Ostermeier, Prenzel & Duit, 2010). In this sense S-TEAM represents an innovate approach with regard to the implementation of reform by coordinating and summarizing knowledge and activities on an European level as well as involving multiple levels of educational systems within countries. In this context, the objective of this report is review the literature in the field of IBST in order to provide summaries of existing conceptualizations, indicators, and measurement instruments as one way to integrate fragmented knowledge distributed across countries and system levels.

Generally, this baseline report focuses on a description of indicators and marks an insight into the research literature. The indicators' research was the base for collecting and developing instruments which will be provided for S-TEAM separately (Heinz, Lipowski, Gröschner, & Seidel, 2010). Both documents should be considered as closely connected.

In the following Section 2 the context of the study will be enclosed and we describe the EU-project "Science-Teacher Advanced Methods" (S-TEAM). In section 3 we refer to the theoretical background of this study and explain indicators for inquiry-based science teaching found in the research literature. Afterwards our research questions (Section 4) are demonstrated and methods for investigation (Section 5) are explained. In Section 6 the research findings are shown. We use the reference frames of target groups given in the project description (policy, teacher education/teacher professional development, teachers/students) for the classification of the results and present results with regard to the research questions. In section 7 we discuss the findings. An outlook in section 8 describes further steps for enhancing IBST within and beyond the project.

2. The context of the review: Science Teacher Education Advance Methods (S-TEAM)

Politics and science point to the necessity to strengthen scientific education and to develop instruction in a way that enables students to leave school with applicable knowledge and empowering competences (American Association for the Advancement of Science, 1993; National Research Council, 1996, 2000; Bybee & McCrae, 2009). Educational attainments are undisputedly considered as a requirement for further profession and career opportunities and thus for successful social participations (Commission of the European Communities, 2009; OECD, 2007).

To enhance innovative methods and to assess ongoing disseminative strategies the project Science Teacher Education Advance Methods (S-TEAM) is funded by the EU from 2009-2012. The project aims to disseminate inquiry-based science teaching methods (IBST) to the widest possible range of teachers and teacher educators across Europe and associated countries. In the project 25 institutions from 15 countries with about 100 teachers, teacher educators, national stakeholders and researchers are involved. The three main objectives of S-TEAM are (1) to improve motivation, learning and pupil attitudes in European science education, resulting in increased scientific literacy and the recruitment to science-based careers, (2) enabling large numbers of teachers to adopt inquiry-based and other proven methods for more effective science teaching and (3) supporting teachers by providing training in, and access to innovative methods and research-based knowledge.

These objectives point to the question how to measure effects attained through inquiry based science teaching methods. Effects such as an increasing number of students choosing science careers exceed the period of the S-TEAM project. However, for example, positive changes of attitudes towards science subjects as a result of different instruction could be measured.

Therefore, the S-TEAM projects aims at analyzing differences in changes of attitudes, and teaching practices after interventions using IBST methods. That requires the identification of adequate and suitable indicators and instruments.

With regard to the formative assessment of S-TEAM the following review summarizes relevant indicators for measuring cognitive, motivational-affective and metacognitive factors of inquiry-based science teaching (IBST) and inquiry-based science teacher education (IBST/E). Thereby, we contribute to the overall idea of the project to remove constraints on the adoption of IBST/E resulting from the lack of knowledge.

Barriers to implementing IBST into the classrooms are expected through specific national curricula and assessment systems relying on individual examinations on the part of the politics, lacking knowledge of teachers in using IBST methods and skepticism of parents and policymakers who are still holding traditional concepts of science instruction.

In order to overcome these obstacles and to successfully adapt the science education to more effective methods, S-TEAM sees the necessity to work with different stakeholders in the fields of policy, teacher education and science classrooms.

Following the overall strategy and general description of S-TEAM (S-TEAM, Technical Annex 1, p. 14f.), we define three levels of stakeholders:

- *policy & stakeholders*
- *teacher education and professional development*
- *teaching, teachers and students (action level)*

2.1 Policy and Stakeholder Level

On this level the focus of S-TEAM is on drawing a picture of national conditions for implementing IBST, especially national policies, curricular frameworks and instructional designs. Furthermore, it seems to be necessary to promote and/or establish networks of policymakers across the EU.

In our study we describe the research concerning policy and stakeholders activities with regard to the use of innovative methods in science education. We also describe the lack of research in IBST on this level and provide approaches for disseminating IBST across Europe.

2.2 Teacher Education and Professional Development Level

By developing training material as well as instruments and knowledge of effects of IBST, the S-TEAM project aims to assist teacher education and professional development in reforming science teaching.

In the following review we characterize indicators in the fields of teacher education and teacher professional development with regard to empirical findings of effective ways – but also barriers – for implementing IBST into TPD and educational programs.

2.3 The Action Level: Teaching, Teachers and Students

Teachers are considered to be the key players in changing science instruction (see Section 1). Analyses within single work packages within S-TEAM will identify how teachers' repertoires of action are affected by the introduction of innovative methods. Another focus lies on identifying constraints and opportunities in relation to inquiry-based science teaching.

In our review we focus on indicators that provide information about teachers' and students' cognitive, motivational-affective and metacognitive abilities concerning science teaching and learning. This level also includes process data of teaching in science classroom.

3. Theoretical Background: Indicators for Inquiry-Based Science Teaching and Teacher Education (IBST/E)

Recent studies on teachers' effectiveness highlight the importance of multiple perspectives and methodological approaches in research on teaching and learning (Seidel & Shavelson, 2007). In this context, indicators of inquiry-based science teaching and inquiry-based science teacher education need to be considered on different levels and for different target groups. According to the target groups S-TEAM identified for the widest possible dissemination of IBST across Europe, we describe approaches and findings with regard to the three levels: policy and administrative stakeholders (3.1), teacher education and professional development (3.2) and teachers (and teaching) as well as students (3.3).

3.1 Policy and Stakeholders

With regard to the policy level, it can be stated that IBST is included in European policy concepts but – as Jorde and colleagues describe – not necessarily as defined as in the research literature (Jorde et al., 2010). Jorde et al. summarize (2010, p. 1): “National and local curriculum frameworks for science in schools do place an emphasis on both the products and processes of science. In national workshops, however, we heard that when teachers implement the science curriculum, they seem to lack the necessary skills to incorporate IBST ideas into their teaching methods.” In reviewing the literature in the area of policy and administrative stakeholders several authors refer to this missing link of transfer policy strategies of disseminating IBST into teachers’ activities.

As Printy (2008) points out communities of practice – characterized by the role of school leaders within a school district – often tend to perpetuate stereotypes, and staid or destructive practices of teacher learning. The transfer of new concepts or approaches – such as IBST – into practice, in this sense, suffers from the lack of concrete policy strategies of dissemination and embedding as well as individual attitudes and beliefs (see also Ansell, Reckhow, & Kelly, 2009). Furthermore, principals, for example, need help to guide implementation of curriculum reforms concerning inquiry based science teaching (Gerard, Bowyer, & Linn, 2008).

Moreover, as the era of unprecedented accountability to high-stakes tests shows, policy has put pressure on teachers to focus on content-based standards rather than inquiry-based teaching (Furtak & Shavelson, 2009). This might be the reason, from a policy perspective, that the use of IBST in classroom is in a difficult condition (see OECD, 2007).

On the one hand, IBST is part of the science curriculum and, on the other hand, it is – particularly in the US, but also increasingly in European countries – partly undermined by standard-based evaluations in a system focused on high-stake accountability.[1]

With regard to science education reform, research on the policy level concentrates especially on urban reform efforts. One aspect of research takes the enactment of new practices into account by providing new science materials (Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, & Tali Tal, 2004; Schneider, Krajcik, & Blumenfeld, 2005) or technologies (Gerard, Bowyer, & Linn, 2008; Hug,

[1] Not at least, the discussion about the advantage of inquiry-based methods compared to traditional teaching (Kirschner, Sweller, & Clark, 2006; Hmelo-Silver, Duncan, & Chinn, 2007) reveals the misunderstandings about IBST.

Krajcik, & Marx, 2005; Zucker & Hug, 2008). As these studies show, materials or technologies alone are not sufficient; rather reform efforts must include systemic change in context and policy to support teacher learning, classroom implementation and student motivation (Horizon Research, 2000; Desimone, Smith, & Phillips, 2007).

The studies emphasize the bottom-up process of assessing teachers' attitudes and beliefs concerning new ideas and materials. This process should be supported by developing materials which are provided to the teachers and/or developed with a clear defined understanding of needs (that also might include needs regarding IBST-materials) (Schuster & Carlsen, 2008).

In the study of Moscovici (2009) secondary science teacher candidates were accompanied during their internships to pursue a teaching license[2]. Multiple data sources over six years were triangulated (Moscovici, 2009, p. 91). Her findings suggest that science internships tend to thrive in schools where efforts of all the stakeholders in the educational community (teachers, students, administration, community, district personnel, university instructors) are focused on reaching a common goal and cohesion. This includes inquiry based science teaching methods as well as traditional science teaching methods in general in secondary schools.

This study emphasizes – exemplified with regard to internships – the necessity of cohesion among teachers, teacher educators, district personnel and students for a successful implementation of science teaching methods in general. This includes communication and attitudes as well as content knowledge and pedagogical content knowledge.

The challenge of communication regarding science is investigated by the research of Nisbet and Goidel (2007) from a public view. They have been interested in citizen perceptions of science controversy and used a nationwide data base of the US. With regard to policy strategies they found that public perceptions sometimes tend to defer automatically to the authority of sciences (e.g. researchers) and are heavily influenced by mass media. They also showed the influence of political party affiliations. The authors suggest that further research on communication in science education should take an ideologically heterogeneous public into account (Scotchmoor, Thanukos, & Potter, 2009). This study points once more to the necessity of the initiation of "roundtables" among different members of communities for implementing new ideas and research findings.

---

[2] The role of certification is recently considered in the educational research and also connected to the role of the implementation of IBST in schools. But with regard to a European teacher education perspective it seems to be rather a phenomenon of the US deregulation policy after the "No-Child-Left-Behind" Act.

The findings can be referred to the results of the preliminary report of Jorde et al. (2010) who highlight needs for an effective TPD system in Europe. In both cases it can be underlined that there is a “need for an effective TPD system where goals need to be closely connected to the goals of an up-to-date pre-service teacher education. In addition, an effective TPD system must also be closely linked to the culture of schools, including support by leadership and time for reflection between teachers” (Jorde et al., 2010, p. 1).

Large scale assessment studies such as PISA 2006 are recognizing scientific literacy as a particularly relevant outcome of educational systems in OECD countries (OECD, 2007). Since PISA is considered as a comparative study which has also an impact on the policy level in terms of governance, the findings on student outcomes quickly lead to questions concerning conditions in the educational system (e.g. educational equality, devolution of decision power at the local level) (Prenzel, Seidel, & Kobarg, in press; Lavonen & Laaksonen, 2009). However, research shows that particularly in the area of teaching there is not a single method or strategy that is the one and only factor for successful student learning. There is rather an interdependency of a large number of school and classroom related characteristics (e.g. school, curriculum, teachers, parents, peers) that can explain successful teaching and learning processes. International comparisons of classroom teaching and learning show different patterns or scripts of typical teaching methods and approaches (Prenzel & Seidel, 2009; Prenzel, Seidel, & Kobarg, in press; Roth et al., 2006). Again, a simple link between typical approaches and successful student learning has not yet been shown. Thus, international comparisons help to describe predominant approaches in different cultural settings which are helpful to learn from each other and to be inspired by different ways of teaching. In most cases, however, simple copies of approaches are not successful if the educational and cultural context is not considered (LeTendre, Baker, Akiba, Goesling, & Wiseman, 2001).

Reviewing the research on the policy level it can be stated that IBST usually is part of national curricula and in the context of science education also part of curriculum reforms. Research in the area of implementing teacher reform points to the need of involving different stakeholders in educational systems. In general, research on the policy level shows high potential for gaining relevant knowledge on IBST implementation. So far, the number of publications is rather limited and should be expanded with regard to a broad range of indicators and measures.

3.2 Teacher Education and Professional Development

The second level that is reviewed with regard to concepts, indicators, and measurement instruments refers to the level of teacher education and professional development. Thereby, the review is based on the need of educational systems to know about effective approaches in teacher education and professional development. One key question, thereby, are comparisons of traditional and "new" models of teacher professional development (TPD) in in- and pre-service training. While, for example, traditional approaches to TPD often follow a top-down strategy and the activities are organized as stand-alone events, "new" practices of effective TPD follow the idea of teachers becoming members of a community of learners (Jorde & Klette, 2008). In Table 2 traditional concepts and new approaches of TPD are exposed:

Table 2

Traditional vs. new approaches of TPD (see Wilson & Berne, 1999; Garet, Porter, Desimone, Birman, & Yoon, 2001; Sherin & Han, 2004, Desimone, 2009; Ostermeier, Prenzel, & Duit, 2010)

Traditional concepts of TPD are characterized by:
▪ top-down approaches ▪ teacher learning: transmission of knowledge ▪ single topics and issues ▪ stand-alone events ▪ participation of single teachers ▪ lacking integration to teaching routines
In contrast, new approaches of TPD are characterized by:
▪ Collaboration of teachers in teacher learning communities ▪ Critical colleagueship ▪ Communication with other teachers or facilitators ▪ Opportunities for teachers to reflect on their learning and obtain feedback ▪ Coherence between professional development with daily life of school ▪ Cooperation between teachers and researchers ▪ Focus on student learning

TPD can be defined as follows: "Professional development is defined as activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher" (OECD, 2009, p. 49). And the OECD (2005) characterizes TPD as follows:

> "Effective professional development is on-going, includes training, practice and feedback, and provides adequate time and follow-up support. Successful programmes involve teachers in learning activities that are similar to ones they will use with their students, and encourage the development of teachers' learning communities. There is growing interest in developing

> schools as learning organisations, and in ways for teachers to share their expertise and experience more systematically” (OECD, 2005, p. 95).

International studies such as TIMSS and PISA have revealed substantial differences in science education across countries (Stigler, Gallimore, & Hiebert, 2000; Bybee & McCrae, 2009). Currently, the knowledge on teacher education and teacher professional development in Europe is rather fragmented and nonspecific. In order to summarize fragmented knowledge it is essential to use the specific advantages of coordinated programs in the EU (Lipowski & Seidel, 2009). Thus, there is the necessity of more and regular meetings across Europe to bring together existing research and development projects and to create synergy effects on a European level (Jorde & Klette, 2008).

Many studies on specific aspects of science teachers' practical knowledge have focused on opinions about the teaching and learning of science. These studies were usually conducted in the context of the implementation of constructivist teaching approaches. Some of these studies focused on the effects of in-service or pre-service programs on teachers' views of teaching and learning science (e.g. Constable & Long, 1991). Other studies reported changes in both teachers' cognitions and their classroom practices in the direction of constructivist ideas (van Driel, Beijaard, & Verloop, 2001). Hewson, Tabachnick, Zeichner, and Lemberger (1999) concluded that specific courses within a teacher education program may substantially promote teachers' adoption of constructivist views (van Driel et al., 2001).

Especially with respect to IBST it can be stated that innovators often tend to consider teachers' practical knowledge as conservative (see Tom & Valli, 1990). However, as it is the expression of what teachers really know and do, it is a relevant source for innovators when implementing educational changes. Thus, for the success of educational programs and TPD the beliefs, intentions, and attitudes of relevant protagonists need to be taken into account. Nevertheless, change is a necessary condition for many in-service professional development programs, including the professional development of teachers (Burden, 1990) and teacher educators (Smith, 2003).

Another strand of research on science teachers' practical knowledge is devoted to cognitions about the nature of science (Lederman, 1992). As the understanding of the nature of science is a central goal of many current reform efforts, teachers' cognitions in this domain are crucial. Moreover, it has been found that teacher conceptions of the nature of science “do not necessarily influence classroom practice'' (Lederman, 1999, p. 927). In their review on education programs Abd-El-Khalick and Lederman (1999) summarize that explicitness with respect to the nature of science is one of the most important feature that appeared successful in facilitating teachers to develop conceptions of the nature of and to translate this concept into an appropriate classroom approach.

Concerning the success of teacher professional development the study of Greensfeld and Elkad-Lehmann (2007) shows new insight into the processes of teacher educators' professional development and change in their thinking. The findings emphasize the importance of questions regarding the knowledge possessed by teacher educators and of the questions regarding the role of science teacher educators. They also found that knowledge of science teacher educators is personal and context-bound.

Another research on teacher educators raises issues regarding the wish to learn more about the professional knowledge of teacher educators (Cochran-Smith, 2003). Cochran-Smith refers to the question of what teacher educators need to know and to do to meet the complex demands of society in the 21st century. In her study she presents some of the professional development programs for teacher educators (in Norway, in Israel and in Australia), and describes different communities of learners of teacher educators by using illustrating examples.

With regard to teacher professional development it can be stated that TPD is organized rather differently in European countries (Lipowski & Seidel, 2009). Although there are many initiatives in Europe, the literature emphasize that educational reform efforts are doomed to fail if the focus only is on developing specific teaching skills (Haney, Czerniak, & Lumpe, 1996). With regard to science education a closer look into key problem areas can help to identify indicators and relevant instruments for further research on IBST.

Furthermore, the following empirical findings can be described for TPD (Jorde et al., 2010):

1. There are only a few national strategies for TPD of science teachers.
2. Where countries have national institutes for TPD, there seems to be little emphasis placed on science TPD.
3. TPD programs are usually offered by the universities, sometimes by other providers.
4. Most activities are offered in the form of short, stand-alone courses.
5. TPD activities focus on content knowledge rather than combining content knowledge and teaching methods thus enabling teachers to create efficient opportunities for student learning.
6. There is a lack of important features of efficient TPD.

Regarding the question, which criteria determine the success of effective models of teacher professional development a broad conformance is spread over the countries. Lipowski and Seidel (2009) interviewed N=16 experts with regard to effective TPD components in their countries. All experts referred to the need of evaluation and measuring, linking TPD with everyday practice of teachers, including research based concepts, ensuring teacher involvement, offering long-term activities, and facilitating the cooperation between teachers and teacher education institutions.

In a recent literature review Desimone (2009) describes a set of core features and a conceptual framework for measuring professional development. Thereby, research reflects a consensus about important general characteristics of TPD that are critical “to increasing teacher knowledge and skills and improving their practice (Desimone, 2009, p. 183). Effective professional development can be characterized by features such as a) content focus, b) active learning, c) coherence, d) duration and e) collective participation.

a) Content focus:

Content focus is characterized as the most influential feature of teacher learning. Almost all kinds of empirical studies point to the link between activities “that focus on subject matter content and how students learn that content with increases in teacher knowledge and skills, improvement in practice, and, to a more limited extent, increases in student achievement” (Desimone, 2009, p. 184).

b) Active learning:

Active learning means that teachers who are receiving opportunities to be engaged in active learning also perceive professional development in a more effective way.

c) Coherence:

Coherence can be characterized as the “extent to which teacher learning is consistent with teachers’ knowledge and beliefs” (Desimone, 2009, p. 184). For example, the question of how the school, the school district leadership as well as policies are configured may have an essential importance for TPD.

d) Duration:

TPD activities need a sufficient duration, including span of time of activity as well as the number of hours spent in the activity. Even when there is not a “tipping point”, Desimone suggests long-term activities instead of short-term workshops.

e) Collective participation:

This feature can be accomplished through participation of teachers from the same school, grade or department. “Such arrangements set up potential interaction and discourse, which can be powerful form of teacher learning” (Desimone, 2009, p. 184).

Taken together, the approach of Desimone (2009) emphasizes that efficiency of TPD has to take teachers’ knowledge as well as (the change of) their attitudes and beliefs into account (p. 184). In the context of the review it is helpful to distinguish between cognitive (e.g. teacher knowledge), motivational-affective (e.g. attitudes, views about sciences) and metacognitive (e.g. teaching and learning strategies) indicators and instruments for measuring IBST. In addition, the review shows that researchers, educators and policymakers conformed in view of important indicators for successful teacher professional development. The education, teacher education and professional development systems in European countries are different, but a broad conformance concerning the aims and ideas can be found (Lipowski & Seidel, 2009). Again, research on IBST on the level of teacher education and professional development is rather fragmented but attempts have been made recently to integrate knowledge and to provide conceptual frameworks for measuring the effectiveness of teacher education and professional development (Desimone, 2009).

3.3 Inquiry-Based Science Teaching in the Classroom

The third level of teaching, teachers, and students refers to the action level of implementing IBST into the classroom and is addressed most frequently in science education research. Given the plenitude of findings the review in this section is focused on a restricted set of conclusion drawn from research in the area of teaching, teachers, and students. In a first step we focus on research findings from international survey studies (3.3.1). In a second step we describe findings from intervention studies with regard to effects of IBST in the classroom (3.3.2).

3.3.1 Findings from International Comparative Survey Studies

With a background of 15 different countries being involved into S-TEAM (see Section 2) the fact has to be stressed that instruction between the single countries as well as within a country differs widely. International comparative studies show culturally embedded concepts of instruction that shape and reproduce communication and action structures in the classroom (Jorde & Klette, 2008). Until now, TIMSS (Stigler, Gallimore, & Hiebert, 2000) and PISA 2006 (OECD, 2007) are the most important representative large-scale studies that highlight these differences in science teaching and learning in an international comparison.

The TIMSS 1999 Science Video Study shows differences between participating countries but also commonalities regarding science instructional organization, content and student actions (Stigler, Gallimore, & Hiebert, 2000; Roth et al., 2006). For instance, at least 98 % of eight-grade science lessons are whole-class seatwork in all the countries, practical activities (e.g. experiments) occur in at least 72 % of science lessons, and at least 84 % of the lessons includes teachers' demonstration of facts and scientific concepts ("canonical knowledge"). With regard to student actions the TIMS Study shows that students participate in at least 81 % in some form of discussion, but they are more likely to observe phenomena during practical activities than to design experiments as well as they do hardly generate own research questions.

Differences between the countries could be shown e.g. in the amount of time spent on practical activities (Australian and Japanese science lessons focus more time than Czech or Dutch lessons), developing new contents (Japanese teachers allocates more time) and public talk time devoted to procedural and experimental knowledge (e.g. Japanese eight-grade lessons allocate a larger average percentage of public talk time compared to the other countries). With regard to scientific inquiry practices students in Japanese and Australian science lessons had more opportunities to collect and record first-hand data or phenomena related to independent practical activities than students in Czech, Dutch, and U.S. science lessons (Roth et al., 2006).

With regard to teaching effectiveness PISA 2006 focused especially on four areas: lesson time, interactive science teaching and learning, hands-on activities and student investigations/real life applications (Prenzel, Seidel, & Kobarg, in press).

In PISA 2006 teaching and learning of science was investigated by means of an analysis of typical classroom activities. Students were asked how often specific learning activities occur in their science classes during the course of the school year. Regarding the frequencies of interactive science teaching and learning the findings show that the majority of the 15-year-olds in the OECD countries report regularly occurrences of interactive science teaching activities in their classrooms. Especially the activities “student explain their ideas” and “students state their opinions” are reported frequently (Prenzel, Seidel, & Kobarg, press).

Furthermore, the results of latent class analysis (LCA) show distinct patterns of student activities, experiments and forms of scientific inquiry that are characteristic for certain teaching and learning approaches (Prenzel, Seidel & Kobarg, in press; Seidel, Prenzel, Wittwer, & Schwindt, 2007; Prenzel & Seidel, 2009). With regard to students’ outcomes findings display that the identified teaching pattern I (in nearly all lessons students plan their own investigations, conduct experiments, draw conclusions, explain own ideas and relate scientific concepts to the world outside school) show the lowest competencies (Seidel, et al., 2007, p. 170f.). Students that have fewer opportunities to plan and conduct their own experiments but more often draw conclusions and render concrete practical references (pattern II) show a considerably higher scientific competence. Students that describe their lessons containing only few scientific investigations (pattern III) reach competency values that were mostly lower than the value for pattern II but above the values of pattern I. This interrelation was visible in nearly all OECD countries.

Beside instruction that does not offer a context for stimulating motivation, the lack of interest in scientific topics is to a large amount ascribed to the inferior importance of scientific issues in public discussions (as well as in peer groups and at home) and to culturally deeply rooted beliefs that scientific achievements depend on natural abilities (Prenzel & Duit, 2000). Therefore it has to be asked how science instruction can be patterned to enhance students’ interest in scientific topics. In PISA 2006 also the effects of instructional patterns on students’ motivation were analyzed. As a result it became apparent that students whose science instruction is characterized by the highest frequency of classroom activities – opportunities to design own investigation, conduct practical experiments in the laboratory, draw conclusions from experiments, explain their own ideas and have the opportunity to relate scientific concepts to the world outside school (instruction pattern I) – showed the highest interest in scientific topics (Seidel et al., 2007, p. 164). The interest of those students learning in a classroom where in nearly all lessons conclusions are drawn, ideas are developed and science is related to the students‘ daily life but own investigations are less often chosen by themselves, designed and conducted (instruction pattern II) was slightly lower than that of students learning in a surrounding of instruction pattern I. In contrast to the other two instruction patterns the lowest interest show students who seldom do experiments and research (instruction pattern III).

In contrast to the large amount of studies investigating student achievements or instruction it is striking that students attitudes towards science and science instruction are rather sparsely covered. One exception on an international level is the ROSE (The Relevance of Science Education) survey. ”Rose” is an international questionnaire based survey asking for context factors of learning science such as interests, opinions and attitudes of young people. In contrast to comparative assessment studies like PISA it is not focused on rankings. It rather aims at developing and improving science instruction as the findings make it possible to identify typical adolescent topics and give information about the change of adolescent interests in the past ten years (Schreiner & Sjøberg, 2004). The underlying assumption of “ROSE” is a close interrelation between the lack of importance given to taught subject in the science lessons and the decreasing motivation for learning science and the low number of chosen carriers in the field of science. The items used in “ROSE” identify a content and a context dimension. Results show that students are especially interested in topics like astrophysics and the universe, human biology, zoology and animals. The respondents show least interest for botany and only little interest for chemistry, physics and earth science.

3.3.2 Findings from Intervention Studies

According to the international survey studies that refer to IBST from a comparative perspective across the countries a large number of intervention studies emphasize the importance of IBST on students' cognitive outcomes and motivational-affective attitudes into science.

Recent intervention studies emphasize the strengths of IBST compared to traditional teaching approaches (Wolf & Fraser, 2008; Silk, Schunn, & Cary, 2009). Research shows, for instance, that a competence such as argumention can be enhanced by using IBST and how this influences cognitive achievements positivly (Kollar, Fischer, & Slotta, 2007; Naylor, Keogh, & Downing, 2007).

A variety of studies explores the role of argumentation skills in combination with methods of collaborative learning. Here IBST is valued as especially effective to develop domain specific and domain general knowledge (Kollar et al., 2007) and to cause a *concept change* with regard to students' deeply entrenched intuitive conceptions about scientific concepts (Ravenscroft, 2007; Lindahl, 2009). Ravenscroft states: "Interactions not only promote cognitive changes but also initiate improved dialogue and reasoning skills" (Ravenscroft, 2007, p. 454 f.).

Numerous studies focusing argumentation and cooperative learning use computer-based learning environments (Saab, Van Joolingen, & Van Hout-Wolters, 2005; Manlove, Lazonder, & Jong, 2006; Quitadamo, Faiola, Johnson, & Kurtz, 2008). These studies assume that computer-based tools can helpl to facilitate understanding and to enhance cognitive achievements. For example, by computer-based argumentation scripts (Kollar, Fischer, & Slotta, 2007) collaborative dialogues are guided (Jang, 2009) and argumentation structures, like questioning, clarifying, challenging and justification moves are practiced (Ravenscroft, 2007, p. 454).

One further result of these studies is that similar to results from research into aptitude-treatment-interactions the benefits of structured argumentations scripts were to a big extent influenced by the differing students' capabilities in argumentation and their prior knowledge (Kollar, Fischer, & Slotta, 2007, p. 719). Furthermore, results show that instruction enhancing argumentation shifts to a more learner-centered teaching (Naylor, Keogh, & Downing, 2007, p. 23).

Few articles report about teaching approaches that are, with regard to specific learning goals, even more effective than IBST alone. One of these studies compares traditional teaching, real experimentation and a combination of real experimentation with virtual experimentation with respect to changes in students' conceptual understanding. The highest learning achievements reach groups learning with a combination of real and virtual experimentation (Zacharia, 2007). Similarly, another experimental study's aim was to investigate if it would be more beneficial to combine simulation and laboratory activities than to use them separately in teaching. Comparing achievements between three different learning environments: computer simulation, laboratory exercise and a simulation–laboratory combination, shows that the simulation–laboratory combination environment leads to statistically greater learning gains than the use of either simulation or laboratory activities alone, and it also promotes students' conceptual understanding most efficiently. There were no statistical differences between simulation and laboratory environments (Jaakkola & Nurmi, 2008).

Another study analyzes students' learning in inquiry versus traditional units measuring content knowledge as well as students' assessments of events in which there are meaningful learning and conceptual changes (Timmerman, Strickland, & Carstensen, 2008). The results reveal that descriptive, concrete topic such as anatomy can be taught effectively using traditional didactic methods as well as IBST. However, the authors assess scientific inquiry especially effective, if the instruction covers topics that require highly abstract or mathematical concepts and greater formal reasoning ability. Furthermore, it was found that the frequency of meaningful learning events is significantly higher in the units using scientific inquiry compared to the traditional units. The authors suggest choosing teaching approaches rationally in relation to specific lesson goals:

> ”[We] feel that when time and resources for curricular reform are limited, those efforts should prioritize abstract and foundational topics such as evolution. Didactic teaching appears sufficient for more concrete topics such as anatomy.” (Timmerman, Strickland, & Carstensen, 2008).

Here the above mentioned internal relationship between learning goals and the assessment of effective teaching and learning is illustrated. Scientific inquiry seems especially effective to trigger deeply rooted knowledge.

Regarding the effects of IBST on students' motivation a large majority of articles come to the result that IBST contributes to increasing students' motivation in science, for example through providing a context for scientific topics and building a bridge to the adolescents' interests and experiences (Sadler, Barab, & Scott, 2007). Taking IBST features such as self-regulated learning, hands-on activities and authentic, problem-based learning activities (Jorde et al., 2010) into account, these features seem to positively correlate with students' subject-related self concept (self-efficacy/sense of competence), students' autonomy (allowing them to pursue personal/authentic learning goals and organizes their own learning processes), students‘ sense of relatedness to others in the classroom and value-orientations as motivational constructs (e.g. situated goals based on values) (see S-TEAM, WP 6, 2009, p. 5).

In fact, studies that consider learning conditions, aspects of learning motivation and cognitive learning activities show negative effects of narrow-focused classwork on students' motivation (Seidel, Prenzel, Rimmele, Schwindt, Herweg, & Dalehefte, 2006).

Focusing on acceptance of IBST in the classroom Maor and Fraser (2005) developed a "Constructivist Multimedia Learning Environment Survey (CMLES)". On the basis of this survey 221 students in 12 high school classrooms were asked about their perceptions of the currently-prevailing classroom learning environment. The participants were furthermore asked to give opinions about their ideal classroom. Maor and Fraser found: "Based on the whole sample, students believed that they should be engaged more frequently in Negotiation, Inquiry Learning and Reflective Thinking" (Maor & Fraser, 2005, p. 237). Thus, these results point to the assumption that students support the use of IBST in the classroom.

By contrast, some studies emphasize that students seem to have arranged with conventional teaching strategies. The following quotation of a study run in Taiwan shows this indication:

> "Two or three high-achievement students were not interested in this [inquiry-based] learning model. They only wanted to get the work done by simply submitting their assignments, or they would ask the teacher not to waste their class time on implementing this model to avoid negative impact on their learning achievement (...). It was a pity that these students became enslaved by tests and could not appreciate the wonder of learning and creativity." (Jang, 2009, p. 253)

Similarly, another study specified missing motivation as one constraint to implementing IBST into the classroom (Gengarelly & Abrams, 2009). The authors conclude: "In order for fundamental change to occur in the science classroom, it is essential that the roles of teachers and students change to be congruent with an inquiry oriented approach" (Gengarelly & Abrams, 2009, p. 82).

Taken together, the results on the classroom level, reveal that IBST stimulates higher cognitive processes, enhances students' argumentative skills and can cause concept changes in students' conception of scientific concepts. From an international comparative perspective it can be summarized that features of IBST are to a different extent already implemented in science instruction. According to the prevailing instruction patterns teachers and students need support, experience and time to change attitutes and activities that meet the characteristics of IBST. The findings emphasize positive effects of IBST on students' motivation and interest into science, but they also argue that not only a change of inquiry-based teaching methods alone promise higher motivation and interest. They rather have to be accompanied by instruction features supporting effective teaching and learning. Thus, meta-cognitive strategies that help to control the provision of extensive choices and simultaneous activities – as provided by IBST features – have to be regarded (Grangeat, 2009).

4. Quantitative Analysis of IBST Indicators and Instruments

4.1 Objective

The objective of this report is to review literature on indicators and instruments targeting levels of educational systems relevant to the implementation of IBST. In the previous sections, an overview of research in the areas of policy and stakeholders, teacher education and professional development, and teaching, teachers, and students has been given. In order to synthesize our review we conducted a quantitative analysis of IBST indicators and instruments. The objective is to provide researchers, policy and stakeholder, teacher educators, and teachers with an overview of publications, indicators, and measurement instruments. In addition to this report, measurement instruments as published in the literature and as stated by experts in the field of IBST are summarized in a second report. Thus, we want to contribute to an effective dissemination of instruments that can be used by researchers and practitioners in the formative assessment of IBST.

Since research on IBST has been intensified to a large degree in the last five years we limited our quantitative analysis as well as our research review to the last five years, including publications from 2005-2009. The following research questions are investigated:

1. How many empirical and non-empirical studies on IBST have been published between 2005-2009?
2. Which levels of implementation (policy and stakeholders; teacher education and professional development; teaching, teachers and students) do indicators mainly focus on?
3. How are instruments distributed across implementation levels? Are studies of qualitative or quantitative nature?
4. Which aspects are mentioned in the literature as supportive or described as barriers for the implementation of IBST?

4.2 Methods

This report compiles indicators and instruments as the result of an extensive literature review. The review was undertaken by using the digital library „Web of Science“. To set limits articles published between 2005-2009 were considered. Furthermore, we used reference lists from studies on IBST and IBST/E as well as experts‘ knowledge of the existence of additional studies.

The following keywords were used for search of studies: *inquiry based science teaching, science teaching and learning, science literacy and scientific literacy, collaborative science learning, argumentation in science education, heuristic in science education, science education, inquiry based instruction, teacher professional development* and *policy analysis.*

Each keyword was crossed with the target group keywords: “policy, stakeholders”, “teacher educators, teacher education”, “teachers” and “students, pupils”.

After downloading articles we screened articles by reading abstracts and developed a coding system to categorize the findings. For that reason we re-organized the articles found for each keyword plus implementation level. After a coding training of three student researchers, in a first step, the categorization of empirical and non-empirical articles was done.

Afterwards three independent coders categorized the publications. Relevant categories were “implementation level” and “indicator areas” (cognitive, motivational-affective, metacognitive). Inter-rater agreement reached a mean of 80 % of codes (Min=65 %, Max= 95 %). Beyond analyzing the type of target groups and the instruments’ area we actually collected and categorized the instruments as reported in the publications. We will provide these for the use as formative assessment instrument in the context of S-TEAM (Heinz et al., 2010).

4.3 Results

4.3.1 Number of Empirical and Non-Empirical Studies

In a first step of this indicators report we are describing in an overview the results of our research. Table 3 shows the total number of studies of our review. In total our literature search resulted in 549 hits. The first analysis of these hits revealed 367 studies were empirical (quantitative and qualitative) and 182 non-empirical (mainly reports) with regard to inquiry-based science teaching and inquiry-based science teacher education.

Table 3

Results of Research Review: Total Number (N) of Empirical and Non-Empirical Studies

Number of studies incl. all keywords/target groups	**549**
Empirical	367
Non-Empirical	182

4.3.2 Indicators Specified According to Implementation Level

Regarding the question of the implementation level our analysis shows that the majority of the empirical studies focus on the action level on teachers and students (Figure 1).

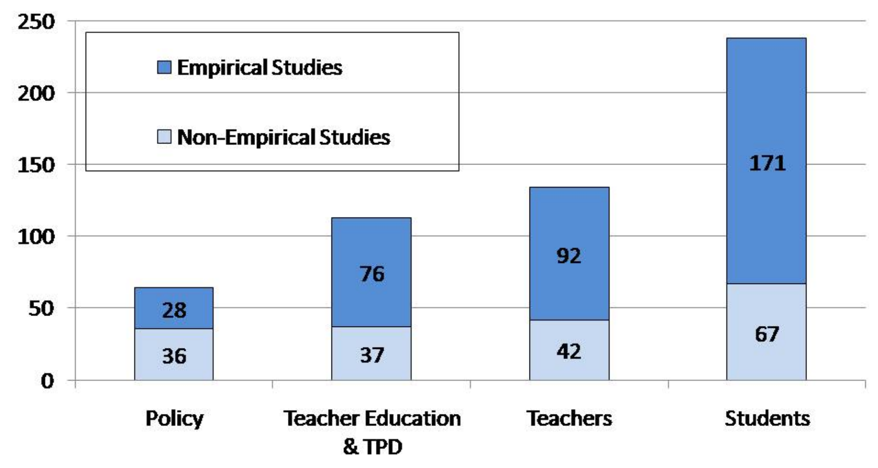


Figure 1. Distribution of Studies per Implementation Level (*N*=549).

92 studies were categorized as teacher implementation level and 171 studies as student implementation level. The lowest amount of studies (empirical as well as non-empirical) has been investigated for the policy level (*n*=28). Concerning teacher education and teachers professional development 76 empirical studies were found between 2005-2009.

Furthermore, by using the software salamander 2.51, we searched for the number of empirical studies that were categorized in more than one indicator area. Figure 2 shows that 67 of our research studies are duplicates. That means that – in a whole – 67 studies focus on different target groups, e.g. contain indicators for teachers as well as for students, or focus on different dimensions (e.g. cognitive, motivational).

In accordance with the previous assumption about the necessity of multiple perspectives in investigating effective teaching and learning (Seidel & Shavelson, 2007) these studies can particularly be interpreted as multi-criteria assessment of teaching and learning, “making it possible to analyze cognitive and motivational-affective processes of learning in parallel” (Seidel et al., 2009, p. 161). This first overview in Figure 2 shows that duplicates could be categorized in two and up to four categories.

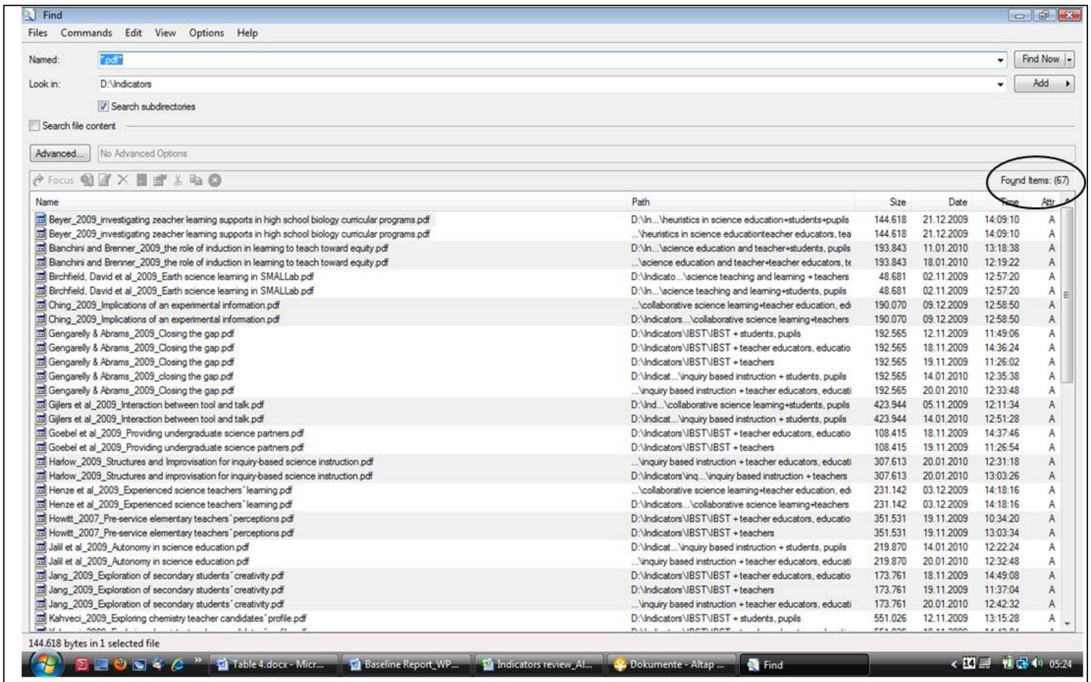


Figure 2. Indicators Review – Duplicates (Screenshot)

4.3.3 Indicator Areas Within Each Implementation Level

The third research question focuses indicator areas within each implementation level. The assumption was that research points to the importance of knowledge about IBST, positive attitudes and interest, as well as strategies to act in an educational system are relevant indicators for implementing IBST for all implementation levels. For that reason we categorized the articles by the following indicator areas: cognitive, motivational-affective and metacognitive.

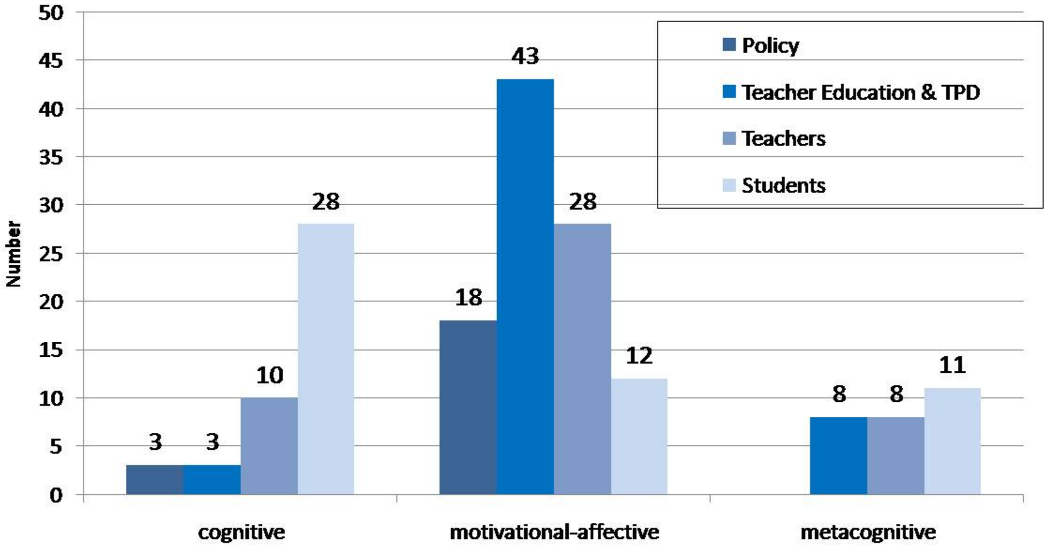


Figure 3. Number of Instruments per Indicator Area and Implementation Level (*N*=145).

Figure 3 shows the number of instruments within each indicator area and implementation level (*N*=145[3]). Cognitive indicators are reported in 44 empirical studies. Three studies included cognitive indicators each on the level of policy and stakeholders, and teacher education and TPD. Ten studies reported cognitive indicators on the level of teachers, whereas 28 studies included cognitive indicators on the student level. Thus, the majority of studies including cognitive indicators focused on the level of students. However, a trend towards including cognitive measures on all implementation levels can be observed.

Motivational-affective indicators were included in 101 publications, showing a strong focus on this indicator area in research of implementing IBST. Motivational-affective indicators are measured both quantitatively and qualitatively. On the policy and stakeholder level n=20 publications were found. The majority of publications referred to the level of teacher education and TPD (n=43), followed by instruments on the teacher level (n=28). The student level was targeted in n=12 publications. Whereas cognitive indicators are mainly focused on the level of students, motivational-affective indicators are more predominant on the level of teacher education, TPD and teachers.

---

[3] It has to be noticed that some of the instruments were used in different studies or for different target groups. With regard to the classification for our study these instruments were repeatedly categorized. In this section, we only report studies that contain different instruments for different target groups. Due to the bias of the number of instruments used in large scale studies (such as PISA 2006) and in the empirical studies in our research we only report the area of the instruments provided by PISA on the policy and action level (teachers, students) once. The edited set of instruments is provided in detail in the indicators' report by the research group (Heinz et al., 2010).

Indicators targeting metacognitive functions of implementing and enacting IBST have been reported to a less degree. Publications including instruments for measuring teaching and learning strategies refer to students (*n*=11), teachers (*n*=8) and teacher education/teacher professional development (*n*=8). No instruments were reported on the policy level.

To gain an insight into the measures and indicators of this research review the following Table 4 presents the articles categorized per implementation level as well as the source of instruments. The instruments as published are summarized in the second report.

Table 4

Database and Source of instruments[4]: Policy Level

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Matsumura, L. C., Sartoris, M., Bickel, D. D., & Garnier, H. E.	2009	Motivational-affective	Leadership for Literacy Coaching: The Principal's Role in Launching New Coaching Program	Qualitative	Individual format with regard to: West, L., & Staub, F. C. (2003). *Content-Focused Coaching: Transforming mathematicslessons,* Portsmouth, NH: Heinemann.
Porter, A. C., Polikoff, M. S., & Smithson, J.	2009	Cognitive	Is There a de Facto National Intended Curriculum? Evidence From State Content Standards	Quantitative	http://www.ccsso.org/projects/SCASS/
Horng, E. L.	2009	Motivational-affective	Teacher Tradeoffs: Disentangling Teachers' Preferences for Working Conditions and Student Demographics	Quantitative	Individual format: School district data
Harris, D. N. & Sass, T. R.	2009	Cognitive	The Effects of NBPTS-Certified Teachers on Student Achievement	Quantitative	Individual format: Database of Florida students' test scores and teacher certification
Hanushek, E. A. & Rivkin, S. G.	2009	Cognitive	Harming the Best: How Schools Affect the Black-White Achievement Gap	Quantitative	Individual format: Database of Texas School Project
Tuytens, M. & Devos, G.	2009	Motivational-affective	Teachers' perception of the new teacher evaluation policy: A validity study of the Policy Characteristics Scale	Quantitative	Tuytens, M. & Devos, G.(2009). Teachers' perception of the new teacher evaluation policy: A validity study of the Policy Characteristics Scale. *Teaching and Teacher Education*, 25, 924-930.
Quitadamo, I. J., Faiola, C. L., Johnson, J. E., & Kurtz, M. j.	2008	Motivational-affective	Community-based inquiry Improves Critical Thinking in General Education Biology	Quantitative, qualitative	Individual format: Multi method (questionnaires, interviews)

[4] The source of instruments contains the references relevant for finding the instruments. When an instrument was not applicable, we present further information on methods or relevant databases. For further details on single scales and information see the indicators' report provided by the research group (Heinz et al., 2010).

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Gerard, L. F., Bowyer, J. B., & Linn, M. C.	2008	Motivational-affective	Principal Leadership for Technology-enhanced Learning in Science	Qualitative	Individual format: (interviews)
Hug, B., Krajcik, J. S., & Marx, R. W.	2005	Motivational-affective	Using Innovative Learning Technologies to Promote Learning and Engagement in an Urban Science Classroom	Qualitative	Individual format (interviews)
Moscovici, H.	2008	Motivational-affective	Science Teacher Retention in Today's Urban Schools: A Study of Success and Failure	Qualitative	Individual format: (interviews)
Schneider, R. M., Krajcik, J., & Blumenfeld, P.	2005	Motivational-affective	Enacting Reform-Based Science Materials: The Range of Teacher Enactments in Reform Classrooms	Qualitative	Individual format: (interviews)
Ansell, C., Reckhow, S., & Kelly, A.	2009	Motivational-affective	How to Reform a Reform Coalition: Outreach, Agenda, Expansion, and Brokerage in Urban School Reform	Qualitative	Individual format: social networking analysis with regard to Borgatti, S. P. (2002). *NetDraw: Graph Visualization Software*. Harvard, MA: Analytic Technologies.
Friedrichsen, P. J., Abell, S. K., Pareja, E. M., Brown, P. L., Lankford, D. M., & Volkmann, M. J.	2009	Motivational-affective	Does teaching experience matter? Examining biology teachers' prior knowledge for Teaching in an Alternative Certification Program	Qualitative	Van der Valk, A.E.,& Broekman, H. (1999). The lesson preparation method: A way of investigating preservice teachers' pedagogical content knowledge. *European Journal of Teacher Education*, 22, 11–22.
Huang S. L. & Fraser, B. J.	2009	Motivational-affective	Science Teachers' Perceptions of the School Environment: Gender Differences	Quantitative	Huang, S. L. (2003). *The development of an instrument assessing science teachers' school-level environment*. Paper presented at the annual meeting of the American Educational Research Association, Chicago.
Saka Y., Souther-land, S. A., & Brooks, J. S.	2009	Motivational-affective	Becoming a Member of a School Community While Working Toward Science Education Reform: Teacher Induction from a Cultural Historical Activity Theory (CHAT) Perspective	Qualitative	Individual format: case study
OECD	2005a	Motivational-affective	School Questionnaire for PISA 2006: Main Study	Quantitative	

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Walter, A. I., Helgen-berger, S., Wiek, A., & Scholz, R. W.	2007	Motivational-affective	Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method	Quantitative	van Schooten, M., Vanclay, F., & Slootweg, R. (2003). Conceptualizing social change processes and social impacts. In H. A. Becker, & F. Vanclay (Eds.), *The international handbook of social impact assessment: Conceptual and methodological advances,* (pp. 74–91). Cheltenham: Edward Elgar.
Nisbet, M. C. & Goldel, R.K.	2007	Motivational-affective	Understanding citizen perceptions of science controversy: bridging the ethnographic survey research divide	Qualitative	Individual format: telephone interviews from a nationwide database
Tenebaum, H. R. & Callanan, M. A.	2008	Motivational-affective	Parents' science talk to their children in Mexican-descent families residing in the USA	Qualitative, quantitative	Callanan, M. A., Perez-Granados, D. R., Barajas, N. H., & Goldberg, J. C. (2005). *Why questions in Mexican-descent children's conversations with parents*. Manuscript.
Printy, S. M.	2008	Motivational-affective	Leadership for Teacher Learning: A Community of Practice Perspective	Quantitative	1) Purkey, S. & Smith, M. (1983). School Reform: The district policy implications of the effective school literature. *Elementary School Journal*, 85(1), 352-389. 2) Wenger, E. (1998). *Communities of Practice: Learning, meaning, and identity*. New York: CUP. 3) National Center for Education Studies (1994). *National education longitudinal study of 1988*. Washington, DC: US Department of Education.
Desimone, L., Smith, T, & Phillips, K. J. R.	2007	Motivational-affective	Does Policy Influence Mathematics and Science Teachers' Participation in Professional Development?	Quantitative	http://nces.ed.gov/surveys/sass/questionnaire.asp

Table 5

Database and Source of instruments: Teacher Education and Teacher Professional Development Level

Author	**Year of Publication**	**Indicator Area**	**Title**	**Methodical Approach**	**Source of Instrument**
Akerson, V. L., Cullen, T. A., & Hanson, D. L.	2009	Motivational-affective	Fostering a Community of Practice through a Professional Development Program to Improve Elementary Teachers' Views of Nature of Science and Teaching Practice	Qualitative	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire. *Journal of Research in Science Teaching*, 39, 497-521.
Karakas, M.	2009	Motivational-affective	Cases of Science Professors’ Use of Nature of Science	Qualitative	1) Individual format: semi-structured interviews 2) Lederman, N.G., Abd-El-Khalick, F., Bell, R. L. & Schwartz, R. S. (2002). Views of nature of science questionnaire. *Journal of Research in Science Teaching*, *39,* 497-521.
Akerson, V. L. & Hanuscin, D. L.	2007	Motivational-affective, metacognitive	Teaching Nature of Science through Inquiry: Results of a three Year Professional Development Program	Qualitative, quantitative	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire. *Journal of Research in Science Teaching*, 39, 497-521.
Banilower, E. R., Heck, D. J., & Weiss, I. R.	2007	Cognitive, motivational-affective	Can Professional Development Make the Vision of the Standards a Reality? The Impact of the National Science Foundation’s Local Systemic Change Through teacher Enhancement Initiative	Quantitative	Flora, D.B. & Panter, A.T. (1999). Analysis of the psychometric structure of the LSC surveys (Technical Report). Chapel Hill, NC: University of North Carolina.
Bantwini, B. D.	2009	Motivational-affective	How teachers perceive the new curriculum reform: Lessons from a school district in the Eastern Cape Province, South Africa	Qualitative	Individual format: (interviews)

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Danielowich, R.	2007	Motivational-affective	Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning	Qualitative	Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91(4),* 629-663.
Greensfeld, H. & Elkad-Lehman, I.	2007	Motivational-affective	An Analysis of the Processes of Change in Two Science Teachers Educators' Thinking	Qualitative	Greensfeld, H. & Elkad-Lehman, I. (2007). An Analysis of the Processes of Change in Two Science Teachers Educators' Thinking. *Journal of Research in Science Teaching, 44 (8),* 1219–1245
Hanuscin, D. L., Akerson, V. L., & Phillipson-Mower, T.	2006	Motivational-affective	Integrating Nature of Science Instruction into a Physical Science Content Course for Preservice Elementary Teachers: NOS Views of Teaching Assistants	Qualitative	Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*(6), 497–521.
Hardrè,P. L. & Sullivan, D. W.	2008	Motivational-affective	Teacher perceptions and individual differences: How they influence rural teachers' motivating strategies	Quantitative, qualitative	Reeve, J., & Sickenius, B. (1994). Development and validation of a brief measure of the three psychological needs underlying intrinsic motivation: The AFS scales. *Educational and Psychological Measurement*, 54, 506–515.
Hoekstra, A., Brekelmans, M., Beijaard, D., & Korthagen, F.	2009	Motivational-affective	Experienced teachers' informal learning: Learning activities and changes in behavior and cognition	Quantitative	Individual format (questionnaires)
Forbes, C. T. & Davis, E. A.	2008	Motivational-affective	The Development of Preservice Elementary Teachers' Curricular Role Identity for Science Teaching	Quantitative, qualitative	Forbes, C. T. & Davis, E. A. (2008). The Development of Pre-service Elementary Teachers' Curricular Role Identity for Science Teaching. *Science Education, 92 (5),* 909-940.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Johnson, C. C. & Fargo, J. D.	2009	Motivational-affective	Urban School Reform Enabled by Transformative Professional Development: Impact on Teacher Change and Student Learning of Science	Quantitative	1) Horizon Research Local Systemic Change (LSC) through Teacher Enhancement Classroom Observation Protocol. Horizon Research, Inc. (2002). Local systemic change classroom observation protocol.Retrieved July 11, 2007, from http://www.horizonresearch.com/LSC/manual/0506/tab6/cop0506.pdf
Laius, A., Kask, K., & Rannikmäe, M.	2009	Motivational-affective	Comparing outcomes from two case studies on chemistry teachers' readiness to change	Qualitative, quantitative	Individual format: case study, interviews, observations, intervention
Lawrenz,F., Wood, N. B., Kirchhoff, A., Kim, N. K., & Eisenkraft, A.	2009	Cognitive	Variables Affecting Physics Achievement	Quantitative	1) Third International Mathematics and Science Study. (1996).*ASplintered vision: An investigation of US Science and Mathematics Education*. Boston, MA: Kluwer. 2) Weiss, I.R., Banilower, E.R., McMahon, K.C., & Smith, P.S. (2001). *Report of the 2000 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research, Inc.
Lee, O., Luykx, A., Buxton, C., & Shaver, A.	2007	Motivational-affective	The Challenge of Altering Elementary School Teachers' Beliefs and Practices Regarding Linguistic and Cultural Diversity in Science Instruction	Qualitative, quantitative	Individual format: interviews, questionnaires
Leou, M., Abder, P., Riordan, M., & Zoller, U.	2006	Metacognitive	Using 'HOCS-Centered Learning' as a Pathway to Promote Science Teachers' Metacognitive Development	Qualitative	Individual format: questionnaire

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Lotter, C., Harwood, W. S., & Bonner, J. J.	2007	Motivational-affective	The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices	Qualitative	Lotter, C. ,Harwood, W. S. & Bonner, J. J. (2007). The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices. *Journal of Research in Science Teaching*, *44 (9),* 1318–1347.
Metz, K. E.	2008	Motivational-affective	Elementary School Teachers as "Targets and Agents of Change": Teachers' Learning in Interaction With Reform Science Curriculum	Qualitative	Individual format: case study
Moore, F. M.	2008	Motivational-affective	Positional Identity and Science Teacher Professional Development	Qualitative	Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45 (6),* 684–710.
Mushayikwa, E. & Lubben, F.	2008	Motivational-affective	Self-directed professional development – Hope for teachers working in deprived environments?	Qualitative	Individual format: interviews
Nelson, T. H.	2008	Metacognitive, Motivational-affective	Teachers' Collaborative Inquiry and Professional Growth: Should We Be Optimistic?	Qualitative	Individual format: interviews
Ruby, A.	2006	Cognitive	Improving Science Achievement at High-Poverty Urban Middle Schools	Quantitative	Harcourt Brace Educational Measurement. (1996a). *Stanford Achievement Test: Open-ended scoring guide—Mathematics*. Chicago: Author. Harcourt Brace Educational Measurement. (1996b). *Stanford Achievement Test: Open-ended scoring guide–Science*. Chicago: Author.
Scantlebury, K., Gallo-Foxa, J., & Wassellb, B.	2008	Metacognitive	Co-teaching as a model for preservice secondary science teacher education	Qualitative	Individual format: interviews

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Schuster, D. A. & Carlsen, W. S.	2008	Motivational-affective	Scientists' Teaching Orientations in the Context of Teacher Professional Development	Quantitative, qualitative	Horizon Research. (2000). Local systemic change through teacher enhancement professional development observation protocol. Retrieved January 30, 2004, from http://www.horizon-search.com/instruments/lsc/pdop.php
Smith, L. K., & Southerland, S. A.	2007	Motivational-affective	Reforming Practice or Modifying Reforms? Elementary Teachers' Response to the Tools of Reform	Qualitative, quantitative	1) Abell, S.K. & Smith, D.C. (1994). What is science? Preservice elementary teachers' conceptions of the nature of science. *International Journal of Science Education*, *16*, 475–487. 2) Moulding, L.R. (2001). *Missouri science teacher survey 2000: Final results of statewide needs assessment.* Jefferson City, MO: Missouri Department of Education.
Syh-Jong, J.	2008	Motivational-affective, metacognitive	Innovations in science teacher education: Effects of integrating technology and team-teaching strategies	Quantitative	Syh-Jong, J. (2008). Innovations in science teacher education: Effects of integrating technology and team-teaching strategies. *Computers & Education*, 51, 646-659.
Bencze, J. L.	2008	Motivational-affective	Promoting student-led science and technology projects in elementary teacher education: entry into core pedagogical practices through technological design	Qualitative, quantitative	Individual format
Bianchini, J. A. & Brenner, M. E.	2009	Motivational-affective	The Role of Induction in Learning to Teach Toward Equity: A Study of Beginning Science and Mathematics Teachers	Qualitative	Individual format: interviews

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Christodoulou, N., Varelas, M., & Wenzel, S.	2009	Motivational-affective	Curricular Orientations, Experiences, and Actions: Graduate Students in Science and Mathematics Fields Work in Urban High School Classrooms	Qualitative	Individual format
Elmesky, R. & Tobin, K.	2005	Motivational-affective	Expanding Our Understandings of Urban Science Education by Expanding the Roles of Students as Researchers	Qualitative	Individual format: interviews, videotapes
Irez, S.	2006	Motivational-affective	Are We Prepared? An Assessment of Preservice Science Teacher Educators' Beliefs About Nature of Science	Qualitative	Lederman, N.G., Abd-El-Khalick, F., Bell, R. L. & Schwartz, R. S. (2002). Views of nature of science questionnaire*. Journal of Research in Science Teaching*, *39,* 497-521.
Crawford, B. A.	2007	Motivational-affective, metacognitive	Learning to Teach Science as Inquiry in the Rough and Tumble of Practice	Qualitative	Individual format
Donnelly, L. A. & Sadler, T. D.	2009	Motivational-affective	High School Science Teachers' Views of Standards and Accountability	Qualitative	Individual format
Friedrichsen, P. J., Abell, S. K., Pareja, E. M., Brown, P. L., Lankford, D. M., & Volkmann, M. J.	2009	Motivational-affective	Does Teaching Experience Matter? Examining Biology Teachers' Prior Knowledge for Teaching in an Alternative Certification Program	Qualitative	Van der Valk, A.E. & Broekman, H. (1999). The lesson preparation method:A way of investigating preservice teachers' pedagogical content knowledge. *European Journal of Teacher Education*, 22, 11–22.
Moore Mensah, F.	2008	Motivational-affective	Positional Identity and Science Teacher Professional Development	Qualitative	Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45*(6)*,* 684–710.
Saitoa, E., Tsukuib, A., & Tanakaa, Y.	2008	Motivational-affective, Metacognitive	Problems on primary school-based in-service training in Vietnam: A case study of Bac Giang province	Qualitative	Individual format: case study, group discussion

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Snider, V. E. & Roehl, R.	2007	Motivational-affective	Teachers' Beliefs about pedagogy and related Issues	Quantitative	Snider, V. E. & Roehl, R. (2007). Teachers' Beliefs about pedagogy and related Issues. *Psychology in the Schools*, 44(8), 873-886.
Spektor-Levy, O., Eylon, B.-S., & Scherz, Z.	2008	Motivational-affective	Teaching communication skills in science: Tracing teacher change	Qualitative	Individual format: interviews
Sperandeo-Mineo, R. M., Fazio, C., & Tarantino, G.	2005	Motivational-affective, metacognitive	Pedagogical Content Knowledge Development and Pre-Service Physics Teacher Education: A Case Study	Qualitative	Individual format: case study
Taylor, A. R., Jones, M. G., Broadwell, B, & Oppewal, T.	2008	Motivational-affective	Creativity, Inquiry, or Accountability? Scientists' and Teachers' Perceptions of Science Education	Qualitative	Taylor, A. R., Jones, M. G., Broadwell, B, & Oppewal, T. (2008). Creativity, Inquiry, or Accountability? Scientists' and Teachers' Perceptions of Science Education. *Science Education*, 92, 1058-1075.
Henze, I., Van Driel, J. H. & Verloop, N.	2009	motivationanl-affective	Experienced Science Teachers' Learning in the Context of Educational Innovation	Qualitative	Beijaard, D., Van Driel, J. H., & Verloop, N. (1999). Evaluation of story-line methodology in research on teachers' practical knowledge. *Studies in Educational Evaluation*, *25*, 47-62.
Aduriz-Bravo, A., Izquierdo-Aymerich, M.	2009	motivational-affective	A Research-Informed Instructional Unit to Teach the Nature of Science to Pre-Service Science Teachers	Qualitative	Individual format: interviews
Williams, P. R., Tabernik, A. M. & Krivak, T.	2009	motivational-affective	The Power of Leadership, Collaboration, and Professional Development: The Story of the SMART Consortium	Quantitative	Individual format: questionnaires
Hilferty, F.	2007	Motivational-affective	Contesting the Curriculum: An Examination of Professionalism as Defined and Enacted by Australian History Teachers	Qualitative	Individual format: case study

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Tytler, R.	2006	Motivational-affective	School Innovation in Science: A Model for Supporting School and Teacher Development	Quantitative, qualitative	Individual format:
Zion, M., Cohen, S., & Amir, R.	2007	Motivational-affective	The Spectrum of Dynamic Inquiry Teaching Practices	Qualitative	Individual format: interviews
Berry, A., Loughran, J., Smith, K., & Lindsay, S.	2008	Motivational-affective	Capturing and Enhancing Science Teachers' Professional Knowledge	Qualitative	Individual format: case study

Table 6

Database and Source of instruments: Action Level Teachers

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Reutzel, D. R., Smith, J. A. & Fawson P. C.	2005	Cognitive	An evaluation of two approaches for teaching reading comprehension strategies in the primary years using science information texts	Qualitative, quantitative	1) Gambrell, L. B. (2003). *Primary student reading motivation survey*. Clemson, S.C, Personal correspondence. 2) Individual format (questionnaire)
Kuiper, E., Volman, M. & Terwel, J.	2009	Cognitive, metacognitive	Developing Web literacy in collaborative inquiry activities	Quantitative, qualitative	Individual format: standardized computer-based tool, interviews

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Larkin, D. B., Seyforth, S. C. & Lasky, H. J.	2009	Motivational-affective	Implementing and Sustaining Science Curriculum Reform: A Study of Leadership Practices Among Teachers Within a High School Science Department	Qualitative	Individual format: interviews
Lawrenz, F., Wood, N. B., Kirchhoff, A., Kim, N. K. & Eisenkraft, A.	2009	cognitive, motivational-affective	Variables Affecting Physics Achievement	quantitative	Individual format: questionnaires
Silverstein, S. C., Dubner, J., Miller, J., Glied, S. & Loike J. D.	2009	Cognitive	Teachers' Participation in Research Programs Improves Their Students' Achievement in Science	Quantitative	Individual format: questionnaires
Beyer, C. J., Delgado, C., Davis, E. A. & Krajcik, J.	2009	motivational-affective	Investigating Teacher Learning Supports in High School Biology Curricular Programs to Inform the Design of Educative Curriculum Materials	Qualitative	Individual format: interviews
Farré, A. S. & Lorenzo, M. G.	2009	Motivational-affective	Another piece of the puzzle: the relationship between beliefs and practice in higher education organic chemistry	Qualitative, quantitative	Individual format: multi methods (case study, questionnaire) 1) Pandit N. R., (1996), The creation of theory: a recent application of the grounded theory method, TQR, 2, http://www.nova.edu/ssss/QR/QR2-4/pandit.html
Gengarelly, L. M. & Abrams, E. D.	2009	Motivational-affective	Closing the Gap: Inquiry in Research and the Secondary Science Classroom	Qualitative	Individual format: interviews
Sherin, M. G., & Drake, C.	2009	Motivational-affective	Curriculum strategy framework: investigating patterns in teachers' use of a reform-based elementary mathematics curriculum	Qualitative	Individual format: case study

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Harlow, D. B.	2009	Motivational-affective	Structures and Improvisation for Inquiry-Based Science Instruction: A Teacher's Adaptation of a Model of Magnetism Activity	Qualitative	Individual format: case study
Howes, E. V., Lim, M. & Campos, J.	2008	Motivationale-affective	Journeys Into Inquiry-Based Elementary Science: Literacy Practices, Questioning, and Empirical Study	Qualitative	Individual format: case study
Sadeh, I. & Zion, M.	2009	Motivational-affective	The Development of Dynamic Inquiry Performances within an Open Inquiry Setting: A Comparison to Guided Inquiry Setting	Qualitative	individual format: interviews
Britsch, S.	2009	Motivational-affective, metacognitive	Differential discourses: the contribution of visual analysis to defining scientific literacy in the early years classroom	Qualitative	Rose, G. (2001) *Visual Methodologies*. London: Sage.
Lavonen, J. & Laaksonen, S.	2009	Motivational-affective, cognitive	Context of Teaching and Learning School Science in Finland: Reflections on PISA 2006 Results	Quantitative	OECD. (2005a). School Questionnaire for PISA 2006: Main Study. Paris: OECD.
Markic, S. & Eilks, I.	2008	Motivational-affective	A case study on German first year chemistry student teaching domains, teachers' beliefs about chemistry teaching, and their comparison with student teachers from other science	Qualitative, Quantitative	Individual format: case study Thomas J., Pedersen J. & Finson K., (2001). Validation of the Draw-A-Science-Teacher-Checklist (DASTT-C). *Journal of Science Teacher Education,* 12, 295-310.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Ratcliffe, M. & Millar, R.	2009	Motivational-affective	Teaching for Understanding of Science in Context: Evidence from the Pilot Trials of the Twenty First Century Science Courses	Qualitative, quantitative	1) Bartholomew, H., Osborne, J., & Ratcliffe, M. (2004). Teaching students 'ideas-about-science': Five dimensions of effective practice. *Science Education*, 88, 655–682. 2) Ratcliffe, M. & Millar, R. (2009). Teaching for Understanding of Science in Context: Evidence from the Pilot Trials of the Twenty First Century Science Courses. Journal of Research in Science Teaching, 46(8), 945-959.
Falk, H. & Yarden, A.	2009	metacognitive	"Here the Scientists Explain What I Said." Coordination Practices Elicited During the Enactment of the Results and Discussion Sections of Adapted Primary Literature	Qualitative	individual format: interviews
Cohen, R. & Yarden, A.	2009	Motivational-affective, metacognitive	Experienced Junior-High-School Teachers' PCK in Light of a Curriculum Change: "The Cell is to be Studied Longitudinally"	Qualitative, quantitative	1) Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome, & N. G. Lederman (Eds.), Examining pedagogical content knowledge, the construct and its implications for science education (pp. 95–132). Dordrecht: Kluwer Academic. 2) Cohen, R. & Yarden, A. (2009). Experienced Junior-High-School Teachers' PCK in Light of a Curriculum Change: "The Cell is to be Studied Longitudinally". *Research Science Education*, 39, 131-155.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Gimenez, J. E., Ruiz, R. M. A. & Listan, M. F.	2008	Cognitive	Primary and secondary teachers' conceptions about heritage and heritage education: A comparative analysis	quantitative	Individual format: questionnaire with regard to Tsai, C. C. (2006). Reinterpreting and reconstructing science: Teachers' view changes toward the nature of science by courses of science education. *Teaching and Teacher Education*, 22(3), 363–375.
Le, V.-N., Lockwood, J. R., Stecher, B. M., Hamilton, L. S. & Martinez J. F.	2009	Cognitive, metacognitive	A Longitudinal Investigation of the Relationship between Teachers' Self-Reports of Reform-Oriented Instruction and Mathematics and Science Achievement	Quantitative	Harcourt Brace Educational Measurement. (1996a). *Stanford Achievement Test: Open-ended scoring* *guide—Mathematics*. Chicago: Author. Harcourt Brace Educational Measurement. (1996b). *Stanford Achievement Test: Open-ended scoring* *guide–Science*. Chicago: Author.
OECD	2005a	Cognitive, motivational-affective	School Questionnaire for PISA 2006: Main Study	Quantitative	
Gimenez, J. E., Ruiz, R. M. A. & Listan, M. F.	2008	Cognitive	Primary and secondary teachers' conceptions about heritage and heritage education: A comparative analysis	quantitative	Individual format: questionnaire with regard to Tsai, C. C. (2006). Reinterpreting and reconstructing science: Teachers' view changes toward the nature of science by courses of science education. *Teaching and Teacher Education*, 22(3), 363–375.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Le, V.-N., Lockwood, J. R., Stecher, B. M., Hamilton, L. S. & Martinez J. F.	2009	Cognitive, metacognitive	A Longitudinal Investigation of the Relationship between Teachers' Self-Reports of Reform-Oriented Instruction and Mathematics and Science Achievement	Quantitative	Harcourt Brace Educational Measurement. (1996a). *Stanford Achievement Test: Open-ended scoring guide—Mathematics*. Chicago: Author. Harcourt Brace Educational Measurement. (1996b). *Stanford Achievement Test: Open-ended scoring guide–Science*. Chicago: Author.
OECD	2005a	Cognitive, motivational-affective	School Questionnaire for PISA 2006: Main Study	Quantitative	
Vogt, F. & Rogalla, M.	2009	Motivational-affective	Developing Adaptive Teaching Competency through coaching	Qualitative	1) West, L., & Staub, F. C. (2003). Content-focused coaching. Transforming mathematics lessons. Portsmouth, NH: Heinemann. 2) Vogt, F. & Rogalla, M. (2009). Developing Adaptive Teaching Competency through coaching. Teaching and Teacher Education, 25, 1051-1060.
Voogt, J., Tilya, F. & Van den Akker, J.	2009	Motivational-affective	Science Teacher Learning of MBL-Supported Student-Centered Science Education in the Context of Secondary Education in Tanzania	Quantitative	Individual format: computer-based tool Ottevanger, W. (2001) *Teacher support materials as a catalyst for science curriculum implementation in Namibia*. Doctoral dissertation. Enschede: University of Twente. Students: Maor D, Fraser BJ (1996) Use of classroom environment perceptions in evaluating inquiry-based computer assisted learning. Int J Sci Educ 18(4):401–422.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Zembal-Saul, C.	2009	Motivational-affective	Learning to Teach Elementary School Science as Argument	Qualitative	Individual format: case study
Zucker, A. A., Tinker, R., Staudt, C., Mansfield, A. & Metcalf, S.	2007	Cognitive, metacognitive, motivational-affective	Learning Science in Grades 3–8 Using Probeware and Computers: Findings from the TEEMSS II Project	Quantitative	Individual format: computer-based tool 1) Zucker, A. A., Tinker, R., Staudt, C., Mansfield, A. & Metcalf S. (2008). Learning Science in Grades 3–8 Using Probeware and Computers: Findings from the TEEMSS II Project. *Journal of Science Education Technology*, 17, 42-48. 2) Kreikemeier, P. A., Gallagher, L., Penuel, W. R., Fujii, R., Wheaton, V., & Bakia, M. (2006). *Technology enhanced elementary and middle school science II (TEEMSS II): Research Report 1*. SRI International, Menlo Park.
Goebel, C. A., Umoja, A., & DeHaan, R. L.	2009	Motivational-affective	Providing Undergraduate Science Partners for Elementary Teachers: Benefits and Challenges	Qualitative	Individual format: interviews, classroom observations
Zucker A. A. & Hug, S. T.	2008	Motivational-affective	Teaching and Learning Physics in a 1:1 Laptop School	Quantitative	Individual format: questionnaire with regard to a computer-based tool
Barab, S. A., Scott, B., Siyahhan S., Goldstone , R., Ingram-Goble, A., Zuiker, S. J. & Warren, S.	2009	Motivational-affective, metacognitive	Transformational Play as a Curricular Scaffold: Using Videogames to Support Science Education	Quantitative	Individual format: computer-based tool
Birchfield, D. & Mego-wan-Romano-wicz, C.	2009	Cognitive	Earth science learning in SMALLab: A design experiment for mixed reality	Quantitative	Individual format: computer-based tool

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Brinkworth, R., McCann, B., Matthews, C. & Nordström, K.	2009	Motivational-affective	First year expectations and experiences: student and teacher perspectives	Quantitative	Brinkworth, R., McCann, B., Matthews, C., & Nordström, K. (2009). First year expectations and experiences: student and teacher perspectives. *High Education*, 58, 157-173.
Lotter, C., Harwood, W. S., & Bonner, J. J.	2007	Motivational-affective	The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices	Qualitative	individual format: case study
MacNabb, C., Lee Schmitt, L., Michlin, M., Harris, I., Thomas, L., Chittendon, D., Ebner, T. J. &, Dubinsky, J. M.	2006	Motivational-affective	Neuroscience in Middle Schools: A Professional Development and Resource Program That Models Inquiry-based Strategies and Engages Teachers in Classroom Implementation	Quantitative	individual format: MacNabb, C., Lee Schmitt,L., Michlin, M., Harris, I., Thomas, L., Chittendon, D., Ebner, T. J. &, Dubinsky, J. M. (2006). A Professional Development and Resource Program That Models Inquiry-based Strategies and Engages Teachers in Classroom Implementation. *Life Sciences Education,* 5, 144–157.
Siegel, C.	2005	Metacognitive	An ethnographic inquiry of cooperative learning implementation	Qualitative	Individual format: interviews, observation
Williams, M.	2008	Motivational-affective	Moving Technology to the Center of Instruction: How One Experienced Teacher Incorporates a Web-based Environment Over Time	Qualitative, quantitative	Individual format: web based environment tool; use of interviews, video-and audiotapes, observations
Capobianco, B. M.	2007	Motivational-affective	Science Teachers' Attempts at Integrating Feminist Pedagogy through Collaborative Action Research	Qualitative	Individual format: Case study, interviews
Zozakiewicz, C. & Rodriguez, A. J.	2007	Motivational-affective,	Using Sociotransformative Constructivism to Create Multicultural and Gender-Inclusive Classrooms	Qualitative	Zozakiewicz, C. & Rodriguez, A.J. (2007). Using Sociotransformative Constructivism to Create Multicultural and Gender-Inclusive Classrooms.*Educational Policy,* 21(2),397-425.

Table 7

Database and Source of instruments: Action Level Students

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Ching, G. S	2009	Cognitive	Implications of an experimental information technology curriculum for elementary students	Quantitative	Individual format: computer-based tool
Geier, R., Blumenfeld, P. C., Marx, R. W., & Krajcik, J. S.	2008	Cognitive	Standardized Test Outcomes for Students Engaged in Inquiry-Based Science Curricula in the Context of Urban Reform	Quantitative	Individual format: students' tests
Jalil, P. A., Abu Sbeih, M. Z., & Boujettif, M.	2009	Motivational-affective	Autonomy in Science Education: A Practical Approach in Attitude Shifting Towards Science Learning	Qualitative, quantitative	Individual format: worksheets, discussions, interviews
Lavonen, J. & Laaksonen, S.	2009	Motivational-affective, cognitive	Context of Teaching and Learning School Science in Finland: Reflections on PISA 2006 Results	Quantitative	OECD. (2005b). Student Questionnaire for PISA 2006: Main Study. Paris: OECD.
Gunel, M., Hand, B. & McDermott, M. A.	2009	Cognitive, metacognitive	Writing for different audiences: Effects on high-school students' conceptual understanding of biology	Quantitative	Gunel, M., Hand, B. & McDermott, M. A. (2009). Writing for different audiences: Effects on high-school students' conceptual understanding of biology. *Learning and Instruction*, 19, 354-367.
OECD	2005b	Cognitive, motivational-affective	Student Questionnaire for PISA 2006	Quantitative	

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Vogt, F. & Rogalla, M.	2009	Cognitive	Developing Adaptive Teaching Competency through coaching	Quantitative	1) Beaton, A. E., Martin, M. O., Mullis, I. V. S., Gonzalez, E. J., Smith, T. A., & Kelly, D. L. (1996). Science achievement in the middle school years. IEA’s third international mathematics and science studie. Chestnut Hill, MA: Boston College. 2) Martin, M. O., Mullis, I. V. S., Beaton, A. E., Gonzalez, E. J., Smith, T. A., & Kelly, D. L. (1997). Science achievement in the primary school years: IEA’s third international mathematics and science studie (TIMSS). Chestnut Hill, MA: Boston College.
Voogt, J., Tilya, F. & Van den Akker, J.	2009	Motivational-affective	Science Teacher Learning of MBL-Supported Student-Centered Science Education in the Context of Secondary Education in Tanzania	Quantitative	Individual format: computer-based tool Maor, D. & Fraser, B. J. (1996). Use of classroom environment perceptions in evaluating inquiry-based computer assisted learning. *International Journal of Science Education,* 18(4), 401–422.
Williams, P. R., Tabernik, A. M. & Krivak, T.	2009	Cognitive	The Power of Leadership, Collaboration, and Professional Development: The Story of the SMART Consortium	Quantitative	Individual format: questionnaires
Howitt, C.	2007	Motivational-affective	Pre-Service Elementary Teachers’ Perceptions of Factors in an Holistic Methods Course Influencing their Confidence in Teaching Science	Quantitative	Individual format: questionnaire

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Jang, S.-J.	2009	Motivational-affective	Exploration of secondary students' creativity by integrating web-based technology into an innovative science curriculum	Qualitative	Individual format: multiple approaches (online discussion data, videos, interviews)
Kahveci, A.	2009	Motivational-affective	Exploring chemistry teacher candidates' profile characteristics, teaching attitudes and beliefs, and chemistry conceptions	Quantitative	1) Woolley S. L., Benjamin W. J. & Woolley A. W., (2004). Construct validity of a self-report measure of teacher beliefs related to constructivist and traditional, approaches to teaching and learning. Educational Psychology Measurement, 64, 319-331. 2) Kahveci, A. (2009). Exploring chemistry teacher candidates' profile characteristics, teaching attitudes and beliefs, and chemistry conceptions. *Chemistry Education Research and Practice*, 10, 109-120.
King, D., Bellocchi, A. & Ritchie, S. M.	2008	Motivational-affective, metacognitive	Making Connections: Learning and Teaching Chemistry in Context	Qualitative	Individual format: interviews King, D., Bellocchi, A. & Ritchie, S. M. (2008). Making Connections: Learning and Teaching Chemistry in Context. *Research on Science Education*, 38, 365-384.
Silk, E. M., Schunn, C. D., Strand Cary, M.	2009	Cognitive	The Impact of an Engineering Design Curriculum on Science Reasoning in an Urban Setting	Quantitative	1) Lawson, A. E. (1987). Classroom test of scientific reasoning: revised paper and pencil version. Arizona State University, Tempe. 2) Toth, E. E., Klahr, D., & Chen, Z. (2000). Bridging research and practice: A cognitively based classroom intervention for teaching experimentation skills to elementary school children. Cognition and Instruction, 18(4), 423–459.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Angeli, C.	2005	Motivational-affective, metacognitive	Transforming a teacher education method course through technology: effects on preservice teachers technology competency	Quantitative	Individual factor: computer-based tool Angeli, C. (2005). Transforming a teacher education method course through technology: effects on preservice teachers technology competency. *Computers & Education*, 45, 383-398.
Sadler, T. D., Barab, S. A., & Scott, B.	2007	Metacognitive	What Do Students Gain by Engaging in Socioscientific Inquiry?	Qualitative	Individual format: interviews
Kelly, G. J. & Mayer, R. E.	2005	Cognitive, metacognitive	Contextual Epistemic Development in Science: A Comparison of Chemistry Students and Research Chemists	Qualitative	Individual format: interviews with regard to Samarapungavan, A., & Wiers, R. (1997). Children's thoughts on the origin of species: A study of explanatory coherence. *Cognitive Science*, 21(2), 147– 177.
Assaraf O. B.-Z., & Damri, S.	2009	Motivational-affective	University Science Graduates' Environmental Perceptions Regarding Industry	Quantitative, qualitative	Adams-Webber, J. (2006). A review of repertory grid theory, research, and applications. *Journal on Constructivist Psychology*, 19(4), 351–353.
Albe, V.	2007	Cognitive, motivational, metacognitive	When Scientific Knowledge, Daily Life Experience, Epistemological and Social Considerations Intersect: Students' Argumentation in Group Discussions on a Socio-scientific Issue	Qualitative	Individual format: Group Discussions
Hoskins, S. G., Stevens, L. M., & Nehm, R. H.	2007	Motivational-affective, cognitive	Selective Use of the Primary Literature Transforms the Classroom Into a Virtual Laboratory	Quantitative	Individual format: computer-based tool

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Kollar, I., Fischer, F. , & Slotta, J. D.	2007	Cognitive	Internal and external scripts in computer-supported collaborative inquiry learning	Quantitative	Individual format: computer-based tool
Lindahl, M. G.	2009	Motivational, cognitive	Ethics or Morals: Understanding Students' Values Related to Genetic Tests on Humans	Qualitative	Individual format: interviews, group discussions
Naylor, S., Keogh, B., & Downing, B.	2007	Cognitive	Argumentation and Primary Science	Qualitative	Individual format: interviews Naylor, S., Downing, B., & Keogh, B. (2001, August). An empirical study of argumentation in primary science, using concept cartoons as the stimulus. Paper presented at the European Science Education Research Association Conference, Thessaloniki, Greece
Foy, J. G. , Feldman, M., Edward, L., Mahoney, M. & Chelsea, S.	2006	Cognitve	Neuroscience Workshops for Fifth-Grade School Children by Undergraduate Students: A University–School Partnership	Quantitative	Individual format: pre-post-test
Gelbart, H., Brill, G., & Yarden, A.	2009	Cognitive, metacognitive	The Impact of a Web-Based Research Simulation in Bioinformatics on Students' Understanding of Genetics	Quantitative	Individual format: computer-based tool, pre-post-test

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Ravenscroft, A.	2007	Cognitive, metacognitive	Promoting thinking and conceptual change with digital dialogue games	Quantitative	Individual format: pre-post-test See http://www.interloc.org/
Saab, N., Van Joolingen, W. R., & Van Hout-Wolters, B. H. A. M.	2005	Cognitive, metacognitive	Communication in collaborative discovery learning	Quantitative	Individual format: pre-post-test Veermans, K. H., De Jong, T., & Van Joolingen, W. R. (2000). Promoting self directed learning in simulation based discovery learning environments through intelligent support. *Interactive Learning Environments*, 8, 229–255
Apedoe, X. S., Reynolds, B., Ellefson, M. R., & Schunn, C. D.	2008	Cognitive, motivational	Bringing Engineering Design into High School ScienceClassrooms: The Heating/Cooling Unit	Quantitative	Mulford, D. S (1996). *An inventory for measuring college students' level of misconceptions in first semester chemistry.* Unpublished Master's Thesis, Purdue University. Eubanks, I.D & Eubanks, L. P (1993). *ACS test-item bank for high school chemistry*. American Chemical Society Division of Chemical Education Examinations Institute, Milwaukee.
Ashmore, P. C.	2005	Cognitive	Role of Physical Anthropology in Intermediate and Secondary Education	Quantitative	Individual format: pre-post-test
Cunningham, S. C., McNear, B., Pearlman, R. S., & Kern, S. E.	2006	Cognitve, metacognitive, motivational-affective	Beverage-Agarose Gel Electrophoresis: An Inquiry-based Laboratory Exercise with Virtual Adaptation	Quantitative	Cunningham, S. C., McNear, B., Pearlman, R. S., & Kern, S. E. (2006). Beverage-Agarose Gel Electrophoresis: An Inquiry-based Laboratory Exercise with Virtual Adaptation. *CBE-Life Science Education*, 5, 281-286.

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Jaakkola, T., & Nurmi, S.	2008	Cognitive	Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities	Quantitative, qualitative	Individual format: technology-enhanced instrument, pre-post-test, interview
Laursen, S., Liston, C., Thiry, H., & Graf, J.	2007	Motivational-affective	What Good Is a Scientist in the Classroom? Participant Outcomes and Program Design Features for a Short-Duration Science outreach Intervention in K–12 Classrooms	Qualitative	Individual format: case study
Manlove, S., Lazonder, A.W., & de Jong, T.	2006	Cognitive	Regulative support for collaborative scientific inquiry learning	Quantitative	Individual format: pre-post-test
Metz, A. M.	2008	Cognitive	Teaching Statistics in Biology: Using Inquiry-based Learning to Strengthen Understanding of Statistical Analysis in Biology Laboratory Courses	Quantitative	Individual format: questionnaire Metz, A. M. (2008). Teaching Statistics in Biology: Using Inquiry-based Learning to Strengthen Understanding of Statistical Analysis in Biology Laboratory Courses *CBE—Life Sciences Education*, 7, 317-326.
Rissing, S. W. & Cogan, J.G.	2009	Cognitive	Can an Inquiry Approach Improve College Student Learning in a Teaching Laboratory?	Quantitative	Individual format: questionnaire pre-post-test
Brossard, D. & Shanahan, J.	2006	Cognitive	Do They Know What They Read? Building a Scientific Literacy Measurement Instrument Based on Science Media Coverage	Quantitative	Individual format: questionnaire

Author	Year of Publication	Indicator Area	Title	Methodical Approach	Source of Instrument
Robbins, J. & Roy, P.	2007	Cognitive	Identifying & Correcting Non-Science Student Preconceptions Through an Inquiry-Based, Critical Approach to Evolution	Quantitative	Individual format: intervention study R obbins, J. & Roy, P. (2007). Identifying & Correcting Non-Science Student Preconceptions Through an Inquiry-Based, Critical Approach to Evolution. *The American Biology Teacher*, 69(8), 460-466.
Timmerman, B. E., Strickland, D. C., &. Carstensen, S. M.	2008	Cognitive	Curricular reform and inquiry teaching in biology: where are our efforts most fruitfully invested?	Quantitative, qualitative	Individual format: experiment with pre-post-test
Gijlers, H., Saab, N., Van Joolingen, W. R., De Jong, T. De, & Van Hout-Wolters, B. H. A. M.	2009	Metacognitive	Interaction between tool and talk: how instruction and tools support consensus building in collaborative inquiry-learning environments	Quantitative	Individual format: Digital Learning Environment Gijlers, H., Saab, N., Van Joolingen, W. R., De Jong, T. De, & Van Hout-Wolters, B. H. A. M. (2009). Interaction between tool and talk: how instruction and tools support consensus building in collaborative inquiry-learning environments. Journal of Computer Assisted Learning, 25(3), 252-267.
Kaya, O. N., Yager, R., & Dogan, A.	2008	Motivational-affective	Changes in Attitudes Towards Science–Technology–Society of Pre-service Science Teachers	Quantitative, qualitative	Individual format: interviews, questionnaire
Brown, B. A.	2006	Motivational-affective	‘‘It Isn’t No Slang That Can Be Said about This Stuff’’: Language, Identity, and Appropriating Science Discourse	Qualitative	Individual format: Interviews

Beyond the area of instruments we were interested in the question, if there are differences in the methodical approaches between qualitative and quantitative studies (Table 5). We, therefore, differentiated between qualitative studies (case studies, interviews) and quantitative studies (questionnaires, tests).

Table 8

Methodical approaches specified

Instruments	Case studies (qualitative)	Interviews (qualitative)	Questionnaires (quantitative)
Implementation level (Number of instruments)			
Policy stakeholders (*n*=21)	1	10	11
Teacher education and professional development (*n*=47)	6	31	16
Teachers (*n*=36)	8	15	18
Students, pupils (*n*=41)	1	13	32

Table 8 shows that on the policy level the focus of methodical approaches is rather on questionnaires and tests (*n*=11), followed by interviews (*n*=10). Only one case study was found between the period from 2005-2009. As this review highlights, measures and indicators with regard to policy and stakeholders mainly use either large-scale quantitative databases or investigate local urban efforts with a rather qualitative perspective on teaching and learning.

On the teacher education and professional development level there are particularly interviews used for research on IBST/E (*n*=31), followed by questionnaires (*n*=16) and case studies (*n*=6). Due to the widely spread differences of TPD programs and teacher education it seems to be difficult to measure IBST in a quantitative way. Moreover, qualitative measures seem to have some advantages, e.g. in terms of collecting teachers' profession-related personnel data and experiences.

According to Table 6 it can be characterized that on the action level teacher (36 instruments) a high degree of quantitative studies are used for research (*n*=18). With regard to teachers 15 interview studies were categorized and 8 case studies. This finding emphasizes that with the increasing opportunity to investigate the use and effects of IBST methods in science classroom the number of quantitative approaches also rises.

Regarding the large number of instruments focused on the cognitive area and student learning also it is not surprising that on the student level mainly questionnaires and tests (*n*=32) could be found in our review. Thus, on the action level there are mainly standardized instruments – especially in the context of large-scale studies (e.g. PISA, TIMSS) but also experimental and intervention studies. 13 qualitative interview instruments and only one case study were detected on the student level.

4.3.4 Scaffolding the Implementation of IBST into the Classroom

As S-TEAM identifies teachers to be key players in the process of bringing IBST into the classroom we put one focus while analyzing the articles on measures that were stated to be supportive in this process. Thereby, many articles point to the teachers' missing experience with scientific inquiry (Akerson & Hanuscin, 2007; Beyer, Delgado, Davis, & Krajcik, 2009; Gengarelly & Abrams, 2009; Kaya, Yager, & Dogan, 2009; Laius, Kask, & Rannikmäe, 2009; Windschitl, Thompson, & Braaten, 2008). However, this finding is also stated for the level of students (Gengarelly & Abrams, 2009; Jang, 2009; Kelly & Mayer, 2006). Some authors identify a gap between the ambitious reform-based pedagogies advocated, for instance by the *National Science Education Standards* (NRC, 1996) or the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) and the actually existing competencies of teachers to enact them (Gengarelly & Abrams, 2009; Kaya, Yager, & Dogan, 2009). All articles agree on the assessment of IBST as highly demanding and therefore a necessary broad support for teachers to gain teaching competences for scientific inquiry (American Association for the Advancement of Science, 1993; NRC, 1996; NRC, 2000).

With regard to the features of IBST, teachers especially need to gain pedagogical content knowledge enabling them to "engage students in asking and answering scientific questions, designing and conducting investigations, collecting and analyzing data, developing explanations based on evidence, and communicating and justifying findings" (Beyer, Delgado, Davis, & Krajcik, 2009, p. 978).

Beside articles pointing to a lack of knowledge of IBST another strand of studies explain that teachers assess inquiry-related features, such as socio-cognitive conflicts (Gijlers, Saab, Van Jolingen, Jong, & Van Hout Wolters, 2009) due to different arguments as complex, controversial and uncertain und thus IBST is felt to be conflictive and hostile (Robbins & Roy, 2007; Ravenscroft, 2007; Naylor, Keogh, & Downing, 2007). For instance, scientific inquiry may contradict teachers' epistemological and teaching practices on the one hand as well as personal believes on the other hand (Naylor, Keogh, & Downing, 2007, p. 18; Albe, 2008, p. 86). Thus, a specific culture for debating and judging arguments on the basis of evidence needs to be established. Furthermore, to control these fears, research into teacher-education suggests a co-operative design of teaching sequences for in-service training (Albe, 2008, p. 86).

Looking at individual dispositions of teachers some of the articles emphasize attitudes that could function as constraints concerning the use of IBST. For example, the estimation that IBST is not necessary, not proven to be effective or having negative effects on classroom management (Laius, Kask, & Rannikmäe, 2009) seems to hinder the implementation of inquiry-based methods in science teaching. Furthermore, teachers' level of receptivity and open-mindedness are regarded as influential factors on the degree to which IBST is implemented (Gengarelly & Abrams, 2009, p. 81)

Constraints on the side of the school administration were seen in curriculum issues and the need for content coverage that limits the time for IBST (Laius, Kask, & Rannikmäe, 2009; Robbins & Roy, 2007). Especially, as IBST is regarded to need a heavy investment of time and energy, some teacher prefer to use traditional teaching methods instead (Ashmore, 2005; Robbins & Roy, 2007).

These features on the side of the individual teachers as well as the on side of administration can establish a specific school culture that serves as a barrier or scaffold for the implementation of IBST (Gelbart, Brill, & Yarden, 2009, p. 81). This kind of school culture can then affect students' and teachers' attitudes towards IBST as well as their competencies and understandings of IBST and creates a kind of self-perpetuating cycle. Another prominent feature of school culture that can support the implementation of IBST is the existence of effective teacher cooperation networks with other teachers as well as with different stakeholders (Printy, 2008). For instance, Laius et al. conclude as a result from two in-service courses which targeted the development of chemistry teachers' skills to promote inquiry or reasoning and creative thinking skills among their students: "While all teachers exhibited change as a result of the intervention, the magnitude of the change was larger in cases where the teachers were working as a team. More interdisciplinary and communication occurs where teachers support each other" (Laius, Kask & Rannikmäe, 2009, p. 149).

Beside approaches like an educative curriculum or teaching material to help teachers expanding their repertoire of instructional practices (Beyer, Delgado, Davis, & Krajcik, 2009) in-service training is the most common way to provide competences and confidence to use scientific inquiry in the classroom (Gengarelly & Abrams, 2009).

One effective type of in-service trainings is university-school-cooperation. Here scientists or undergraduates of educational sciences bring their content expertise or pedagogical knowledge into school. These co-operations differ with regard to their duration; there are short term co-operations or long term partnerships. One model is the so-called "scientist in the classroom", where short-visits of the scientist to the classroom are prepared to "give a presentation, lead a hands-on activity, or discuss scientific careers with students" (Laursen, Liston, Thiry & Graf, 2007, S. 49).

Studies analyzing changes in teacher's attitudes towards IBST and teaching approaches as a result of in-service training assess the following features as especially supportive (Albe, 2008; Akerson & Hanuscin, 2007; Laius, Kask & Rannikmäe, 2009). They agree with Desimone's (2009) suggestions for teacher development courses on the time that teachers need for professional growth but add features that focus on the arrangement of in-service courses:

1. Teachers need sufficient time to change their teaching routine (Laius, Kask & Rannikmäe, 2009). This requirement can for instance be implemented by workshops at regular intervals.
2. On-site support for individual teachers allows teachers to get feedback on their instruction, to get individual support for their lessons and assessments for their students.
3. Including teacher goals as well as the project staff goals in the program is regarded as key feature that teacher really transfer contents of the in-service training to their classroom.

To support teachers in using IBST in the classroom, policy could support the provision of effective-in-service courses, develop incentives for teacher to attend these, support changes in curricula to the requirements of IBST instead of putting pressure on teachers to adapt their lessons towards content based standards and provide public activities to disseminate IBST and scientifically substantiated effects of IBST (see Section 3.1). For instance, Scotchmoor et al. (2009) show, how effective projects – designed to improve public understanding of and interest in science – can create a public awareness of the nature of science and the need for advanced teaching methods in science instruction. As mentioned above, the lack of importance given to scientific issues by parents and peer group contributes to students' low motivation for science (Prenzel & Duit, 2000). Thus, projects as described by Scotchmoor et al. (2009), can increase teachers' dispositions to use advanced teaching methods and can establish a supportive public awareness for the effectiveness of IBST in the classroom. The following Table 5 summarizes these findings:

Table 9.

Constrains and suggestions for solutions specified according to target groups

Constraints in implementing IBST…	**…can be removed on**
on the **policy level**	

missing value of scientific topics in public, peer-groups, parents	*through*: projects, to stimulate public discussion about science networks with different stakeholders to disseminate IBST widely
narrow curricula	*through:* curricula adapted to nature of science and correlating teaching methods like IBST incentives for teacher to attend in-service
	on the **teacher education/TPD level**
missing knowledge in IBST and lack confidence to enact IBST	*through:* effective pre- and in-service training university-school co operation educative curricula, teaching material
perceptions of IBST as conflictive	developing teaching sequence with teachers
	on the **action level**
missing knowledge in IBST and lack confidence to enact IBST	*through:* teacher-cooperation
perceptions of IBST as conflictive	*through:* developing a positive conflict culture

5. Discussion

The aim of this review is to summarize indicators and measurement instruments for IBST specified for different implementation levels (policy, teacher education/TPD, teachers and students) and to show potential for further research.

The literature review presents an overview about measures and indicators from 2005-2009. Generally, the number of published articles shows substantical activities of science researchers in the area of IBST. According to the EU project S-TEAM and its aim to develop strategies and materials to disseminate IBST/E throughout Europe we focused especially on empirical studies and found in total 367 empirical (quantitative and qualitative) studies. We therefore assumed that empirical data is helpful for collecting indicators for the formative assessment of the dissemination within S-TEAM.

The indicators' research highlights the focus on the action level. Thus, teachers and students are mainly in the backsight of research on IBST. On the level of teacher education and professional development also numerous empirical studies published between 2005 and 2009 were found. The lowest amount of studies could be identified for the policy level. Thus, our research emphasizes the importance of further empirical studies, because the implementation of IBST does not only benefit from empirical data on the action level but also from leaders and stakeholders on the policy level (see Jorde et al., 2010).

To gain an insight into specific areas of indicators we decided to specify the research dependent on cognitive, motivational-affective and metacognitive indicators. As the findings highlight, the focus of cognitive instruments is mainly on students and student learning. By contrast, the area of motivational-affective instruments is mainly focused on teacher education, teacher professional development and teachers. Thereby, this finding shows that research concentrates on attitudes, beliefs and opinions about IBST/E. It is not surprising due to the fact that the implementation of IBST depends on positive attitudes and beliefs of teachers, teacher educators and stakeholders. However, this finding also points to the demand of the development of adequate instruments to measure IBST related knowledge of teachers, university instructors and administrative stakeholders who rather are responsible for the implementation of IBST into the classroom teaching practice. Moreover, our results of research into teacher professional development point to the lack of instruments that measure the effectiveness of in-service and pre-service courses. With regard to metacognitive instruments – focused on e.g. learning strategies and tasks – there seems also to be a gap of elaboration. Therefore, they should increasingly be considered in further research on IBST/E (Grangeat, 2009).

According to the demonstration of measures' and indicators' foci in the recent research this review points to gaps and constraints about the implementation of inquiry-based methods into science teaching and science teacher education. In the context of the EU-project S-TEAM and the targeted development of instruments and other products for the dissemination of IBST across Europe we report constraints as well as supportive ways to implement IBST with regard to further dissemination and research activities within and beyond the project. Importing aspects for a successful implementation of IBST activities are e.g. the development of appropriate materials, the support of individual beliefs about the usefulness of IBST, the provision of teacher trainings as well as the improvement of teacher collaboration and communication.

This review emphasizes the fact, that the majority of existing instruments on measuring IBST in the classroom and beyond is rather fragmented and specific to individual research questions. One aim of this review, therefore, was to provide researchers and practitioners an overview about existing measures and indicators for IBST, to collect instruments and to make them available to the widest possible range of public interest in the context of S-TEAM.

Acknowledgments

We would like to thank Raphael Bernhardt, Linda Kohlbrenner, Sylvia Pfeifer and Stephanie Müller who helped us categorizing the articles and preparing tables and figures for this report.

References

** Articles have been part of the review investigation*

Abell, S. K. (2000). *International Perspectives on Science Teacher Education. Science Teacher Education. An International Perspective*. London: Kluwer.

Abd-el-Khalick, F., & Lederman, N.G. (1999). *Success of the attempts to improve science teachers' conceptions of nature of science: A review of the literature*. Paper presented at the 5th History and Philosophy of Science & Science Teaching conference, Padova, Italy.

*Akerson, V. L., & Hanuscin, D. L. (2007). Teaching Nature of Science through Inquiry: Results of a 3-Year Professional Development Program. *Journal of Research in Science Teaching*, 44 (5), 653–680.

*Albe, V. (2008). When Scientific Knowledge, Daily Life Experience,Epistemological and Social Considerations Intersect: Students' Argumentationin Group Discussions on a Socio-scientific Issue. *Research on Science Education , 38*, 67–90.

American Association for the Advancement of Science. (1993). *Benchmark for Scientific Literacy.* Washington, D.C.

*Ansell, C., Reckhow, S., & Kelly, A. (2009). How to reform a reform coalition: Outreach, Agenda Expansion, and Brokerage in Urban School Reform. *The Policy Studies Journal*, 37(4), 717–743.

*Ashmore, P. C. (2005). Role of Physical Anthropology in Intermediate and Secondary Education. *Yearbook of Physical Anthroplogy*, 48, 154–162.

*Bell, L. R., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction: assessing the inquiry level of classroom activities. *Science Teaching*, 72(7), 30–33.

*Beyer, C. J., Delgado, C., Davis, E. A., & Krajcik, J. (2009). Investigating Teacher Learning Supports in High School Biology Curricular. *Journal of Research in Science Teaching*, 46, 977–998.

*Budnitz, N. (2001). *Center for Inquiry-Based-Learning*. Durham, NC: Duke University. http://www.biology.duke.edu/cibl (accessed 20 March 2010).

Burden, P. R. (1990). Teacher development. In R. Houston (Ed.), *Handbook of teacher education* (pp. 311–328), New York: McMillan.

*Bybee, R. W. & B. J. McCrae, Eds. (2009). *PISA 2009. Implications for Science Teachers and Teaching*. Arlington, Virginia, NSTA Press.

Cochran-Smith, M. (2003): Learning and Unlearning: The education of teacher educators. *Teaching and Teacher Education*, 19, 5–28.

Commission of the European Communities (2009). *Consultations on the future "EU 2020" strategy.* Brussels: EU.

Constable, H. & Long, A. (1991). Changing science teaching: Lessons from a long-term evaluation of a short in-service course. *International Journal of Science Education*, 13, 405–419.

*Cunningham, S. C., McNear, B., Pearlman, R. S., & Kern, S. E. (2006). Beverage-Agarose Gel Electrophoresis: An Inquiry-based Laboratory Exercise with Virtual Adaptation. *CBE—Life Sciences Education , 5*, 281–286.

Darling-Hammond, L., & Sykes, G. (Eds.) (1999). *Teaching as the learning profession: Handbook of policy and practice.* San Francisco: Jossey-Bass.

*Desimone, L. M. (2009). Improving impact studies of teachers' professional development: toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181–199.

*Desimone, L., Smith, T. M., & Phillips, K. J. R. (2007). Does Policy Influence Mathematics and Science Teachers' Participation in Professional Development? *Teachers College Press*, 109(5), 1086–1122.

Duschl, R. A. (2003). Assessment of Inquiry. In J. M. Atkin & J. Coffey (Eds.), *Everyday Assessment in the Science Classroom* (pp. 41–59). Arlington, Virginia: NSTA Press.

*Foy, J. G., Marissa Feldman, L. E., & Mahoney, M. M. (2006). Neuroscience Workshops for Fifth-Grade School Children by Undergraduate Students: A University–School Partnership. *CBE—Life Sciences Education*, *5*, 128–136.

*Furtak, E. M. & Shavelson, R. J. (2009). Guidance, Conceptual Change, and Student Learning: An Investigation of Inquiry-Based Teaching in the US. In: T. Janik & T. Seidel (Eds.), *The Power of*

Video Studies in Investigating Teaching and Learning in the classroom (pp. 181–206). Münster: Waxmann.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (in prep.). Recent experimental studies of inquiry-based teaching: A conceptual review and meta-analysis.

Garet, M. S., Porter, A. C., Desimone, L. M., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Analysis of a national sample of teachers. *American Educational Research Journal, 38* (3), 915–945.

*Gelbart, H., Brill, G., & Yarden, A. (2009). The Impact of a Web-Based Research Simulation in Bioinformatics on Students' Understanding of Genetics. *Research in Science Education ,* 39, 725–751.

*Gengarelly, L. M. & Abrams, E. D. (2009). Closing the Gap: Inquiry in Research and the Secondary Science Classroom. *Journal of Science Education Technology*, 18, 74–84.

*Gerard, L. F., Bowyer, J. B., & Linn, M. C. (2008). Principal Leadership for Technology-enhanced Learning in Science. *Journal of Science Education Technology*, 17, 1–18.

*Gijlers, H., Saab, N., Van Joolingen, W.R., De Jong, T. & Van Hout-Wolters, B.H.A.M. (2009). Interaction between tool and talk. *Journal of Computer Assissted Learning,* 25, 252–267.

*Goebel, C. A., Umoja, A., & DeHaan, R. L. (2009). Providing Undergraduate Science Partners for Elementary Teachers: Benefits and Challenges. *CBE—Life Sciences Education*, 8, 239–251.

Grangeat, M. (2009). *Effects of teaching approaches on learning outcomes: The role of metacognition in developing indicators*. Presentation at the Annual Conference of the European Educational Research Association in Vienna/Austria.

*Greensfeld, H. & Elkad-Lehman, I. (2007): An Analysis of the Processes of Change in Two Science Teacher Educators Thinking. *Journal of Research in Science Teaching,* 44, 1219–1245.

Haney, J. J., Czerniak, C. M., & Lumpe, A. T. (1996). Teacher beliefs and intentions regarding the implementation of science education reform strands. *Journal of Research in Science Teaching*, 33, 971–993.

Heinz, J., Lipowski, K., Gröschner, A., & Seidel, T. (2010). *Indicators review in the context of S-TEAM*. Munich: TUM.

Hewson, P. W., Tabachnick, B. R., Zeichner, K. M., & Lemberger, J. (1999). Educating prospective teachers of biology: Findings, limitations and recommendations. *Science Education*, 83, 373–384.

Hmelo-Silver, C. E., Dunca, R. G., & Chinn, C. A. (2007). Scaffolding and Achievement in Problem-Based and Inquiry Learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, 42(2), 99–107.

Horizon Research (2000). *Local Systemic Change Through Teacher Enhancement Professional Development Observation Protocol*. Retrieved January 30, 2004, from http://www.horizon-research.com/instruments/lsc/pdop.php

*Hug, B., Krajcik, J. S., & Marx, R. W. (2005). Using Innovative Learning Technologies to Promote Learning and Engagement in an Urban Science Classroom. *Urban Education*, 40(4), 446–472.

IEA International Association for the Evaluation of Educational Achievement. (2007). *TIMSS Trends in Intenational Maths and Science Study. Assessment Frameworks.* Boston.

*Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning, 24*, 271–283.

*Jang, S.-J. (2009). Exploration of secondary students' creativity by integrating web-based technology into an innovative science curriculum. *Computers & Education, 52*, 247–255.

*Jorde, D., & Klette, K. (2008): *Mind the Gap. EU Grant Agreement*. Oslo: University of Oslo.

Jorde, D., Moberg, A. O., Prenzel, M., Rönnebeck, S., & Stadler, M. (2010). *S-TEAM Preliminary Report: Work packages 2 & 3*. Trondheim: NTNU.

*Kaya, D. O., Yager, R., & Dogan, A. (2009). Changes in Attitudes Towards Science–Technology. *Research in Science Educatio ,* 39, 257–279.

*Kelly, G. J., & Mayer, R. E. (2006). Contextual Epistemic Development in Science: A Comparison of Chemistry Students and Research Chemists. *Science Education*, 90(3), 468–495.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why Minimal Guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and Inquiry-Based Teaching. *Educational Psychologist*, 41(2), 75–86.

*Kollar, I., Fischer, F., & Slotta, J. D. (2007). Internal and external scripts in computer-supported collaborative inquiry learning. *Learning and Instruction , 17*, 708–721.

*Krajcik, J., Blumenfeld, P., Marx, R., & Soloway, E. (2000). Instructional, curricular, and technological supports for inquiry in science classrooms. In J. Minstrell & E. Van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 283–315). Washington, DC: American Association for the Advancement of Science.

*Laius, A., Kask, K., & Rannikmäe, M. (2009). Comparing outcomes from two case studies on chemistry teachers' readiness to change. *Chemistry Educational Research Practice*, 10, 142–153.

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What Good Is a Scientist in the Classroom? Participant Outcomes and Program Design Features for a Short-Duration Science Outreach Intervention in K–12. *CBE—Life Sciences Education ,* 6, 49–64.

*Lavonen, J. & Laaksonen, S. (2009). Context of Teaching and Learning School Science in Finland: Reflections on PISA 2006 Results. *Journal of Research in Science Teaching*, 46(8), 922–944.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29, 331–359.

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching*, 36, 916–929.

LeTendre, G. K., Baker, D. P., Akiba, M., Goesling, B., & Wiseman, A. (2001). Teachers' Work: Institutional Isomorphism and Cultural Variation in the U.S., Germany, and Japan. *Educational Researcher, 30*(6), 3–15.

*Lindahl, M. G. (2009). Ethics or Morals: Understanding Students' Values. *Science & Education*, 1285–1311.

Lipowski, K. & Seidel, T. (2009). *Report on existing models of teacher professional development on IBST in seven European countries*. Jena: Friedrich-Schiller-University.

Lipowski, K. & Stadler, M. (2009, 9 January). *Mind the Gap: Teacher professional development in Europe*. Paper presented at the ASE Annual Conference, Reading, United Kingdom.

*Manlove, S., Lazonder, A., & de Jong, T. (2006). Regulative support for collaborative scientific inquiry learning. *Journal of Computer Assisted Learning, 22,* 87–98.

*Maor, D., & Fraser, B. J. (2005). An Online Questionnaire for Evaluating Students' and Teachers' Perceptions. *Research in Science Education*, 35, 221–244.

Marx, R.W., Blumenfeld, P.C., Krajcik, J.S., Fishman, B., Soloway, E., Geier, R., & Tali Tal, R. (2004). Inquiry-based Science in the Middle Grades: Assessment of Learning in Urban Systemic Reform. *Journal of Research in Science Teaching*, 41 (10), 1063–1080.

*Moscovici, H. (2009). Science Teacher Retention in Today's Urban Schools. *Urban Education*, 44(1), 88–105.

*Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and Primary Science. *Research in Science Education*, 37, 17–39.

National Research Council (1996). *National Science Education Standards*. Washington, D.C.: National Academy of Sciences.

National Research Council (2000). *Inquiry and the National Science Education Standards. A Guide for Teaching and Learning*. Washington, D.C.: The National Academy Press.

*Nisbet, M. C. & Goidel, R. K. (2007). Understanding citizen perceptions of science controversy: bridging the ethnographic-survey research divide. *Public Understanding of Science*, 16, 421–440.

OECD (2005). *Teachers matters: Attracting, Developing and Retaining Effective Teachers*. Paris: OECD.

*OECD (2007). *PISA 2006. Competencies for tomorrow's world. Volume 1: Analysis.* Paris: OECD.

OECD (2009). *Creating Effective Teaching and Learning Environments. First Results from TALIS*. Paris: OECD.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25, 1049–1079.

Ostermeier, C., Prenzel, M., & Duit, R. (2010). Improving Science and Mathematics Instruction: The SINUS Project as an example for reform as teacher professional development. *International Journal of Science Education*, 32(3), 303–327.

Prenzel, M. (2000). Steigerung der Effizienz des mathematisch-naturwissenschaftlichen Unterrichts: Ein Modellversuch von Bund und Ländern. *Unterrichtswissenschaft*, 28, 103–126.

Prenzel, M. & Duit, R. (2000). *Increasing the efficiancy of science and mathematics instruction: Report of a national quality development program.* New Orleans: Paper presented at the Annual Meeting of the National Association for Resarch in Science Teaching.

Prenzel, M. & Seidel, T. (2009). A Perspective on U.S. Science Teaching and Learning. In R. W. Bybee & B. J. McCrae (Eds.), *PISA Science 2006. Implications for Science Teachers and Teaching* (pp. 111–115). Arlington, Virginia: NSTA Press.

Prenzel, M., Seidel, T., & Kobarg, M. (in press). Science teaching and learning: An international comparative perspective. In B. Fraser, K. Tobin, & C. McRobbie (Eds.), *Second International Handbook of Science Education*. New York: Springer.

*Printy, S. M. (2008). Leadership for Teacher Learning: A Community of Practice Perspective. *Educational Administration Quarterly*, 44 (2), 187–226.

*Quitadamo, I. J., Faiola, C. L., Johnson, J. E., & Kurtz, M. J. (2008). Community-based Inquiry Improves Critical Thinking in General Education Biology. *Life Sciences Education, 7*, 327–337.

*Ravenscroft, A. (2007). Promoting thinking and conceptual change with digital dialogue games. *Journal of Computer Assisted Learning, 23, 453–465*.

*Robbins, J. R. & Roy, P. (2007). Identifying & Correcting Non-Science Student Preconceptions Through an Inquiry-Based, Critical Approach to Evolution. *The American Biology Teacher, 69*, 460–466.

Roth, K. J., Druker, S. L., Garnier, H. E., Lemmens, M., Chen, C., Kawanaka, T., Rasmussen, D. et al. (2006). *Teaching Science in Five Countries: Results from the TIMSS Video Study. Statistical Analysis Report*. Washington, D.C.: National Center for Education Statistics, U.S. Department of Education.

*Saab, N., Van Joolingen, W. R., & Van Hout-Wolters, B. H. (2005). Communication in collaborative discovery learning. *British Journal of Educational Psychology , 75*, 603–621.

*Sadler, T. D., Barab, S. B., & Scott, B. (2007). What Do Students Gain by Engaging in Socioscientific Inquiry? *Research in Science Education, 37*, 371–391.

*Schneider, R. M., Krajcik, J., & Blumenfeld, P. (2005). Enacting Reform-Based Science Materials: The Range of Teacher Enactments in Reform Classrooms. *Journal of Research in Science Teaching*, 42(3), 283–312.

Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.* Manuscript.

*Schuster, D. A. & Carlsen, W. S. (2008). Scientists' Teaching Orientations in the Context of Teacher Professional Development. *Science Education Policy*, 93, 635–655.

Scotchmoor, J.,Thanukos, A., & Potter, S. (2009). Improving the public understanding of science: New Initiatives. *American Journal of Botany,* 96(10), 1760–1766.

Seidel, T. & Prenzel, M. (2006a). Teaching and Learning of Science. In Australian Council for Educational Research (Ed.), *PISA 2006 Contextual Framework* (pp. 57–73). Camberwell: Australian Council of Educational Research (ACER).

Seidel, T. & Prenzel, M. (2006b). Stability of teaching patterns in physics instruction: Findings from a video study. *Learning and Instruction*, 16(3), 228–240.

Seidel, T., Prenzel, M., Rimmele, R., Schwindt, K. K., Herweg, C., & Dalehefte, I. M. (2006). Unterrichtsmuster und ihre Wirkungen. Eine Videostudie im Physikunterricht. In: M. Prenzel, & L. Allolio-Näcke (Eds.), *Untersuchungen zur Bildungsqualität von Schule. Abschlussbericht des DFG-Schwerpunktprogramms* (pp. 99–126). Münster: Waxmann.

Seidel, T., Prenzel, M., Schwindt, K., Rimmele, R., Kobarg, M., & Dalehefte, I. M. (2009). The Link between Teaching and Learning – Investigating Effects of Physics Teaching on Student Learning in the Context of the IPN Video Study. In T. Janik & T. Seidel (Eds.), *The Power of Video Studies in Investigating Teaching and Learning in the Classroom* (pp. 161–180). Münster: Waxmann.

Seidel, T., Prenzel, M., Wittwer, J., & Schwindt, K. (2007). Unterricht in den Naturwissenschaften. In M. Prenzel, C. Artelt, J. Baumert, W. Blum, M. Hamman, E. Klieme, & R. Pekrun (Eds.), *PISA 2006 Die Ergnisse der dritten internationalen Vergleichsstudie* (pp. 147–179). Münster: Waxmann.

Seidel, T., Rimmele, R., & Prenzel, M. (2005). Clarity and coherence of lesson goals as a scaffold for student learning. *Learning and Instruction*, 15(6), 539–556.

Seidel, T., Schwindt, K., Kobarg, M., & Prenzel, M. (2008). Grundbedingungen eines lernwirksamen Unterrichts erkennen - Eine Untersuchung zur Erfassung pädagogisch-psychologischer Kompetenzen bei Lehrerinnen und Lehrern. In W. Lütgert, A. Gröschner, & K. Kleinespel (Eds.), *Die Zukunft der Lehrerbildung. Entwicklungslinien, Rahmenbedingungen, Forschungsbeispiele* (pp. 198–214). Weinheim/Basel: Beltz.

Seidel, T., & Shavelson, R. J. (2007). Teaching effectiveness research in the last decade: Role of theory and research design in disentangling meta-analysis results. *Review or Educational Research*, 77, 454–499.

Sherin, M., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education, 20,* 163–183.

*Silk, E. M., Schunn, C. M., & Cary, M. S. (2009). The Impact of an Engineering Design Curriculum on Science Reasoning in an Urban Setting. *Journal of Science Education Technology, 18*, 209–223.

Smith, K. (2003): *Teacher Educators Professional Knowledge – How does it differ from Teachers Professional Knowledge*. Paper presented at the Annual AERA meeting, Chicago, April.

S-TEAM, WP 6 (without reference names) (2009). *Improving teachers' capacities to motivate students. Baseline report,* S-TEAM. Oslo: NTNU.

Stigler, J.W., Gallimore, R., & Hiebert, J. (2000). Using video surveys to compare classrooms and teaching across cultures: Examples and lessons from the TIMSS video studies. *Educational Psychologist*, 35, 87–100.

Supovitz, J. A., Mayer, D. P., & Kahle, J. B. (2000). Promoting Inquiry-Based Instructional Practice: The Longitudinal Impact of Professional Development in the Context of Systematic Reform. *Educational Policy*, 14(3), 331–356.

*Tammi, T. (2009). The competitive funding of university research: the case of Finnish science universities. *Higher Education*, 57, 657–679.

*Tenenbaum, H. R., Snow, C. E., Roach, K. A., & Kurland, B. (2005). Talking and reading science: Longitudinal data on sex differences in mother-child conversations in low-income families. *Applied Developmental Psychology*, 26, 1–19.

*Timmerman, B. E., Strickland, D. C., & Carstensen, S. M. (2008). Curricular reform and inquiry teaching in biology: where are our efforts most fruitfully invested? *Integrative and Comparative Biology , 48 (2)*, 226–240.

Tom, A.R. & Valli, L. (1990). Professional knowledge for teachers. In W.R. Houston (Ed.), Handbook of research on teacher education (pp. 372–392). New York: Macmillan.

van Driel, J. H., Beijaard, D.. & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching,* 2001*, 38*, 137–158.

Wilson, S.M. & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. In: Iran-Nejad, A. & Pearson, P.D. (Eds.), *Review of research in education* (pp. 173–210)**.** Washington, DC: American Educational Research Association.

*Windschitl, M., Thompson, J., & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in Classrooms. *Cognition and instruction*, 26 (3), 310–378.

*Wolf, S. J. & Fraser, B. J. (2008). Learning Environment, Attitudes and Achievement among Middle-school Science Students Using Inquiry-based Laboratory Activities. *Research on Science Education*, 321–341.

*Zacharia, Z. (2007). Comparing and combining real and virtual experimentation: an effort to enhance students' conceptual understanding of electric circuits. *The Author. Journal compilation,* 120–132.

*Zucker, A. A. & Hug, S. T. (2008). Teaching and Learning Physics in a 1:1 Laptop School. *Journal of Science Education Technology*, 17, 586–594.

Appendix: References of the Review Investigation

Policy Level

Ansell, C., Reckhow, S., & Kelly, A. (2009). How to reform a reform coalition: Outreach, Agenda Expansion, and Brokerage in Urban School Reform. *The Policy Studies Journal*, *37*(4), 717–743. doi: 0190-292X

Desimone, L., Smith, T. M., & Phillips, K. J. R. (2007). Does Policy Influence Mathematics and Science Teachers' Participation in Professional Development? *Teachers College Press*, *109*(5), 1086–1122.

Friedrichsen, P. J., Abell, S. K., Pareja, E. M., Brown, P. L., Lankford, D. M., & Volkmann, M. J. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for Teaching in an Alternative Certification Program. *Journal of Research in Science Teaching*, *46*(4), 357–383. doi: 10.1002/tea.20283

Gerard, L. F., Bowyer, J. B., & Linn, M. C. (2008). Principal Leadership for Technology-enhanced Learning in Science. *Journal of Science Education Technology*, *17*, 1–18. doi: 10.1007/s10956-007-9070-6

Hanushek, E. A. & Rivkin, S. G. (2009). Harming the Best: How Schools Affect the Black-White Achievement Gap. *Journal of Policy Analysis and Management, 28*(3), 366–393. doi: 10.1002/pam.20437

Harris, D. N. & Sass, T. R. (2009). The Effects of NBPTS-Certified Teachers on Student Achievement. *Journal of Policy Analysis and Management*, *28*(1), 55–80. doi: 10.1002/pam.20402

Horng, E. L. (2009). Teacher Tradeoffs: Disentangling Teachers' Preferences for Working Conditions and Student Demographics. *American Educational Research Journal, 46*(3), 690–717. doi: 10.3102/0002831208329599

Huang S. L. & Fraser, B. J. (2009). Science Teachers' Perceptions of the School Environment: Gender Differences. *Journal of Research in Science Teaching, 46*(4), 404–420. doi: 10.1002/tea.20284

Hug, B., Krajcik, J. S., & Marx, R. W. (2005). Using Innovative Learning Technologies to Promote Learning and Engagement in an Urban Science Classroom. *Urban Education*, *40*(4), 446–472. doi: 10.1177/0042085905276409

Matsumura, L. C., Sartoris, M., Bickel, D. D., & Garnier, H. E.(2009). Leadership for Literacy Coaching: The Principal's Role in Launching New Coaching Program. *Educational Administration Quarterly, 45*(5), 655–693. doi: 10.1177/0013161X09347341

Moscovici, H. (2009). Science Teacher Retention in Today's Urban Schools. *Urban Education*, *44*(1), 88–105. doi: 10.1177/0042085908318527

Nisbet, M. C. & Goidel, R. K. (2007). Understanding citizen perceptions of science controversy: bridging the ethnographic-survey research divide. *Public Understanding of Science, 16*, 421–440. doi: 10.1177/0963662506065558

OECD (2005a). School Questionnaire for PISA 2006: Main Study. Paris: OECD.

Porter, A. C., Polikoff, M. S., & Smithson, J. (2009). Is There a de Facto National Intended Curriculum? Evidence From State Content Standards. *Educational Evaluation and Policy Analysis, 31*(3), 238—268. doi: 10.3102/0162373709336465

Printy, S. M. (2008). Leadership for Teacher Learning: A Community of Practice Perspective. *Educational Administration Quarterly, 44*(2), 187–226. doi: 0.1177/0013161X07312958

Quitadamo, I. J., Faiola, C. L., Johnson, J. E., & Kurtz, M. J. (2008). Community-based Inquiry Improves Critical Thinking in General Education Biology. *Life Sciences Education, 7*, 327–337. doi: 10.1187/cbe.07–11–0097

Saka Y., Souther-land, S. A., & Brooks, J. S. (2009). Becoming a Member of a School Community While Working Toward Science Education Reform: Teacher Induction from a Cultural Historical Activity Theory (CHAT) Perspective. *Science Education, 93,* 996 – 1025. *doi: 10.1002/sce.20342*

Schneider, R. M., Krajcik, J., & Blumenfeld, P. (2005). Enacting Reform-Based Science Materials: The Range of Teacher Enactments in Reform Classrooms. *Journal of Research in Science Teaching, 42*(3), 283–312. doi: 10.1002/tea.20055

Tenenbaum, H. R. & Callanan, M. A. (2008). Parents' science talk to their children in Mexican-descent families residing in the USA. *International Journal of Behavioral Development, 32*(1), 1–12. doi: 10.1177/0165025407084046

Tuytens, M. & Devos, G. (2009). Teachers’ perception of the new teacher evaluation policy: A validity study of the Policy Characteristics Scale. *Teaching and Teacher Education, 25*, 924–930. doi: 10.1016/j.tate.2009.02.014

Walter, A. I., Helgen-berger, S., Wiek, A., & Scholz, R. W. (2007). Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method. *Evaluation and Program Planning, 30*, 325–338. doi: 10.1016/j.evalprogplan.2007.08.002

Teacher Education and Teacher Professional Development Level

Aduriz-Bravo, A., Izquierdo-Aymerich, M. (2009). A Research-Informed Instructional Unit to Teach the Nature of Science to Pre-Service Science Teachers. *Science & Education, 18*, 1177–1192. doi: 10.1007/s11191-009-9189-3

Akerson, V. L., Cullen, T. A., & Hanson, D. L. (2009). Fostering a Community of Practice through a Professional Development Program to Improve Elementary Teachers' Views of Nature of Science and Teaching Practice. *Journal of Research in Science Teaching, 46*(10), 1090–1113. doi: 10.1002/tea.20303

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching Nature of Science through Inquiry: Results of a 3-Year Professional Development Program. *Journal of Research in Science Teaching, 44*(5), 653–680.

Banilower, E. R., Heck, D. J., & Weiss, I. R.(2007). Can Professional Development Make the Vision of the Standards a Reality? The Impact of the National Science Foundation's Local Systemic Change Through teacher Enhancement Initiative. *Journal of Research in Science Teaching, 44*(3), 375–395. doi: 10.1002/tea.20145

Bantwini, B. D. (2009). How teachers perceive the new curriculum reform: Lessons from a school district in the Eastern Cape Province, South Africa. *International Journal of Educational Development, 30*, 83–90. doi:10.1016/j.ijedudev.2009.06.002

Bencze, J. L. (2008). Promoting student-led science and technology projects in elementary teacher education: entry into core pedagogical practices through technological design. *International Journal of Technology and Design Education, 20*, 43–62. doi: 10.1007/s10798-008-9063-7

Berry, A., Loughran, J., Smith, K., & Lindsay, S. (2008). Capturing and Enhancing Science Teachers' Professional Knowledge. *Research in Science Education, 39*, 575–594. doi: 10.1007/s11165-008-9095-8

Bianchini, J. A. & Brenner, M. E. (2007). The Role of Induction in Learning to Teach Toward Equity: A Study of Beginning Science and Mathematics Teachers. *Science Education, 94*, 164 – 195. doi: *10.1002/sce.20353*

Christodoulou, N., Varelas, M., & Wenzel, S. (2009). Curricular Orientations, Experiences, and Actions: Graduate Students in Science and Mathematics Fields Work in Urban High School Classrooms. *JOURNAL OF RESEARCH IN SCIENCE TEACHING, 46*(1), 1–26. doi: 10.1002/tea.20264

Crawford, B. A. (2007). Learning to Teach Science as Inquiry in the Rough and Tumble of Practice. *Journal of Research in Science Teaching, 44*(4), 613–642. doi: 10.1002/tea.20157Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the

Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91,* 629–663. doi: *10.1002/sce.20207*

Donnelly, L. A. & Sadler, T. D. (2009). High School Science Teachers' Views of Standards and Accountability. *Science Education, 93*, 1050–1075. doi: 10.1002/sce.20347

Elmesky, R. & Tobin, K. (2005). Expanding Our Understandings of Urban Science Education by Expanding the Roles of Students as Researchers. *JOURNAL OF RESEARCH IN SCIENCE TEACHING, 42*(7), 807–828. doi: 10.1002/tea.20079

Forbes, C. T. & Davis, E. A. (2208). The Development of Preservice Elementary Teachers' Curricular Role Identity for Science Teaching. *Science Education, 92,* 909—939. doi: 10.1002/sce.20265

Friedrichsen, P. J., Abell, S. K., Pareja, E. M., Brown, P. L., Lankford, D. M., & Volkmann, M. J. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for Teaching in an Alternative Certification Program. *Journal of Research in Science Teaching*, *46*(4), 357–383. doi: 10.1002/tea.20283

Greensfeld, H. & Elkad-Lehman, I. (2007): An Analysis of the Processes of Change in Two Science Teacher Educators Thinking. *Journal of Research in Science Teaching, 44*, 1219–1245. doi: 10.1002/tea.20185

Hardrè,P. L. & Sullivan, D. W. (2008). Teacher perceptions and individual differences: How they influence rural teachers' motivating strategies. *Teaching and Teacher Education, 24*, 2059–2075. doi:10.1016/j.tate.2008.04.007

Hanuscin, D. L., Akerson, V. L., & Phillipson-Mower, T. (2006). Integrating Nature of Science Instruction into a Physical Science Content Course for Preservice Elementary Teachers: NOS Views of Teaching Assistants. *Science Education, 90,* 912–935. doi: 10.1002/sce.20149

Henze, I., Van Driel, J. H. & Verloop, N. (2009). Experienced Science Teachers' Learning in the Context of Educational Innovation. *Journal of Teacher Education, 60*(2), 184–199. doi: 10.1177/0022487108329275

Hilferty, F. (2008). Contesting the Curriculum: An Examination of Professionalism as Defined and Enacted by Australian History Teachers. Curriculum Inquiry, 37(3), 239–261.

Hoekstra, A., Brekelmans, M., Beijaard, D., & Korthagen, F. (2009). Experienced teachers' informal learning: Learning activities and changes in behavior and cognition. *Teaching and Teacher Education, 25*, 663–673. doi:10.1016/j.tate.2008.12.007

Irez, S. (2006). Are We Prepared? An Assessment of Preservice Science Teacher Educators' Beliefs About Nature of Science. *Science Education, 90*, 1113–1143. doi: 10.1002/sce.20156

Johnson, C. C. & Fargo, J. D. (2009). Urban School Reform Enabled by Transformative Professional Development: Impact on Teacher Change and Student Learning of Science. *Urban Education, 45*(1), 4–29. doi: 10.1177/0042085909352073

Karakas, M. (2009). Cases of Science Professors' Use of Nature of Science. *Journal of Science Education and Technology, 18*, 101–119. doi: 10.1007/s10956-008-9136-0

Laius, A., Kask, K., & Rannikmäe, M. (2009). Comparing outcomes from two case studies on chemistry teachers' readiness to change. *Chemistry Educational Research Practice*, 10, 142–153. doi: 10.1039/b908251b

Lawrenz,F., Wood, N. B., Kirchhoff, A., Kim, N. K., & Eisenkraft, A. (2009). Variables Affecting Physics Achievement. *Journal of Research in Science Teaching, 46*(9), 961–976. doi: 10.1002/tea.20292

Lee, O., Luykx, A., Buxton, C., & Shaver, A. (2007). The Challenge of Altering Elementary School Teachers' Beliefs and Practices Regarding Linguistic and Cultural Diversity in Science Instruction. *Journal of Research in Science Teaching, 44*(9), 1269–1291. doi: 10.1002/tea.20198

Leou, M., Abder, P., Riordan, M., & Zoller, U. (2006). Using 'HOCS-Centered Learning' as a Pathway to Promote Science Teachers' Metacognitive Development. *Research in Science Education*, *36*, 69–84. doi: 10.1007/s11165-005-3916-9

Lotter, C., Harwood, W. S., & Bonner, J. J. (2007). The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices. *Journal of Research in Science Teaching*, *44*(9), 1318–1347. doi: 10.1002/tea.20191

Metz, K. E. (2008). Elementary School Teachers as "Targets and Agents of Change": Teachers' Learning in Interaction With Reform Science Curriculum. *Science Teacher Education, 93*, 915–954. doi: 10.1002/sce.20309

Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45*(6), 684–710. doi: 10.1002/tea.20258

Mushayikwa, E. & Lubben, F. (2008). Self-directed professional development – Hope for teachers working in deprived environments? *Teaching and Teacher Education, 25*, 375–382. doi:10.1016/j.tate.2008.12.003

Nelson, T. H. (2008). Teachers' Collaborative Inquiry and Professional Growth: Should We Be Optimistic? *Science Education, 93,* 548—580. doi: 10.1002/sce.20302

Ruby, A. (2006). Improving Science Achievement at High-Poverty Urban Middle Schools. *Science Education, 90,* 105—1027. doi: 10.1002/sce.20167

Saitoa, E., Tsukuib, A., & Tanakaa, Y. (2008). Problems on primary school-based in-service training in Vietnam: A case study of Bac Giang province.

Scantlebury, K., Gallo-Foxa, J., & Wassellb, B. (2008). Co-teaching as a model for preservice secondary science teacher education. *Teaching and Teacher Education, 24*, 967–981. doi:10.1016/j.tate.2007.10.008

Schuster, D. A. & Carlsen, W. S. (2008). Scientists' Teaching Orientations in the Context of Teacher Professional Development. *Science Education Policy*, *93*, 635–655. doi: *10.1002/sce.20310*

Smith, L. K., & Southerland, S. A. (2007). Reforming Practice or Modifying Reforms? Elementary Teachers' Response to the Tools of Reform. *Journal of Research in Science Teaching, 44*(3), 396–423. doi: 10.1002/tea.20165

Snider, V. E. & Roehl, R. (2007). Teachers' Beliefs about pedagogy and related Issues. *Psychology in the Schools, 44*(8), 873—886. doi: 10.1002/pits.20272

Spektor-Levy, O., Eylon, B.-S., & Scherz, Z. (2008). Teaching communication skills in science: Tracing teacher change. *Teaching and Teacher Education, 24,* 462–477. doi: 10.1016/j.tate.2006.10.009

Sperandeo-Mineo, R. M., Fazio, C., & Tarantino, G. (2005). Pedagogical Content Knowledge Development and Pre-Service Physics Teacher Education: A Case Study. *Research in Science Education*.

Syh-Jong, J. (2008). Innovations in science teacher education: Effects of integrating technology and team-teaching strategies. *Computers & Education, 51*, 646–659. doi: 10.1016/j.compedu.2007.07.001

Taylor, A. R., Jones, M. G., Broadwell, B, & Oppewal, T. (2008). Creativity, Inquiry, or Accountability? Scientists' and Teachers' Perceptions of Science Education. *Science Education, 92*, 1058–1075. doi: 10.1002/sce.20272

Tytler, R. (2006). School Innovation in Science: A Model for Supporting School and Teacher Development. *Research in Science Education, 37,* 189–216. doi: 10.1007/s11165-006-9022-9

Williams, P. R., Tabernik, A. M. & Krivak, T. (2009). The Power of Leadership, Collaboration, and Professional Development: The Story of the SMART Consortium. *Education and Urban Society, 41*(4), 437—456. doi: 10.1177/0013124509331606

Zion, M., Cohen, S., & Amir, R. (2007). The Spectrum of Dynamic Inquiry Teaching Practices. *Research in Science Education, 37*, 423–447. doi: 10.1007/s11165-006-9034-5

Action Level Teachers

Barab, S. A., Scott, B., Siyahhan S., Goldstone , R., Ingram-Goble, A., Zuiker, S. J. & Warren, S. (2009). Transformational Play as a Curricular Scaffold: Using Videogames to Support

Science Education. *Journal of Science Education and Technology,, 18*, 305–320. doi: 10.1007/s10956-009-9171-5

Beyer, C. J., Delgado, C., Davis, E. A., & Krajcik, J. (2009). Investigating Teacher Learning Supports in High School Biology Curricular. *Journal of Research in Science Teaching*, *46,* 977–998. doi: 10.1002/tea.20293

Birchfield, D. & Mego-wan-Romano-wicz, C. (2009). Earth science learning in SMALLab: A design experiment for mixed reality. *Computer-Supported Collaborative Learning, 4*, 403–421. doi: 10.1007/s11412-009-9074-8

Brinkworth, R., McCann, B., Matthews, C. & Nordström, K. (2009). First year expectations and experiences: student and teacher perspectives. *Higher Education, 58*, 157–173. doi: 10.1007/s10734-008-9188-3

Britsch, S. (2009). Differential discourses: the contribution of visual analysis to defining scientific literacy in the early years classroom. *Visual Communication, 8*(2), 207-228. doi: 10.1177/1470357209102114

Capobianco, B. M. (2007). Science Teachers' Attempts at Integrating Feminist Pedagogy through Collaborative Action Research*. Journal of Research in Science Teaching, 44*(1), 1–32. doi: 10.1002/tea.20120

Cohen, R. & Yarden, A. (2009). Experienced Junior-High-School Teachers' PCK in Light of a Curriculum Change: "The Cell is to be Studied Longitudinally". *Research in Science Education, 39*, 131–155. doi: 10.1007/s11165-008-9088-7

Falk, H. & Yarden, A. (2009). "Here the Scientists Explain What I Said." Coordination Practices Elicited During the Enactment of the Results and Discussion Sections of Adapted Primary Literature. *Research in Science Education, 39*, 349–383. doi: 10.1007/s11165-008-9114-9

Farré, A. S. & Lorenzo, M. G. (2009). Another piece of the puzzle: the relationship between beliefs and practice in higher education organic chemistry. *Chemistry Education Research and Practice, 10*, 176–184. doi: 10.1039/b908256p

Gengarelly, L. M. & Abrams, E. D. (2009). Closing the Gap: Inquiry in Research and the Secondary Science Classroom. *Journal of Science Education and Technology*, *18*, 74–84. doi: 10.1007/s10956-008-9134-2

Gimenez, J. E., Ruiz, R. M. A. & Listan, M. F. (2008). Primary and secondary teachers' conceptions about heritage and heritage education: A comparative analysis.

Goebel, C. A., Umoja, A., & DeHaan, R. L. (2009). Providing Undergraduate Science Partners for Elementary Teachers: Benefits and Challenges. *CBE—Life Sciences Education, 8*, 239–251. doi: 10.1187/cbe.08–07–0041

Harlow, D. B. (2009). Structures and Improvisation for Inquiry-Based Science Instruction: A Teacher's Adaptation of a Model of Magnetism Activity. *Science Education, 94*, 142 – 163. doi: 10.1002/sce.20348

Howes, E. V., Lim, M. & Campos, J. (2008). Journeys Into Inquiry-Based Elementary Science: Literacy Practices, Questioning, and Empirical Study. *Science Education, 93*, 189 – 217. doi: 10.1002/sce.20297

Kuiper, E., Volman, M. & Terwel, J. (2009). Developing Web literacy in collaborative inquiry activities. *Computers & Education, 52*, 668–680. doi: 10.1016/j.compedu.2008.11.010

Larkin, D. B., Seyforth, S. C. & Lasky, H. J. (2009). Implementing and Sustaining Science Curriculum Reform: A Study of Leadership Practices Among Teachers Within a High School Science Department. *Journal of Research in Science Teaching, 46*(7), 813–835. doi: 10.1002/tea.20291

Lavonen, J. & Laaksonen, S. (2009). Context of Teaching and Learning School Science in Finland: Reflections on PISA 2006 Results. *Journal of Research in Science Teaching*, *46*(8), 922–944. doi: 10.1002/tea.20339

Lawrenz,F., Wood, N. B., Kirchhoff, A., Kim, N. K., & Eisenkraft, A. (2009). Variables Affecting Physics Achievement. *Journal of Research in Science Teaching, 46*(9), 961–976. doi: 10.1002/tea.20292

Le, V.-N., Lockwood, J. R., Stecher, B. M., Hamilton, L. S. & Martinez J. F. (2009). A Longitudinal Investigation of the Relationship between Teachers' Self-Reports of Reform-Oriented Instruction and Mathematics and Science Achievement. *Educational Evaluation and Policy Analysis, 31*(3), 200–220. doi: 10.3102/0162373709336238

Lotter, C., Harwood, W. S., & Bonner, J. J. (2007). The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices. *Journal of Research in Science Teaching, 44*(9), 1318–1347. doi: 10.1002/tea.20191

MacNabb, C., Lee Schmitt, L., Michlin, M., Harris, I., Thomas, L., Chittendon, D., Ebner, T. J. &, Dubinsky, J. M. (2006). Neuroscience in Middle Schools: A Professional Development and Resource Program That Models Inquiry-based Strategies and Engages Teachers in Classroom Implementation. *CBE—Life Sciences Education, 5,* 144–157. doi: 10.1187/cbe.05–08–0109

Markic, S. & Eilks, I. (2008). A case study on German first year chemistry student teaching domains, teachers' beliefs about chemistry teaching, and their comparison with student teachers from other science. *Chemistry Education Research and Practice, 9*, 25–34. doi: 10.1039/b801288c

OECD (2005a). School Questionnaire for PISA 2006: Main Study. Paris: OECD.

Ratcliffe, M. & Millar, R. (2009). Teaching for Understanding of Science in Context: Evidence from the Pilot Trials of the Twenty First Century Science Courses. *Journal of Research in Science Teaching, 46*(8), 945–959. doi: 10.1002/tea.20340

Reutzel, D. R., Smith, J. A. & Fawson P. C. (2005). An evaluation of two approaches for teaching reading comprehension strategies in the primary years using science information texts. *Early Childhood Research Quarterly, 20*, 276–305. doi: 10.1016/j.ecresq.2005.07.002

Sadeh, I. & Zion, M. (2009). The Development of Dynamic Inquiry Performances within an Open Inquiry Setting: A Comparison to Guided Inquiry Setting. *Journal of Research in Science Teaching, 46*(10), 1137–1160. doi: 10.1002/tea.20310

Siegel, C. (2005). An ethnographic inquiry of cooperative learning implementation. *Journal of School Psychology, 43*, 219–239. doi: 10.1016/j.jsp.2005.04.005

Silverstein, S. C., Dubner, J., Miller, J., Glied, S. & Loike J. D. (2009). Teachers' Participation in Research Programs Improves Their Students' Achievement in Science. *SCIENCE, 326*, 440—442. doi: 10.1126/science.1177344

Vogt, F. & Rogalla, M. (2009). Developing Adaptive Teaching Competency through coaching. *Teaching and Teacher Education, 25*, 1051–1060. doi: 10.1016/j.tate.2009.04.002

Voogt, J., Tilya, F. & Van den Akker, J. (2009). Science Teacher Learning of MBL-Supported Student-Centered Science Education in the Context of Secondary Education in Tanzania. *Journal of Science Education and Technology, 18*, 429–438. doi: 10.1007/s10956-009-9160-8

Williams, M. (2008). Moving Technology to the Center of Instruction: How One Experienced Teacher Incorporates a Web-based Environment Over Time. *Journal of Science Education and Technology, 17,* 316–333. doi: 10.1007/s10956-008-9101-y

Zembal-Saul, C. (2009). Learning to Teach Elementary School Science as Argument. *Science Education, 93*, 687 – 719. doi: 10.1002/sce.20325

Zozakiewicz, C. & Rodriguez, A. J. (2007). Using Sociotransformative Constructivism to Create Multicultural and Gender-Inclusive Classrooms. *Educational Policy, 21*(2), 397-425. doi: 10.1177/0895904806290126

Zucker, A. A. & Hug, S. T. (2008). Teaching and Learning Physics in a 1:1 Laptop School. *Journal of Science Education and Technology*, *17*, 586–594. doi: 10.1007/s10956-008-9125-3

Action Level Students

Albe, V. (2008). When Scientific Knowledge, Daily Life Experience,Epistemological and Social Considerations Intersect: Students' Argumentationin Group Discussions on a Socio-scientific Issue. *Research on Science Education, 38*, 67–90. doi: 10.1007/s11165-007-9040-2

Angeli, C. (2005). Transforming a teacher education method course through technology: effects on preservice teachers technology competency. *Computers & Education, 45*, 383–398. doi: 10.1016/j.compedu.2004.06.002

Apedoe, X. S., Reynolds, B., Ellefson, M. R., & Schunn, C. D. (2008). Bringing Engineering Design into High School ScienceClassrooms: The Heating/Cooling Unit. *Journal of Science Education and Technology, 17*, 454–465. doi: 10.1007/s10956-008-9114-6

Ashmore, P. C. (2005). Role of Physical Anthropology in Intermediate and Secondary Education. *Yearbook of Physical Anthroplogy*, *48*, 154–162. doi: 10.1002/ajpa.20350

Assaraf O. B.-Z., & Damri, S. (2009). University Science Graduates' Environmental Perceptions Regarding Industry. *Journal of Science Education and Technology, 18*, 367–381. doi: 10.1007/s10956-009-9147-5

Brossard, D. & Shanahan, J. (2006). Do They Know What They Read? Building a Scientific Literacy Measurement Instrument Based on Science Media Coverage.

Brown, B. A. (2006). ''It Isn't No Slang That Can Be Said about This Stuff'': Language, Identity, and Appropriating Science Discourse. *Journal of Research in Science Teaching, 43*(1), 96–126. doi: 10.1002/tea.20096

Ching, G. S (2009). Implications of an experimental information technology curriculum for elementary students. *Computers & Education, 53*, 419–428. doi: 10.1016/j.compedu.2009.02.019

Cunningham, S. C., McNear, B., Pearlman, R. S., & Kern, S. E. (2006). Beverage-Agarose Gel Electrophoresis: An Inquiry-based Laboratory Exercise with Virtual Adaptation. *CBE—Life Sciences Education , 5*, 281–286. doi: 10.1187/cbe.06–01–0139

Foy, J. G., Marissa Feldman, L. E., & Mahoney, M. M. (2006). Neuroscience Workshops for Fifth-Grade School Children by Undergraduate Students: A University–School Partnership. *CBE—Life Sciences Education*, *5*, 128–136. doi: 10.1187/cbe.05–08–0107

Gelbart, H., Brill, G., & Yarden, A. (2009). The Impact of a Web-Based Research Simulation in Bioinformatics on Students' Understanding of Genetics. *Research in Science Education ,* 39, 725–751. doi: 10.1007/s11165-008-9101-1

Geier, R., Blumenfeld, P. C., Marx, R. W., & Krajcik, J. S. (2008). Standardized Test Outcomes for Students Engaged in Inquiry-Based Science Curricula in the Context of Urban Reform. *Journal of Research in Science Teaching, 45*(8), 922–939. doi: 10.1002/tea.20248

Gijlers, H., Saab, N., Van Joolingen, W.R., De Jong, T. & Van Hout-Wolters, B.H.A.M. (2009). Interaction between tool and talk. *Journal of Computer Assissted Learning, 25*, 252–267. doi: 10.1111/j.1365-2729.2008.00302.x

Gunel, M., Hand, B. & McDermott, M. A. (2009). Writing for different audiences: Effects on high-school students' conceptual understanding of biology. *Learning and Instruction, 18*, 354—367. doi: 10.1016/j.learninstruc.2008.07.001

Hoskins, S. G., Stevens, L. M., & Nehm, R. H. (2007). Selective Use of the Primary Literature Transforms the Classroom Into a Virtual Laboratory. *Genetics Education, 176*, 1381–1389. doi: 10.1534/genetics.107.071183

Howitt, C. (2007). Pre-Service Elementary Teachers' Perceptions of Factors in an Holistic Methods Course Influencing their Confidence in Teaching Science. *Research in Science Education, 37*, 41–58. doi: 10.1007/s11165-006-9015-8

Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning, 24*, 271–283. doi: 10.1111/j.1365-2729.2007.00259.x

Jalil, P. A., Abu Sbeih, M. Z., & Boujettif, M. (2009). Autonomy in Science Education: A Practical Approach in Attitude Shifting Towards Science Learning. *Journal of Science Education and Technology, 18*, 476–486. doi: 10.1007/s10956-009-9164-4

Jang, S.-J. (2009). Exploration of secondary students' creativity by integrating web-based technology into an innovative science curriculum. *Computers & Education, 52*, 247–255. doi:10.1016/j.compedu.2008.08.002

Kahveci, A. (2009). Exploring chemistry teacher candidates' profile characteristics, teaching attitudes and beliefs, and chemistry conceptions. *Chemistry Education Research and Practice, 10*, 109–120. doi: 10.1039/b908248b

Kaya, D. O., Yager, R., & Dogan, A. (2009). Changes in Attitudes Towards Science–Technology. *Research in Science Education, 39*, 257–279. doi: 10.1007/s11165-008-9084-y

Kelly, G. J., & Mayer, R. E. (2006). Contextual Epistemic Development in Science: A Comparison of Chemistry Students and Research Chemists. *Science Education, 90*(3), 468–495.

King, D., Bellocchi, A. & Ritchie, S. M. (2008). Making Connections: Learning and Teaching Chemistry in Context. Research in Science Education, *38*, 365–384. doi: 10.1007/s11165-007-9070-9

Kollar, I., Fischer, F., & Slotta, J. D. (2007). Internal and external scripts in computer-supported collaborative inquiry learning. *Learning and Instruction , 17*, 708–721. doi: 10.1016/j.learninstruc.2007.09.021

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What Good Is a Scientist in the Classroom? Participant Outcomes and Program Design Features for a Short-Duration Science Outreach Intervention in K–12. *CBE—Life Sciences Education , 6,* 49–64. doi: 10.1187/cbe.06–05–0165

Lavonen, J. & Laaksonen, S. (2009). Context of Teaching and Learning School Science in Finland: Reflections on PISA 2006 Results. *Journal of Research in Science Teaching*, *46*(8), 922–944. doi: 10.1002/tea.20339

Lindahl, M. G. (2009). Ethics or Morals: Understanding Students' Values. *Science & Education, 18*, 1285–1311. doi: 10.1007/s11191-008-9148-4

Manlove, S., Lazonder, A., & de Jong, T. (2006). Regulative support for collaborative scientific inquiry learning. *Journal of Computer Assisted Learning, 22,* 87–98.

Metz, A. M. (2008). Teaching Statistics in Biology: Using Inquiry-based Learning to Strengthen Understanding of Statistical Analysis in Biology Laboratory Courses. *CBE—Life Sciences Education, 7*, 317–326. doi: 10.1187/cbe.07–07–0046

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and Primary Science. *Research in Science Education, 37,* 17–39. doi: 10.1007/s11165-005-9002-5

OECD (2005b). Student Questionnaire for PISA 2006: Main Study. Paris: OECD.

Ravenscroft, A. (2007). Promoting thinking and conceptual change with digital dialogue games. *Journal of Computer Assisted Learning, 23*, 453–465. doi: 10.1111/j.1365-2729.2007.00232.x

Rissing, S. W. & Cogan, J.G. (2009). Can an Inquiry Approach Improve College Student Learning in a Teaching Laboratory? *CBE—Life Sciences Education, 8*, 55–61. doi: 10.1187/cbe.08–05–0023

Robbins, J. R. & Roy, P. (2007). Identifying & Correcting Non-Science Student Preconceptions Through an Inquiry-Based, Critical Approach to Evolution. *The American Biology Teacher, 69*, 460–466.

Saab, N., Van Joolingen, W. R., & Van Hout-Wolters, B. H. (2005). Communication in collaborative discovery learning. *British Journal of Educational Psychology , 75,* 603–621. doi: 10.1348/000709905X42905

Sadler, T. D., Barab, S. B., & Scott, B. (2007). What Do Students Gain by Engaging in Socioscientific Inquiry? *Research in Science Education, 37*, 371–391. doi: 10.1007/s11165-006-9030-9

Silk, E. M., Schunn, C. M., & Cary, M. S. (2009). The Impact of an Engineering Design Curriculum on Science Reasoning in an Urban Setting. *Journal of Science Education and Technology, 18*, 209–223. doi: 10.1007/s10956-009-9144-8

Timmerman, B. E., Strickland, D. C., & Carstensen, S. M. (2008). Curricular reform and inquiry teaching in biology: where are our efforts most fruitfully invested? *Integrative and Comparative Biology , 48*(2), 226–240. doi: 10.1093/icb/icn064

Vogt, F. & Rogalla, M. (2009). Developing Adaptive Teaching Competency through coaching. *Teaching and Teacher Education, 25*, 1051–1060. doi: 10.1016/j.tate.2009.04.002

Voogt, J., Tilya, F. & Van den Akker, J. (2009). Science Teacher Learning of MBL-Supported Student-Centered Science Education in the Context of Secondary Education in Tanzania. *Journal of Science Education and Technology, 18*, 429–438. doi: 10.1007/s10956-009-9160-8

Williams, P. R., Tabernik, A. M. & Krivak, T. (2009). The Power of Leadership, Collaboration, and Professional Development: The Story of the SMART Consortium. *Education and Urban Society, 41*(4), 437—456. doi: 10.1177/0013124509331606

Part B

Indicators Review for Science Teaching Methods and Attitudes

Edited Set of instruments, indicators and measurements methods for other WPs.

Jana Heinz, Katrin Lipowski, Alexander Gröschner, & Tina Seidel

TUM School of Education, Munich, Germany

EU-Project:

Science-Teacher Advanced Methods (S-TEAM)

Citation: *Heinz, J., Lipowski, K., Gröschner, A., Seidel, T. (2010): Indicators Review for Science Teaching Methods and Attitudes. Munich: TUM.*

Contact information:

TUM School of Education
Friedl Schöller Professorship of Teaching and Learning
Schellingstr. 33
80799 München
Germany
Mail:
tina.seidel@tum.de
alexander.groeschner@tum.de
jana.heinz@tum.de
katrin.lipowski@tum.de

The S-Team project has received funding from the European Community's Seventh Framework Programme [FP7/2007-2013] under grant agreement n°234870

Contents-Part B

1. Introduction

S-TEAM aims at strengthening inquiry based science teaching and education in Europe. The three main objectives of S-TEAM are (1) to improve motivation, learning and pupil attitudes in European science education, resulting in increased scientific literacy and the recruitment to science-based careers, (2) enabling large numbers of teachers to adopt inquiry-based and other proven methods for more effective science teaching and (3) supporting teachers by providing training in, and access to innovative methods and research-based knowledge (S-TEAM, 2009).

Inquiry based science teaching and education is characterized by activities that engage students in:

- authentic, problem-based learning activities where there may not be a correct answer;
- a certain amount of experimental procedures, experiments and "hands on" activities, including searching for information;
- self-regulated learning sequences where student autonomy is emphasized;
- discursive argumentation and communication with peers (‘talking science’) ((Jorde, Moberg, Prenzel, Rönnebeck, & Stadler, 2010, p. 3).

To achieve its objectives, S-TEAM disseminates improved methods of science teaching, specifically IBST/E widely and thus supports large numbers of teachers to adopt these methods for more effective science teaching.

The function of our work package (WP9) is to identify and to provide suitable indicators, instruments and measurement techniques of IBST/E. This report is an add-on to an extensive literature review “*Baseline Report and Indicators Review for Science Teaching Methods and Attitudes in the context of S-TEAM”* (Gröschner, Heinz, Lipowski & Seidel, 2010), and provides a summary of state-of-the-art instruments to be used in the context of IBST/E. The objective is to provide researchers, practitioners and teachers with instruments and measurement techniques that can be used formatively. In this sense, the report represents a coordinating activity in which knowledge of EU-partners as well as international researchers is bundled. Therefore, the two reports are closely linked. While in the following a survey of the instruments and measurements in the field of IBST/E is given, the above mentioned baseline reports contains information about the theoretical background of IBST/E as well as about S-TEAM, and an analysis of the measures and its outcomes.

In reviewing the literature on IBST/E indicators refer to the measurement of cognitive, motivational-affective and metacognitive factors involved in inquiry-based science teaching (IBST) and inquiry-based science teacher education (IBST/E). These three aspects are represented on different levels and target groups involved in IBST/E teaching and teacher education: Policy makers, teacher educators, teacher, students, etc. The summary of indicators and instruments allows receiving an overview of the usage of IBST in teacher education and the classroom, its measurement and effectiveness.

The following report compiles indicators and instruments as the result of several literature researches. First, we undertook a literature review by using the digital library "Web of Science". To set limits only articles published between 2005-2009 were considered. Furthermore, we used reference lists from studies on IBST and IBST/E as well as experts' knowledge of the existence of additional studies. The following keywords were used for search of studies: "inquiry based science teaching"," science teaching and learning", "science literacy and scientific literacy", "collaborative science learning", "argumentation in science education", "heuristic in science education", "science education"," inquiry based instruction"," teacher professional development" and "policy analysis". Each keyword was crossed with the target group keywords: "*policy, stakeholders*", "*teacher educators, teacher education*", "*teachers*" and "*students, pupils*".

In total our literature search resulted in 549 hits. The first analysis of these revealed that 367 studies were empirical (quantitative and qualitative) and 182 non-empirical (mainly reports). We further analyzed the results of our research by using the software salamander 2.51 to identify the number of studies that were double coded. Thus it became obvious that 117 of our research studies were duplicates. That means that – in a whole – 117 studies focused on different target groups, e. g. contained indicators for teachers as well as for students, or measured different dimensions, e. g. cognitive outcomes and affective-motivational aspects.

The majority of empirical studies focused on science instruction and the class room. Here it has to be noticed that not only surveys in elementary, secondary and high school were compiled but also in the field of universities. We decided not to exclude studies conducted in universities, as effects of IBST, like a positive correlation with affective-motivational outcomes, the stimulation of high-cognitive learning, the influence of prior knowledge on the effectiveness of IBST – to name just a few –were found in school as well as in university instruction. Furthermore, indicators, instruments and measures might also be of interest for teaching advanced students and could be used formatively.

The lowest amount of studies (empirical as well as non-empirical) investigated the policy level: 21 studies examined the use and implementation of innovative methods with regard to IBST/E.

The outline of this report corresponds with the stakeholder groups that S-TEAM regards to be especially important for implementing IBST in the classroom. These are person groups in the area of 1) policy and school management, 2) teacher education and teacher professional development and 3) instruction and the classroom. The large number of indicators and measures in the area of instruction and the classroom made it necessary to specify on this level between *teaching, teachers* and *students*. To achieve more clarity we further divided the indicators and measures according to their focus on cognitive, motivational-affective or metacognitive outcomes in relation to IBST/E. Cognitive dimensions are for instance students' knowledge and understanding of scientific issues and were often measured in pre-and posttests.[5] Learning and teaching strategies are an example of metacognitive competences. Attitudes towards IBST or students' and teachers' self-concepts are regarded as affective-motivational features. The review showed that in the field of teacher education and teacher professional development many indicators and measures were deployed that focused on teacher's experiences. We brought these together to the category: *Teachers' knowledge and experience*. However, it has to be noticed that this classification is only partly able to acquire the instruments used in the area of policy and school management, as policy analyses also used other data sources, such as financial data or interviews with parents.

As shown more detailed in the baseline report it can be summarized that the majority of instruments focused on instruction and the classroom. In many cases quantitative measures were used to analyze students' cognitive achievements as a result of different learning and teaching approaches and to acquire a description of science instruction and learning activities. Metacognitive instruments were most commonly found for students and teachers. While the main focus of quantitative measures laid on cognitive learning outcomes the main focus of qualitative measures laid on affective-motivational outcomes. That distribution was visible in the fields of instruction and teacher education and professional development. The majority of these measures in the area of teacher education and

[5] Computer-based instruments that were especially often used to foster collaborative and argumentative competences in science instruction were not considered in this report, when they needed specific computer technology. Furthermore, pre- and posttests that measured specific content knowledge were often based on domain specific language. As these are therefore only limited suited for international disseminating activities of S-TEAM, they are not listed here.

teacher professional development analyzed the changes of teachers' attitudes towards IBST and searched for factors that support the effectiveness of pre-and in-service courses.

Finally we would like to mention that this report is a first draft to be reviewed and supplemented by work package leaders during the second year of S-TEAM. Thus, our review of measures and indicators is still in progress and will be continued with regard to the developments of other work package partners as well as the positive replies of authors who were especially asked for their allowance to provide instruments within the project. We are aware that this report does not encompass all instruments and indicators in the field of IBST/E. Nevertheless it depicts the breadth of indicators and measures and can encourage to use these instruments as well as to classify and refine own measures.

Acknowledgments

We would like to thank Raphael Bernhardt, Linda Kohlbrenner, Sylvia Pfeifer and Stephanie Müller who helped us categorizing the articles and preparing tables and figures for this report.

2. Policy and School Management

The majority of measures in the area of policy and school management is focused on activities to disseminate inquiry based science teaching and education.

2.1 Satisfaction Questionnaire National Workshop WP4, item 10: What I get out of the workshop

Reference Grangeat, M. & Leroy, N. (2009). Satisfaction Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording The national workshop permits me to clarify my point of view on:

Items

a) Inquiry based learning/teaching
b) The collective aspects of teaching
c) Public policies in the field of science teaching
d) Research development in the field of science teaching
e) The implementation of inquiry based method in class
f) The European dynamism about inquiry based learning/teaching in science
g) Other

Item categories Multiple answers possible

2.2 Satisfaction Questionnaire National Workshop WP4, item 11: My own project

Reference Grangeat, M. & Leroy, N. (2009). Satisfaction Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording Following this National Workshop, I would:

Items

a) Develop inquiry based teaching pratices in my class
b) Reinforce the collective work in teaching practices
c) Contribute to the development of teacher training based on inquiry based teaching

d) Contribute to reflection about the way to better understand the inquiry based learning/ teaching methods
e) Reinforce research on inquiry based learning/ teaching
f) Reinforce research on the collective aspects of teaching
g) Look for more information about inquiry based learning/teaching methods in Europe
h) Other

Item categories Multiple answers possible

2.3 Satisfaction Questionnaire National Workshop WP4, item 12: Perspectives

Reference Grangeat, M. & Leroy, N. (2009). Satisfaction Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording For me, it would be important to:

Items

a) Put the conference contents on-line
b) Publish the National Workshop proceedings
c) Reproduce identical Workshop every year
d) Reproduce identical Workshop every two years
e) Other

Item categories Multiple answers possible

2.4 Dissemination of Workshop Contents/Persongroups

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording Which of the following persons/groups of persons do you want to pass on the contents of this workshop to?

Items

a) students

b) colleagues at school
c) school leader (principal)
d) school administration
e) teacher union
f) ministry
g) university
h) others

Item categories Multiple answers possible

2.5 Dissemination of Workshop Contents/Number of Persons

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording How many persons do you want to introduce to the contents of the workshop? (Please fill in the approximate minimum and maximum number of persons)

Items

a) Minimum
b) Maximum

Item categories Open categories

2.6 IBST in Science Education

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording In which way is IBST represented in science education in your country?

Items

a) curriculum frameworks in schools
b) initial teacher education (pre-service)
c) teacher professional development (in-service)
d) I don´t know

Item categories Multiple answers possible

2.7 Dissemination of IBST

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording How high would you estimate the chance for the ideas of IBST to get successfully disseminated in your country?

Items

a) within the next 3 months
b) within the next 12 months
c) until the end of the S-TEAM project (May 2012)

Item categories Low, Rather low, Rather high, High, Not applicable

2.8 Planned Dissemination Activities

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording Which actions do you want to take next to spread the contents of the workshop?

Items

a) to provide written information on the contents of the workshop
b) to tell colleagues about this workshop of S-TEAM
c) to organize a workshop in the area of IBST
d) to offer an IBST workshop myself
e) to get lecturers to make an IBST workshop
f) to encourage colleagues to participate in an IBST workshop
g) something else, namely

Item categories No, Yes, Not applicable

2.9 Important conditions for successfully disseminating IBST for pre-service training

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording Which framework and conditions are important to successfully disseminate IBST for *pre-service* teacher professional development?

Items

a) change of the framework of professional development (material, budget, rooms, equipment)
b) more courses on methods/programs to improve science teaching
c) make the participation in teacher education courses (for instance IBST courses) obligatory
d) plan teacher education for a long-term basis
e) integration of a regular and intensive cooperation among teachers as an important component of the daily routine at school
f) far reaching involvement of schools concerning science education
g) intensive institutional cooperation (e.g. school-university)
h) positive attitudes and interests of teachers and students towards sciences
i) more teaching materials for IBST and aspects of SINUS
j) reduce the size of classes
k) more student-focused ways of teaching
l) special learning possibilities for girls in sciences
m) more active learning possibilities for teachers/students

Item categories Unimportant, Rather unimportant, Rather important, Important, Not applicable

2.10 Important Conditions for Successful Dissemination IBST for In-service Training

Reference Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Item wording Which framework and conditions are important to successfully disseminate IBST for in-service professional teacher development?

Items

a) change of the framework of professional development (material, budget, rooms, equipment)
b) more courses on methods/programs to improve science teaching
c) make the participation in teacher education courses (for instance IBST courses) obligatory
d) plan teacher education for a long-term basis
e) integration of a regular and intensive cooperation among teachers as an important component of the daily routine at school
f) far reaching involvement of schools concerning science education
g) intensive institutional cooperation (e.g. school-university)
h) positive attitudes and interests of teachers and students towards sciences
i) more teaching materials for IBST and aspects of SINUS
j) reduce the size of classes
k) more student-focused ways of teaching
l) special learning possibilities for girls in sciences
m) more active learning possibilities for teachers/students

Item categories Unimportant, Rather unimportant, Rather important, Important, Not applicable

2.11 S-TEAM Teacher Education Questionnaire,

Reference Jorde, D. & Stadler, M. (2009). S-TEAM Teacher Education Questionnaire.

Item wording

Items

Initial Teacher Education (Pre-Service)

1. Who enters teacher education programs in sciences and math?
2. Are teacher education programs the same or different for all grade/levels?
3. Responsibility for teacher education
   - National frameworks
   - Funding
   - Organization; connected to subject and/or education
   - Practical experience
4. Content of science courses included in teacher education programs; including ECTS points, titles of courses if available, links to courses, etc.
      - How is Inquiry Based Science represented in the teacher education program?
5. Content of math courses included in teacher education programs; including

ECTS points, titles of courses, links to courses, etc
- How is Inquiry Based Math represented in the teacher education program?

Teacher Professional Development (in-service including novice and experienced teachers) [6]

1. Who is in charge of Teacher Professional Development (TPD)?
2. Who are important stakeholders?
3. What are the main problems that need to be tackled in science instruction?

Item categories Qualitative

2.12 Cooperation with Stakeholders

Reference Lipowski, K., Seidel, T., Seidel, M. & Gröschner, A. (2009). Questionnaire: Personal Information. Jena: Friedrich-Schiller-University.

Item wording Which institutions do you cooperate within the context of your professional field of activity:

Items

a) university
b) ministry
c) schools
d) teacher unions
e) commercial enterprises
f) other, namely

Item categories Multiple answers possible

2.13 Guide for Interview Questions: Teacher professional development in Science Education in European countries

Reference Lipowski, K. & Seidel, T. (2009). Guide for Interview Questions: Teacher professional Development in Science Education in European countries. Jena: Friedrich-Schiller-University.

[6] These questions were combined with the second part (Teacher Professional Development) from Lipowski, K. & Seidel, T. (2009). Guide for Interview Questions: Teacher professional Development in Science Education in European countries. Jena: Friedrich-Schiller-University.

Item wording What do you think as an expert in TPD in Science education?

Items

1) How is TPD is in general organized in your country? (for instance, compulsory/voluntary, single courses or sets of aligned courses, with individual teachers or groups from the same school)
2) Which main conditions are necessary to support continuous learning in the teacher profession?
3) How do you currently assess conditions leading to successful TPD in your country?
4) Do you see the necessity for improving the way your country implements TPD?
5) How does TPD support the use of IBST in Science Education (Instruction)?
6) In which way is IBST represented in science education in your country? (a) curriculum frameworks, (b) teacher education programs, (c) TPD
7) Which developments do you envision for teacher professional development in your country in 10 years?
8) Which kinds of TPD will teachers in science education need in future?
9) Which aspects of continuous learning in teacher profession do you consider to be successful in your country?
10) Are you able to provide 2 examples of what you would consider as good practice programs in TPD in science education in your country?
11) Which criteria do you use to determine success of these examples? / Why are these good examples?
12) Is the SINUS model for TPD one you could use in your country?
13) If you are familiar with the SINUS TPD project developed in Germany, which ideas from the SINUS program do you find particularly fruitful?
14) Which European country (s) do you consider to be successful in their TPD programs? Why?
15) Are you able to tell me your professional biography in some short notes?

Item categories Qualitative survey

2.14 Science and the Environment Q20

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 16). Paris: OECD.

Item wording Is your school involved in any of the following activities to promote engagement with science among students in <national modal grade for 15-year-olds>?

Items
a) Science clubs
b) Science fairs
c) Science competitions
d) Extracurricular science projects (including research)
e) Excursions and field trips

Item categories Yes, No

2.15 Science and the Environment Q21

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 17). Paris: OECD.

Item wording Where do topics on the environment sit in the curriculum received by students in <national modal grade for 15-yearolds> at your school?

Environmental topics include all topics related to environmental science. These may include environmental issues such as pollution or the degradation of the environment. Relationships between organisms, biodiversity and conservation of resources would also be examples of environmental topics.

Items
a) In a specific environmental studies course
b) In the natural sciences courses – for example as part of biology, chemistry, physics, earth science or within an integrated science course
c) As part of a geography course
d) As part of another course

Item categories Yes, No

2.16 Science and the Environment Q22.

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 18). Paris: OECD.

Item wording Does your school organise any of the following activities to provide opportunities to students in <national modal grade for 15-year-olds> to learn about environmental topics?

Items
a) <Outdoor education>
b) Trips to museums
c) Trips to science and/or technology centres
d) Extracurricular environmental projects (including research)
e) Lectures and/or seminars (e.g. guest speakers)

Item categories Yes, No

2.17 Careers and Further Education Q23

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 19). Paris: OECD.

Item wording How often would students in <national modal grade for 15-yearolds> have the opportunity to participate in the activities below as part of their normal schooling?

Items
a) <Job fairs>
b) Lectures (at school) by business or industry representatives
c) Visits to local businesses or industries

Item categories Never, Once a year, More than once a year

2.18 Careers and Further Education Q24

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 19). Paris: OECD.

Item wording In your school, about how many students in <national modal grade for 15-year-olds> receive some training within local businesses as part of school activities during the normal school year (e.g. apprenticeships)?

Items
a) This is not offered to students in <national modal grade for 15-year-olds>
b) Half or less of students in <national modal grade for 15-year-olds>
c) More than a half of students in <national modal grade for 15-year-olds>

Item categories Single choice

2.19 Careers and Further Education Q26

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 20). Paris: OECD.

Item wording To what extent do you feel that teachers in your school concentrate on developing in students the skills and knowledge that will help them progress towards science related careers? *Science-related career has been used here to include careers that involve a considerable amount of science but are beyond the traditional idea of a scientist as someone who works in a laboratory or academic environment (like a nuclear physicist). As such, a science-related career is not only one in physics, chemistry or biology. Any career that involves tertiary education in a scientific field is considered science-related. Therefore careers like engineer (involving physics), weather forecaster (involving earth science), optician (involving biology and physics), and medical doctors (involving the medical sciences) are all examples of science related careers.*

Items

a) These skills and knowledge are incidental to teachers' pedagogical activities
b) These skills and knowledge are integrated into teachers' pedagogical activities, but they are not emphasised
c) These skills and knowledge are a focus of teachers' pedagogical activities

Item categories Single choice

2.20 Careers and Further Education Q27

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 21). Paris: OECD.

Item wording To what extent do you feel that teachers in your school concentrate on developing in students the skills and knowledge that will help them in tertiary education?

Items

a) These skills and knowledge are incidental to teachers' pedagogical activities
b) These skills and knowledge are integrated into teachers' pedagogical activities, but they are not emphasised
c) These skills and knowledge are a focus of teachers' pedagogical activities

Item categories Single choice

2.21 Careers and Further Education Q28

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 21). Paris: OECD.

Item wording Who has the main responsibility for career guidance of students in <national modal grade for 15-year-olds> at your school?

Items
a) Not applicable, career guidance is not available in this school
b) All teachers share the responsibility for career guidance
c) Specific teachers have the main responsibility for career guidance
d) We have one or more specific career guidance counsellors **employed** at school
e) We have one or more specific career guidance counsellors who regularly **visit** the school

Item categories Single choice

2.22 Careers and Further Education Q29

Reference OECD (2005). School Questionnaire for PISA 2006. Main Study (p. 22). Paris: OECD.

Item wording If career guidance is available at your school, which of the statements below best describes the situation for students in <national modal grade for 15-year-olds>?

Items
a) Career guidance is sought voluntarily by students
b) Career guidance is formally scheduled into students' time at school

Item categories Single choice

2.23 Teachers' perception of the new teacher evaluation policy

Reference Tuytens, M. & Devos, G. (2009). Teachers' perception of the new teacher evaluation policy: A validity study of the Policy Characteristics Scale. *Teaching and Teacher Education, 25*, 924-930.

Item wording I think

Items

1. job descriptions for teachers are useful in our school
1. …our school has suitable instruments to formulate job descriptions for teachers.
2. …our principal has suitable knowledge and skills to formulate job descriptions.
3. ...of a job description as a list of tasks with which a principal can inspect his teachers.
4. …of a job description as a constructive and positive policy instrument
5. ….job descriptions should make clear what is expected of teachers
6. ...job descriptions should originate in consultation with the teachers
7. ...a performance evaluation for tenured teachers is useful in our school
8. …a performance evaluation for non-tenured teachers is useful in our school.
9. ...our school has suitable instruments to carry out performance evaluations with teachers
10. …our principal has suitable knowledge and skills to carry out performance evaluations with teachers
11. …of a performance evaluation as a means to be able to fire tenured teachers who don’t function well anymore.
12. …of a performance evaluation as a means to improve the functioning of teachers when necessary and to support teachers
13. …of a performance evaluation as a means to modulate the teacher in the future by setting new objectives
14. …performance evaluations should be based on job descriptions
15. …performance evaluations will cause tensions within the team of teachers.
16. …performance evaluations will cause more administrative burden within the school

Item categories Five point Likert-scale ranging from 1 (totally disagree) to 5 (totally agree).

3. Teacher Education and Teacher Professional Development

The following chapter presents separately measures that focus on novice teachers understandings of scientific inquiry and their attitudes and measures that are used in teacher professional development courses.

3.1 Teacher education

The instruments and indicators in this area can be classified according to their focus on scientific literacy, epistemological aspects of science and attitudes towards science instruction and teachers' expectation of their own professional role.

3.1.1 Cognitive measures

The following instrument measures teachers' understanding of science.

3.1.1.1 Definitions of science (science literacy)

Reference	Abell, S.K. & Smith, D.C. (1994). What is science? Preservice elementary teachers' conceptions of the nature of science. *International Journal of Science Education, 16,* 475–487.
Item wording	
Items	1. What do you mean by the term science? 2. Define the discipline in your own words' or 'What do you think science is about?
Item categories	Qualitative

3.1.2 Affective-motivational measures

In contrast to instruments in the area of teacher professional development the following instruments focus on novice teachers' expectations of teaching and their own learning and teaching experiences.

3.1.2.1 Science Teacher Education – Interview Protocol

Reference Crawford, B. A. (2007). Learning to Teach Science as Inquiry in the Rough and Tumble of Practice. *Journal of Research in Science Teaching*, *44 (4)*, 613–642.

Item wording Interview Protocol for Interns

Items

1. Tell me about your background and pre-service training.
2. Tell me about your experiences with science courses in middle-high school and college. Lab experiences? Long-term investigations?
3. Why should we teach science? What are your broad goals for teaching science?
4. How do you believe students learn science best?
5. If I ask you to give me a metaphor for ‘‘scientific inquiry’’ what would you tell me? Explain how this relates to what scientists do (inquiry)?
6. Current reform in science education calls for teaching ‘‘science as inquiry.’’ Tell me, how would you teach science as inquiry? What practices, in your view, account for teaching science as inquiry? What are your views of teaching science as inquiry?
7. How well do you think your pre-service teacher education courses (both science and science education) prepared you? What are some things you feel well prepared to do; things you feel you are not very prepared?
8. Describe for me how you would teach a unit of your choice, from beginning to the end, in terms of the sequence of events that would occur? Lab at the end, beginning? Why? Think of an example of a unit. Tell me what you would teach first, second, last.
9. How much freedom would you give your students to investigate problems of their own choosing?
10. 10. Is there anything you would like to add, related to anything that we talked about today?

Item categories Qualitative

3.1.2.2 Views of Nature of Science Questionnaire (VNOS) - Dimension 1: Curricular role identity for general use of science curriculum materials

Reference Forbes, C.T., Davis, E. A. (2008): The Development of Pre-service Elementary Teachers’ Curricular Role Identity for Science Teaching. *Science Education*, *92 (5),* 909-940.

Item wording Please answer each of the following questions that refer to either you specifically or effective science teachers in general. Note that in this survey, the words terms instructional materials, curriculum materials, and lessons are used synonymously to refer to types of curriculum resources used in the science classroom (textbooks, worksheets, laboratory manuals, lesson plans, etc.).

Items

1. I am to evaluate curriculum materials for activities students are to carry out.
2. Effective science teachers are to evaluate curriculum materials for activities students are to carry out.
3. I am to evaluate curriculum materials for instructions and guidance they provide me as the teacher.
4. Effective science teachers are to evaluate curriculum materials for instructions and guidance they provide the teacher.
5. I am to adapt and modify curriculum materials than I am to use them as they're designed and written.
6. Effective science teachers are to adapt and modify curriculum materials than they are to use them as they're designed and written.
7. I am to evaluate curriculum materials based on how science concepts are presented and organized.
8. Effective science teachers are to evaluate curriculum materials based on how science concepts are presented and organized.

Item categories Qualitative

3.1.2.3 Views of Nature of Science Questionnaire (VNOS) - Dimension 2: Curricular role identity for scientific inquiry

Reference Forbes, C. T. & Davis, E. A. (2008). The Development of Pre-service Elementary Teachers' Curricular Role Identity for Science Teaching. *Science Education*, *92 (5),* 909-940.

Item wording Please answer each of the following questions that refer to either you specifically or effective science teachers in general. Note that in this survey, the words terms instructional materials, curriculum materials, and lessons are used synonymously to refer to types of curriculum resources used in the science classroom (textbooks, worksheets, laboratory manuals, lesson plans, etc.).

Items

1. I am to use, adapt, or create science lessons that engage students in scientifically oriented questions.
2. Effective science teachers are to use, adapt, or create science lessons that engage students in scientifically-oriented questions.
3. I am to use, adapt, or create science lessons that encourage students to communicate and justify explanations.
4. Effective science teachers are to use, adapt, or create science lessons that encourage students to communicate and justify explanations.
5. I am to use, adapt, or create science lessons that encourage students to collect and analyze data and formulate explanations from evidence.
6. Effective science teachers are to use, adapt, or create science lessons that encourage students to collect and analyze data and formulate explanations

from evidence.
7. I am to help students make connections between science lessons and their own preexisting ideas about a topic.
8. Effective science teachers are to help students make connections between science lessons and their own preexisting ideas about a topic.

Item categories Qualitative

3.1.2.4 Views of Nature of Science Questionnaire (VNOS) - Dimension 3: Curricular role identity for curriculum materials' use in context

Reference Forbes, C. T. & Davis, E. A. (2008). The Development of Pre-service Elementary Teachers' Curricular Role Identity for Science Teaching. *Science Education*, *92 (5),* 909-940.

Item wording Please answer each of the following questions that refer to either you specifically or effective science teachers in general. Note that in this survey, the words terms instructional materials, curriculum materials, and lessons are used synonymously to refer to types of curriculum resources used in the science classroom (textbooks, worksheets, laboratory manuals, lesson plans, etc.).

Items:

1. I am to evaluate curriculum materials for how well learning objectives are aligned with science standards.
2. Effective science teachers are to evaluate curriculum materials for how well learning objectives are aligned with science standards.
3. I am to use lessons that relate science concepts to students lives outside of school.
4. Effective science teachers are to use lessons that relate science concepts to students lives outside of school.
5. I am to recognize that students may experience and react differently to science concepts based on their own values, beliefs, and culture.
6. Effective science teachers are to recognize that students may experience and react differently to science concepts based on their own values, beliefs, and culture.
7. I am to choose or modify science lessons based on what resources I have available.
8. Effective science teachers are to choose or modify science lessons based on what resources they have available.
9.

Item categories Qualitative

3.1.2.5 Views of Nature of Science Questionnaire (VNOS) - Dimension 4: Curricular role identity for teacher learning from curriculum materials

Reference Forbes, C. T. & Davis, E. A. (2008). The Development of Pre-service Elementary Teachers' Curricular Role Identity for Science Teaching. *Science Education*, *92 (5),* 909-940.

Item wording Please answer each of the following questions that refer to either you specifically or effective science teachers in general. Note that in this survey, the words terms instructional materials, curriculum materials, and lessons are used synonymously to refer to types of curriculum resources used in the science classroom (textbooks, worksheets, laboratory manuals, lesson plans, etc.).

Items

1. It is that the way I teach a science lesson will change after I've taught it many times.
2. It is that the way an effective science teacher teaches a science lesson will change after he or she has taught it many times.
3. I am to learn new instructional approaches from curriculum materials.
4. Effective science teachers are to learn new instructional approaches from curriculum materials.
5. I am to use curriculum materials to strengthen my content knowledge.
6. Effective science teachers often use curriculum materials to strengthen their content knowledge.
7. I am to reflect on my use of curriculum materials in order to improve my practice.
8. Effective science teachers are to reflect on their use of curriculum materials in order to improve their practice.
9. I am to use curriculum materials to promote student learning, not my own learning.
10. Effective science teachers are to use curriculum materials to promote student learning, not their own learning.

Item categories Qualitative

3.1.2.6 Modified version of STEBI[7] for S-Team IBST for SL Training Module

Reference Evans, R. & Dolin, J. (2009). Modified version of STEBI[8] for S-Team IBST for SL Training Module, Copenhagen: University of Copenhagen.

---

[7] Modified from Enochs, L., & Riggs, I. (1990)

[8] Modified from Enochs, L., & Riggs, I. (1990)

Enochs, L.G. & Riggs, I.M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90,* 695-706.

Item wording Please indicate the degree to which you agree or disagree with each statement below.

Items

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.
2. I will continually find better ways to teach for scientific literacy, using inquiry based science teaching methods.
3. Even if I try very hard, I will not teach science as well as I will most subjects.
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.
5. I know the steps necessary to teach science concepts using inquiry based science teaching methods effectively.
6. I will not be very effective in monitoring science experiments.
7. If students are underachieving in science, it is most likely due to ineffective science teaching.
8. I will generally teach for scientific literacy using inquiry based science teaching methods ineffectively.
9. The inadequacy of a student's science background can be overcome by good teaching which uses inquiry based science teaching methods.
10. The low science achievement of some students cannot generally be blamed on their teachers.
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.
12. I understand science concepts well enough to be effective in teaching secondary science.
13. Increased effort in science teaching produces little change in some students' science achievement.
14. The teacher is generally responsible for the achievement of students in science.
15. Students' achievement in science is directly related to their teacher's effectiveness in using inquiry based science teaching methods.
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
17. I will find it difficult to explain to students why science experiments work.
18. I will typically be able to answer students' science questions.
19. I wonder if I will have the necessary skills to teach science.
20. Given a choice, I will not invite the principal to evaluate my science teaching.
21. When a student has difficulty understanding a science concept, I will usually be

at a loss as to how to help the student understand it better.

22. When teaching science using inquiry based science methods, I will usually welcome student questions.
23. I do not know what to do to turn students on to science.

Item categories Strongly agree, Agree, Uncertain, Disagree, Strongly disagree

3.1.2.7 Feeback on S-Team Training Module

Reference Evans,R. & Dolin, J. (2009).Feedback on S-TEAM Training Module, Copenhagen: University of Copenhagen.

Item wording

Items PART I: USING CONCEPT MAPS TO UNDERSTAND SCIENTIFIC LITERACY BY COMPARING MAPS FROM OTHER COUNTRIES TO SEE HOW THEY SEE IT

A. What about the way we did this first part of the workshop should we use in our education modules?

B. Tell us what should be changed about this first part AND any suggestions for changing it.

PART II: USING VIDEOS OF SCIENCE TEACHING TO FIND GOOD AND NOT-AS-GOOD EXAMPLES OF INQUIRY BASED SCIENCE TEACHING

A. What about the way we did this second part of the workshop should we use in our education modules?

B. Tell us what should be changed about this second part AND any suggestions for changing it.

PART III. MAKING VIDEOS AS A WAY TO CONSTRUCT UNDERSTANDING OF TEACHING SCIENTIFIC LITERACY WITH INQUIRY AND GETTING FEEDBACK ON THEM

A. What about the way we did this third part of the workshop should we use in our education modules?

B. Tell us what should be changed about this third part AND any suggestions for changing it.

Item categories Qualitative

3.1.2.8 Inquiry in Research and the Secondary Science Classroom

Reference Gengarelly, L. M. & Abrams, E. D. (2009). Closing the Gap: Inquiry in Research and the Secondary Science. *Journal of Science Education and Technology*, *18,* 74–84.

Item wording

Items

1. How have you progressed in your research process?
2. What has been your greatest challenge in research so far? How did you resolve it?
3. Based on your experience so far as a researcher how would you define inquiry?
4. As a classroom teacher, how would you define inquiry?
5. Do you think it is important to incorporate inquiry-based learning into all of your teaching? If not, when? What is your evidence or justification?
6. Have you incorporated inquiry-based learning into their classroom? Give an example from your most recent teaching experience.
7. How did your high school students respond to this approach? Please give examples?
8. What do you perceive as the challenges in integrating inquiry into the classroom?
9. How would you solve those challenges?
10. Did you give your students a similar inquiry experience to that of yours as a researcher? If not, why? If yes, how?
11. What do you think the purpose of inquiry in the classroom or lab is?
12. Do you think your teacher changed her or his idea of inquiry in the classroom? How?
13. What did you gain from being a PROBE fellow that you could use in future?

Item categories Qualitative

3.1.2.9 Novice Science Teacher – Pre Course Interview

Reference Windschitl, M., Thompson, J. & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in

Classrooms. *Cognition and Instruction*, *26 (3),* 310-378.

Item wording Pre-Course Interview

Items A.

1. What area of science do you want to specialize in when you go into the schools?
   Prompt for how they become interested in a specialty: Was it affinity from childhood, influential teacher, recent experience in university coursework, research experience, previous career?
2. Can you tell me anything, in addition to your coursework, that's got you involved in science, like research experiences as an undergrad or in a career?
   Prompt for features of any research experiences that signal intellectual involvement with posing questions, generating and using evidence—as opposed to "technical assistance" to a researcher or mentor.
3. Tell me a little bit about your history of science-related coursework as an undergraduate. Prompt for nature of lab experiences, number and level of courses in various science domains.
4. Can you remember a time when you felt you learned a lot about how science is done?
5. Prompt: If asked what this means, reference learning how scientists develop questions, make decisions about what to study and how, what the outcomes of "doing science" are. Probe for talk about characteristic practices of the discipline.
6. Did you ever have anyone in your coursework talk about investigating a science idea—not the content, but the actual process?
   Prompt: Such as in university lectures, was it ever an explicit topic to discuss what counts as a scientific question, hypothesis, what counts as evidence, etc?
7. Did any instructor or teacher ever give you the chance to do your own investigations any time? This includes the span between middle school and the most recent courses you've taken.
   Prompt: Has anyone helped you with a guided investigation or a guided inquiry where they might have taken on parts of the process and you participated fully in other aspects?

B.

1. When you hear people talk about "advancing science" or "making progress" in science, what does that mean to you?
   Probe for whether it is accumulating new facts or is it developing new ways (theory) to think about phenomena?
2. When someone uses the term "experiment," what comes into your mind? Can you think of examples?
   Prompt: Is experimentation synonymous with scientific investigation?
   Prompt for notion of always needing a "controlled randomized experimental design" or are there alternatives?
3. What qualities are essential to make something a scientific investigation as opposed to investigations that non-scientists would engage in?
4. When scientists go through the process of posing a question and then they design a way to collect data and then they analyze that data, what process follows the analysis of data?

Prompt: If respondent mentions “conclusions,” unpack that.

5. How do you recognize a scientific argument from other kinds of argument that historians or lawyers might engage in?
6. What makes a scientific argument convincing?
7. Should creativity play any role in science? If so, what role? If not, why not?
8. Have any of your instructors ever talked about scientific theory, what a theory is?
   Prompt: if they mention any connections between the scientific method or science advances and theory: What do you see as the connection?
9. What would be the difference between a scientist who says, “I have a theory about something,” and a person out there on the street somewhere, the average pedestrian, who says "I have a theory" about X?
10. Have you ever had any instructor discuss the term “law”? What a law is as opposed to theory?

C.

1. How about the term model? Have any of your instructors used the term model? If so, can you elaborate?
2. Have you ever used a scientific model? What was the context for that? How did you use it?
3. If you had to talk with middle school or high school students about things that scientists make models of, what examples might you give them?
4. What about the purpose of creating models?
   Prompt if they allude to “real things”—What do you mean by real things?
   Prompt for “What does it mean to use a model to explain?” Do you mean to explain to another person?
5. When creating a model, what types of things do you have to think about or consider?
   Prompt: What kinds of choices do you have to make?
6. What is the relationship between a model and the thing that’s being modeled?
7. Can you have more than one model for the same thing?
   Prompt: Can you think of an example where you might have two models for the same thing? Why?
8. Is there a way to decide if one model is better than another one?
   Prompt: What criteria are used to determine if one model is better than another?
   Prompt: What are shortcomings some models might have?
9. Would a scientist ever change a model? Why or Why Not?
   Prompt for any other reason than because of new facts coming to light.

D.

1. Is teaching about models important in the area of science that you’re specializing in?
   Prompt: If respondent begins talking about teaching with models, probe whether to important to teach about models.
2. What is it you want your students to understand about the processes of science by the end of your school year with them?

Item categories Qualitative

3.1.2.10 Novice Science Teacher – Post course Interview

Reference Windschitl, M., Thompson, J. & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in Classrooms. *Cognition and Instruction*, *26 (3),* 310-378.

Item wording Post-course Interview

Items A.

1. When you hear people talk about "advancing science" or "making progress" in science, what does that mean to you? Probe for whether it is accumulating new facts or is it developing new ways (theory) to think about phenomena?
2. When someone uses the term "experiment," what comes into your mind? Can you think of examples? Prompt: Is experimentation synonymous with scientific investigation? Prompt for notion of always needing a "controlled randomized experimental design" or are there alternatives?
3. What qualities are essential to make something a scientific investigation as opposed to investigations that non-scientists would engage in? When scientists go through the process of posing a question and then they design a way to collect data and then they analyze that data, what process follows the analysis of data? Prompt: If respondent mentions "conclusions," unpack that.
4. How do you recognize a scientific argument from other kinds of argument that historians or lawyers might engage in?
5. What makes a scientific argument convincing?
6. Should creativity play any role in science? If so, what role? If not, why not?
7. What would be the difference between a scientist who says, "I have a theory about something," and a person out there on the street somewhere, the average pedestrian, who says "I have a theory" about X?

B.

1. If you had to talk with middle school or high school students about things that scientists make models of, what examples might you give them?
2. What about the purpose of creating models? Prompt if they allude to "real things"—what do you mean by real things? Prompt for "What does it mean to use a model "to explain?" Do you mean to explain to another person?
3. When creating a model, what types of things do you have to think about or consider? Prompt: What kinds of choices do you have to make?
4. What is the relationship between a model and the thing that's being modelled?
5. Can you have more than one model for the same thing?
   Prompt: Can you think of an example where you might have two models for the same thing? Why?
6. Is there a way to decide if one model is better than another one? Prompt: What criteria are used to determine if one model is better than another? Prompt: What are shortcomings some models might have?

7. Would a scientist ever change a model? Why or Why Not? Prompt for any other reason than because of new facts coming to light.
8. Is teaching about models important in the area of science that you're specializing in? Prompt: If respondent begins talking about teaching with models, probe whether to important to teach about models.
9. Are there any differences between real science, school science, and the science you did during the model-testing project?

C.

1. Is there any role for models in your unit plan? How are they used?
2. What is it you want your students to understand about the processes of science by the end of your school year with them?
3. How will you know that your students understand how science is done?

Item categories Qualitative

3.1.2.11 34-Item Teacher Beliefs Survey - validity of a self-report measure of teacher beliefs related to constructivist and traditional approaches to teaching and learning

Reference Woolley S. L., Benjamin W. J. & Woolley A. W. (2004). Construct validity of a self-report measure of teacher beliefs related to constructivist and traditional approaches to teaching and learning. *Educational and Psychological Measurement*, *64,* 319-331.

Item wording Imagine how you will set up your own future classroom as you read each of the following survey statements. As you think about your classroom (not your cooperating teachers' classrooms), write a number on the line beside each statement to indicate how much you disagree or agree with the statement on a scale ranging from 1 (strongly disagree) to 6 (strongly agree).

Items

1. It is important that I establish classroom control before I become too friendly with students. (TM, behavior management)
2. I believe that expanding on students' ideas is an effective way to build my curriculum. (CT, curriculum)
3. I prefer to cluster students' desks or use tables so they can work together. (CT, classroom learning environment)
4. I invite students to create many of my bulletin boards. (CT, classroom learning environment)
5. I like to make curriculum choices for students because they can't know what they need to learn. (TT, curriculum)
6. I base student grades primarily on homework, quizzes, and tests. (TT, assessment)

7. An essential part of my teacher role is supporting a student's family when problems are interfering with a student's learning. (CT, working with parents)
8. To be sure that I teach students all necessary content and skills, I follow a textbook or workbook. (TT, curriculum)
9. I teach subjects separately, although I am aware of the overlap of content and skills. (TT, curriculum)
10. I involve students in evaluating their own work and setting their own goals. (CT, assessment)
11. My primary role as a teacher is to help students become learners, not to teach particular content knowledge. (teaching strategies)
12. When there is a dispute between students in my classroom, I try to intervene immediately to resolve the problem. (TM, behavior management)
13. I believe students learn best when there is a fixed schedule. (TM, classroom learning environment)
14. I communicate with parents mainly through report cards and parent-teacher conferences. (working with parents)
15. I make it a priority in my classroom to give students time to work together when I am not directing them. (CT, teaching strategies)
16. I have centers in my classroom that students can work at, but only after their assigned work is finished. (teaching strategies)
17. I make it easy for parents to contact me at school or home. (CT, working with parents)
18. During discussions I ask many open-ended questions and encourage students to ask questions of each other. (teaching strategies)
19. If I am not directing classroom events, the most likely result is chaos. (behavior management)
20. My students spend the majority of their seatwork time working individually. (student roles)
21. For assessment purposes, I am interested in what students can do independently. (TT, assessment
22. One way I get my students ready for the next activity is to compliment students who have followed my directions quickly (e.g., "I see that Group 3 is ready with all of your materials."). (behavior management)
23. I invite parents to volunteer in or visit my classroom almost any time. (CT, working with parents)
24. Instead of assigning students jobs, I encourage them to show initiative in helping keep our classroom clean and neat. (student roles)
25. I generally use the teacher's guide to lead class discussions of a story or text. (TT, teaching strategies)
26. I prefer to assess students informally through observations and conferences. (CT, assessment)
27. I find that textbooks and other published materials are the best sources for creating my curriculum. (TT, curriculum)
28. If students are interested in a topic I try to help them, but I don't use class time because I have a lot of curriculum to cover. (curriculum)
29. I decorate my classroom primarily with posters, pictures, or teaching charts. (classroom learning environment)
30. In my classroom I take care of the learning materials and set them out for students when they need them. (student roles)

31. It is more important for students to learn to obey rules than to make their own decisions. (TM, behavior management)
32. I am a firm believer in paper-and-pencil tests. (assessment)
33. I often create thematic units based on the students'interests and ideas. (CT, curriculum)
34. Students need to learn that there are consequences for inappropriate behavior. (behavior management)

Item categories Scale ranging from 1 (strongly disagree) to 6 (strongly agree).

3.1.3 Metacognitive measures

In the following instruments are introduced that mainly focus on instruction protocols and on teachers' reflections on their own lessons.

3.1.3.1 Questionnaire on Investigative Science in your Placement School (QISPS)

Reference Blake, A., McNally, J. & Smith, C. (2010). Questionnaire on Investigative Science in your Placement School Glasgow: University of Strathclyde.

Item wording: The following four questions are about your early impressions of investigative work in your placement school (please interpret the term 'investigative' broadly).

Items

1. Describe an example of investigative science that you observed or took part in.
2. Describe the atmosphere in the classroom during the investigation (for example, what do you think the pupils got out of it?).
3. Describe an opportunity that was missed, but in which you could have supported investigative work.
4. Based on what you've seen, what are the main constraints on or opportunities for introducing investigation into a lesson?

Item categories Qualitative

3.1.3.2 Novice Science Teacher – Initial Pass at Analysis

Reference Windschitl, M., Thompson, J. & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in Classrooms. *Cognition and Instruction*, *26 (3),* 310-378.

Item wording Initial Pass at Analysis

Items

1. Did student-teacher talk about/scaffold ideas about evidence and supporting claims or explanations? How? What was the nature of the claims/ explanations (i.e., did they stop with description or discuss why/underlying mechanisms)?
2. Did they talk about/scaffold ideas about scientific models/representations? How? Were these nominal references to models or more sophisticated ideas about models? Reference level of nature/function of models.
3. Is there evidence that they used student thinking to adjust instruction?
   a. 1st did they provide opportunities to hear the student's ideas by eliciting students' ideas or engaging the students in sense-making talk? Describe.
   b. 2nd did they use students' words or ideas?
   c. 3rd did they modify their instruction or differentiate instruction for some based on how students were learning?
4. Is there evidence of student learning?
   a. Evidence for how their pupils used evidence to support claims and explanations
   b. Evidence for how their pupils understood scientific models
   c. Evidence for how their pupils understood a specific science concept/idea

Item categories Qualitative

3.1.3.3 Novice Science Teacher – Observation timing, equipment, cooperating teacher

Reference Windschitl, M., Thompson, J. & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in Classrooms. *Cognition and Instruction*, *26 (3*), 310-378.

Item wording Observation Protocol

Items

1. Script all teacher and student talk during lesson
2. Add notes re: teacher language around models, evidence, data, claims, arguments, observable/unobservable data, theoretical components,

hypotheses/hypothesizing & highlight the degree of sophistication students used this type of talk
3. Highlight questions teacher asked & questions students asked (differentiate clarifying and scientific questions: CQ & SQ)

Item categories Qualitative

3.1.3.4 Novice Science Teacher – Debrief Lesson with Teacher

Reference Windschitl, M., Thompson, J. & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in Classrooms. *Cognition and Instruction*, *26 (3),* 310-378.

Item wording Debrief Lesson with Teacher

Items

1. What did you try that seemed successful, why would you call it successful?
2. What were your goals for this lesson? (inquiry goals, content goals, skillbased goals) Do you think your students met those goals? What do you think your students were thinking about? What did you hear them talking about?
3. What informed your planning for this lesson? (university course work, CT, text; listen for impact of broader school context & for productive/nonproductive conflicts across contexts) (we provided additional prompts not relevant to this study)
4. How did your students' prior knowledge or their current thinking help you design this lesson? How might you adapt your next lesson based on what you saw today?

Item categories Qualitative

3.2 Teacher Professional Development

In the area of teacher professional development the instruments mainly focus on teachers' attitudes towards IBST/E as well as on their prior teaching experiences and their professional growth.

3.2.1 In-service Training

The following measures are used for the evaluation of teacher professional development courses.

3.2.1.1 Experience with IBST

Reference Lipowski, K., Seidel, T., Seidel, M. & Gröschner, A. (2009). Questionnaire: Personal Information. Jena: Friedrich-Schiller-University.

Item wording

Items

a. Before attending the workshop I knew about IBST approaches.
b. I have heard the first time about IBST approaches in the context of this workshop.
c. I have held an IBST course/IBST courses myself.
d. How many courses of IBST have you attended during the last 5 years?

Item categories No, Yes

3.2.1.2 Professional Development, measure 8

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8 (p.6). Washington D.C.

Item wording How often do you have the following types of interactions with other teachers?

Items

a) Discussions about how to teach a particular concept
b) Working on preparing instructional materials
c) Visits to another teacher's classroom to observe his/her teaching
d) Informal observations of **my** classroom by another teacher

Item categories Daily or almost daily, 1-3 times per week, 2 or 3 times per month, Never or almost never

3.2.1.3 Professional Development, measure 9

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8. (p. 6) Washington D.C.

Item wording In the past two years, have you participated in professional development in any of the following?

Items

a. Science content
b. Science pedagogy/instruction
c. Science curriculum
d. Integrating information technology into science
e. Improving students' critical thinking or inquiry skills
f. Science assessment

Item categories Yes, No

3.2.1.4 The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices –Post SRI Interview

Reference Lotter, C. ,Harwood, W. S. & Bonner, J. J. (2007). The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices. *Journal of Research in Science Teaching*, *44 (9),* 1318–1347.

Item wording

Items

1. What do you think you learned from the workshop that will be the most beneficial to your teaching?
2. How will you incorporate your bottleneck plan into your teaching? [If it will not be incorporated, why not?]
3. Describe your research laboratory experience. [What questions did you investigate? What laboratory methods did you learn?] What, if anything, will you take from your research experience back to your classroom?
4. In what way has the workshop changed the way you think about your teaching?
5. Are there issues that you would have liked discussed or discussed more during the workshop?
6. Did the workshop meet your expectations? [Why/why not]
7. Describe an effective teaching lesson and why you think it is effective. [Can be one already taught or one not yet taught]
8. How would you define inquiry science teaching?
9. Do you now believe you teach using the inquiry method?
   If yes, describe in your own words what a typical inquiry lesson looks like in your classroom. Include the following parts in your description:
   a. What are you doing? [What is your role as the teacher?] What are your students doing? How are books and resources used? How is science content taught?

   If no, is there a particular reason why you do not use this method? What do you think an inquiry lesson would look like if you did teach it?
10. Do you think that inquiry teaching is a good way to teach science content?Why or why not.
11. Are there times or situations where inquiry teaching is not a useful method? Tell me about these.
12. What constraints do you feel you have to using inquiry teaching?

Item categories Qualitative

3.2.2 Affective-motivational measures

The following measures mainly aim at triggering teachers' views on nature of science and their instruction practice.

3.2.2.1 Views of Nature of Science Questionnaire (VNOS-B)

Reference Lederman, N.G., Abd-El-Khalick, F., Bell, R. L. & Schwartz, R. S. (2002). Views of nature of science questionnaire. *Journal of Research in Science Teaching*, *39*, 497-521.

Item wording VNOS-B

Items

1. After scientists have developed a theory (e.g. atomic theory), does the theory ever change? If you believe that theories do change, explain why we bother to teach scientific theories. Defend your answer with examples.
2. What does an atom look like? How certain are scientists about the nature of the atom? What specific evidence do you think scientists use to determine what an atom looks like?
3. Is there a difference between a scientific theory and a scientific law? Give an example to illustrate your answer.
4. How are science and art similar? How are they different?
5. Scientists perform experiments/investigations when trying to solve problems. Other than the planning and design of these experiments/investigations, do scientists use their creativity and imagination during and after data collection? Please explain you answer and provide examples if appropriate.
6. Is there a difference between scientific knowledge and opinion? Give an example to illustrate your answer.
7. Some astronomers believe that the universe is expanding while others believe that it is shrinking; still others believe that the universe is in a static state without any expansion or shrinkage. How are these different conclusions possible if all of these scientists are looking at the same experiments and data?

Item categories Qualitative

3.2.2.2 Views of Nature of Science Questionnaire (VNOS-C)

Reference Lederman, N.G., Abd-El-Khalick, F., Bell, R. L. & Schwartz, R. S. (2002). Views of nature of science questionnaire. *Journal of Research in Science Teaching*, *39*, 497-521.

Item wording VNOS-C

Items

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?
2. What is an experiment?
3. Does the development of scientific knowledge require experiments?
   - If yes, explain why. Give an example to defend your position.
   - If no, explain why. Give an example to defend your position.
4. After scientists have developed a scientific theory (e.g., atomic theory, evolution theory), does the theory ever change?
   - If you believe that scientific theories do not change, explain why. Defend your answer with examples.
   - If you believe that scientific theories do change: (a) Explain why theories change; (b) Explain why we bother to learn scientific theories. Defend your answer with examples.
5. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.
6. Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting the nucleus. How certain are scientists about the structure of the atom? What specific evidence do you think scientists used to determine what an atom looks like?
7. Science textbooks often define a species as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring. How certain are scientists about their characterization of what a species is? What specific evidence do you think scientists used to determine what a species is?
8. It is believed that about 65 million years ago the dinosaurs became extinct. Of the hypothesis formulated by scientists to explain the extinction, two enjoy wide support. The first, formulated by one group of scientists, suggests that a huge meteorite hit the earth 65 million years ago and led to a series of events that caused the extinction. The second hypothesis, formulated by another group of scientists, suggests that massive and violent volcanic eruptions were responsible for the extinction. How are these different conclusions possible if scientists in both groups have access to and use the same set of data to derive their conclusions?
9. Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and

intellectual norms of the culture in which it is practiced.
If you believe that science reflects social and cultural values, explain why. Defend your answer with examples.
If you believe that science is universal, explain why. Defend your answer with examples.

10. Scientists perform experiments/investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?
    - If yes, then at which stages of the investigations do you believe scientists use their imagination and creativity: planning and design, data collection, after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.
    - If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.

Item categories Qualitative

3.2.2.3 Relationship between Teaching Goals and Teaching Practices

Reference Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Item wording Examining the Relationship Between Teaching Goals and Teaching Practices

Items

1. Why did you decide to become a teacher?
2. What did you like most about your teacher education program?
3. What one new idea or experience in your teacher education program is still strongly influencing your teaching today?
4. Can you think of lessons you taught more than once that best represent you as a teacher who is developing that idea or experience more?
5. How did you prepare for these lessons? Did anyone watch you teach these lessons? Did you talk to anyone else about any part of these lessons?
6. When you taught these lessons again, what did you change and why?

Item categories Qualitative

3.2.2.4 Connecting between Previous Science Learning and Current Science Teaching

Reference Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Item wording Connecting Previous Science Learning With Current Science Teaching

Items

1. Describe what would be, for you, an "ideal" education for any students of biology/chemistry.
2. What underpinning themes of biology/chemistry do you think are most important for students to understand? Why?
3. How do you think, in general, your conceptions of science differ from your students' conceptions? How does this difference impact your teaching and their learning?
4. What are your views about the new Living Environment/Physical Setting: Chemistry state assessment for biology/chemistry? Are we moving in the right direction?
5. What gaps have you been able to identify in your science education? In your teacher education? What elements of your teacher education do you find the most useful today?
6. How has your conception of science been changed by teaching it to students?

Item categories Qualitative

3.2.2.5 Critical Issues in Science Teaching

Reference Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Item wording Considering Critical Issues in Science Teaching in the Local Context

Items

1. If you had the choice, for what reasons did you decide to get involved with teaching at this academic level (either "plus"/lower-track students or AP/honors/upper-track students)?
2. How does the population of students you now teach differ from the general

population of students at this school? What factors do you think have resulted in this difference?

3. What particular teaching strategies have you found to be the most effective with this population? The least effective? Why?
4. What would you consider to be an “ideal” education for these students of biology/ chemistry?
5. How do you feel about the fact that there are so few students of color in the honors tracks in this school (leading, for example, to the taking of AP courses)? How do you think we could change that, if at all?
6. What problems do you think the new “teaming” system being implemented for the ninth graders will solve for teachers and students? What problems do you think it will create?

Item categories Qualitative

3.2.3 Metacognitive measures

In this chapter the measures deal with teaching approaches and their effects on instruction.

3.2.3.1 Questions about interpretive goals lessons

Reference Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Item wording View the DVD of the lesson as soon after teaching it as possible. While watching, write in the journal by responding similarly as you responded to the observation notes I made of your last two lessons:

Items

1. What surprised you? What did you like about what you and your students did? What didn't you like?
2. If someone else were to see this lesson, what would they think? What else would you want them to know about you or your students to put the lesson into context?

3. Was the lesson successful? How are you defining success?
4. Are there other approaches you could have taken to improve or replace this lesson?
5. How did you make the content covered important to students?
6. What qualities do you have as a person that you see coming through in your teaching? Which ones do you think are supporting learning? Which ones might need work so you can better support learning?

Item categories Qualitative

3.2.3.2 Questions about critical goals lessons (1)

Reference Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Item wording Please respond to as many parts of these questions as you can in your journal at some time before you teach the lesson:

Items

1. Why do you think you chose this social topic for a lesson? Why is it important to you, both as a person and as a teacher?
2. Why are the goals of your lesson important for all of the students? How did you try to meet all of those needs in the way you set up the lesson?
3. How did you design the lesson to target learning for this particular group of students?
4. How did your evaluation of your current relationship with them affect how you designed the lesson?
5. What features of your lesson do you think might make students a little more capable to make decisions related to your social issue?

Item categories Qualitative

3.2.3.3 Questions about critical goals lessons (2)

Reference Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Items

1. How did the students respond to your lesson? What actually happened that you predicted would happen? What were you surprised about? Why do you think you were surprised?
2. Did students that typically don't respond to your teaching as much as you want respond a little better to this lesson? What happened in the lesson that you think "grabbed" them? Why?
3. How did you decide how "far" to take the conversations? Where, if at all, did you "draw the line" about what was and what was not talked about? Why?
4. If you had to teach a lesson on the same issue again to this group of students, what would you have done differently? Why?

Item categories Qualitative

3.2.3.4 Teacher Questionnaire. C Your Opinion about Open Activities, Item 1

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording What do you put behind the expression open activity (or situation)? Among the 8 proposals, choose 3of them to be more pertinent. You can also add another proposal.

Items

1. An activity during which students are in autonomy during a long time (Specify in minutes the approximate duration)
2. An activity during which students have to formulate assumptions, conjectures.
3. An activity during which students have to elaborate an experiment.
4. An activity that allows or that easily generates debate between students in the class
5. An activity during which students are confronted with a problem of their every day life or with a problem they heard on TV, in the newspaper, on Internet…
6. An activity where students start to freely express their way of describing or to interpret the situation under study
7. An activity with very few questions but with a problem to be solved.
8. An activity during which students must carry out an important number of

reasoning stages without being explicitly invited to do it by the statement of the activity.
9. Other

Item categories Multiple answers are possible

3.2.3.5 Teacher Questionnaire. C Your Opinion about Open Activities, Item 2

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording The expression open activity refers to different practices among science teachers. Which name would you prefer?

Items

1. Starting situation
2. Problem situation
3. Situation close to daily life
4. Inquiry based activity
5. TP TOP, Mosaic TP
6. None the proposal, specify:

Item categories Single Choice

3.2.3.6 Teacher Questionnaire. C Your Opinion about Open Activities, Item 3

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording 3. According to you, what are the main advantages of this kind of activity

Items

1. To collect the initial representations of students
2. To motivate students by suggesting them to solve a problem
3. To diversify the kind of activities
4. To leave initiatives to students and leave them to grope in experiments
5. To leave the possibility to formulate questions
6. To leave the possibility to formulate assumptions
7. To allow students to make their own ideas explicit before confronting them with things they have to learn

8. To obtain a large variety of students suggestions in order to produce a richer debate in the class
9. To show the class that several ways can lead to the solution of a unique problem
10. Other

Item categories Multiple answers possible

3.2.3.7 Teacher Questionnaire. C Your Opinion about Open Activities, Item 4

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording Please, specify the approximate frequency of the teaching time you devote to open activities.

Items

1. Never
2. Sometimes
3. Once a month
4. Once a week
5. More than once a week

Item categories Multiple answers possible

3.2.3.8 Teacher Questionnaire. C Your Opinion about Open Activities, Item 5

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording In your teaching activity, when you use the word "assumption" or "conjecture", what meaning do you give to it?

Items

1. A prediction of what will happen
2. A possible explanation to an observation
3. An idea to be tested experimentally
4. An idea stated as established (for example speed of light in the vacuums is

a fundamental constant)

Item categories Multiple answers possible

3.2.3.9 Teacher Questionnaire. C Your Opinion about Open Activities, Item 6

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording Could you give an example of an open activity that you have already practiced and that appeared to be characteristic of what you put behind such an expression?

Items

Item categories Open category

3.2.3.10 Teacher Questionnaire. C Your Opinion about Open Activities, Item 7

Reference Grangeat, M. & Leroy, N. (2009). Teacher Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording According to you, what are the disadvantages of open activities?

Items

Item categories Qualitative

3.2.3.11 Development of chemistry teachers' skills – Study B

Reference Laius, A., Kask, K. & Rannikmäe, M. (2009). Comparing outcomes from two case studies on chemistry teachers' readiness to change. *Chemistry Educational Research Practice*, *10,* 142-153.

Item wording

Items

1. Please tell me how you conducted your teaching of science and what did you emphasise? (Subsidiary questions were asked were necessary: How do you begin your lesson? In what way did you motivate your students? What attributes, useful for students' future lives, did you develop in your lessons? Did you include activities in your lessons such as designing posters? If not, why did you feel this was inappropriate? What did your students like most in science classes? Do you face any obstacles to teaching science as you would wish?).
2. Will you continue using similar approaches and materials (to those put forward in the in-service course) during the next school year? Will you recommend those approaches and materials to other teachers and why?

Item categories Qualitative

3.2.3.12 Teachers' readiness for fostering students' inquiry skills as a development of their understanding of scientific literacy (1)

Reference Laius, A., Kask, K. & Rannikmäe, M. (2009). Comparing outcomes from two case studies on chemistry teachers' readiness to change. *Chemistry Educational Research Practice*, *10,* 142-153.

Item wording

Items

1. Please tell me how you organised your lessons that included practical work for the students. (Additional questions if needed: how did you start the lesson? what kind of barriers occurred in carrying out practical work? did you create any instruction materials yourself? did you consider it important that students understood the purpose of practical work? If so, how did you determine this? how did your students like practical work?)
2. Please tell me your goals for teaching chemistry and how you achieve those goals.
3. What did you gain from the in-service course?
4. Would you continue using the approaches and type of instructional materials (gained from the in-service course) in the next school year? Would you recommend them to other teachers?

Item categories Qualitative

3.2.3.13 Teachers' Readiness for Fostering Students' Scientific Creativity and Reasoning Skills as a Development of their Understanding of Scientific Literacy (2)

Reference Laius, A., Kask, K. & Rannikmäe. M. (2009). Comparing outcomes from two case studies on chemistry teachers' readiness to change. *Chemistry Education Research and Practice 2009, 10,* 142-153.

Item wording

Items

1. Please tell me how you conducted your teaching of science and what did you emphasise? (Subsidiary questions were asked where necessary: how do you begin your lesson? in what way did you motivate your students? what attributes, useful for students' future lives, did you develop in your lessons? did you include activities in your lessons such as designing posters? if not, why did you feel this was inappropriate?; what did your students like most in science classes? do you face any obstacles to teaching science as you would wish?).
2. Will you continue using similar approaches and materials (to those put forward in the in-service course) during the next school year? Will you recommend those approaches and materials to other teachers and why?

Item categories Qualitative

3.2.4 Teachers' experience and knowledge

3.2.4.1 An Analysis of the Processes of Change in Two Science Teachers Educators' Thinking

Reference Greensfeld, H. & Elkad-Lehman, H. (2007). An Analysis of the Processes of Change in Two Science Teachers Educators' Thinking. *Journal of Research in Science Teaching, 44 (8),* 1219–1245.

Item wording

Items

1. Tell us about your professional life and your professional worldview.
2. Over the years you must have experienced changes in thinking processes regarding your area of teaching. Please describe the process.
3. Please describe significant or important milestones in the narrative about your thinking in teaching your discipline.
4. Can you reconstruct the situation or the moment when you became aware of your thinking about teaching your discipline? How did it happen? Why did it happen when it did?'
5. Can you describe difficulties in the process?
6. We asked each interviewee to suggest an appropriate metaphor for the processes he or she described, to choose a title for the processes out of a list of possible titles we presented (Change, Development, Addition, Expansion, Revolution, Variation), or to suggest a title of their own. In addition, we asked the interviewees to explain their suggestions.

Item categories Qualitative

3.2.4.2 Positional Identity and Science Teacher Professional Development - Professional Development Activities (Past, Present, Future)

Reference Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45 (6),* 684–710.

Item wording Professional Development Activities (Past, Present, Future)

Items

1. What are your goals or plans for professional development: past, currently, future?

2. What strategies do you have for your goals, for making the goals, and reaching the goals?
3. What areas do you think you need to grow in or develop in?
4. How is your professional development related to your personal development in any way?
5. How is your professional development connected to student achievement?
6. How did you enter teaching?
7. What were your experiences like in science as a student: elementary, middle, high, and college? What do you remember about your teachers?
8. How would you describe your teaching style?

Item categories Qualitative

3.2.4.3 Positional Identity and Science Teacher Professional Development - Past Experiences and Relationships

Reference Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45 (6),* 684–710.

Item wording Past Experiences and Relationships

Items

1. What is it like teaching in Carver County?
2. Have you always taught predominantly African American students?
3. What do you want to accomplish personally and professionally as a teacher?
4. What are some challenges and successes as a teacher in Carver County?
5. What kinds of barriers do you have in teaching science?
6. What was science like as a young child? Do you remember learning science in elementary, middle, and high school?
7. What are your views of teaching and learning science?

Item categories Qualitative

3.2.4.4 Positional Identity and Science Teacher Professional Development - Positional Identity

Reference Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45 (6),* 684–710.

Item wording Positional Identity

Items

1. What are some extracurricular activities that you do at school?
2. How important is language in the classroom to learning science?
3. How does your race, gender, or age affect your teaching of science?
4. Do you see yourself being female/male and African American as a privilege?
5. Do you feel that you have power as a teacher; define that word in any way you like.
6. Are you a different person in different contexts: school, church, in the community?
7. How much of an impact has your family been on your development as a teacher: how has your family encouraged you or helped you to develop as a teacher?
8. As a parent, are there things that help you as a teacher?
9. What is your relationship like with other teachers, students, and administration?
10. You have been assigned a first year teacher to mentor. What kind of advice would you give to the teacher about: teaching, teaching science, teaching in Carver County School district, and professional development?
11. What are your plans for yourself over the next year or two: How do you see yourself as a teacher in the next 5 or 10 years: What have you learned about yourself as a teacher over the years?
12. If you had to write an educational obituary, what would you say about yourself as a teacher: how do you want to be remembered as a teacher?

Item categories Qualitative

4. Instruction and the Classroom

Instruments and indicators in the following chapters capture instruction patterns and classroom activities from the teachers' and the students' perspective.

4.1 Classroom Evaluation (Inquiry-based Laboratory Exercise with Virtual Adaptation)

Reference Cunningham, S. C., McNear, B., Pearlman, R. S., & Kern, S. E. (2006). Beverage-Agarose Gel Electrophoresis: An Inquiry-based Laboratory Exercise with Virtual Adaptation. *CBE—Life Sciences Education , 5,* 281–286.

Item wording Please rate your agreement with the following eight statements.

Items

1. It was enjoyable;
2. I would recommend it to a friend;
3. It made me think;
4. It should be adopted as a standard part of the curriculum;
5. I hated every minute of it;
6. It was an active process for me;
7. I learned something from it; and
8. It made me ask questions, for example, "Why did I get that result?"

Item categories Strongly agree, Agree, Neutral, Disagree, Strongly disagree.

4.2 Student Questionnaire. G. My sciences classes

Reference Grangeat, M. & Leroy, N. (2009). Student Questionnaire. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Item wording

Items

1. School science is a difficult subject
2. School science is interesting
3. School science is rather easy for me to learn

4. School science has opened my eyes to new and exciting jobs
5. I like school sciences better than most other subjects
6. I think everybody should learn science at school
7. The things that I learn in science at school will be helpful in my everyday life
8. I think that the science I learn at school will improve my career chances
9. I would like to have as much science as possible at school
10. I like school science better than most other subjects

Item categories Strongly disagree, Disagree, Neutral, Agree, Strongly agree

4.3 Teacher Questionnaire. D. Your Action to Help Students to Learn

Reference Grangeat, M. & Leroy, N. (2009). Satisfaction Questionnaire National Workshop WP 4. S-TEAM, WP 4, 3. Grenoble: University Pierre-Mendes-France.

Item wording

Items

1. In my class, I try to encourage students to memorize factual informations (rules, formulas, theorem etc….) by repetition
2. In my class, I try to encourage students to organize their knowledge (by making tables, diagrams, classifications) in order to integrate new information more easily
3. In my class, I try to encourage students to make inference or links between the various concepts presented in order to create new information networks
4. In my class, I try to encourage students to set goals that will help them to achieve the suggested activities.
5. In my class, I try to encourage students to evaluate the efficacy of their learning strategies in order to adjust them with their needs.
6. In my class, I try to encourage students to evaluate themselves by considering the achievement degree of their goal.

Item categories Never, Rarely, Sometimes, Quite often, Very often

4.4 Questionnaire on ASL conceptions

Reference Hoekstra, A., Brekelmans, M. ,Beijaard, D. & Korthagen, F. (2009). *Teaching and Teacher Education, 25,* 663–673.

Item wording

Items

1. Student regulation
   - Cognitive
     Students learn better, if they themselves assess whether the learning process evolves according to plan. It is important that I as a teacher ask the students how they think to address a task effectively.
   - Affective
     Students learn better if they are aware of their emotions. It is important that I as a teacher stimulate the students to think about what they like to do and what they like less.
2. Construction
   - Students learn better if they themselves create links between components of the subject matter. It is important that I stimulate students to underpin their own opinion.
3. Collaboration
   - Students learn better if they think about their tasks together with their peers. It is important that I as a teacher let the students regularly collaborate.

Item categories 5-point Likert scale ranging from (1) absolutely disagree to (5) absolutely agree

4.5 Questionnaire on ASL Behavior

Reference Hoekstra, A., Brekelmans, M. ,Beijaard, D. & Korthagen, F. (2009). *Teaching and Teacher Education, 25*, 663–673.

Item wording Student questionnaire on their teachers' ASL behavior

Items

1. Stimulation student regulation
   - Cognitive
     This teacher asks us how we think we should address a task.
   - Affective
     This teacher encourages us to think about how we can deal with feelings of anxiety and uncertainty.
2. Stimulation construction
   - This teacher stimulates us to underpin our own opinion.
3. Stimulation collaboration

- This teacher gives us collaborative tasks.
-

Item categories 5-point Likert scale, ranging from (1) This teacher hardly ever does this to (5) This teacher almost always does this

4.6 Module based Laboratory - incorporate inquiry into Cell Biology Course

Reference Howard, D. R. & Miskowski, J. A. (2005). Using a Module-based Laboratory To Incorporate Inquiry into a Large Cell Biology Course. *Cell Biology Education, 4,* 249–260.

Item wording

Items

1. Where more like a real-life lab situation
2. Allowed for more in-depth data analysis so the results were more meaningful
3. Allowed me to be more involved in the experiments
4. Helped me to make connections between different concepts and see the big picture
5. Helped me better understand the material, and therefore, learn more
6. Helped me improve my oral and written communication skills
7. Did not feel as rushed
8. Allowed me to work more independently

Item categories Strongly agree, Agree, Neutral, Disagree, Strongly disagree

4.7 Module based Laboratory - incorporate inquiry into Cell Biology Course (end-of-the-semester assessment)

Reference Howard, D. R. & Miskowski, J. A. (2005). Using a Module-based Laboratory To Incorporate Inquiry into a Large Cell Biology Course. *Cell Biology Education, 4*, 249–260.

Item wording

Items Do you feel that completing the entrance requirements usually made you better prepared for lab?

Item categories Yes, Maybe, No

Item wording

Items How do you think your critical thinking/problem solving skills have developed over the course of this semester?

Item categories Improved, Stayed the same, Worsened

Item wording

Items Level of interest in the Field of Cell Biology

Item categories Strong interest, Some interest, Indifferent, Strong dislike

4.8 Constructivist Multimedia Learning Environment Survey (CMLES) Student Actual Form What actually happens in my classroom

Reference Maor, D., & Fraser, B. J. (2005). An Online Questionnaire for Evaluating Students' and Teachers' Perceptions. *Research in Science Education, 35,* 221–244.

Item wording Please select *how often* the following learning activities actually DO occur in your classroom.

Items Learning to Communicate
In this class. . .
1 I get the chance to talk to other students
2 I discuss with other students how to conduct investigations
3 I ask other students to explain their ideas
4 other students ask me to explain my ideas
5 other students discuss their ideas with me
Learning to Investigate
In this class. . .
6 I find out answers to questions by investigation
7 I carry out investigations to test my own ideas
8 I conduct follow-up investigations to answer new questions
9 I design my own ways of investigating problems
10 I approach a problem from more than one perspective
Learning to Think
In this class. . .
11 I get to think deeply about how I learn
12 I get to think deeply about my own ideas

13 I get to think deeply about new ideas
14 I get to think deeply how to become a better learner
15 I get to think deeply about my own understandings

Item categories Almost Seldom, Sometimes, Often, Always, Never

4.9 Science in School, Measure 9

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. 4th Grade Student Questionnaire (p.12). D.C.

Item wording In school, how often do you do these things?

Items
a) I look at something like the weather or a plant growing and write down what I see
b) I watch the teacher do a science experiment
c) I design or plan a science experiment or project
d) I do a science experiment or project
e) I work with other students in a small group on a science experiment or project
f) I read books about science
g) I memorize science facts
h) I write or give an explanation for something I am studying in science
i) I work science problems on my own
j) I use a computer in science lessons

Item categories At least once a week, Once or twice a month, A few times a year, Never

4.10 Science in School, measure 14

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. 8th Grade Student Questionnaire (p.15). D.C.

Item wording How often do you do these things in your science lessons?

Items
a) We make observations and describe what we see
b) We watch the teacher demonstrate an experiment or investigation
c) We design or plan an experiment or investigation

d) We conduct an experiment or investigation
e) We work in small groups on an experiment or investigation
f) We read our science textbooks and other resource
g) We memorize science facts and principles
h) We use scientific formulas and laws to solve problems
i) We give explanations about what we are studying
j) We relate what we are learning in science to our daily lives
k) We review our homework
l) We listen to the teacher give a lecture-style presentation
m) We work problems on our own
n) We begin our homework in class
o) We have a quiz or test

p) We use computers

Item categories Every or almost lessons, About every half the lessons, Some lesson, Never

4. 11 The TIMSS Class, measure 16

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8 (p.8). Washington D.C.

Item wording In a typical week of science lessons for the class with the TIMSS students, what percentage of time do students spend on each of the following activities?

Items

a) Reviewing homework
b) Listening to lecture-style presentations
c) Working problems with your guidance
d) Working problems on their own without your guidance
e) Listening to you re-teach and clarify content/procedures
f) Taking tests or quizzes
g) Participating in classroom management tasks not related to the lesson's content/purpose(e.g., interruptions and keeping order)
h) Other student activities

Item categories Write in the percent. The total should add to 100%

4.12 Teaching Science to the TIMSS Class, measure 18

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8 (p. 10). Washington D.C.

Item wording In teaching science to the students in the class with the TIMSS students, how often do you usually ask them to do the following?

Items

a) Observe natural phenomena and describe what they see
b) Watch me demonstrate an experiment or investigation
c) Design or plan experiments or investigations
d) Conduct experiments or investigations
e) Work together in small groups on experiments or investigations
f) Read their textbooks or other resource materials
g) Have students memorize facts and principles
h) Use scientific formulae and laws to solve routine problems
i) Give explanations about something they are studying
j) Relate what they are learning in science to their daily lives

Item categories Every or almost every lesson, About half the lessons, Some lessons, Never

4.13 Computers in the TIMSS Class, measure 23

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8 (p. 16).Washington D.C.

Item wording In teaching science to the class with the TIMSS students, how often do you have students use a computer for the following activities?

Items

a) Do scientific procedures or experiments
b) Study natural phenomena through simulations
c) Practice skills and procedures
d) Look up ideas and information
e) Process and analyze data

Item categories Every or almost every lesson, About half the lessons, Some lessons, Never

4.14 Homework, measure 27

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8. (p. 17). Washington D.C.

Item wording How often do you assign the following kinds of science homework to the class with the TIMSS students?

Items
a) Doing problem/question sets
b) Finding one or more applications of the content covered
c) Reading from a textbook or supplementary materials
d) Writing definitions or other short writing assignments
e) Working on projects
f) Working on small investigations or gathering data
g) Preparing reports

Item categories Always or almost always, Sometimes, Never or almost never

4.15 Assessment, measure 32

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8 (p. 18). Washington D.C.

Item wording How often do you include the following types of questions in your science tests or examinations? Do not include quizzes.

Items
a) Questions based on knowing facts and concepts
b) Questions based on the application of knowledge and understanding
c) Questions involving developing hypotheses and designing scientific investigations
d) Questions requiring explanations or justifications

Item categories Always or almost always, Sometimes, Never or almost never

4.16 Argumentation in primary science (cartoon stimulus concept)

Reference Naylor, S., Downing, B. &Keogh, B. (2001). An empirical study of argumentation in primary science, using Concept Cartoons as the stimulus. *Paper presented at the European Science Education Research Association Conference, Thessaloniki, Greece.* August 2001.

Item wording During the lessons tick sheet to record the predominant classroom activity at 30-second intervals.

Items Level 1: reflects a refusal, or inability, to enter into a discussion

Can incorporate several different behaviours, all of which close down the argument and prevent reasoned discussion, e.g.:

a) fighting or physically attacking an opponent
b) leaving the room or crying
c) tutting loudly and fidgeting
d) aggressive use of language such as threatening or swearing

Level 2: makes a claim to knowledge

a) Statements begin with "I think…" "I believe…" "I know…" or "I want…"
b) Agrees or disagrees with the claims of others
c) May counter claims with an opposing position or repeat a claim made earlier

Level 3: Offers grounds to support claim

a) Offers a single reason to support his or her statement of position
b) Uses words like "because"
c) Beginning to listen to others and answer directly to develop simple dialogue.

Level 4: supports claim with further evidence

a) Offers two or more reasons for the stance adopted
b) Beginning to evaluate the "quality" or "validity" of reasons or different kinds of "proof"
c) Brings in personal first hand experience or knowledge from other areas to act as verifiers

d) Uses phrases such as might, definite, sure, maybe etc.

Level 5: Responds to ideas from others

a) Listens to other contributors and adjusts position accordingly.
b) Demonstrates an awareness of the differing ideas of others and of the need to address those differences
c) Gives due consideration to the views of others

Level 6: Able to sustain an argument

a) Uses skills necessary to sustain an argument eg listening to others' arguments, reinforcing, adjusting one's own position
b) Invites others to voice an opinion, or direct questioning and challenging of what they say

Level 7: Evaluates the evidence and draws conclusions

a) Allows all parties to say their piece, then evaluates and comes to a reasoned judgement
b) Can include recognition that the argument is never really over and any conclusion is provisional
c) May recognise the need to gather further information including empirical data

Item categories Qualitative/Observation

Level 1: refuses or is unable to enter into a discussion
Level 2: makes a claim to knowledge
Level 3: offers grounds to support a claim to knowledge
Level 4: supports a claim to knowledge with further evidence
Level 5: shows awareness of the ideas of others and responds to them
Level 6: sustains an argument, including responding to other positions
Level 7: evaluates the evidence and comes to a reasoned judgement

4.17 Item parameters for science teaching: interaction

Reference OECD (2009). PISA 2006. Technical Report (p. 333). Paris: OECD.

Item wording When learning <school science> topics at school, how often do the following activities occur?

Items
a) Students are given opportunities to explain their ideas
b) The lessons involve students' opinions about the topics
c) There is a class debate or discussion
d) The students have discussions about the topics

Item categories In all lessons, In most lessons, In some lessons, Never or hardly ever

4.18 Item parameters for science teaching: hands-on activities

Reference OECD (2009). PISA 2006. Technical Report (p. 333). Paris: OECD:

Item wording: When learning <school science> topics at school, how often do the following activities occur?

Items
a) Students spend time in the laboratory doing practical experiments
b) Students are required to design how a <school science> question could be investigated in the laboratory
c) Students are asked to draw conclusions from an experiment they have conducted
d) Students do experiments by following the instructions of the teacher

Item categories In all lessons, In most lessons, In some lessons, Never or hardly ever

4.19 Item parameters for science teaching: student investigations

Reference OECD (2009). PISA 2006. Technical Report (p. 333). Paris: OECD.

Item wording: When learning <school science> topics at school, how often do the following activities occur?

Items
a) Students are allowed to design their own experiment

b) Students are given the chance to choose their own investigations
c) Students are asked to do an investigation to test out their own ideas

Item categories In all lessons, In most lessons, In some lessons, Never or hardly ever

4.20 Item parameters for science teaching: focus on models or applications

Reference OECD (2009).PISA 2006. Technical Report (p. 334). Paris: OECD.

Item wording: When learning <school science> topics at school, how often do the following activities occur?

Items

a) The teacher explains how a <school science> idea can be applied to a number of different phenomena (*e.g.* the movement of objects, substances with similar properties)
b) The teacher uses science to help students understand the world outside school
c) The teacher clearly explains the relevance of <broad science> concepts to our lives
d) The teacher uses examples of technological application to show how <school science> is relevant to society

Item categories In all lessons, In most lessons, In some lessons, Never or hardly ever

4.21 Constructivist pedagogy in conventional on-campus and distance learning practice

Reference Tenenbaum, G., Naidu, S., Jegede, O. & Austin, J. (2001). Constructivist pedagogy in conventional on-campus and distance learning practice: An exploratory investigation. *Learning and Instruction 11*, 87–111.

Item wording For each of the items in this section please tick the box which best represents your perception regarding the unit you are currently studying

Items	1 The unit allowed for arguments, discussions and debates 2 The unit encouraged originality of ideas 3 The unit allowed for constant exchange of ideas between student and teacher 4 I learned to develop mind tools in this unit (e.g. critical thinking) 5 Multiple perspectives of situations were often presented in the unit 6 The unit posed some dilemmas for me 7 The unit caused confusion among conceptual ideas for me 8 The unit caused conflicts for me among various concepts 9 The unit allowed social interaction 10 The unit comprised a variety of learning activities 11 I was given sufficient opportunities to express myself 12 I was given sufficient opportunities to share my own experiences with others 13 The unit taught me how to arrive at appropriate answers 14 The unit resources effectively conveyed information to be learned 15 The unit included relevant examples 16 The unit motivated me to think reflectively 17 The unit encouraged me to examine several perspectives of an issue 18 The ideas in the unit motivated me to learn 19 The unit taught me to investigate concepts 20 The unit enabled me to use knowledge acquired for abstract thinking 21 The unit motivated me for further learning of related subjects 22 The unit took into consideration my needs and concerns 23 I felt pleased with what I learned in the unit 24 The unit helped me to benefit from my learning difficulties 25 The unit allowed for the negotiation of the instructional goals & objectives 26 The unit helped me to pursue personal goals 27 The learning environment encouraged me to think 28 The unit focused more on making meaning of the learned concepts rather than just answering questions 29 The unit addressed real-life events 30 The unit was rich in examples
Item categories	Not at all, A little, Somewhat, Much, Very much

4.22 Development of the Activity-Felling States (AFS) Scales

Reference	Reeve, J. & Sickenius, B. (1994). Development and validation of a brief measure of the three psychological needs underlying intrinsic motivation: The AFS scales. *Educational and Psychological Measurement, 54*, 506–515.
Item wording	13
Items	1. Self-Determination – free, offered choice what to do, I want to do this, and my participation is voluntary

2. Competence – capable, competent, and achieving
3. Relatedness-involved with friends, part of a team, and brotherly/sisterly
4. Tension-pressured, stressed and uptight

Item categories Response stem, "Activity X makes me feel" (e.g., "Solving SOMA puzzles makes me feel") with 1-7 response scale (strongly disagree through strongly agree).

4.23 Constructivist pedagogy in conventional on-campus and distance learning practice

Reference Tenenbaum, G., Naidu, S., Jegede, O. & Austin, J. (2001). Constructivist pedagogy in conventional on-campus and distance learning practice: An exploratory investigation. *Learning and Instruction 11*, 87–111.

Item wording: I design the unit in a manner that:

Items

1 Allows for arguments, discussions and debates
2 Encourages students to express original ideas
3 Allows a constant exchange of ideas between teacher and student
4 Encourages the student to develop mind tools (e.g. critical thinking)
5 Will present multiple perspectives of situations
6 It will pose some dilemmas for students
7 It will cause confusion among conceptual ideas
8 It will cause conflict among various concepts
9 Allows for social interaction
10 It will comprise a variety of learning activities
11 Will give students sufficient opportunities to express themselves
12 Encourage interaction between students to share experiences
13 Will develop techniques to arrive at appropriate answers
14 Unit resources effectively convey information to learn
15 Will include relevant examples
16 Will motivate students to think reflectively
17 Encourage students to examine several perspectives of an issue
18 Will present students with ideas to motivate learning
19 Allow students to investigate concepts in depth
20 Encourage students to use knowledge acquired for abstract thinking
21 Will motivate students for further learning of related subjects
22 Will take into consideration students' needs and concerns
23 Will encourage positive thinking in students
24 Will benefit those students with learning difficulties
25 Encourage students to negotiate the instructional goals & objectives
26 Encourage personal goals of students
27 Will have a position learning environment to promote thinking
28 Will focus on meaningful concepts

29 Will address real-life events
30 Will be rich in examples

Item categories Not at all, A little, Somewhat, Much, Very much

5. Students

The international large scale assessment studies like PISA and TIMSS developed students questionnaires to capture not only scientific knowledge and understanding but also attitudes towards science. Besides these measures we included here as well measures that ask for students' interest in scientific topics and their evaluation of classroom activities and classroom atmosphere.

5. 1 Cognitive measures

In the following three measures are listed that capture the level of scientific literacy. Additionally, in the course of our literature review we found a large number of cognitive pre-and posttests. However, they most commonly focused on specific knowledge and required knowledge of domain specific English terminology. Thus they were not suitable for disseminating in the context of S-TEAM and were not included in this report.

5.1.1 Media Scientific Literacy Questionnaire

(not limited to students)

Reference	Brossard, D., & Shanahan, J. (2006). Do They Know What They Read? Building a Scientific Literacy Measurement Instrument Based on Science Media Coverage. *Science Communication, 1*, 47-63.
Item wording	A. Please complete the following statements to the best of your knowledge, with one or two words. We expect that you will have trouble with many of the statements. If you do not know the answer, just write "don't know."
Items	1. A star that over a period of only a few days becomes 100 – 1000 times brighter than it once was, is called a *[nova]*. 2. *[Genetic engineering]* is the technique involved in altering the characters of an organism by inserting genes from another organism into its DNA. 3. The device that is the central processing unit of most smaller, personal computers is also called a *[microprocessor]*.

4. A 120 mm disk on which there is a digital recording of audio information, providing high quality recording and reproduction of music, speech, etc., is called a *[compact disc]*.
5. *[LSD]* is a chemical derivative of lysergic acid that has potent hallucinogenic properties.
6. A *[gill]* is the respiratory organ used by aquatic animals to obtain oxygen from the surrounding water.
7. *[Aluminum]* is a silvery-white lustrous metallic element which is highly reactive, lightweight, strong (when alloyed), corrosive, resistant, and electrically conductive. These features make it suitable for a variety of uses, including vehicle and aircraft construction, building and overhead power cables.
8. *[Fiber optic]* systems use threads that conduct light to transmit information in the form of coded pulses or fragmented images, from a source to a receiver.
9. The diverse group of ubiquitous microorganisms all of which consist of a single cell which lacks a distinct nuclear membrane and has a cell wall of a unique composition is referred to as *[bacteria]*.
10. The invasion of any living organism by disease-causing microorganisms which proceed to establish themselves, multiply and produce various symptoms in their host is called an *[infection]*.
11. The provision of water for crops by artificial methods; for example by constructing pipe systems, ditches, and canals is called *[irrigation]*.
12. A sudden movement or fracturing within the earth's lithosphere causing a series of shocks is called a(n) *[earthquake]*. It can range from a mild tremor to a large scale earth movement, causing extensive damage over a wide area.
13. A tropical cyclone with surface wind speeds in excess of 64 knots that occurs in the North Atlantic Ocean, Caribbean Sea, or the Gulf of Mexico is a(n) *[hurricane]*.
14. This is a fibrous mineral with widespread commercial use because of its resistance to heat, chemical inertness and high electrical resistance. The fibers may be spun and woven into fireproof cloth for use in protective clothing and curtains or molded into blocks. In the 1970's it was discovered that the short fiber form of this mineral can cause serious lung disorders which has in turn limited its use. This mineral is *[asbestos]*.
15. The earth's only natural satellite is the *[moon]*.
16. All the plant life present in a given habitat at a given time constitutes the *[flora]* of that habitat.
17. *[Proteins]* are any of a large group of organic compounds found in all living organisms. They comprise carbon, hydrogen, oxygen, and nitrogen, and most also contain sulphur. Their molecules consist of one or several long chains of amino acids linked in a characteristic sequence.
18. Weapons in which an explosion is caused by nuclear fission, nuclear fusion or a combination of both are called *[nuclear weapons]*.
19. A violently rotating column of air, usually made visible by a funnel cloud, ich may reach the ground surface, is called a *[tornado]*.
20. *[Lightning]* is a high-energy luminous electrical discharge that passes between a charged cloud and a point on the surface of the earth, between two charged clouds, or between oppositely charged layers of the same cloud.
21. The yellow non-metallic element, whose symbol on the periodic table of elements is S, is *[sulfur]*.

22. The “Systeme International” (SI) unit of power, defined as a power of one joule per second is the *[watt]*, widely used in electrical contexts.
23. The *[World Wide Web]* is a computer based information service. It is a hypermedia system distributed over a large number of computer sites that allows users to view and retrieve information from documents containing links.
24. Individuals use *[electronic mail]* to send messages, documents, etc., between computer systems.
25. One thousandth of a kilogram is a *[gram]*.
26. *[Petroleum]* is a naturally occurring oil that consists chiefly of hydrocarbons. In its unrefined form it is known as crude oil.
27. *[X-rays]* are electromagnetic radiations of shorter wavelength. They are used medically and industrially to examine internal structures.
28. A relatively small natural body that orbits a planet or a man-made spacecraft that orbits the earth, sun, moon or a planet is called a(n) *[satellite]*.
29. The electromagnetic energy radiated from the sun is called *[solar energy]*.
30. The property of a body or region of space that determines whether or not there will be a net flow of heat into it or out of it from a neighboring body or region and in which direction the heat will flow is called the *[temperature]*.
31. The production of immunity in an individual by artificial means is called *[vaccination]*.

Item categories “fill-in-the-blank” items

5.1.2 Conventional Scientific Literacy Questionnaire

(not limited to students)

Reference Brossard, D. & Shanahan, J. (2006). Do They Know What They Read? Building a Scientific Literacy Measurement Instrument Based on Science Media Coverage. *Science Communication, 1*, 47-63.

Item wording Now please answer the following questions about scientific terms and concepts.

Items
1. All radioactivity is man-made.
True False
2. Electrons are smaller than atoms.
True False
3. The earliest humans lived at the same time as the dinosaurs.
True False
4. The continents on which we live have been moving their location for millions of years and will continue to move in the future.
True False
5. Which travels faster: light or sound?

____
6. Does the Earth go around the Sun, or does the Sun go around the Earth?
____
7. How long does it take for the Earth to go around the Sun: one day, one month, or one year?
____
8. Please tell us, in your own words, what is DNA?
9. Please tell us in your own words, what is a molecule?
10. Please tell us, in your own words, what is radiation?

Item categories True/false questions, open-end questions

5.1.3 Knowledge about earth (shape)

Reference Vosniadou, S. & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology*, 24, 535– 585.

Item wording

Items

a) What is the shape of the earth?
b) Which way do we look to see the earth?
c) What is above the earth?
d) What is below the earth?
e) What is to the sides of the earth?
f) Can you draw a picture of the earth?
g) Now on this drawing, show me where the moon and stars go. Now draw the sky, we asked the children to add the stars, the moon, and the sky to their drawing of the earth.
h) Show me where the people live with respect to their earth drawing.
i) Here is a picture of a house. This house is on the earth, isn't it? Assuming that the child would agree that the house is located on the earth, the experimenter went on to ask, "How come here the earth is flat but before you made it round?"
j) If you walked for many days in a straight line, where would you end up?
k) Would you ever reach the end or the edge of the earth?
l) Is there an end or an edge to the earth?
m) Can you fall off that end or edge?
n) Where would you fall?
o) Now, I want you to show me where Champaign is. Where is China?

p) Now tell me what is down here below the earth, was asked with specific reference to the area below the child's drawing depicting the earth.

Item categories Qualitative

5.2 Affective-Motivational Measures

The following measures capture students' judgments of inquiry centered classroom activities, their interest for specific scientific topics, their attitudes towards science and their motivation to learn science.

5.2.1 INQUIRACT instrument.

Reference Blake, A., McNally, J. & Smith, C. (2010). INQUIRACT instrument. *Indicators of pupil opinion and teacher interactivity for inquiry-based science teaching.* Strathclyde: University of Strathclyde.

Item wording The purpose of this instrument is to improve understanding of inquiry-based science teaching in the classroom.

What makes particular investigative activities significant or useful? What are the opportunities for introducing, recognising, or increasing inquiry? What prevents you from using inquiry-based methods as successfully as you might have intended?

This instrument is designed to find some answers to these questions. We are also interested in any comments that you might have about the instrument itself (e.g. Is it easy to follow? Is it comprehensive? Was it useful to you in thinking about inquiry?). Please add any observations to the final page. Thank you very much for your help.

Instructions

For each significant investigative activity or opportunity that occurs:

1. Draw lines through the statements (or tick the boxes) that apply. As in the

example above, more than one statement may apply to a given activity.

2. Write a brief description of the activity, including the year group of the class involved.

There are no hard and fast rules about what constitutes a 'significant' investigative activity, except that it is one which mattered to you at the time and which you remember afterwards.

Items In order to keep the original structure of the this instrument it was not attempted to change it, see Appendix on page 112

Item categories Multiple answers are possible

5.2.2 Student Questionnaire. D. My Goals in Class

Reference Grangeat, M. & Leroy, N. (2009). Student Questionnaire. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Item wording

Items

1. It's important for me to show students that I'm good in class
2. It's important for me to learn new things this year
3. It's important for me to do better than other students in my class
4. It's important for me to learn as much as I can this year
5. It's important for me to prove other students in my class that work is easy for me
6. It's important for me to master new skills and knowledge this year
7. It's important for me to look smarter than the other students in my class
8. It's important for me to do my work in class because I want to get better at it

Item categories Strongly disagree, Disagree, Neutral, Agree, Strongly agree

5.2.3 Student Questionnaire. E My Perception of the Classroom Climate

Reference Grangeat, M. & Leroy, N. (2009). Student Questionnaire. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Item wording

Items

1. My teacher tells us that how much you improve is really important
2. My teacher tells us that getting good grades is the main goal
3. My teacher tells us that really understanding the material is the main goal
4. My teacher tells us that getting right answers is very important
5. My teacher tells us that learning new ideas and concepts is very important
6. My teacher tells us that it's important to look smarter than the other students
7. My teacher tells us that mistakes are okay as long as we are learning
8. My teacher tells us that it's important to get high scores on tests

Item categories Strongly disagree, Disagree, Neutral, Agree, Strongly agree

5.2.4 Science in School, measure 12

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Grade 8 Student Questionnaire (p.13). D.C.

Item wording How much do you agree with these statements about learning science?

Items

a) I usually do well in science
b) I would like to do more science in school
c) I enjoy learning science
d) I learn things quickly in science
e) I like science
f) Science is harder for me than for many of my classmates
g) I am just not good at science
h) Science is boring

Item categories Agree a lot, Agree a little, Disagree a little, Disagree a lot

5.2.5 Science in School, measure 13

Reference National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. 8th Grade Student Questionnaire (p. 14). D.C.

Item wording How much do you agree with these statements about science?

Items
a) I think learning science will help me in my daily life
b) I need science to learn other school subjects
c) I need to do well in science to get into the university or college of my choice
d) I need to do well in science to get the job I want

Item categories Agree a lot, Agree a little, Disagree a little, Disagree a lot

5.2.6 Item parameters for instrumental motivation to learn science

Reference OECD (2009). PISA 2006. Technical Report (p. 320). Paris: OECD.

Item wording How much do you agree with the statements below?

Items

a. Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on
b. What I learn in my <school science> subject(s) is important for me because I need this for what I want to study later on
c. I study <school science> because I know it is useful for me
d. Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects
e. I will learn many things in my <school science> subject(s) that will help me get a job

Item categories Strongly agree, Agree, Disagree, Strongly disagree

5.2.7 Item parameters for interest in science learning

Reference OECD (2009). PISA 2006.Technical Report (p. 318). Paris: OECD.

Item wording: How much interest do you have in learning about the following <broad science> topics?

Items

a. Topics in physics
b. Explanations
c. Topics in chemistry
d. The biology of plants
e. Human biology
f. Topics in astronomy
g. Topics in geology
h. Ways scientists design experiments
i. What is required for scientific

Item categories High interest, Medium interest, Low interest, No interest

5.2.8 Section 3: Your Views on Broad Science, Q 16

Reference OECD (2005) Student Questionnaire for PISA 2006. Main Study (p. 11). Paris: OECD.

Item wording: How much do you agree with the statements below?

Items

a) I generally have fun when I am learning <broad science> topics
b) I like reading about <broad science>
c) I am happy doing <broad science> problems
d) I enjoy acquiring new knowledge in <broad science>
e) I am interested in learning about <broad science>

Item categories Strongly agree, Agree, Disagree, Strongly disagree

5.2.9 Section 3: Your Views on Broad Science, Q17

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 12). Paris: OECD.

Item wording How easy do you think it would be for you to perform the following tasks on your own?

Items

a) Recognise the science question that underlies a newspaper report on a health issue
b) Explain why earthquakes occur more frequently in some areas than in others
c) Describe the role of antibiotics in the treatment of disease
d) Identify the science question associated with the disposal of garbage
e) Predict how changes to an environment will affect the survival of certain species
f) Interpret the scientific information provided on the labelling of food
g) Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars
h) Identify the better of two explanations for the formation of acid rain

Item categories I could do this easily, I could do this with a bit of effort, I would struggle to do this on my own, I couldn't do this

5.2.10 Section 3: Your Views on Broad Science, Q18

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 13). Paris: OECD.

Item wording How much do you agree with the statements below?

Items

a) Advances in <broad science and technology> usually improve people's living conditions
b) <Broad science> is important for helping us to understand the natural world
c) Some concepts in <broad science> help me see how I relate to other people
d) Advances in <broad science and technology> usually help improve the economy
e) I will use <broad science> in many ways when I am an adult
f) <Broad science> is valuable to society
g) <Broad science> is very relevant to me
h) I find that <broad science> helps me to understand the things around me
i) Advances in <broad science and technology> usually bring social benefits
j) When I leave school there will be many opportunities for me to use <broad science>

Item categories Strongly agree, Agree, Disagree, Strongly disagree

5.2.11 Section 3: Your Views on Broad Science, Q19

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 14). Paris: OECD.

Item wording How often do you do these things?

Items

a) Watch TV programmes about <broad science>
b) Borrow or buy books on <broad science> topics
c) Visit web sites about <broad science> topics
d) Listen to radio programmes about advances in <broad science>
e) Read <broad science> magazines or science articles in newspapers
f) Attend a <science club>

Item categories Very Often, Regularly, Sometimes, Never or hardly ever

5.2.12 Section 3: Your Views on Broad Science, Q21

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 16). Paris: OECD.

Item wording How much interest do you have in learning about the following <broad science> topics?

Items

a) Topics in physics
b) Topics in chemistry
c) The biology of plants
d) Human biology
e) Topics in astronomy
f) Topics in geology
g) Ways scientists design experiments
h) What is required for scientific explanations

Item categories High Interest, Medium Interest, Low Interest, No Interest

5.2.13 Section 4: The Environment Q22

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 17). Paris: OECD.

Item wording How informed are you about the following environmental issues?

Items

a) The increase of greenhouse gases in the atmosphere
b) Use of genetically modified organisms (<GMO>)
c) Acid rain
d) Nuclear waste
e) The consequences of clearing forests for other land use

Item categories I have never heard of this, I have heard about this but I would not be able to explain what it is really about, I know something about this and could explain the general issue I am familiar with this and I would be able to explain this well

5.2.14 Section 4: The Environment Q24

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 19). Paris: OECD.

Item wording Do you see the environmental issues below as a serious concern for yourself and/or others?

Items

a) Air pollution
b) Energy shortages
c) Extinction of plants and animals
d) Clearing of forests for other land use
e) Water shortages
f) Nuclear waste

Item categories This is a serious concern for me personally as well as others, This is a serious concern for other people in my country but not me personally, This is a seriousconcern only for people in other countries, This is not a serious concern to anyone

5.2.15 Section 4: The Environment Q25

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 20). Paris: OECD.

Item wording Do you think problems associated with the environmental issues below will improve or get worse over the next 20 years?

Items

a) Air pollution
b) Energy shortages
c) Extinction of plants and animals
d) Clearing of forests for other land use
e) Water shortages
f) Nuclear waste

Item categories Improve, Stay about the same, Get worse

5.2.16 Section 4: The Environment Q26

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 21). Paris: OECD.

Item wording How much do you agree with the statements below?

Items

a) It is important to carry out regular checks on the emissions from cars as a condition of their use
b) It disturbs me when energy is wasted through the unnecessary use of electrical appliances
c) I am in favour of having laws that regulate factory emissions even if this would increase the price of products
d) To reduce waste, the use of plastic packaging should be kept to a minimum
e) Industries should be required to prove that they safely dispose of dangerous waste materials
f) I am in favour of having laws that protect the habitats of endangered species
g) Electricity should be produced from renewable sources as much as possible, even if this increases the cost

Item categories Strongly agree, Agree, Disagree, Strongly disagree

5.2.17 Section 5: Careers and broad Science Q 27

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p.22). Paris: OECD.

Item wording How much do you agree with the statements below?

Items

a) The subjects available at my school provide students with the basic skills and knowledge for a <science-related career
b) The <school science> subjects at my school provide students with the basic skills and knowledge for many different careers.
c) The subjects I study provide me with the basic skills and knowledge for a <science related career>
d) d) My teachers equip me with the basic skills and knowledge I need for a <science-related career>

Item categories Strongly agree, Agree, Disagree, Strongly disagree

5.2.18 Section 5: Careers and broad Science Q28

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 23). Paris: OECD.

Item wording How informed are you about these topics?

Items

a) <Science-related careers> that are available in the job market
b) Where to find information about <science related careers>
c) The steps students need to take if they want a <science-related career>
a) d) Employers or companies that hire people to work in <science-related careers>

Item categories Very well informed, Fairly informed, Not well informed, Not informed at all

5.2.19 Section 5: Careers and broad Science Q29

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 23). Paris: OECD.

Item wording How much do you agree with the statements below?

Items

a) I would like to work in a career involving <broad science>
b) I would like to study <broad science> after <secondary school>
c) I would like to spend my life doing advanced <broad science>
d) I would like to work on <broad science> projects as an adult

Item categories Strongly agree, Agree, Disagree, Strongly disagree

5.2.20 Section 5: Careers and broad Science Q30

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 23). Paris: OECD.

Item wording What kind of job do you expect to have when you are about 30 years old?

Items Write the job title ____________________________________

Item categories Qualitative

5.2.21 Section 7: Teaching and Learning Science Q36

Reference OECD (2005) Student Questionnaire for PISA 2006. Main Study (p. 30). Paris: OECD.

Item wording: In general, how important do you think it is for you to do well in the subjects below?

Items

a) <School science> subjects
b) Mathematics subjects

a) <test language> subjects

Item categories Very important, Important, Of little importance, Not important at all

5.2.22 What I want to learn about

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording How interested are you in learning about the following?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Items

1. Stars, planets and the universe
2. Chemicals, their properties and how they react
3. The inside of the earth
4. How mountains, rivers and oceans develop and change
5. Clouds, rain and the weather
6. The origin and evolution of life on earth
7. How the human body is built and functions
8. Heredity, and how genes influence how we develop
9. Sex and reproduction
10. Birth control and contraception
11. How babies grow and mature
12. Cloning of animals
13. Animals in other parts of the world
14. Dinosaurs, how they lived and why they died out
15. How plants grow and reproduce
16. How people, animals, plants and the environment depend on each other
17. Atoms and molecules
18. How radioactivity affects the human body
19. Light around us that we cannot see (infrared, ultraviolet)
20. How animals use colours to hide, attract or scare
21. How different musical instruments produce different sounds
22. Black holes, supernovas and other spectacular objects in outer space
23. How meteors, comets or asteroids may cause disasters on earth
24. Earthquakes and volcanoes
25. Tornados, hurricanes and cyclone

26. Epidemics and diseases causing large losses of life
27. Brutal, dangerous and threatening animals
28. Poisonous plants in my area
29. Deadly poisons and what they do to the human body
30. How the atom bomb functions
31. Explosive chemicals
32. Biological and chemical weapons and what they do to the human body
33. The effect of strong electric shocks and lightning on the human body
34. How it feels to be weightless in space
35. How to find my way and navigate by the stars
36. How the eye can see light and colours
37. What to eat to keep healthy and fit
38. Eating disorders like anorexia or bulimia
39. The ability of lotions and creams to keep the skin young
40. How to exercise to keep the body fit and strong
41. Plastic surgery and cosmetic surgery
42. How radiation from solariums and the sun might affect the skin
43. How the ear can hear different sounds
44. Rockets, satellites and space travel
45. The use of satellites for communication and other purposes
46. How X-rays, ultrasound, etc. are used in medicine
47. How petrol and diesel engines work
48. How a nuclear power plant functions

Item categories Not very interested, Low not interested, Low very interested, Very interested

5.2.23 My future job

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording How important are the following issues for your potential future occupation or job?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Items

1. Working with people rather than things
2. Helping other people

3. Working with animals
4. Working in the area of environmental protection
5. Working with something easy and simple
6. Building or repairing objects using my hands
7. Working with machines or tools
8. Working artistically and creatively in art
9. Using my talents and abilities
10. Making, designing or inventing something
11. Coming up with new ideas
12. Having lots of time for my friends
13. Making my own decisions
14. Working independently of other people
15. Working with something I find important and meaningful
16. Working with something that fits my attitudes and values
17. Having lots of time for my family
18. Working with something that involves a lot of travelling
19. Working at a place where something new and exciting happens frequently
20. Earning lots of money
21. Controlling other people
22. Becoming famous
23. Having lots of time for my interests, hobbies and activities
24. Becoming 'the boss' at my job
25. Developing or improving my knowledge and abilities
26. Working as part of a team with many people around me

Item categories Not very important, Low not important, Low very important, Very important

5.2.24 What I want to learn about

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Items 1.How crude oil is converted to other materials, like plastics and textiles
2. Optical instruments and how they work (telescope, camera, microscope, etc.)
3. The use of lasers for technical purposes (CD-players, bar-code readers, etc.)
4. How cassette tapes, CDs and DVDs store and play
sound and music

5. How things like radios and televisions work
6. How mobile phones can send and receive messages
7. How computers work
8. The possibility of life outside earth
9. Astrology and horoscopes, and whether the planets can influence human beings
10. Unsolved mysteries in outer space
11. Life and death and the human soul
12. Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are
13. Why we dream while we are sleeping, and what the dreams may mean
14. Ghosts and witches, and whether they may exist
15. Thought transference, mind-reading, sixth sense, intuition, etc. .
16. Why the stars twinkle and the sky is blue
17. Why we can see the rainbow
18. Properties of gems and crystals and how these are used for beauty

Item categories Not very interested, Low not interested, Low very interested, Very interested

5.2.25 Me and the environmental challenges

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording To what extent do you agree with the following statements about problems with the environment (pollution of air and water, overuse of resources, global changes of the climate etc.)? (Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Items

1. Threats to the environment are not my business
2. Environmental problems make the future of the world look bleak and hopeless
3. Environmental problems are exaggerated
4. Science and technology can solve all environmental problems
5. I am willing to have environmental problems solved even if this means sacrificing many goods
6. I can personally influence what happens with the environment
7. Environmental problems can be solved without
8. big changes in our way of living
9. People should care more about protection of the environment
10. It is the responsibility of the rich countries to solve the environmental problems of the world
11. I think each of us can make a significant contribution to environmental

protection
12. Environmental problems should be left to the experts
13. I am optimistic about the future
14. Animals should have the same right to life as people
15. It is right to use animals in medical experiments if this can save human lives
16. Nearly all human activity is damaging for the environment
17. The natural world is sacred and should be left in peace

Item categories Disagree, Low disagree, Low agree, Agree

5.2.26 What I want to learn about

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Items

1. Symmetries and patterns in leaves and flowers
2. How the sunset colours the sky
3. The ozone layer and how it may be affected by humans
4. The greenhouse effect and how it may be changed by humans
5. What can be done to ensure clean air and safe drinking water
6. How technology helps us to handle waste, garbage and sewage
7. How to control epidemics and diseases
8. Cancer, what we know and how we can treat it
9. Sexually transmitted diseases and how to be protected against them
10. How to perform first-aid and use basic medical equipment
11. What we know about HIV/AIDS and how to control it
12. How alcohol and tobacco might affect the body
13. How different narcotics might affect the body
14. The possible radiation dangers of mobile phones and computers
15. How loud sound and noise may damage my hearing
16. How to protect endangered species of animals
17. How to improve the harvest in gardens and farms
18. Medicinal use of plants
19. Organic and ecological farming without use of pesticides and artificial fertilizers
20. How energy can be saved or used in a more effective way
21. New sources of energy from the sun, wind, tides, waves, etc.
22. How different sorts of food are produced, conserved and stored

23. How my body grows and matures
24. Animals in my area
25. Plants in my area
26. Detergents, soaps and how they work
27. Electricity, how it is produced and used in the home
28. How to use and repair everyday electrical and mechanical equipment
29. The first landing on the moon and the history of space exploration
30. How electricity has affected the development of our society
31. Biological and human aspects of abortion
32. How gene technology can prevent diseases
33. Benefits and possible hazards of modern methods of farming
34. Why religion and science sometimes are in conflict
35. Risks and benefits of food additives
36. Why scientists sometimes disagree
37. Famous scientists and their lives
38. Big blunders and mistakes in research and inventions
39. How scientific ideas sometimes challenge religion, authority and tradition
40. Inventions and discoveries that have changed the world
41. Very recent inventions and discoveries in science and technology
42. Phenomena that scientists still cannot explain

Item categories Not very interested, Low not interested, Low very interested, Very interested

5.2.27 My science classes

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording To what extent do you agree with the following statements about the science that you may have had at school?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

Items

1. School science is a difficult subject
2. School science is interesting
3. School science is rather easy for me to learn
4. School science has opened my eyes to new and exciting jobs
5. I like school science better than most other subjects
6. I think everybody should learn science at school
7. The things that I learn in science at school will be helpful in my everyday life
8. I think that the science I learn at school will

9. improve my career chances
10. School science has made me more critical and sceptical
11. School science has increased my curiosity about things we cannot yet explain
12. School science has increased my appreciation of nature
13. School science has shown me the importance of science for our way of living
14. School science has taught me how to take better care of my health
15. I would like to become a scientist
16. I would like to have as much science as possible at school
17. I would like to get a job in technology

Item categories Disagree, Low disagree, Low agree, Agree

5.2.28 G. My opinions about science and technology

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wordin: To what extent do you agree with the following statements?

(Give your answer with a tick on each row. If you do not understand, leave the line blank.)

Items

1. Science and technology are important for society
2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.
3. Thanks to science and technology, there will be greater opportunities for future generations
4. Science and technology make our lives healthier, easier and more comfortable
5. New technologies will make work more interesting
6. The benefits of science are greater than the harmful effects it could have
7. Science and technology will help to eradicate poverty and famine in the world
8. Science and technology can solve nearly all problems
9. Science and technology are helping the poor
10. Science and technology are the cause of the environmental problems
11. A country needs science and technology to become developed
12. Science and technology benefit mainly the developed countries
13. Scientists follow the scientific method that always leads them to correct answers
14. We should always trust what scientists have to say
15. Scientists are neutral and objective

16. Scientific theories develop and change all the time

Item categories Disagree, Low disagree, Lo agree, Agree

5.2.29 H. My out-of-school experiences

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording How often have you done this outside school?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

I have ...

Items

1. tried to find the star constellations in the sky
2. read my horoscope (telling future from the stars)
3. read a map to find my way
4. used a compass to find direction
5. collected different stones or shells
6. watched (not on TV) an animal being born
7. cared for animals on a farm
8. visited a zoo
9. visited a science centre or science museum
10. milked animals like cows, sheep or goats
11. made dairy products like yoghurt, butter, cheese or ghee
12. read about nature or science in books or magazines
13. watched nature programmes on TV or in a cinema
14. collected edible berries, fruits, mushrooms or plants
15. participated in hunting
16. participated in fishing
17. planted seeds and watched them grow
18. made compost of grass, leaves or garbage
19. made an instrument (like a flute or drum) from natural materials
20. knitted, weaved, etc
21. put up a tent or shelter
22. made a fire from charcoal or wood
23. prepared food over a campfire, open fire or stove burner
24. sorted garbage for recycling or for appropriate disposal
25. cleaned and bandaged a wound
26. seen an X-ray of a part of my body

27. taken medicines to prevent or cure illness or infection
28. taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.)
29. been to a hospital as a patient
30. used binoculars
31. used a camera
32. made a bow and arrow, slingshot, catapult or boomerang
33. used an air gun or rifle
34. used a water pump or siphon
35. made a model such as toy plane or boat etc
36. used a science kit (like for chemistry, optics or electricity)
37. used a windmill, watermill, waterwheel, etc
38. recorded on video, DVD or tape recorder
39. changed or fixed electric bulbs or fuses
40. connected an electric lead to a plug etc.
41. used a stopwatch
42. measured the temperature with a thermometer
43. used a measuring ruler, tape or stick
44. used a mobile phone
45. sent or received an SMS (text message on mobile phone)
46. searched the internet for information
47. played computer games
48. used a dictionary, encyclopaedia, etc. on a computer
49. downloaded music from the internet
50. sent or received e-mail
51. used a word processor on the computer
52. opened a device (radio, watch, computer, telephone, etc.) to find out how it works
53. baked bread, pastry, cake, etc
54. cooked a meal
55. walked while balancing an object on my head
56. used a wheelbarrow
57. used a crowbar (jemmy)
58. used a rope and pulley for lifting heavy things
59. mended a bicycle tube
60. used tools like a saw, screwdriver or hammer
61. charged a car battery

Item categories Never, Low never, Low often, Often

5.2.30 I. Myself as a scientist

Reference Schreiner, C. & Sjøberg, S. (2004). Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

Item wording Assume that you are grown up and work as a scientist. You are free to do research that you find important and interesting. Write some sentences about what you would like to do as a researcher and why.

Items

1. I would like to
2. Because
3.

Item categories Open

5.2.31 Cooperation between peers

Reference Seidel, T., Prenzel, M. & Kobarg, M. (Eds.) (2005). *How to run a video study. Technical report of the IPN Video Study*. Münster: Waxmann.

Item wording Students of one class get along with one another more or less well. How do you experience the physics instruction in your class?

Items

a. Students in my class often help each other in physics when working
b. If somebody does not understand something in physics it will be explained to him by a fellow student
c. Students help each other in physics homework
d. If I have problems in physics, my fellow students help me

Item categories Absolutely not true, Rather not true, Partly true, True for the most part, Absolutely true

5.2.32 Competition in science

Reference Seidel, T., Prenzel, M. & Kobarg, M. (Eds.) (2005). How to run a video study.

Technical report of the IPN Video Study. Münster: Waxmann.

Item wording: Students of one class get along with one another more or less well. How do you experience the physics instruction in your class?

Items

a) A lot of students are jealous when other students have better results in physics
b) In physics everybody in my class is in competition with one another
c) A lot of students just focus on being better and knowing more in physics than other
d) A lot of students do not tell others the answers because they want to answer the teacher's question themselves

Item categories Absolutely not true, Rather not true, Partly true, True for the most part, Absolutely true

5.2.33 Motivational orientation

Reference Seidel, T., Prenzel, M. & Kobarg, M. (Eds.) (2005). How to run a video study. Technical report of the IPN Video Study. Münster: Waxmann, 249.

Item wording Usually, I am participating and learning in physics lessons

Items

a. …because I want good grades (success orientation 1)
b. …because I want to finish this class with a good result (success orientation 2)
c. …because I want to do better in exams than my fellow students (competition orientation 1)
d. …because I want to be one of the best students in class (competition orientation 1)
e. …because it is important to me to know a lot about physics (competence orientation 2)
f. … because my parents expect it of me (commitment to parents 1)
g. … because I do not want my parents to be disappointed (commitment to parents 2)
h. .. because I want to avoid trouble with my teacher (commitment to teacher 1)
i. … because I want the teacher to think of me as a good student (commitment to teacher 2)
j. … because I want my friends to think of me as being good in physics (commitment to peers 1)
k. … because I earn my friends' recognition for that (commitment to peers 2)

Item category Absolutely correct, Rather correct, Rather not correct, Absolutely not correct

5.3 Metacognitive measures

Followingly metacognitive measures are listed that ask students for the source of their learning of scientific contents.

5.3.1 Language, Identity, and Appropriating Science Discourse

Reference Brown, B. A. (2006). ''It Isn't No Slang That Can Be Said about This Stuff'': Language, Identity, and Appropriating Science Discourse. *Journal of Research in Science Teaching, 43 (1),* 96-126.

Item wording

Items

A. Preparatory statements:
1. Explain to each of the students that the interviews will be tape-recorded. Be sure to explain that the reason for tape-recording is to completely eliminate the necessity of note taking.
2. State the purpose of the group discussions: The purpose is to find out how students a George Washington Carver High School view learning science. Be careful to note that the more honest and clear their information is, the easier it is to know how to improve our teaching.
3. Pledge confidentiality. Assure all students that no names, or faces, will be used in this project. The identity of all the students will be kept completely private.
4. Offer to share the results of the interview with the interviewee.
B. Science artifacts and methods:
1. In order for me to understand how you feel about science, could you describe, what types of tools and material scientists use in their work?
''Use probes; that is, return the informant to a description and ask them to provide more information (i.e., . . .Good . . . I thought what you said about . . . was interesting. . . please explain to me . . . I am interested in as much detail as you can give me.''
2. How are the tools that scientists use to conduct scientific research different from those used in science classrooms?
Then ask an elaboration probe:
Please describe _____ _____ _____ _____ in more detail. ''That's helpful. I would appreciate it if you could give me more detail about some of those differences.''
C. Scientific discourse
3. Please describe the type of language and writing used in science.
A. Then ask an elaboration probe: Please describe _____ _____ _____ _____ in more detail. ''That's helpful. I would appreciate it if you could give me more detail about some of those differences.''
B. Use a clarification probe. ''What you're saying is very important, and I want to be sure I understand you correctly. Let me repeat what you're saying. . .''

OR
‘’I’m not sure I understand what you meant, can you clarify that for me?’’
4. Howare they ways that scientists communicate different or the same as the way you do at home?
A. Return to elaboration probes.
B. Use clarification probes to incorporate group discussion.
‘’What you’re saying is interesting, do the rest of us feel about her/him saying. . .?’’
5. Do you feel that the topics you discuss in science are connected?
If so, then explain how.
6. In your opinion, describe why you believe scientists communicate the way they do in
their writings and talk?
D. Scientific epistemology
7. Explain how you believe scientists solve problems.
8. How does the way that you solve problems compare with the way that scientists solve
problems?
Ask comparison probes:
How does your experience compare with those of other people you know?
How are they different?
How are they similar?
10. How is the way that scientists solve problems, unique to only scientists?

Item categories Qualitative

5.3.2 Student Questionnaire. F. My learning strategies

Reference Grangeat, M. & Leroy, N. (2009). Student Questionnaire. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Item wording

Items

1. While studying I prepare a planning to organize my personal school work each week
2. I would prefer to do class work that is familiar to me, rather than work I would have to learn how to do
3. I do my homework regularly day by day
4. In class I prefer when teacher gives exercises that I am sure to achieve

quickly (to make index cards, plans, etc.)

5. For test, I generally study regularly and not only the day before
6. In class, I like academic concepts that are familiar to me, rather than those I haven't thought about before (to write, to make questions, to recite aloud, etc.)
7. I would choose class work I knew I could do, rather than work I haven't done before
8. When I have homework to return (exercise, etc…) I do it in advance rather than the day before
9. While studying I only concentrate on the subject I study
10. Before starting to study, I take stock of what I need to learn
11. While studying, if I do not understand something, I look for additional information
12. While studying, I try to memorize exactly a maximum of information
13. While studying I try to establish link between what I study and knowledge in other matters
14. While studying, I try to better understand lessons by associating new information with previous knowledge
15. While studying, I recite the contents of the lesson as much time as necessary
16. In class have difficulties to know what to do in I don't understand something

Item categories Strongly disagree, Disagree, Neutral, Agree, Strongly agree

5.3.3 Section 3: Your Views on Broad Science, Q20

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p.15). Paris: OECD.

Item wording Here is a list of <broad science> topics. From which source(s) did you mainly learn about each of these topics?

Items

a) Photosynthesis
b) Formation of the continents
c) Genes and chromosomes
d) Soundproofing
e) Climate change
f) Evolution
g) Nuclear energy

h) Health and nutrition

Item categories None of these, I am not sure what this is, My school, The TV, radio, newspaper or Magazines, My friends, My family, The Internet or books

5.3.4 Section 4: The Environment Q23

Reference OECD (2005). Student Questionnaire for PISA 2006. Main Study (p. 18). Paris: OECD.

Item wording From which source(s) did you mainly learn about each of these environmental issues?

Items
a) Air pollution
b) Energy shortages
c) Extinction of plants and animals
d) Clearing of forests for other land use
e) Water shortages
f) Nuclear waste

Item categories None of these, I am not sure what this is, My school, The TV, Radio, Newspaper or Magazines, My friends, My family, The Internet or books

References

Abell, S.K. & Smith, D.C. (1994). What is science? Preservice elementary teachers' conceptions of the nature of science. *International Journal of Science Education*, *16*, 475–487.

Blake, A., McNally, J. & Smith, C. (2010). INQUIRACT instrument. *Indicators of pupil opinion and teacher interactivity for inquiry-based science teaching.* Strathclyde: University of Strathclyde.

Blake, A., McNally, J. & Smith, C. (2010). SCEPSATI (Science Classroom Environment Pupil Satisfaction & Achievement Instrument). *Indicators of pupil opinion and teacher interactivity for inquiry-based science teaching.* Strathclyde: University of Strathclyde.

Blake, A., McNally, J. & Smith, C. (2010). Questionnaire on Investigative Science in your Placement School. *Indicators of pupil opinion and teacher interactivity for inquiry-based science teaching.* Glasgow: University of Strathclyde.

Brossard, D. & Shanahan, J. (2006). Do They Know What They Read? Building a Scientific Literacy Measurement Instrument Based on Science Media Coverage. *Science Communication, 1*, 47-63.

Brown, B. A. (2006). ''It Isn't No Slang That Can Be Said about This Stuff'': Language, Identity, and Appropriating Science Discourse. *Journal of Research in Science Teaching, 43 (1),* 96-126.

Crawford, B. A. (2007). Learning to Teach Science as Inquiry in the Rough and Tumble of Practice. *Journal of Research in Science Teaching, 44 (4),* 613–642.

Cunningham, S. C., McNear, B., Pearlman, R. S. & Kern, S. E. (2006). Beverage-Agarose Gel Electrophoresis: An Inquiry-based Laboratory Exercise with Virtual Adaptation. *CBE—Life Sciences Education , 5*, 281–286.

Danielowich, R. (2007). Negotiating the Conflicts: Reexamining the Structure and Function of Reflection in Science Teacher Learning. *Science Education, 91 (4),* 629-663.

Evans,R. & Dolin, J. (2009).Feedback on S-TEAM Training Module, Copenhagen: University of Copenhagen.

Evans, R. & Dolin, J. (2009). Modified version of STEBI for S-Team IBST for SL Training Module, Copenhagen: University of Copenhagen.

Forbes, C. T. & Davis, E. A. (2008). The Development of Pre-service Elementary Teachers' Curricular Role Identity for Science Teaching. *Science Education, 92 (5),* 909-940.

Enochs, L.G. & Riggs, I.M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90,* 695-706.

Gengarelly, L. M. & Abrams, E. D. (2009). Closing the Gap: Inquiry in Research and the Secondary Science. *Journal of Science Education and Technology, 18*, 74–84.

Grangeat, M. & Leroy, N. (2009). Satisfaction Questionnaire National Workshop WP 4. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Grangeat, M. & Leroy, N. (2009). Student Questionnaire. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Grangeat, M. & Leroy, N. (2009).Teacher Questionnaire. S-TEAM, WP 4, Grenoble: University Pierre-Mendes-France.

Greensfeld, H. & Elkad-Lehman, H. (2007). An Analysis of the Processes of Change in Two Science Teachers Educators' Thinking. *Journal of Research in Science Teaching, 44 (8),* 1219–1245.

Gröschner, A., Heinz, J., Lipowski, K. & Seidel, T. (2010). Baseline Report and Indicators Review for Science Teaching Methods and Attitudes in the context of S-TEAM, München: TUM.

Gröschner, A., Seidel, M., Lipowski, K. & Seidel, T. (2009). Questionnaire: Dissemination of S-TEAM. Jena: Friedrich-Schiller-University.

Hoekstra, A., Brekelmans, M. ,Beijaard, D. & Korthagen, F. (2009). *Teaching and Teacher Education*, *25*, 663–673.

Howard, D. R. & Miskowski, J. A. (2005). Using a Module-based Laboratory to Incorporate Inquiry into a Large Cell Biology Course. *Cell Biology Education*, *4*, 249–260.

Jorde, D. & Stadler, M. (2009). S-TEAM Teacher Education Questionnaire.

Jorde, D., Moberg, A. O., Prenzel, M., Rönnebeck, S. & Stadler, M. (2010). S-TEAM Preliminary Report: Work packages 2 & 3. Trondheim: NTNU.

Laius, A., Kask, K. & Rannikmäe, M. (2009). Comparing outcomes from two case studies on chemistry teachers' readiness to change. *Chemistry Educational Research Practice*, *10,* 142-153.

Lederman, N.G., Abd-El-Khalick, F., Bell, R. L. & Schwartz, R. S. (2002). Views of nature of science questionnaire. *Journal of Research in Science Teaching*, *39,* 497-521.

Lipowski, K. & Seidel, T. (2009). Guide for Interview Questions: Teacher professional Development in Science Education in European countries. Jena: Friedrich-Schiller-University.

Lotter, C. ,Harwood, W. S. & Bonner, J. J. (2007). The Influence of Core Teaching Conceptions on Teachers' Use of Inquiry Teaching Practices. *Journal of Research in Science Teaching*, *44 (9),* 1318–1347.

Maor, D. & Fraser, B. J. (2005). An Online Questionnaire for Evaluating Students' and Teachers' Perceptions. *Research in Science Education, 35,* 221–244.

Moore, F. M. (2008). Positional Identity and Science Teacher Professional Development. *Journal of Research in Science Teaching, 45 (6),* 684–710.

National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. 4th Grade Student Questionnaire. D.C.

National Center for Education Statistics. Institute of Education Sciences U.S. Department of Education Washington (2007). Trends in International Mathematics and Science Study. Teacher Questionnaire. Science Grade 8, Washington D.C.

Naylor, S., Downing, B & Keogh, B. (2001). An empirical study of argumentation in primary science, using Concept Cartoons as the stimulus*. Paper presented at the European Science Education Research Association Conference, Thessaloniki, Greece.* August 2001

OECD (2005). School Questionnaire for PISA 2006. Main Study. Paris: OECD.

OECD (2005) Student Questionnaire for PISA 2006. Main Study. Paris: OECD.

OECD (2009).PISA 2006. Technical Report. Paris: OECD.

Reeve, J. & Sickenius, B. (1994). Development and validation of a brief measure of the three psychological needs underlying intrinsic motivation: The AFS scales. *Educational and Psychological Measurement*, *54,* 506–515.

Seidel, T., Prenzel, M. & Kobarg, M. (Eds.) (2005). How to run a video study. Technical report of the IPN Video Study. Münster: Waxmann.

Schreiner, C. & Sjøberg, S. (2004): Sowing the Seeds of Rose. Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.

S-TEAM (2009). Science-Teacher Education Advanced Methods. Innovative Methods in Science Education. *Annex 1,* Trondheim: NTNU.

Tenenbaum, G., Naidu, S., Jegede, O. & Austin, J. (2001). Constructivist pedagogy in conventional on-campus and distance learning practice: An exploratory investigation. *Learning and Instruction 11,* 87–111.

Tuytens, M. & Devos, G. (2009). Teachers' perception of the new teacher evaluation policy: A validity study of the Policy Characteristics Scale. Teaching and Teacher Education, 25, pp. 924-930

Vosniadou, S. & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology*, *24,* 535– 585.

Windschitl, M., Thompson, J. & Braaten, M. (2008). How Novice Science Teachers Appropriate Epistemic Discourses Around Model-Based Inquiry for Use in Classrooms. *Cognition and Instruction*, *26 (3),* 310-378.

Woolley S. L., Benjamin W. J. & Woolley A. W., (2004). Construct validity of a self-report measure of teacher beliefs related to constructivist and traditional approaches to teaching and learning, *Educational and Psychological Measurement*, *64,* 319-331.

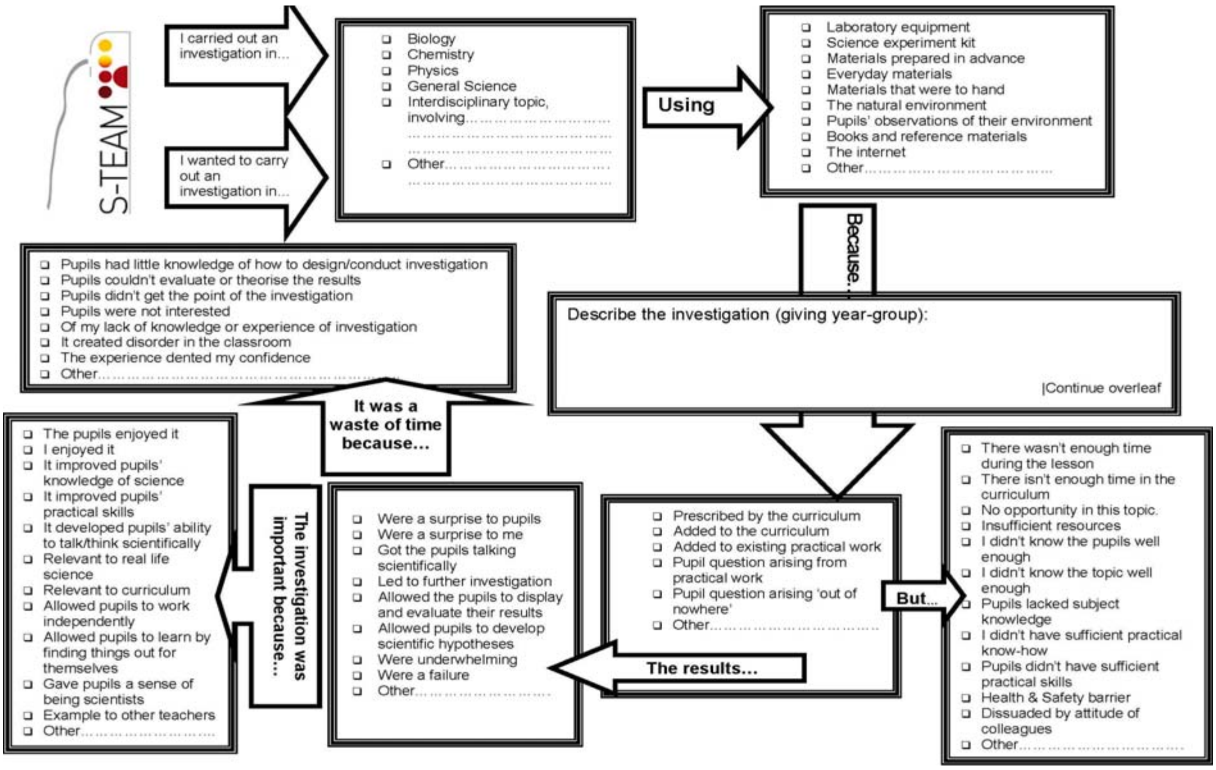
Index

List of Measures

Appendix

5.2.1 INQUIRACT instrument (items)

Blake, A., McNally, J. & Smith, C. (2010). INQUIRACT instrument. *Indicators of pupil opinion and teacher interactivity for inquiry-based science teaching.* Strathclyde: University of Strathclyde.



S-TEAM Partners

ISBN 978-82-93118-06-0

Cyprus	• European University – Cyprus *
Czech R.	• University of South Bohemia *
Denmark	• University of Copenhagen *
	• Aarhus Universitet
Estonia	• University of Tallinn *
Finland	• Abo Akademi University
	• Helsinki University *
	• University of Jyväskylä
France	• Centre National de la Recherche Scientifique
	• Université Pierre Mendes-France *
	• Université Rennes 2 – Haute Bretagne
Germany	• Friedrich Schiller University of Jena (1)
	• Leibniz Institute for Science Education at the University of Kiel *
	• Technical University Munich (2)
Israel	• Technion – Israel Institute of Technology *
Lithuania	• Kaunas University of Technology *
	• Vilnius Pedagogical University
Norway	• **Norwegian University of Science and Technology (coordinator)**
	• University of Oslo *
Spain	• Universidade de Santiago de Compostela *
Sweden	• Karlstad University* (3)
	• Mälardalen University
Turkey	• Hacettepe University *
	• Gazi University
UK	• University of Bristol *
	• University of Leeds
	• University of Strathclyde *

* National Liaison Partner

(1) To March 2010, (2) From April 2010 (3) From June 2010