Theory of Inquiry Learning Arrangements

Research, Reflection, and Implementation

Johannes Reitinger
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(Eds.)

kassel university press

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This is a place from which to see the unexplored,
to come together as we reach the peak,
to think of things as if they could be otherwise.

Maxine Greene, *Variations on a Blue Guitar*

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Preface

Directive instruction in institutionalized learning settings is still prevalent, as well as the disposition towards heteronomy that is widely observable in contemporary society and media culture. Fostering a self-determined, inquisitive mind is, therefore, highly desirable and should be given priority. The authors of *Theory of Inquiry Learning Arrangements. Research, Reflection, and Implementation*, consequently, regard the constructs of self-determination and Inquiry Learning as promising concepts. The Theory of Inquiry Learning Arrangements (TILA) concretizes these concepts according to the precepts of a critical multiplism. The effectivity of TILA is scrutinized via the personalized concepts AuRELIA (Authentic Reflective Exploratory Learning and Interaction Arrangements) and CrEEd (Criteria-based Explorations in Education). These concepts are presented in detail, empirically investigated, and underpinned with practical examples.

In Part I of this volume (Chapters 1–4), the theoretical framework of TILA as well as its corollary pragmatic concepts AuRELIA and CrEEd are presented in detail. Further, a summary of research which has been carried out in order to evaluate Inquiry Learning based on TILA, AuRELIA, and CrEEd is given. In the concluding chapter of Part I, the theoretical considerations are rounded off with a review of a project of scale development. The Criteria of Inquiry Learning Inventory (CILI) is introduced to the interested reader and offered to practitioners and researches as a useful tool to evaluate their own endeavors at self-determined Inquiry Learning Arrangements according to the discussed theory.

Part II represents a collection of empirical studies based on CrEEd and AuRELIA. Chapter 5 discusses the application of the CrEEd concept in the context of education of student teachers of English. This qualitative study gives insight into how the Criteria and Principles of Inquiry Learning unfolded in the participants' points of view. Chapter 6 also reflects on the benefits and challenges of CrEEd in a qualitative-empirical way, and with a focus on its application in student teacher training in English as a Foreign Language (EFL). The authors of Chapter 7 reflect on the relevance of Principles of Inquiry Learning in the course of a CrEEd arrangement within a university tutorial for student

teachers. The results of their qualitative analysis allow the establishment of action inducing conclusions, which are also presented in this chapter. Chapter 8 describes a quantitative study employing the AuRELIA concept. It explores the application of a self-determined Inquiry Learning arrangement in the field of mathematics didactics and shows the effectiveness of the concept with regard to the special self-efficacy of student teachers concerning the realization of inquiry-based learning arrangements. Chapter 9 returns to a qualitative approach and discusses the results of a case study of the *Autonomous Weeks* where student teachers experienced self-determined Inquiry Learning within a period of two weeks in the course of their teacher training. The final chapter of Part II presents a quasi-experimental study about the impact of AuRELIA in the field of teaching physics. Significant results are presented, suggesting that AuRELIA is an appropriate teaching concept for lower secondary school, triggering intrinsic motivation, involvement with educational content in physics, and perceived self-determination of girls aged 11–14 years.

In Part III of this volume, four authors discuss TILA in relationship to other theories or concepts. Chapter 11 addresses approaches like critical multiplism and viability check. In Chapter 12, a cultural-historical perspective is outlined by discussing compatibilities between the theory of expansive learning and TILA, as well as potentials of reciprocal support on various levels. In Chapter 13, TILA is critically compared with inquiry-based science education. Closing Part III of this book, Chapter 14 introduces a novel conceptual framework for Musical Inquiry Learning, which is theoretically affiliated with TILA.

Part IV contains a short reflective paper (Chapter 15) written by the developer of TILA, CrEEd, and AuRELIA. The paper comprises a set of commentaries on the various empirical and theoretical contributions presented in Part II and Part III, as well as further implications for the implementation of TILA and its corollary concepts. Further, this closing chapter intends to recall the very mission of this book by emphasizing its dedication to self-determination and acknowledging all its supporters.

It is worth mentioning that the Chapters 3–14 of this volume went through a double blind peer review process. Chapters 1 and 2 represent revised reprints of peer reviewed original articles.

If *Theory of Inquiry Learning Arrangements. Research, Reflection, and Implementation* at least at one point or another has the effect that institutionalized learning settings once more turn into a personally meaningful, authentic, and autonomous experience for learners, as well as for educators, the major objective of its editors and authors will have been achieved.

Johannes Reitinger
Christina Haberfellner
Eric Brewster
Martin Kramer

13 Inquiry Based Science Education and Teacher Professional Development

Christian Bertsch
Irene Gritschenberger

Inquiry Based Science Education has been shown to foster both understanding of scientific concepts as well as an understanding of how scientists work when solving problems. Besides the raising popularity of Inquiry Learning a current unified view of precisely how inquiry should be defined does not exist. The article tries to compare current conceptions of Inquiry Based Science Education (IBSE) with Reitingers (2013) Theory of Inquiry Learning Arrangements (TILA) and discusses the implications of Continuous Professional Development focusing on Inquiry Based Science Education (IBSE) on teaching practice in the primary science classroom.

Keywords: inquiry based science education, primary science, continuous professional development

1 Introduction

Inquiry has been a central term in the rhetoric of science education reforms around the globe over the last two decades. One goal of these reforms is promoting positive attitudes towards science and learning science. The importance of this promotion is emphasized by the mounting evidence of a decline in young peoples' interest in science studies and careers in industrialized countries (OECD, 2006). Motivating students to study science is a worthy aim, however, the primary goal of science education must not be to produce the next generation of scientists but to offer an education that develops students' basic understanding both of the major ideas which science offers and the way it produces reliable knowledge. The aim of science education should be educating students in and about science (Osborne & Dillon, 2009). To achieve this goal, we need to refocus science teaching on meaningful learning and conceptual understanding of scientific ideas rather than teaching and learning isolated fragments of theoretical knowledge.

Inquiry Based Science Education, if carried out effectively, is an efficient way to facilitate conceptual understanding and deepen the understanding of the nature of scientific inquiry. Learning with understanding differs from remembering facts, such as the names of the planets in the solar system, which particular objects float or sink, or the photosynthesis equation (Harlen, Artigue, Dillon, & Lena, 2012). Facts alone are insufficient to develop understanding. Understanding means that students can explain why there are four seasons in Austria, why things do or do not float, why plants cannot grow in the dark, and which evidence supports these concepts. A review of 138 studies focused on the outcome of Inquiry Based Science Education has shown that students who have the opportunity to engage in active thinking and being subsequently asked to draw conclusions from data are more likely to understand the inherent scientific content than in traditional teacher-centered lessons (Minner, Levy, & Century, 2010).

Inquiry Based Science Education and Inquiry Based Education in general require students to become more independent learners. Teachers must allow students to develop their own ideas taking into account that these ideas can also be incorrect at first. Teachers used to teaching science by giving information from text books need the chance to experience, understand, and value Inquiry Based Learning if they are to develop the confidence and skills to implement Inquiry Based Education in their classroom (Harlen & Allende, 2009). To achieve a change in teaching practices, Professional Development is still seen as the most effective way.

In the first part of this article current conceptions of Inquiry Based Science Education (IBSE) are compared with Reitingers (2013) Theory of Inquiry Learning Arrangements (TILA). The second part focuses on Teacher Professional Development in Inquiry Based Primary Science Education.

2 Inquiry Based Science Education (IBSE) and the Theory of Inquiry Learning Arrangements (TILA)

It is difficult to exactly trace the first appearance of Inquiry Based Learning and Instruction. John Dewey, Jean Piaget, and Lev Vygotsky anticipated in their work about the nature of learning and teaching many aspects of IBSE, such as the need to motivate students in hands-on activities and the opportunities for students to engage in active thinking and drawing conclusions from data they gathered on their own. In 1910, John Dewey criticizes that "science has been taught too much as an accumulation of ready-made materials with which students are to be made familiar and not enough as a method of thinking" (Dewey 1910, p. 122). Dewey placed inquiry at the center of his educational philosophy. For him, learning was best approached by engaging student communities in an inquiry process (Dewey, 1933).

While Inquiry Based Learning is not especially new in science education, it has been increasingly engrossed in reform documents over the last 20 years. In 1996 the

US National Science Education Standards declared that "inquiry is central to science learning" (NRC 1996, p. 2). In 2007, the European Commission demanded a "reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods" (EC 2007, p. 2). In 2015, one can find the term inquiry in almost any curriculum in industrialized countries, from primary to higher education.

Aside from its raising popularity, we still do not have a current unified view of precisely how inquiry should be defined. Some researchers assess its definition as "the most confusing thing about inquiry" (Colburn 2000, p. 42). Part of this confusion lies in the fact that inquiry often simultaneously refers to the learning of both scientific concepts and the skills scientists use to solve problems of the natural world (Magee & Meier, 2011). Abd-El-Khalick et al. (2004) distinguish between "inquiry as means" and "inquiry as ends". The former sees inquiry as an instructional approach intended to help students develop understanding of science content, the latter refers to inquiry as an instructional outcome. Students learn to inquire in the context of science content and develop epistemological understandings about the nature of science and the development of scientific knowledge, as well as relevant inquiry skills, e.g., identifying problems, generating research questions, designing and conducting investigations, and drawing evidence-based conclusions.

One definition that is often referred to within the science education research community is the one given by the US National Research Council. It defines inquiry

> "… as 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." (NRC 1996, p. 23)

The NRC also defines essential features of classroom inquiry and gives variations in the amount of learner self-direction, as illustrated in Table 1.

TABLE 1. *Essential features of classroom inquiry and their variations in the NRC concept (NRC 2000)*

Essential Feature	**Variations**			
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner clarifies questions provided by teacher, materials, or other source	Learner engages in questions provided by teacher, materials, or other source
Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze

Essential Feature	Variations			
Learner formulates explanations from evidence	Learner formulates explanations after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanations	Learner provided with evidence and shown how to use evidence to formulate explanation
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpen communication	Learner given steps and procedure for communication

Within the EU Seventh Framework Programme (FP 7) funded project "Primary Science Network" the University of Teacher Education (Pädagogische Hochschule) Vienna coordinated Continuous Professional Development activities focusing on Inquiry Based Science Education in primary schools for 60 Austrian teachers over a period of two years. Within the project, a framework for Inquiry Based Science teaching and learning at primary level was defined. In this framework, learners

- engage actively in the learning process with emphasis on observations and experiences as sources of evidence;
- tackle authentic and problem based learning activities where the correctness of an answer is evaluated only with respect to the available evidence and getting to a correct answer may not be the main priority;
- practice and develop the skills of systematic observation, questioning, planning and recording to obtain evidence;
- participate in collaborative group work, interact in a social context, construct discursive argumentation and communicate with others as the main process of learning;
- develop autonomy and self-regulation through experience (Gatt & Scheersoi, 2014, p. 2).

Within this framework the teacher scaffolds and guides learning by being a role model of an inquiring learner. The teacher does not perform, in the eyes of the children, as the sole bearer of expert knowledge. Instead, the main role of the teacher is to provide possibilities to negotiate ideas and to highlight criteria for formulating classroom knowledge (Gatt & Scheersoi, 2014).

Whereas the various definitions of inquiry in the science education research community are strongly linked to the processes of inquiry undertaken by natural scientists, Reitinger (2013) made an attempt to conflate the earlier roots of Inquiry Learning coined by Dewey with recent findings from motivational psychology (Ryan & Deci, 2004), as well as arguments derived from the European *Bildungstheorie* (Klafki, 1999)

in his Theory of Inquiry Learning Arrangements (TILA). According to Reitinger (2013) Inquiry Learning is characterized by six criteria: (1) General Discovery Interest, (2) Method Affirmation, (3) Experience-based Hypothesizing, (4) Authentic Exploration, (5) Critical Discourse and (6) Conclusion-based Transfer. One can find a detailed description of the TILA framework in this volume (see Chapter 1).

Table 2 shows a comparison of the three mentioned frameworks focusing on Inquiry Learning. All frameworks were initially developed for science classes, but can easily be adapted to other subjects. The comparison of the frameworks shows significant overlap, however, some aspects can only be found in one or two of the frameworks. According to the TILA, Inquiry Learning is underpinned by two dispositions which foster the act of questioning, namely General Discovery Interest and Method Affirmation. The NRC framework does not mention preconditions that lead to the formulation of research questions.

TABLE 2. *Comparison of different frameworks dealing with classroom inquiry*

NRC Framework	Pri-Sci-Net Framework	TILA Framework
	Learner engages actively in the learning process	General Discovery Interest
	Learner develops autonomy and self-regulation	Method Affirmation
Learner engages in scientifically oriented questions		Experience-based Hypothesizing
Learner gives priority to evidence in responding to questions	Learner tackles authentic and problem based learning activities where the correctness of an answer is evaluated only with respect to the available evidence	Authentic Exploration
	Learner practices and develops the skills of systematic observation, questioning, planning and recording to obtain evidence	
Learner formulates explanations from evidence	Learner constructs discursive argumentation	Critical Discourse
Learner connects explanations to scientific knowledge		
Learner communicates and justifies explanations	Learner participates in collaborative group work, interacts in a social context, constructs discursive argumentation and communicates with others as the main process of learning	Conclusion-based Transfer
	Teacher scaffolds and guides learning by providing a role model of an inquiring learner. Teacher facilitates negotiation of ideas and highlights criteria for formulating classroom knowledge.	

Both the NRC and the Pri-Sci-Net framework see Inquiry Based Learning as evidence-based learning, but they differ in the aim of the inquiry process. In the Pri-Sci-Net framework "the correctness of an answer is evaluated only with respect to the available evidence and getting to a correct answer may not be the main priority" (Gatt & Scheersoi, 2014, p. 2), whereas in the NRC framework the "learner connects explanations to scientific knowledge". The question inevitably arises, what if the students' findings con-

tradict the current scientific view on a given topic? The NRC framework gives different variations on how to connect students' explanations to scientific knowledge. It assumes that students' investigations cannot contradict scientific knowledge. TILA is not very specific on how to connect students' findings to current scientific knowledge on the topic. Concerning the role of the teacher, only the Pri-Sci-Net framework is specific and defines the teacher as a role model for an inquiring learner, who scaffolds the learning process and sums up classroom knowledge.

Three different definitions of Inquiry Learning were chosen and overlaps were found but also different aspects in these definitions. Looking at other curricula or reform documents would probably have yielded more definitions, more overlaps and more different aspects. Not all, but many of these definitions do have a strong theoretical foundation (Abd-El-Khalick et al., 2004). Sometimes the basis is more epistemological and refers strongly to the philosophy of science. Sometimes the foundation refers to educational theories.

From a scientific point of view, a unified definition of Inquiry Learning by means of clearly defined criteria would ease the access for empirical work in the field. Current meta-analyses on the effects of Inquiry Learning (Hattie, 2010, Minner et al., 2009) are difficult to interpret because it is not clear what different studies meant when they evaluated Inquiry Learning.

However, restrictive definitions with the idea that an endeavor can only be classified as Inquiry Learning if all the criteria of the definitions are met have little value for educational settings because these are highly situated and contextual. One wonderful example of Inquiry Learning I recently saw in preschool education is the research conducted by the young learners on snails and their favorite food. The research question, "What is the favorite food of snails?", was posed by the kindergarten teacher. The children developed an experimental setting to find out if snails prefer lettuce, cucumber, grass, or dried leaves. On the basis of their observation, they came to the conclusion that snails' favorite food is lettuce. This might not be scientifically correct, and one could criticize that the chosen research design is not suitable to answer the posed research question. One could also criticize that the posed research question is probably too unspecific. However, one could also focus on a group of young learners that developed an experimental setting on their own, were enthusiastic when they came to kindergarten the next morning to observe what happened over night, and reported to their parents what they found out in kindergarten. In the lesson described many aspects of the presented definitions were met, but not necessarily all of them. However, who could argue that this is not Inquiry Learning?

If we want to integrate Inquiry Learning into daily classroom routines, we need to have a clear understanding what Inquiry Learning is. Based on this understanding we can define curricular goals and develop pedagogical tools and professional development sessions for in-service and pre-service teachers.

However, having a clear understanding of Inquiry Learning does not mean that we have to follow a unified definition of Inquiry Learning. Instead of thinking of a generalized definition of Inquiry Learning in science and assuming it will allow achieving multiple goals, i.e., developing understanding of scientific concepts, helping students to acquire integrated inquiry skills, learning about the nature of science, it might be more useful to think of several dimensions of Inquiry Learning that are intimately linked with measurable instructional outcomes.

Inquiry Learning is seen as evidence-based learning where one can use different methods of investigation to find evidence for defensible conclusions. When planning Teacher Professional Development sessions on Inquiry Learning in science several dimensions of Inquiry Learning can come to mind. One dimension can be *Conceptual Understanding*. How must inquiry lessons be structured to allow better understanding of a given topic? Another dimension can be *Inquiry Skills*, e.g., how can a teacher support the systematic collection of data and fair testing? A third dimension can be the *Nature of Science*, e.g., how can a teacher support the epistemological understanding about how scientists work?

To achieve Inquiry Based Science learning teachers themselves must be aware of how science works and what the characteristics of scientific investigations are. This can only be facilitated if the nature of science is made explicit in the pre-service and in-service training of teachers (Sadler, Burgin, McKinney, & Ponjuan 2010; Capps & Crawford, 2013).

3 From Theory to Classroom Culture: Continuous Professional Development on Inquiry Based Science Education at Primary Level

Teacher Professional Development (PD) is seen as the most powerful tool to change teaching practices. Alternative methods, such as policies to support ambitious instructional reforms, have been found to have little impact on basic classroom routines (Suppovitz & Turner, 2000).

Within the EU FP7 project Primary Science Network (www.prisci.net) the University of Teacher Education Vienna and its Educational Competence Center for Science and Mathematics designed, implemented and evaluated Continuous Professional Development (CPD) sessions on IBSE over a period of two years for 60 primary school teachers.

Usually teacher trainings in Austria only span one or two afternoons. Evaluation of various projects on the dissemination of IBSE shows that short term teacher trainings do not necessarily lead to a change in classroom routines. Harlen and Allende (2009) concluded in their evaluation of various Professional Development (PD) programs on IBSE that

> "when teachers learn to use new materials and pedagogy, their needs are similar to those of any learners, particularly the need to communicate with

> and have feedback from others and to have time for reflection. These are more likely to be provided, and teachers take ownership of their learning, when professional development sessions take place intermittently over a period of time, with opportunities between sessions for teachers to practice what they have learned in their own classrooms and to share experiences with others." (Harlen & Allende, 2009, p. 25)

Suppovitz and Turner (2000) identified six critical components of Professional Development in science education. If PD includes most or all these six components they call it *high quality professional development*. In the developed PD sessions on Inquiry Learning, five of the six mentioned components were included. One component, namely showing teachers how to connect their work to specific standards for student performance, was neglected because there are no standard tests in science at primary level in Austria. Yet, we added another crucial component when it comes to PD in IBSE. We included a workshop focusing specifically on the Nature of Science into our trainings. The following six criteria were met in the Pri-Sci-Net PD sessions:

1. High quality Professional Development must immerse participants in inquiry, questioning, and experimentation and, therefore, model inquiry forms of teaching. In each of our eight workshops teachers had the possibility to experience Inquiry Learning.
2. Professional Development must be both intensive and persistent. We organized eight workshops (40 hours) over a period of two years. If this is intensive enough could be discussed. Austrian primary school teachers would definitely argue that eight workshops on primary science education are intensive. In addition to the 40 hours, the participants engaged in a number of in-class tasks, i.e., testing materials, interviewing children about their pre-instructional concepts.
3. PD must engage teachers in concrete teaching tasks and allow personal experiences. Teachers were asked to put into practice what we discussed in the workshops between the training sessions and discuss their experiences with the other participants.
4. PD must focus on subject-matter knowledge and deepen teachers' IBSE skills. Many primary school teachers feel insecure in science and lack the confidence in science teaching. Therefore, the developed PD program engaged teachers in learning core concepts of primary science, e.g., magnetism, state of matter, floating and sinking through inquiry at their own level, providing them with first-hand experience of using inquiry skills, as well as a deeper understanding of the phenomena they studied. We also provided the needed background knowledge, possible students' conceptions, as well as possible age-adequate explanations.
5. Primary school teachers normally lack authentic research experience. Therefore, we added a workshop focusing on the nature of science explicitly to support teachers in

learning about inquiry. Therefore, teachers had opportunities for learning through inquiry and learning about inquiry.

6. Staff development cannot be separated from school development. In the workshops, we provided and discussed development tools that support schools in reforms towards a "culture of inquiry" in science teaching at their school. These SQA (Schulqualität Allgemeinbildung) guidelines can be found at www.science2school.at.

EVALUATION OF THE PD COURSES

Sixty teachers started the two year training, among this group 42 teachers took part in all eight workshops. The course was evaluated with a pre and posttest design with questionnaires and interviews. Teachers' concepts of Inquiry Learning and their science teaching self-efficacy beliefs were already published (Bertsch, 2014). In this article, some results of the post-questionnaire will be discussed.

Figure 1 shows the impact of the PD course on teacher knowledge and self-confidence. 91% of the participants strongly agree that the PD course improved their understanding of Inquiry Based Science Education, while 76% of the teachers reported a strong influence on their content knowledge of relevant primary science topics. More than 85% strongly agree that the PD course improved their self-confidence in science teaching.

FIGURE 1. *Impact of PD within the Pri-Sci-Net project on teacher knowledge and self-confidence (n=42)*

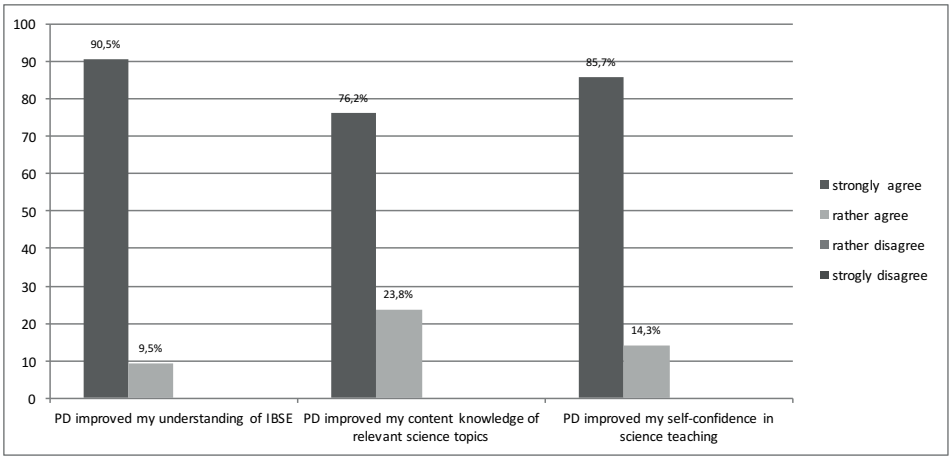
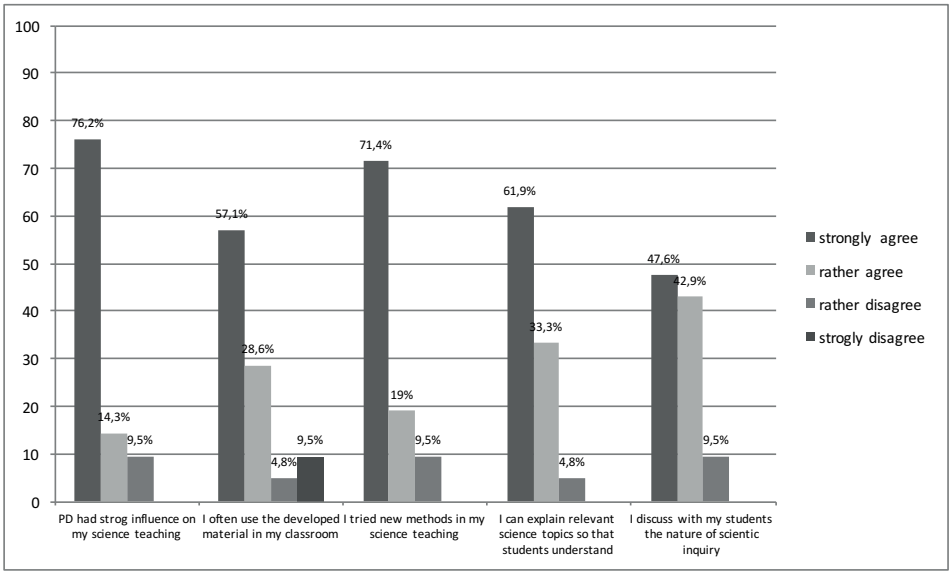


Figure 2 shows the impact of the PD course on primary science classroom routine. 76% of the participants reported that the PD had a strong influence on their science teaching, while 57 % strongly agree that they often use the material that was developed during the PD sessions in their classroom. 71% reported that they worked with new methods in their science classrooms, and 62% strongly agree that they can teach relevant science topics in a way that their students develop conceptual understanding.

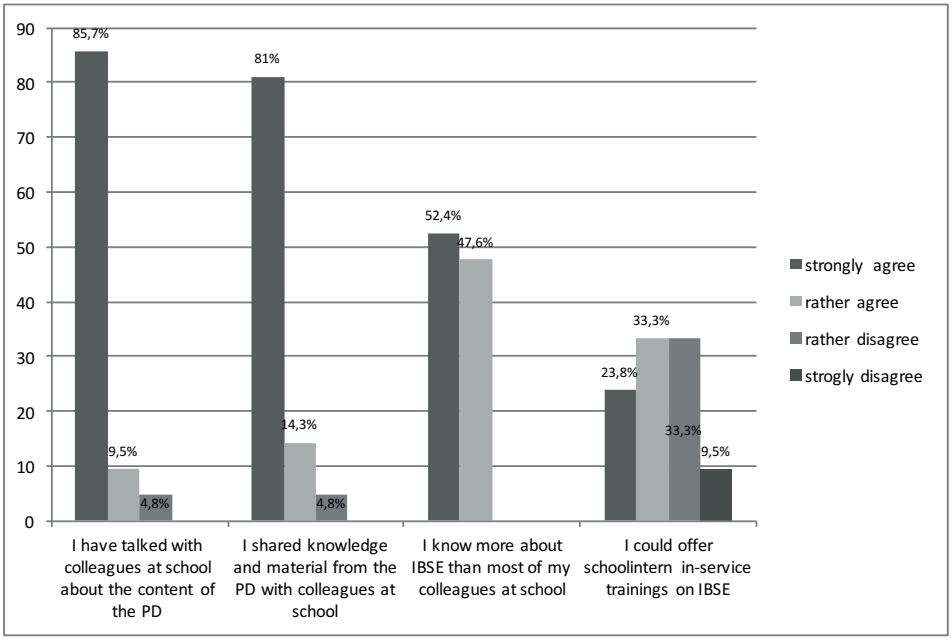
In the literature it is suggested that PD on IBSE should contain opportunities for learning through inquiry and learning about inquiry. Therefore, one workshop on the Nature of Science was added. Teachers were very enthusiastic about this workshop and in the interviews they mentioned that this workshop had a strong influence on their own understanding about inquiry. However, only 48% of the teachers strongly agree that they discuss the nature of scientific inquiry with their students. The material used in this workshop was developed for 8-10 year old children. As many of the participants also teach younger students this could explain the lower transfer of the material into classroom routine.

FIGURE 2. *Impact of PD within the Pri-Sci-Net project on science teaching (n=42)*



Successful PD should empower teachers not only to use new methods in their teaching but also to promote new learning methods at their schools. Figure 3 shows how knowledge acquired during the PD course was disseminated at their schools. At the end of the PD course, 86% of the participants said that they had discussed content of the workshops with colleagues at school, 81% had shared knowledge and materials. 52% strongly and 48% rather agree that they know more about IBSE than most of their colleagues at school. However, only 24% strongly agree that they are able to offer in-school trainings on IBSE for their colleagues.

FIGURE 3. *In-school dissemination of knowledge acquired within the Pri-Sci-Net project PD courses (n=42)*



4 Conclusion

Inquiry Based Science Education has been shown to foster both understanding of scientific concepts as well as understanding of how scientists work when solving problems. Besides the raising popularity of Inquiry Learning, a current unified view of precisely how inquiry should be defined does not exist. In this article three different frameworks defining Inquiry Learning were compared. Even if a unified definition of Inquiry Learning by means of clearly defined criteria would ease the access for empirical work in the field, the author comes to the conclusion that a too restrictive definition of Inquiry Learning would be of little value for the dissemination of Inquiry Learning in highly situated and contextual educational settings. Instead of thinking of a generalized definition of Inquiry Learning in science, it might be more useful to think of several dimensions of Inquiry Learning that are intimately linked with measurable instructional outcomes. Based on this assumption, Professional Development sessions on Inquiry Learning in science were planned, implemented, and evaluated. The PD focused on Inquiry Learning in Primary Science and emphasis was placed on increasing teachers' content knowledge and developing Inquiry Learning skills, opportunities for "learning through inquiry" and "learning about inquiry", and methods and principles of Inquiry Learning in the primary science classroom. The two year training improved participant's knowledge of Inquiry Based Science Education and their self-confidence in science teaching. It also had a strong influence on teachers' content knowledge of relevant

primary science topics. Teachers reported a strong influence of the training on their science teaching practices.

The major determinant of any education system is the quality of its teachers. If we want a reversal of school science-teaching pedagogy from mainly deductive to inquiry-based methods investment in long-term Professional Development is crucial. Changing teacher pedagogy cannot be done through short, one-off courses, which currently dominate Professional Development for teachers in Austria.

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