Teachers' Professional Development of IBL skills in science through PRIMAS project

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Abstract

Inquiry-based learning (IBL) promotes student learning and the development of competencies like self-directed learning and exploring new knowledge areas. Unfortunately, many teachers lack experience in IBL and they need further support through, for instance, Professional Development courses (PD). The effect of PD on teachers' IBL beliefs and skills was observed by examining the potential change in teachers' beliefs and practices after their participation in PD for a year. Moreover, we examined the effective characteristics of PD in terms of content and organization. Interviews with teachers were carried out as well as observations of PD and classroom observations. The results indicate that when teachers participated in PD for a year, they became more willing and positive towards IBL and managed to change their teaching practices. The extent to which change occurred depended on previous experience working with IBL. The most effective characteristics of PD were Reflection, Collaborative working and Including content knowledge. This research highlights the importance of providing practical information to teachers during PD that could be of direct use in their lessons. We conclude that participation in PD can have beneficial effects on teachers' IBL skills.

Introduction

Educational research has been focusing on the effectiveness and necessity of Professional Development courses to support teachers in enhancing their knowledge and helping them in developing inquiry-based lessons. Many initiatives aim at facilitating teachers to enrich traditional teaching approaches with inquiry-based approaches. One such initiative is the project PRIMAS (Promoting Inquiry-based learning in Mathematics and Science). The goal of PRIMAS PD is to encourage teachers to experience and explore the impact of using effective IBL pedagogies in their own classrooms as well as to encourage

and support them to implement those pedagogies. Through the PD sequence teachers are invited to take risks and adapt new practices in order to modify their beliefs (Swan, Doorman, & Mooldijk, in press).

According to Guskey (1986), Professional Development programs are generally unsuccessful in modifying teachers' beliefs but when teachers are encouraged to adopt a procedure and find that it improves student achievement, significant changes in attitude may be attained (Swan, Doorman, & Mooldijk, in press). Moreover, based on Swan et al. (in press), teachers frequently reported that their understanding of new pedagogies develops slowly, and that they continue to struggle with embedding and sustaining them.

On the other hand, well-designed PD experiences that engage teachers in an authentic investigation can effectively enhance teachers' subject matter knowledge (Capps & Crawford, 2013). According to a study by Capps and Crawford (2013), PD resources appear to be powerful tools for developing new pedagogical knowledge and skills for inquiry-based learning. Professional Development courses provide a basis for discussion and active participation as well as support for using new ideas into every day practices.

General aim of this research

The main aim of this research is to investigate if teachers of a particular school in the Netherlands, participating in PRIMAS PD for one year, managed to change their beliefs and practices of IBL while taking into consideration their background and teaching experiences as well as their disposition and motivation. Furthermore, what will be examined is if the content and organization of PRIMAS PD sessions are indeed helpful and effective for the teachers. Investigating those three aspects will help to gain insights into the effect of Professional Development on teachers' IBL beliefs and skills.

Theoretical Background

The concepts that will be discussed here are Inquiry-based learning (IBL), change in beliefs, change in practices and finally Professional Development (PD) with a focus on content and organization.

IBL and its importance to learning

There is a need to promote IBL in science and mathematics education. The last decades there has been a lot of research concerning the effectiveness of IBL. One of the advantages of IBL is the fact that students are given the chance to gather information and data through their active participation (Bell, Urhahne, Schanze, & Ploetzner, 2010). With the process of inquiry, students construct their understanding and are led step by step to scientific knowledge. Furthermore, through IBL researchers support that children become more interested in science (Van Schijndel, Singer, van der Maas, & Raijmakers, 2010).

Brandon, Young, Pottenger, and Taum (2009) define science inquiry as a hands-on, constructivist approach to science education. In inquiry science students work together in groups and reach decisions about processes, procedures, analyses, and outcomes. The results of a study on IBL by Van Schijndel, Singer, van der Maas and Raijmakers (2010) that are in agreement with the constructivist view, suggest that when children explore their environment they make connections between their actions and the effects and for this reason students should be engaged in sciencing programs. In such programs teachers can design rich learning environments with science activities that support children's learning (Van Schijndel, Singer, van der Maas & Raijmakers, 2010).

The teachers' role is of importance in these processes as they scaffold the scientific learning procedure (Van Schijndel, Singer, van der Maas & Raijmakers, 2010). Teachers

involved in inquiry science support students and interact with them, encourage dialogues and debates among students, motivate them to participate in inquiry learning and evoke students' curiosity, openness to new ideas and skepticism. Their role is to challenge students to actively participate in science learning (Brandon, Young, Pottenger & Taum, 2009).

Finally, Van Schijndel et al. (2010) conclude that there is a need for properly trained teachers in science-related subjects, who can support students' curiosity and exploratory learning through inquiry-based activities. Enthusiastic and scaffolding teachers are the key characteristic of an effective learning environment.

While inquiry-based learning may have certain positive aspects and obvious advantages, some educational researchers claim that this is not always the case. A review study reported that close guidance during instruction can be more efficient compared to IBL (Kirschner, Sweller & Clark, 2006). The authors claim that unguided or minimally guided instruction is not only less effective but it also may have negative results when students acquire misconceptions or incomplete knowledge.

Silver, Duncan, and Chinn (2007) contradict Kirschner, Sweller, and Clark (2006) by saying that IBL is a scaffolded method and it is not an unguided type of discovery learning. They claim that IBL is a powerful and effective model that reduces the cognitive load and allows students to learn in complex domains (Silver, Duncan, & Chinn, 2007).

Whether or not to use the method of inquiry-based learning has been a problem that educational scientists started facing the last decades. A further elaboration of the existing debate is beyond the scope of this research. Inquiry-based learning is indeed an important teaching approach which is effective when guidance and scaffolding are provided by teachers. Therefore, the teacher's role is essential. The focus of this study is on teachers'

Professional Development while trying to adapt inquiry-based techniques and new teaching practices without eliminating guidance and scaffolding.

Teacher change

Many teachers lack the necessary experience and background in inquiry-based approaches. Therefore, it is essential to change teachers' roles and help them adopt new teaching behavior. The way to achieve that is by changing their *beliefs* as well as their teaching *professional practices*.

The aim of a study by Bakkenes, Vermun and Wubbels (2009) was to increase the understanding of how teachers learn. The focus was on teachers' learning activities and learning outcomes. The reported learning outcomes were associated with changes in *knowledge and beliefs, emotions, practices* and *intentions for practice.* Change in knowledge and beliefs were most frequently reported while change in teaching practices was rarely reported. However, intentions for practice were often reported.

The main categories referring to teacher change can be subdivided into several subcategories (Bakkenes, Vermun & Wubbels, 2009). Those are the following: teacher awareness, confirmed and new ideas (changes in knowledge and beliefs); intentions to try new practices, to continue new practices, to continue current (old) practices (intentions for practice); new practices, back to old practices (changes in practices); positive and negative emotions, and surprise (changes in emotions).

By teachers' *beliefs*, we refer to teachers' adequate knowledge of inquiry processes meaning their perception and willingness towards inquiry-based learning and teaching (Kim & Chin, 2011). It is of interest to know the in-depth knowledge and understanding teachers

have on inquiry and learning as well as to discover if over time they manage to deepen those views and their held beliefs.

By teachers' *professional practices* we mainly refer to teachers' work in the classroom. According to Altrichter and Krainer (1996), there are four dimensions describing teacher professional practice. Those are action, reflection, autonomy and networking. Action refers to experimental, constructive and goal-directed work and the reflection is about self-critical and one's own reflecting work. Coming to autonomy, it refers to self-initiating, self-organized and self-determined work and finally networking is the attitude towards communicative and cooperative work (Alsina, Alvarez, Hodgson, Laborde, & Perez, 1996). A combination of all those four aspects can lead to effective teaching and meaningful learning.

Regarding *teacher change*, an alternative to that is called "teacher growth" which reflects the changing nature of teachers' knowledge, attitudes and beliefs (Primas, 2011). More precisely, there are different forms of teacher change. According to PRIMAS report the change comes in the following forms: change as training, change as adaptation, change as Professional Development, change as local reform, change as systematic restructuring and change as growth or learning. In this study, the focus is on change as Professional Development which refers to teachers who are “seeking to change” in an attempt to improve their performance or develop additional skills or strategies (Primas, 2011).

Teachers' attitude towards PD

According to the results of a research carried out by Wellcome Trust foundation (Batterham, Page & Boon, 2006), a teacher in order to be effective needs to be also a learner which can be achieved through Continuing PD courses (CPD). With life-long learning in teaching professions, teachers are not only supported to improve their skills and enhance

classroom performance but also to gain a better understanding of the curriculum developments or the latest work in their subject (Batterham, Page & Boon, 2006).

A particular survey carried out as part of this research demonstrated that it is crucial to investigate teachers' expectations from CPD courses, their beliefs on CPD, what different types of teachers want from the CPD, the various benefits and for whom and finally the hindering factors of getting what they want from the CPD with the aim to make CPD courses more successful. Moreover, social and ethical context need to be taken into account as they are becoming two important factors of science and science teaching (Batterham, Page & Boon, 2006).

The results and findings of this research highlight four types of attitudes toward CPD which are: Believers, Seekers, Sceptics and Agnostics. Based on the analysis of those peoples' responses, there are both positive and negative attitudes towards the effectiveness of CPD. A more similar pattern is apparent between the Sceptics and the Agnostics with the second being more open to persuasion than the Sceptiscs. The latter, associated CPD with imposed changes or new initiatives that do not improve the quality of education. The Agnostics needed to ensure that the CPD courses would be of high quality and enhance their development and teaching approach but would not be overly time-consuming.

On the contrary, the Believers' attitude was more optimistic and enthusiastic; they said that they benefited from the CPD and through these courses, teachers' skills and confidence can be reinforced. Furthermore, Seekers supported the opinion that CPD should be offered to all but they were not satisfied with the amount of opportunities provided. They would like the schools to be more involved in planning their future and Professional Development.

On the whole, the level of satisfaction concerning different types of CPD was relatively low. According to the results, more than half of the teachers would expect and desire more amount of CPD regarding subject updating particularly in science, as well as a focus on teaching skills and classroom management. Lastly, the large majority of respondents felt that CPD was important, although far fewer were impressed with the CPD courses they had attended to.

Future organization of PD sessions should take into account teachers' expectations, beliefs and needs. Moreover, different levels of experience and disciplines are two important aspects that affect the outcomes and should also be considered. As demonstrated by this research, science teachers are more keen to update their subject knowledge compared to other subject teachers (Batterham, Page & Boon, 2006).

Furthermore, when designing PD it is crucial to recognize that teacher change happens gradually and it might be a difficult process. In addition, teachers need regular feedback on their and students' learning progress. Moreover, follow-up support and pressure is needed because change will take place after the implementation of IBL and once there is evidence of enhanced student learning (Primas, 2011). Finally, the study by Bakkenes et.al (2009) highlighted the importance of associating teachers' learning activities and outcomes with the type of learning environment they are in. The results indicated that organized learning environments (reciprocal peer-coaching, collaborative project groups) seem to derive better learning activities and outcomes than informal learning in the workplace.

Content and organization of PD

The way PD courses are structured is of importance as the content and organization have an impact on their effectiveness. In this section the results of different studies on the characteristics that compose an effective and successful PD are provided.

As Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) suggest effective PD experiences should provide links to other parts of the educational system as well as opportunities for teachers to build their content and pedagogical content knowledge and skills. Moreover, effective PD should be research-based and engage adult learners in the learning approaches they will use with their students. Finally, PD courses should provide opportunities for the teachers to collaborate with colleagues or other experts in the educational community in order to reflect on and improve their practices (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). Those last two characteristics, collaborative working and reflection, are also apparent in PRIMAS PD courses. The following study of Swan et al. that is described was part of PRIMAS project.

The focus of that research was designing and refinement of PD resources with the aim to help teachers move from traditional approaches to more inquiry-based strategies. Moreover, the goal was to encourage teachers to explore the results of using inquiry-based pedagogies in their classrooms (Swan, Doorman, & Mooldijk, in press).

Through PRIMAS PD, teachers are invited to take risks in adopting new practices in order to change their beliefs through reflection, collaborative working, discussion and giving feedback on their classroom experimentation. The focus of the study by Swan et al. (in press) was on two countries; England and the Netherlands. In the Netherlands teachers were free to experiment with the suggested pedagogies and were not subject to persuasion to change their held beliefs.

Concerning the research's results, in both countries teachers reported an increased level of student engagement and creativity when using IBL methods in the classroom. Furthermore, some teachers reported that they developed a more diverse repertoire of

teaching methods and that they were challenging and questioning students more carefully to evoke their understanding and misconceptions (Swan, Doorman, & Mooldijk, in press).

On the other hand, some teachers reported a number of difficulties. The main aspects concerned the introduction of collaborative learning between students, the lack of individual writing products from students and them feeling uncomfortable with the new approaches. Finally, teachers found it difficult to embed and sustain the approaches and claimed that their understanding of new pedagogies developed slowly.

Overall, teachers supported that their beliefs and practices changed which was also confirmed by students. However, Swan et al. (in press) support that there is still room for improvement in particular aspects which seem to influence the change in teachers' beliefs and practices.

Further research tries to shed light on the implications for promoting effective PD (Capps, Crawford & Constas, 2012). More specifically, Capps, Crawford and Constas (2012) investigated if teachers are indeed supported by PD courses to enhance or change their knowledge, beliefs and practices and if these changes eventually promote student achievement.

Capps et al. (2012) developed a list of nine common characteristics of effective inquiry PD based on literature analysis which are: *Total Time* available for PD meaning the amount of time required for an effective PD, providing *Extended Support* to teachers over time, engagement in *Authentic Experiences* which refers to PD programs in which teachers conduct an inquiry study that is not predefined, *Coherency* which refers to PD programs that are relevant to teachers' everyday work. *Developed Lessons* meaning programs in which teachers learn about inquiry as a teaching strategy by designing inquiry-based lessons for use in their classrooms, *Modeled Inquiry* meaning that the program models inquiry-based

instruction for the teachers during the PD, *Reflection* on experiences, *Transference* which is about discussing how teachers can apply new experiences and material in their classrooms and finally *Content Knowledge* indicates that the PD program focuses on increasing teachers' science subject matter and content knowledge.

Moreover, four categories concerning the results of PD intervention were developed: enhanced teacher knowledge, enhanced teacher practice, change in teachers' beliefs and enhanced student knowledge. This study focused on how inquiry PD courses having the aforementioned characteristics supported teachers in those four categories.

The results indicate that there is a range of outcomes concerning inquiry PD models, including enhanced teacher knowledge, changes in teacher beliefs and practice, and growth in student knowledge but there is no study that reports on all of the categories or on all of the nine characteristics of effective PD. Therefore, they suggest that future research studies should investigate the connection between PD design and the four categories as well as to explore which of the nine characteristics of effective PD are most important for teacher growth.

Finally, based on the results of Capps and Crawford (2013), it is suggested that when teachers are participating in short-term yet intensive PD programs their knowledge and beliefs on inquiry are enhanced. In addition, they point out the importance of reflection on former and new teaching practices. Therefore, a combination of enhancing knowledge and reflecting activities lead to promoting teacher change. Not all teachers though changed their beliefs towards inquiry which implies that there is a need to extend the activities beyond PD sessions. Some teachers need more time and support to assimilate new knowledge and concepts to their understanding and practices.

To summarize, research has shown that IBL in science education is a way of engaging students in being active learners and taking part in the construction of scientific knowledge. Students, in order to achieve that successfully need scaffolding teachers who can provide the necessary guidance and support. Many teachers though do not have the required background and experience in implementing IBL and therefore need support in order to change their beliefs towards IBL as well as to change their teaching practices. One way to achieve teacher change is through PD courses which aim at supporting teachers to improve or develop their inquiry skills and strategies. Different researches have suggested various characteristics of effective PD and the tables below summarize them (Table 1 and 2). Moreover, Table 3 summarizes the aspects that PD designers should take into account when considering the content of PD.

Table 1

Effective characteristics of PD as suggested by different authors.

Common characteristics		
Loucks-Horsley et al.	**Capps et al.**	**Primas**
Collaborative working	-	Collaborative working
Reflection	Reflection	Reflection

Research Goal and Research Questions

Many teachers would like to have more IBL going on in their classrooms, but it can be difficult for them to get started (Primas, 2011). According to PRIMAS project, there is a need to promote IBL methods performed by scaffolding teachers.

Table 2

Effective characteristics of PD as suggested by different authors.

Rest of the characteristics		
Loucks-Horsley et al.	**Capps et al.**	**Primas**
Research-based PD	Coherence with everyday work	Discussion
Provide links to other parts of educational system	Total time (required duration)	Feedback
Build on content knowledge and skills	Discussion of knowledge Transference	
	Focus on Content knowledge	
	Engagement in Authentic experiences	
	Modeling inquiry instruction	
	Providing Extended Support	
	Developing inquiry lessons	

Note. These are the basic features observable in different researches. As we can see Collaborative working and Reflection are the two common characteristics.

Table 3

What the content of PD should promote, as suggested by different authors.

Loucks-Horsley et al.	**Capps et al.**	**Primas**
Enhance and build on teachers' Knowledge	Enhance teacher's knowledege	Change teachers' beliefs
Engage adults in the learning approaches they will use	Enhance teachers' practices	Support teachers' to adopt new practices
	Enhance student knowledge	Provide inquiry tools and resources
	Change teachers' beliefs	

Successful inquiry requires new learning tasks, new teaching procedures and changing roles for both teachers and pupils. The role of the teacher is essential for promoting this type of learning. Teachers must be able to create the necessary context for inquiry-based activities and attain the relevant abilities. In daily classroom practices some teachers mostly rely on routine teaching strategies that fit a lesson schedule of discussing homework, introducing and explaining new topics and presenting new theory and homework. Science teachers that are used to these teaching strategies need support in integrating and applying new IBL pedagogies in their classrooms.

The goal of this research is to investigate what are the results and effects on teacher growth when providing support to teachers through PD in order to develop their IBL skills and practices. Moreover, the elements that render the content and organization of PRIMAS PD more effective are investigated. More specifically, the core research question is:

What is the effect of Professional Development courses on teachers' IBL beliefs and skills when participating in PD sessions for a year?

In order to answer this research question the following sub-questions were formulated:

1. What changes can be observed in teachers' beliefs towards inquiry?

2. What changes can be observed in teachers' IBL practices when they are supported through PD courses to implement IBL?

3. To what extent are the choices of the content and organization of PRIMAS PD effective?

Methods

Context of study and Participants

The study was conducted within PRIMAS international project. The duration of the this project is from 2010 to 2013. During this time many resources and support measures were developed and were available to teachers. Some of these are teaching materials and strategies, Professional Development courses which provide long-term support for teachers and material databases (Primas, 2011). The following research project is a case study based on qualitative data. The school in which this research took place is Maasland College at Oss, the Netherlands. The teachers who participated in PRIMAS project attend throughout the year five PD sessions (five different modules). In total the sessions provided by PRIMAS were seven but at this particular school only five were carried out (see Appendix C, 4c, for all modules).

Moreover, two of the teachers agreed to collaborate with us in order to support this study. One is a physics teacher (3-year teaching experience), teacher A and the other a biology teacher (14-year teaching experience), teacher B. No math teachers participated in the PD sessions. They were interviewed and observations of some of their classes took place. The students' age of teacher's A class was 12 years old and of teacher's B, 13 years old. The selection of those two particular teachers was not intended but after getting to know the group of the teachers at Oss during the 2 nd PD session, further communication with them was developed and consequently we agreed to work together in order to collect the data for the research. Final interviews were carried out after the completion of the PD sequence.

Description of Instruments

The first part of the research focused on observations of the following: Observation of PD sessions and Classroom Observations. Moreover, another focus of the research was interviews of the two aforementioned teachers and interviews with the multiplier of the PD (the multiplier is the person who conducted the PD sessions). Finally, a questionnaire was developed and addressed to 80 teachers from other Dutch schools who participated in PRIMAS PD.

A proposal of an Observation Sheet for PD courses was available from PRIMAS for facilitating PD observations (see Appendix A for Observation Sheets). It provides an outline of the basic perspectives that the observer needs to keep in mind and take notes of. Those include the aims of the PD sequence, Obstacles and Difficulties, Phases of the session, Type of work done in each phase and the Resources used. The Classroom Observation Sheets are formulated in the same pattern (see Appendix A).

The above Observation Sheets include considerations and questions for the observer's reflection *after* the observations. For the classroom observations these are concerned with teacher's characteristics, learning environment, students' inclusion and their activities and finally classroom interactions. For the effectiveness of PD sessions, the considerations and questions focus on teacher's reflection, analysis, preparation in order to implement IBL in the classroom and teacher's (final) reflection.

The questions asked in the interviews are provided in an Interview Guide which includes questions concerning the Biographic Background of the teacher, Arrangement of the learning environment, Students, Classroom Culture, Professional Development (see Appendix A, Interview Guide). Concerning the third research sub-question, not only the questions suggested in the Interview Guide were used but also some extra questions that

were developed e.g., specific questions concerning the *topics* of the different PD courses. This way, it was possible to answer questions about the content because the Interview Guide focuses mostly on the organization of PD.

The interviews with the multiplier were based on questions derived from the Observation Sheets PD which involve considerations and questions for reflection after the PD. Specific questions were chosen and the multiplier was asked to provide answers from her point of view (See Appendix A, Observation Sheet PD, Considerations and questions for reflection after PD sequence).

Moreover, the questionnaire was developed in order to compare our findings with the experiences of other Dutch teachers participating in PRIMAS PD and help us generalize (see Appendix C).

An extra part of this project was a visit to Manchester in the UK. The University of Manchester is also participating in PRIMAS project and that visit enriched our findings by attending a PD course using similar resources and by observing a lesson of a group of science teachers. This visit provided information concerning effective PD characteristics as valued by British teachers and it was useful in order to further support our findings especially with respect to the third research question.

Instruments used to answer the sub-questions

The recorded interviews and the PD observations helped us gain insight into the changes in beliefs towards inquiry as reported by the teachers. (see Appendix A, Interview Guide and Observation Sheet PD).

In order to understand the changes in teachers' practices the interviews and the Classroom Observations were used. This way the changes as reported by teachers were examined (interviews) and as observed in the Classroom Observations too.

In order to answer the third sub-question the following were examined: to what extend are the content and organization of the PD effective as reported by teachers and the multiplier in post-interviews (see Appendix A, Interview Guide, VII for more information on types of questions).

The instruments that were used have been validated by PRIMAS project and all material is provided in the Appendices.

Data Collection

The interviews were divided into the following parts; pre-interviews before the first PD session, intermediate interviews after each session and post-interviews after the last session. Since this project initiated after the first PD session, pre-interviews and the interviews after the first session could not be part of the research. Furthermore, it was not possible to interview the teachers after each session because of limited time at their disposal.

We developed regular communication via e-mail with the teachers. Therefore, together we scheduled the days on which the Classroom Observations took place. Again post- and intermediate observations occurred (excluding the pre-observations). Those helped reach conclusions about the development of IBL skills and practices of the teachers throughout the year and it was also a way to see students' reactions towards IBL methods.

Data Analysis

The importance of the observation of the PD sessions was to see the development of the teachers from one session to the other. This allowed us to observe how they were helped

from a previous course and how they reflected on it. In what way they managed to incorporate aspects of IBL to their classes and to what extent they believe they sustained this development and made IBL practice a habit. The point of the different types of interviews was to gain insight into teachers' development from the beginning till the end of their participation in PRIMAS PD.

The data analysis that followed was based on the observation and interview material. For the qualitative analysis, research software ATLAS.ti was used which is a workbench for the analysis of large bodies of textual, graphical, audio, and video data (Van Nes & Doorman, 2010). This software enabled the organization and coding of data with the use of a Coding Agenda provided by PRIMAS which involves codes concerning Teacher's beliefs, Teaching and PD sessions (see Appendix B). The coding system was already established and top down coding was performed. Moreover, ATLAS.ti was used to transcribe verbatim the recorded interviews of the teachers.

The instruments used for this qualitative analysis were the interviews and the observations which were a proper choice since the intention was to gain insights into teacher's feelings, experiences and most importantly beliefs on IBL. Classroom Observations helped mainly to understand the change in teachers' practices concerning inquiry and PD Observations to see how teachers reflected on their practices and how they collaborated with the rest of the teachers.

Finally, in order to have credible inferences and ensure as much validity as possible, the method of *investigator triangulation* was used and we did a *member check* with the participating teachers concerning their interviews and our interpretation of them. Regarding *investigator triangulation,* a master's student performed the coding of the data and assigned codes based on the Coding Agenda. Therefore, internal reliability was checked when the data

were reanalyzed by the other researcher and there was an agreement on the assigned codes at a rate of 77 percent.

Results

The following emergent themes were identified from the analysis: Regarding *change in beliefs*, both teachers reported that PD courses have deepened their knowledge about how to approach IBL and opened their mind towards it. Moreover, both of them became more willing and positive towards IBL with the difference that teacher A (who was already implementing inquiry more) tried to use more inquiry-based techniques while teacher B had not done a lot with inquiry yet because as he reported "life has been hectic and I could not really find the time for it". (Teacher B, Interview May 29, 2013).

What the multiplier reported concerning teachers willingness towards IBL is that, "IBL was not a habit for most of the teachers and they are not used to practicing it. They postponed using IBL even if they were willing to do it because it is a time-consuming process [designing a lesson from scratch]". (Multiplier, Interview January 18, 2013).

The results of the questionnaire indicate that most teachers became more willing towards IBL but the difference from those who reported that their attitude remained neutral was not significant. A great number of teachers reported the time factor as being important and that designing IBL lessons can be time consuming. More specifically they said that, "time constraints are relevant", that "time is the most important factor", "Time is limited and implementing IBL in lessons takes a lot of time. I hope I can improve my time-management and just do it". Another teacher said that, "to change parts of your lessons requires sometimes time you don't have at that moment" and finally a relatively inexperienced teacher said that, "It's only my second year of teaching so everything still takes me a lot of time".

Regarding *change* in *teaching practices*, teacher A reported that he already used IBL quite a lot.

> I do it more consciously now and I get more out of it by allowing them [the students] more time having to look at it from different angles. I have become more aware of how I teach; as you know I am not an experienced teacher but I am an experienced researcher so I guess I know how to do an investigation and everything I have always done was inquiry-based. But now I know better how to translate that in practice into a good lesson. I engage everybody in class not just the ones that raise their hand. My number of tools that I have is bigger now. (Teacher A, Interview May 29, 2013).

On the contrary, teacher B initially was not implementing inquiry so much in his lessons compared to the previous teacher. He had some experience working this way but rather limited. He said that, "Providing instructions is an important activity of a lesson, linking subjects to subjects pupils can relate to, let pupils discuss subjects in groups, discuss questions from pupils or discuss assignments. Every now and then [performing] a practical". (Teacher B, Interview January 28, 2013). In the final interviews he said that he now has a more open mind in doing things. He has got some new ideas but just has not worked with that. Every time he wants to prepare his lessons or first set on a subject or chapter, he thinks about this way of teaching as well. He has more options and the PD opened up his mind. (Teacher B, Interview May 29, 2013). Moreover, he said that pupils from the first and second grade asked him to do things like this more often. "They made me promise. It is satisfying to see the pupils work on it with enthusiasm".

After analyzing the Classroom Observation Sheets and having examined the frequencies of specific codes, the following patterns about teaching practices emerged.

Teacher A always valued the importance of initiating plenary discussions in his lessons, student-led inquiry and student interaction through group work. Especially student interaction was of importance to this teacher since in almost all of his lessons he chose to let the students work together, interact, cooperate and exchange ideas. In most of the lessons from the beginning till the end of the year he was using those approaches almost at the same rate.

Teacher B, initially performed lessons that evolved around plenary discussions while student-led inquiry was rather limited and student interaction almost absent. What was observable over time is that he limited the plenary discussions which involved teacher's participation a lot and gave way to group work and student interaction. Subsequently, this teacher (who initially was not using IBL a lot) did change his practices to a small amount even though the teacher himself reported the opposite.

The results of the questionnaire indicate that the vast majority of the teachers changed their teaching practices. Most of them reported that the PD courses helped them develop their teaching practices and their IBL skills but we do not know the extent to which their teaching practices changed. Also, they reported that after their participation in the PD they started implementing more IBL in their lessons.

Concerning the *organization* of PD courses, both teachers value the importance of Reflection during the PD and Collaborative working with their colleagues. More specifically, teacher A said that:

> Reflection during the PD is pretty useful because it makes you think about how you have done things in the past. So, otherwise it is just too easy to sit in the course and come to the next course a month later and in between.. you intend to do something with it, but you are so busy that you forget actually to implement what you've done.

> By giving you an assignment, you implement this and report on it during the next meeting and really helps you to actively think, "Well..how am I going to do it?" and then after you've done it, "How did I do it?" or "What came out of it". (Teacher A, Interview May 29, 2013).

Regarding Collaborative working he reported that, "Through the collaboration with other teachers you get inspired and inspire as well". While talking about a particular lesson he performed he said that:

> This is [an experiment] something that I introduced and he [another science teacher] was really eager to learn what I did there and how we did it and he has also implemented that to his own lesson. Last year we collaborated as well but definitely increased this year [after the PD]. (Teacher A, Interview May 29, 2013).

Teacher B also found the Reflection part during the PD useful.

> For one, [it is useful] hearing what the others did, [because] you are getting new ideas and sometimes [you think] "oh, yeah I am doing that as well myself". So, some things we did in the course I had already done in my lessons myself and it is good. You feel well about yourself if you hear that this is what other people do, [and you think] "I am not that bad a teacher". So, for that it's ok. On the other hand, if they discuss the lessons I did and make new suggestions it will help you to improve this kind of lessons the next time. (Teacher B, Interview May 29, 2013).

Furthermore, regarding Collaborative working he reported that

> There are a few things that you can pass on to the other teachers like, "we are doing it this way and maybe that's an idea or how would you do that?" I haven't done that yet [with teachers not participating in PRIMAS] but I really thought about it. That would

> be a good idea because if we are already doing the course with the three of us and we are like eight of us in the biology department then we would have to pass this on to the other teachers as well. (Teacher B, Interview May 29, 2013).

The results of the questionnaire demonstrate that teachers most frequently report Collaborative working and Discussion as the most effective characteristics but Reflection and Feedback were reported as well.

Finally, the results from Manchester indicate that Discussion and Reflection were effective characteristics of PD. The teachers during the PD exchanged ideas of how a lesson can be performed or after the lesson what could have been done differently. Moreover, after performing the lessons, each group of teachers reported their own experiences and particular aspects of them were recognized by many other teachers. Generally, all of them willingly interacted throughout the whole day. This interaction seemed to be something that the teachers themselves pursued.

Concerning the *content* of the different modules, teacher A reported that since he is relatively new as a teacher he would like to get practical tips on how to do certain things (first interview) and teacher B in his final interview said, "I would like to have more about science. And I thought we were going to discuss and introduce science as such in a different way, and it was more like *teaching* science in a different way ". He was satisfied but expected more tips and information about IBL in science.

When the multiplier was interviewed after the final session, she said that "The teachers were provided with practical tips which they could apply the very next day and that was what they really enjoyed". Her overall feeling was that the teachers liked the PD and she said that "the sessions came at right time, they [the teachers] really needed to do something more". (Multiplier, Interview May 22, 2013).

Overall, the teachers that participated in the PD courses, when asked in the final PD course which two of the five modules they valued the most, the majority said that modules 2 ('Learning concepts through IBL') and 3 ('Asking questions that promote reasoning') were the most useful and interesting. These two modules were the ones that provided practical information and tips to the teachers. The same result is confirmed by the questionnaire in which the majority of the teachers reported that these two modules were the most useful.

With reference to the visit to Manchester, the British teachers reported that they would have wanted more practical tips concerning the actual lessons they needed to perform, even regarding simple things like after how much time the teacher needs to intervene. They said that, "Just the theory about IBL is not actually helpful". (Observation Sheet PD, June 11, 2013).

Discussion

The overall direction of the results suggested that teacher change in beliefs and teaching practices did occur and that there are certain characteristics of PD which are considered by the teachers to be effective and useful. The most important points that can be induced from the Results are:

Teacher change in beliefs indeed occurred for both the experienced (in terms of implementing inquiry and not in terms of number of teaching years) and inexperienced teacher; both became more willing towards inquiry approaches and more open towards the positive impact of IBL.

Furthermore, teacher change in practices was not that significant for the teachers. The one already implementing IBL kept on using investigative and inquiry activities in his lessons at the same rate while the other reported that he did not have the time to adjust his

lessons and start using IBL activities more. Both of them though said that they have a greater number of tools at their disposal. One important aspect was that teacher A became more conscious and aware of what he is doing while in the past he was practicing IBL teaching more intuitively. Even though he was already rather experienced in inquiry during practical tasks, now he feels more supported and is more able to articulate what he was doing, why he was doing it and why that is important for students' learning. He is more confident concerning IBL practices because he has a better understanding of his intuitive practices.

Finally, according to both teachers the content of the PD courses needs to be centered towards specific practical tips and information that relates to science teaching and not teaching in general. Moreover, as far as the organization of PD is concerned, both of them greatly value the significance of Reflection during the PD courses as well as Collaborative working. Indirectly, they say that Discussion and exchanging ideas was important as well.

The first conclusion that can be reached from the results of our research is that teachers' attitude towards IBL does change and mostly when it comes to their beliefs and less when it comes to their teaching practices.

Wellcome Trust foundation research suggests that there are four different types of attitudes towards PD: Believers, Seekers, Sceptics and Agnostics (Batterham, Page & Boon, 2006). In our research the two teachers belong in the categories of Believers for teacher A and Agnostics for teacher B, with the believers being more optimistic and enthusiastic and with the agnostics still being positive towards inquiry while regarding time as an important factor which could hinder the implementation of IBL.

Moreover as the results of Wellcome Trust indicate, different levels of experience and disciplines are two important aspects that affect the outcomes and should also be considered. In the case of the two teachers of our research, not only experience in working

with IBL techniques was an important factor but also teacher's motivation, disposition and positive attitude kept emerging as significant characteristics while the different disciplines (science and biology) did not have any particular effect on the results.

As suggested by the research results of Bakkenes et al. (2009), change in knowledge and beliefs was most frequently reported in their study while change in teaching practices was rarely reported. In the case of the study presented here, teacher B indeed reported the same. He said that he now has a more open mind towards IBL and that he considers more this way of teaching when planning his lessons but still did not manage to do a lot with that yet. My personal interpretation of these results is that less experienced teachers in IBL, feel less secure and motivated to work with new methods and teaching approaches even though they recognize the beneficial effects on student learning. Therefore, this means limited change in teaching practices.

What is striking is that teachers' attitude towards IBL does change mostly when it comes to their beliefs and less when it comes to their teaching practices but the results of the questionnaire indicate that change in practices is more apparent than change in teachers' beliefs.

Even though teachers reported change in practices in the questionnaire (both experienced and inexperienced teachers), many of them expressed their concern about time constraints and that it can be a hindering factor in order to reform whole lessons and start using more IBL. Because we do not know the extent of change in teaching practices, no clear conclusions can be reached about the second research question based on the questionnaire.

A second conclusion that can be drawn from the results in the light of those considerations is that teacher change indeed takes place and one important factor that affects teacher change in both beliefs and practices is the initial attitude (Believer, Agnostic) the

teacher has towards inquiry which is directly related to the amount of *experience* in IBL that he/she has already acquired. Both teachers eventually were more willing and positive towards IBL but the less experienced teacher still found obstacles (time restrictions) in implementing IBL. He was less motivated to change his lessons into investigative ones and was more skeptical of the necessity to do so. Even though the teacher himself could see that the students enjoyed this type of lessons and that they were enthusiastic he still had trouble altering the structure of his lessons.

Regarding the third research question with a focus on the *content* of the PD courses, teacher B said that he expected more tips and information about IBL in science specifically. He found some of the sessions relatively general and not focused on science teaching but teaching in general. Therefore, need for less general and more specific subject (science) related teaching material was reported. This is in agreement with the results of the Wellcome trust research where it is indicated that teachers would expect and desire more amount of CPD regarding subject updating particularly in science, as well as a focus on teaching skills and classroom management.

Another conclusion that can be reached which concerns the content of PD is that, providing practical advice and information which can be of direct use in science classes is of great importance to the teachers. That was a need expressed by the teachers themselves (both in the Netherlands and in the UK) and by the multiplier of the PD. Generally, the teachers expect a PD course that revolves around their particular practical needs and not around teaching as a theoretical matter.

As already stated above, the results of this research point out that both teachers A and B consider Reflection and Collaborative working to be effective characteristics of the organization of PD courses.

Different authors suggest that effective and successful PD courses consist of these two characteristics. Focusing on PRIMAS report, there are four main features: Reflection, Collaborative working, Discussion and Feedback (Primas, 2011). In the case of teacher A of our research, what is observable is that he tends to interrelate Collaborative working with Discussion (in the context of the PD and not outside) of experiences with fellow teachers which could lead to the conclusion that he equally values Discussion. As this teacher specifically said, "Through the collaboration with other teachers you get inspired and you inspire as well". This can be done through engagement in common experimental work within lessons and also though exchange of ideas during the Discussion part within the PD courses.

Furthermore, both teachers reported that Reflection is important for different reasons. For teacher B because you have the chance to see what other teachers are doing, what difficulties and problems they are facing and what the obstacles are. That helped him realize that he is not the only one dealing with particular problems. For teacher A because through Reflection you can organize your actions and really think how you did things in the past and identify what went wrong. This way in the future you remember what you did, how you did it and how you are going to improve yourself next time.

Finally, the research by Bakkenes et al. (2009) suggests that organized learning environments (reciprocal peer-coaching, *collaborative project groups*) seem to derive better learning activities and outcomes (and consequently lead to teacher change) than informal learning in the workplace. This is in accordance with the results of the other researches regarding the effectiveness of PD courses, which are a form of an organized learning environment in which Collaborative working takes place.

Capps, Crawford and Constas (2012) suggest that *Content Knowledge* is significant. Content knowledge refers to the focus of the PD program on science subject matter and

content learning for teachers which are elements not mentioned in PRIMAS report. As teacher B said he found some of the sessions relatively general and not focused on science teaching but teaching in general. This leads to the conclusion that he would have liked more subject matter learning that could be directly related to the particular scientific context of his lessons. Moreover, the opportunity to build on Content Knowledge is mentioned by Loucks-Horsley et al. (2003), (see Table 1).

Therefore, a final conclusion regarding the organization of PD is that including Content Knowledge is another effective characteristic as reported by teacher B. Moreover, Reflection and Collaborative working were already identified by all researches as two of the most important characteristics and the results of this research verify that with the addition that Discussion is also highly valued. What was not clear concerning both teachers is how they valued Feedback either from their colleagues or from the multiplier of the PD.

Generalizability

This research is a case study and the results cannot be automatically generalized. The way to generalize though was the formulation of the questionnaire based on inferential results that were obtained from the research. This questionnaire was addressed to other teachers involved in PRIMAS project not only from Maasland College but also from other 14 Dutch participating schools. The focus of these questions was on inferred results concerning the overall effectiveness of PD courses and some questions concerning changes in beliefs and practices. Therefore, the emerging conjectures which became clear towards the end of this research project, were used to form a questionnaire that was useful in order to generalize our results.

Limitations

Concerning the selection of the classes that were observed, that was the teachers' choice. Random selection of the teachers was not an option which is one limitation of this research. Moreover, other schools were participating in PRIMAS project but I did not choose the school in which this research was conducted as it was assigned to me by my supervisor who was also the person leading PRIMAS project in the Netherlands.

Another drawback of this study is that the results for teacher B and his teaching practices come from just two classroom observations in the beginning and one after the last PD course. Therefore, the conclusions reached might have differentiated if more of his lessons were observed especially towards the end of his participation in the PD sessions.

Implications

The results of this study have some implications for teachers' PD and for teacher change. First, our findings suggest that apart from the four PD characteristics as suggested by PRIMAS, focusing on Content knowledge was also identified as an important characteristic. Future research studies should attempt to explore which of the above characteristics of effective PD are most crucial and essential for teacher growth.

Moreover, the results suggest that teachers participating in PD highly value the importance of receiving practical tips and help that can be of direct use and application in the classroom. Therefore, when designing future PD this aspect needs to be taken into account.

Finally, further research is necessary in order to find the relation between teacher change (in both beliefs and practices) and teachers' previous experience using IBL.

This research suggests that teachers' participation in PD has beneficial effects; teachers become more willing and positive towards IBL and they try to implement more

inquiry techniques in their lessons. Teachers that are less used to such practices though feel skeptical and sometimes insecure, factors that can hinder the productive implementation of IBL.

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Appendix A
Research Instruments

1. Interview Guide

WP 8_Interview guide

I. Introduction	
1. Brief introduction of interviewer	• Coherency of the interviewer with PRIMAS. • Handling of the the results from the interview. • Agreement for recording the interview. (Signature!)
2. Brief introduction of the casestudies	• Guiding research question: How does a teacher in his different communities of practice evolve during the lifetime of Primas (in relation to his beliefs, pedagogies, knowledge). • Cases: At least two cases with specialist teachers, one in mathematics, and one in science. • Methods: Interview with teacher (before and after PD), PD observation, classroom observation, context (school) observation.

II. Biographic background

Compulsory question(s)
(1) Why did you choose to be a teacher? How long have you been teaching? Subjects?

optional questions	• Describe your student teaching experience. • Tell me about your experience in mathematics and science. • What previous experiences do you have in IBL? Please give examples. • What else would you like to share about yourself?

III. Teacher

Compulsory question(s)
(1) Which way of teaching do you consider to be most effective? Why?
(2) What are the three most important characteristics of an effective educator/teacher?/
(3) Describe a good lesson, explain why it was/is good.
(3) What is important about mathematics and science?

optional questions	• What is your educational philosophy? State you educational philosophy. How do you incorporate it into your daily instruction? • Is there a part of your education experience that has inspired you or guided you in developing your own personal teaching philosophy? • Please complete the sentence: " For me as a teacher, mathematic/science is..." and " For students, mathematic/science is..." • How would you go about planning and carry out an IBL lesson? (particular topic. Math: Geometry/Surface area. Science: ?)

IV. Arrangement of the learning environment

Compulsory question(s)
(1) When teaching maths/science to your class, what activities occur in your lesson? (2) What are the most important activities for students in your class? (3) What should students learn in mathematics / science education? (4) What teaching materials/tasks have you found to be educationally useful in the classroom? Why? (5) Please comment on weak and strong points of the instant task. (task: tabletennis) (6) In relation to PD course, are there any changes in your repertoire for promoting IBL? Which? (7) What are the main aspects of IBL? Name the key features of IBL. (8) How much experience do you have working with IBL task? What's difficult/easy? Give examples. (9) In how far do you consider yourself as prepared for teaching IBL? (10) In relation to the implementation of IBL, describe some of your experiences when collaborating with other staff members. Are your colleagues used to IBL?

optional question(s)	• What teaching materials/tasks have you found to be educationally useful in the classroom? Why? • What are your concerns in relation to the implementation of IBL? • What advice would you give to a new teacher/other teachers (which are not used to IBL) regarding the implementation of IBL in a classroom? • Did you change/evolve in using the textbook/resources and planing your lessons and classroom discussion after you took part in the PD course?

V. Students

Compulsory question(s)
(1) In your own words, how do students get on with the implementation of IBL in the classroom? What is easy/difficult for them? In your opinion, they like IBL tasks? Why? (2) Describe a few ways that you can positively influence and assist your students in relation to their learning behaviour/ study habits? (3) How do you motivate students to become active learners in your classroom?/ What motivation tactics do you employ to keep students focused on the subject?

optional question(s)	• Which way of learning do you consider to be most effective? Why? Please give examples. • How would you characterize good learning? Please point out basic aspects. • What methods have you used or would you use to assess student learning? Provide an example.

VI. Classroom Culture

Compulsory question(s)
(1) How do you react towards student's mistakes? Give examples.

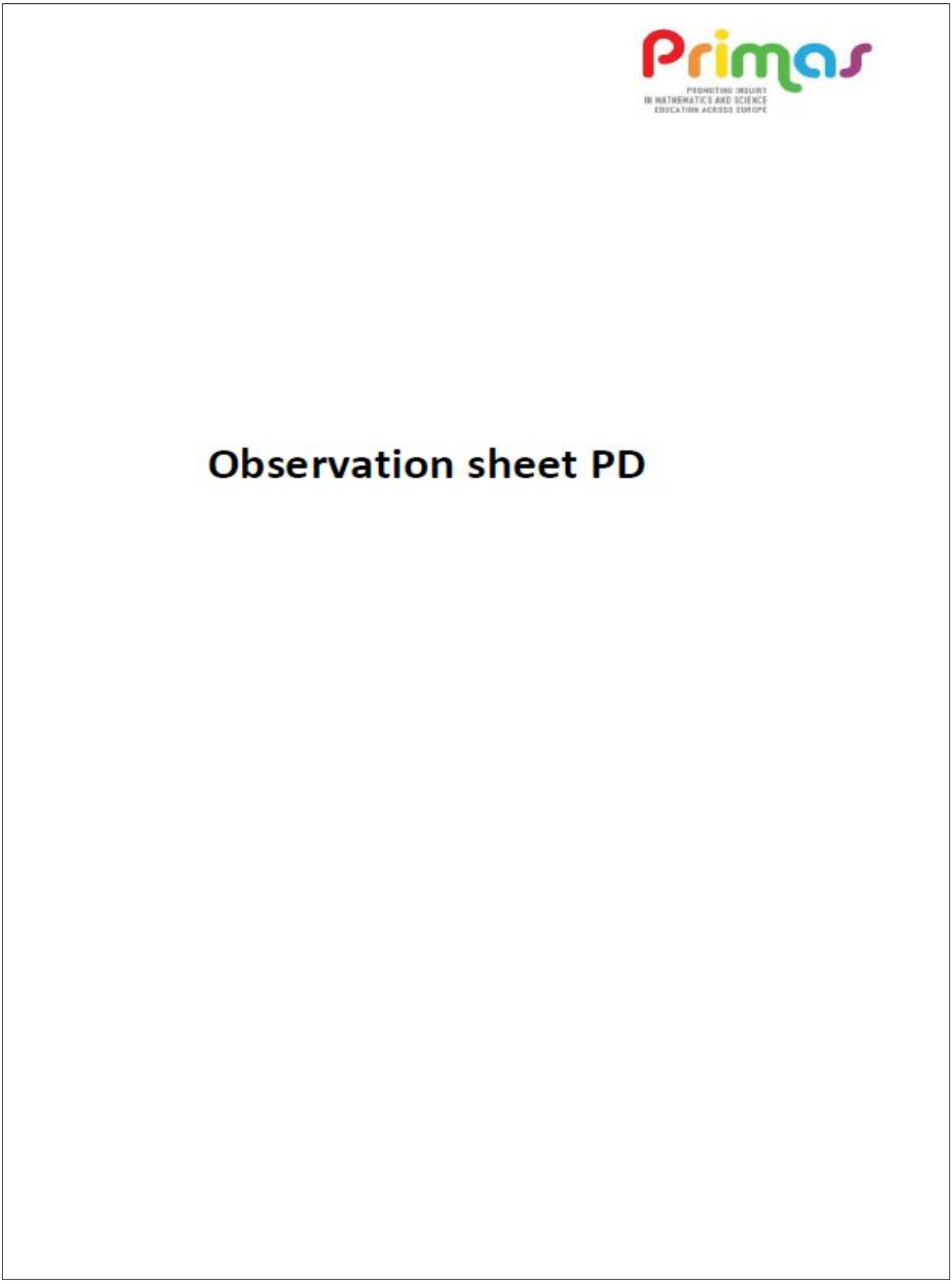
optional question(s)	• How would you/do you identify special needs of students? • What do you think the key difference between criticism and positive reinforcement is? • What methods would/do you employ to maintain successful two-way communication with pupils?

VII. Professional Development

Compulsory question(s)
(1) What were your motives to follow this course? (Why?) (2) What did you learn/like? (3) How do you judge the usefullness of the collaboration and debates held with other colleagues attending the PD course? (4) In wich way has the PD course help you in your pedagogical or teaching practices?

optional question(s)	• What are your expectations? • What was most striking? • What did/do want to learn? Did you miss s.th.? • Did the PD courses have an optimal lenght or would you have prefered them to be longer or shorter? • Comment on the support you received by PD teachers/or multipliers. What was most striking? Did you miss s.th.? • What would you say was the most valuable lesson learned over the course of your PD training ? • Regarding the implementaion of IBL, what would you say has been your greatest challenge in the classroom/ critical moments, and how did you approach it?

2. Observation Sheet PD



Proposal of an observation sheet for PD

Context		
Multiplier/ Group leader	School	No. of teachers/ participants
Day/Time	Observed by	Topic/Subject/Session

Aims of the PD sequence	
Learning's purpose of (if possible to identify):	
Pre knowledge (about IBL) necessary for teacher's/ participant's learning:	

Obstacles and difficulties	
Description of the perceived obstacles and difficulties	
Reactions of multiplier	
Mutiplier not aware of them?	

Notes of observation

Draw a line any time any of this column changes apart from the description

Time (indicative)	Phases*	Type of work**	Resources***	Description on what is going on, as plain/ factual as possible
	Introduction or presentation			
	Working phase			
	Result assurance/ ascertain conclusions			

*

Phases	
Introduction	Introduction into the topic
Working phase	The subject is explored
Result assurance/ ascertain conclusions	The results are summarized at the end of the session

**

Type of work	
Group work	
Work in pairs	
Indivudual work	
Plenary discussion	
Multipliers explains, while teachers listen	
Participants present results of their work	
World café	
Other pedagogies	If other pedagogies are used please explain them

***

Resources	
Multiplier's documents	Take them with you
Blackboard	
Computer	
Teacher's/ participant's documents	Take them with you
Poster	Take them with you or take a photo of them
Post-it labels	Take them with you or take a photo of them
Other resources	If other resources are used please explain them

Considerations and questions for reflection after PD sequence

Comment on the following (the observer of the PD has to comment on the following after the PD sequence)

The observer has to reflect on the attitude of the entire group and also has to deliberate the specific case.

About the teacher's/ participant's reflection		
PD1: Reflect on the **contexts** in which they work	PD1.1: How do/does the teacher(s) describe/ characterize/ specify the context in which they/he/she work? (eg. school/class/colleagues)	
PD2: Reflect their **values and beliefs** about discipline and subject matter	PD2.1: What values and beliefs about discipline and subject matter were named?	
PD3: Reflect on **teaching**	PD3.1: Which way of teaching do/does the teacher(s) consider/argue to be most effective? Why? Examples?	
	PD3.2: How do/does the teacher(s) characterize "good teaching"? How do/does the teacher(s) characterize "good learning"?	
	PD3.3: In relation to teaching are there any other aspects the teacher(s) highlight?	
PD4: Reflect on teachers/ participants **current classroom practices**	PD4.1: How do/does the teacher(s) describe/ characterize/ specify their/his/her current classroom practices? (examples)	
	PD4.2: How do/does the teacher(s) describe themselves/himself/herself? (role of the teacher)	

About the teacher's/ participant's analysis		
PD5: Analyse **contrasting practises** by working on classroom tasks	PD5.1: How do/does the teacher(s)/ participant(s) evaluate/value the contrasting practices?	
	PD5.2: In relation to their/his/her current classroom practices/ classroom tasks which differences do they/he/she carve out? (examples) Do they/he/she carve out any differences at all?	
PD6: Analyse **the use of the contrasting practices/ the tasks on video**	PD6.1: How do/does the teacher(s) react when seeing themselves/himself/herself using contrasting practices?	
	PD6.2: What were/was the participant(s) learning?	
	PD6.3: What teaching strategies were being used?	
	PD6.4: Which factors do/does they/he/she consider as supportive?	
	PD6.5: Which factors do/does they/he/she consider as hindering?	
PD7: Analyse **challenges/ conflicts** that might arise from contrasting the teachers/ participants with teachers'/ participants' existing practises	PD7.1: Are there any conflicts that were caused by contrasting the teacher(s) with their/his/her existing practices (caused by video for example)?	
	PD7.2: How were the teacher(s)/ participant(s) beeing assessed? (by the multipliers or by participants)	

About the teacher's/ participant's preparation in order to implement IBL in the classroom		
PD8: **Encouragement** of teacher's/ participant's to use the (IBL) tasks in their own classroom	PD8.1: How does the multiplier encourage the teacher(s)/ participant(s) to use the tasks in their own classroom?	
	PD8.2: What's the motivation of teacher(s) to implement IBL? Which aspects do they/he/she name?	
	PD8.3: Which obstacles do/does the teacher(s) see/name for the implementation of IBL?	
	PD8.4: In relation to the obstacles, how does the multiplier react?	
	PD8.5: Which ideas do/does the teacher(s) have/name for the implementation?	
PD9: **Concept** of the PD session	PD9.1: Was the session inquiriy-based? Name examples.	
	PD9.2: Did teacher(s) experience the pedagogies they are expected to use? Examples.	

About the teacher's/ participant's (final) reflection		
PD10: **Sharing classroom experiences** the teachers/ participants made	PD10.1: What experiences do/does the teacher(s)/ participant(s) name?	
	PD10.2: Which factors do/does they/he/she consider as supportive? Which factors do they/he/she consider as hindering?	
	PD10.3: Do/does they/he/she use the opportunity of collaboration and debates held with other colleagues? How?	
	PD10.4: Do/does the teacher(s)/ participant(s) help and support each other? Examples.	
	PD10.5: Which practice did they/he/she take back to their own class?	
PD11: Discussion in reference to **pedagogical implications**	PD11.1: What implications do/does the teacher(s)/ participant(s) highlight? Give examples.	
PD12: Reflect on the **growth of new practices and beliefs**	PD12.1: What were/was the participant(s) learning? (In relation to their/his/her point of view)	
	PD12.2: Do/does the teacher(s)/ participant(s) provide PD for colleagues within their/his/her own schools?	

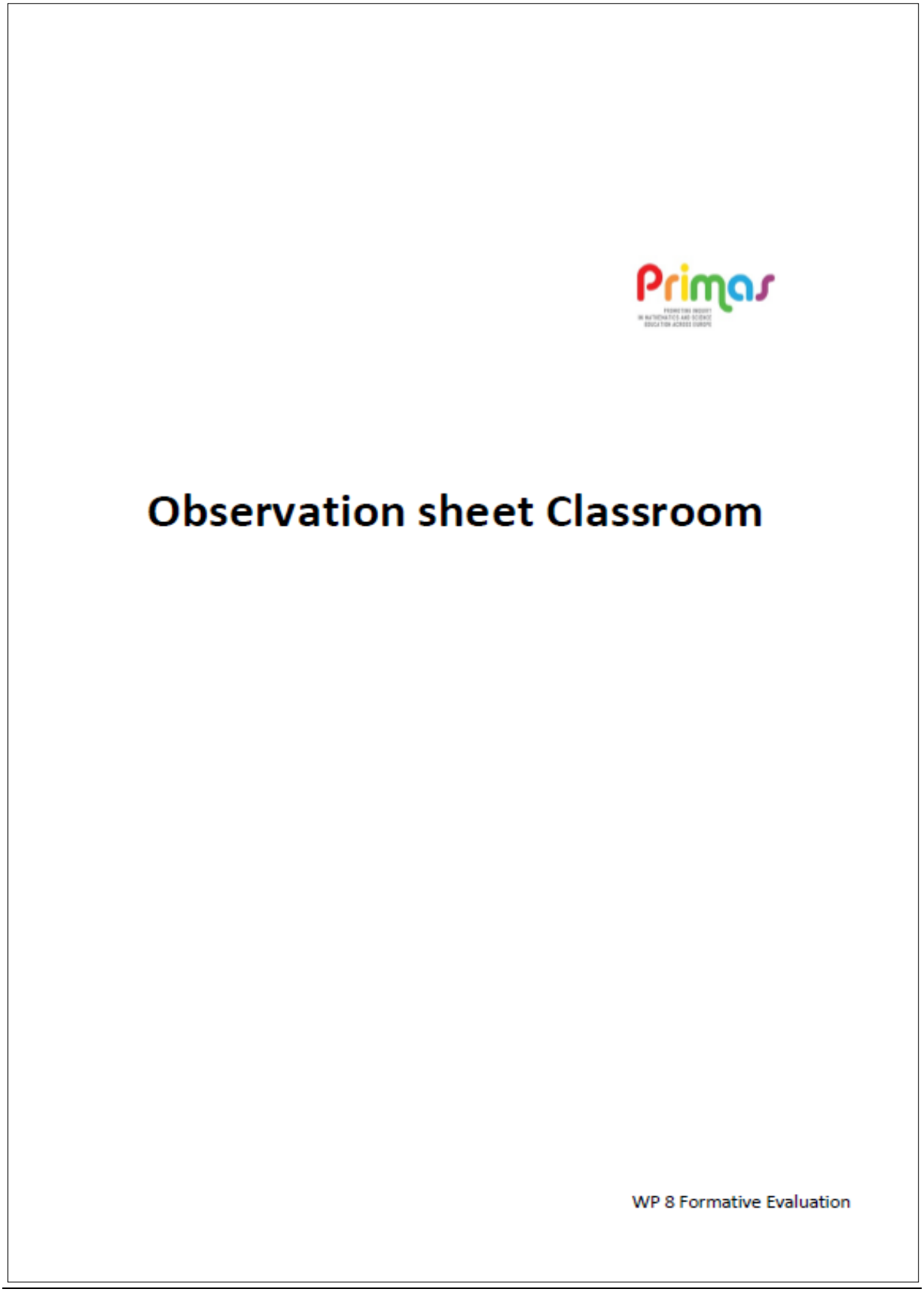
About multiplier's characteristics/ attitude

PD13: Multipliers **pedagogical practice**	PD13.1: How were resources matched to the needs of the target group?	
	PD13.2: What "teaching" strategies were being used?	
PD14: Participant-multiplier **interactions**	PD14.1: How did the multiplier match his/her communication to the needs of the group?	
	PD14.2: How were/was teacher(s)/ participant(s) being assessed?	
	PD14.3: How were/was teacher(s)/ participant(s) involved in their own assessment and given feedback?	

Additional comments

... any other incidents that should be pointed out

3. Observation Sheet Classroom



Proposal of an observation sheet for classroom observation

Context		
Teacher	School	No. And age group of students
Day/Time	Observed by	Topic/Subject/Session

Aims of the lesson	
Learning's purpose of (if possible to identify):	
Pre knowledge (about IBL) necessary for student's learning:	

Obstacles and difficulties	
Description of the perceived obstacles and difficulties	
Reactions of teacher	
Teacher not aware of them?	

Notes of observation

Draw a line any time any of this column changes apart from the description

Time (indicative)	Phases*	Type of work**	Resources***	Description on what is going on, as plain/ factual as possible
	Introduction or presentation			
	Working phase			
	Result assurance/ ascertain conclusions			

*

Phases	
Introduction	Introduction into the topic
Working phase	The subject is explored
Result assurance/ ascertain conclusions	The results are summarized at the end of the session

**

Type of work	
Group work	
Work in pairs	
Think-pair-share	
Indivudual work	
Plenary discussion	
Teacher explains, while students listen	
Students present results of their work	
World café	
Other pedagogies	If other pedagogies are used please explain them

***

Resources	
Teacher's documents	Take them with you
Blackboard	
Computer	
Student's documents	Take them with you
Poster	Take them with you or take a photo of them
Post-it labels (sticky notes)	Take them with you or take a photo of them
Other resources	If other resources are used please explain them

Primas

Considerations and questions for reflection after classroom observation

Comment on the following (the observer of the lesson has to comment on the following after the lesson)

About teacher's characteristcs		
C1: Reflect on teachers pedagogical practice	C1.1: What "teaching" strategies were being used?	
	C1.2: How were resources matched to the needs of the target group?	
C2: Reflect on teacher's questioning strategies	C2.1: What type of questions did the teacher pose? Give reasons for your decision.	
	C2.2: What teaching strategies did the teacher utilize to engage the students and to promote student's learning? Give examples.	
	C2.3: Did the teacher initiate/ facilitate discussions and debates? Give examples.	
C3: Reflect on student-teacher interactions/ comments	C3.1: How did the teacher match his/her communication to the needs and abilities of the group?	
	C3.2: How were students being assessed (e.g. to promote learning)? How were students involved in their own assessment and given feedback?	
	C3.3: How did the teacher react towards student's mistakes? Give examples.	
	C3.4: How did the students interact with the teachers?	
	C3.5: Did the teacher support cooperative forms of interaction between the students? How? Give Examples.	

C4: Reflect on **teacher's pedagogies**	C4.1: Did the teachers built on student's reasoning and reflections? How?	
	C4.2: Did the teacher built on student's prior knowledge or previous answers? How?/ How did the teacher connect to student's experience? Name examples.	
	C4.3: Did the teachers give students the leeway to find their own solutions?	

About the learning environment

C5: Reflect on the **concept** of the lesson	C5.1: Was the session inquiriy-based? Name examples.	
	C5.2: Did students experience the pedagogies the teachers are expected to use? Give examples.	
	C5.3: Describe strategies, techniques and factors that were supportive/ hindering for implementation of IBL (during the lesson).	
C6: Reflect on the **representations and tasks** used (e.g. planning investigations, selecting or constructing representations and tools)	C6.1: How were tasks constructed/ composed? Did the tasks center on a topic or a problem? Give examples.	
	C6.2: How did the students react to the tasks/ pedagogies used?	
	C6.3: Dis the task involve the students in inquiry? Give examples. (cf. observing and visualising, classifying and creating definitions, making representations and translating between them, finding connections and relationships, estimating, measuring and quantifying,evaluating, experimenting and controlling variables)	

C7: Reflect on **student's inclusion and their activities** (e.g. exploring situations and formulating problems)	C7.1: Was student-led inquiry provided? How? Name examples.	
	C7.2: What was the relationship between building knowledge and applying critical thinking or problem-solving?	
	C7.3: How did the teacher motivate the students to become active learners in his/ her classroom? What motivation tactics did the teacher employ to keep students focused on the subject? Give examples.	
	C7.4: Did the teacher help the students to tackle problems? How? Name examples.	
	C7.5: Did the student's explain situations and phenomena autonomously? Give examples.	
	C7.6: Did the students reflect on the results and processes? How? Give examples.	

About classroom interactions

C8: Reflect on **student-student interactions** (Communicating results and reflecting)	C8.1: Was collaborative work supported? Name examples.	
	C8.2: What was the student interaction desired by the teacher?	
	C8.3: How did the students use each other for support and as ressources?	

Additional comments

... any other incidents that should be pointed out

Appendix B
Coding Agenda

Coding agenda_WP8_formative evaluation_abstract

Indicator	Category
Teacher's beliefs	C1: Biographic background
	C2: Values/Beliefs
	C3: Teaching
	C4: Self-assessment
	C5: Teaching materials
	C6: IBL
	C7: Preparation
	C8: Learning behavior
Teaching	C9: Discussion
	C10: Student Interaction
	C11: Student-led inquiry
	C12: Communication CL
	C13: Tasks
PD	C14: Discussion
	C15: Teacher-led inquiry
	C16: Communication PD
	C17: Confrontation
	C18: Teacher Interaction and Collaboration
	C19: Dissemination

Coding agenda_WP8_formative evaluation

Effectiveness of PRIMAS/PD

Indicator	Category	Descriptive account of the category	Examples	Coding Rules
Teacher's beliefs	C1: Biographic background	The teacher names information about his/her biographic background as well as his/her incitements to become a teacher.		The category "Biographic background" comprises all text passages where information about teachers biographic background as well as his/her incitement to become a teacher are named.
	C2: Values/Beliefs	The teacher adduces values and beliefs about discipline and subject matter.		The category "Values/beliefs" subsumes text passages in which values and beliefs about discipline and subject matter are named.
	C3: Teaching	The teacher characterizes his/her concept of good teaching.		Text passages concerning teachers concept of good teaching are captured by the category "Teaching".
	C4: Self-assessment	The teacher reports on his/her current classroom practices as well as on his/her context of work.		The category "Self-assessment" comprises passages in the text that inform about teachers' current classroom practices. Furthermore text passages that inform about teachers' context of work are subsumed under this category.
	C5: Teaching materials	The teacher indicates which teaching materials he/she has found to be educationally useful.		Passages of the text concerning teachers' appraisal of teaching materials are subsumed under the category "Teaching materials".
	C6: IBL	The teacher names the key features of IBL. The teacher also name pedagogical implications in relation to the implementation of IBL as well as student's handling of IBL tasks.		The category "IBL" comprises all text passages in which key features of IBL, pedagogical implications as well as students' handling of IBL tasks are picked out as central theme.
	C7: Preparation	The teacher consider himself/herself as prepared for teaching IBL. Reasons for teachers appraisal are entitled.		The category "Preparation" covers text passages that broach the issue of teachers' preparation for teaching IBL.
	C8: Learning behavior	The teacher disposes of knowledge how to influence and to assist students in relation to their learning behavior.		This category covers all aspects of teachers' knowledge how to influence and to assist students in relation to their learning behavior.

Indicator	Category	Descriptive account of the category	Examples	Coding Rules
Teaching	C9: Discussion	Discussions and debates are initiated/ facilitated by the teacher. The teacher builts on students' prior knowledge or previous answers. The teacher poses questions which inspire the students.		This category covers all text passages that shed light on discussions and debates held in the context of the lesson. Teachers questioning technique as well as his/her reference to students previous answers are considered as well.
	C10: Student Interaction	Student interaction is desired by the teacher. Students use each other for support and as ressources.		The category "Student interaction" covers text passages that give information about student interaction in the context of the lesson.
	C11: Student-led inquiry	Student-led inquiry is provided by the teacher. The teacher gives the students the leeway to find their own solutions. The teacher fosters and values students' reasoning.		Text passages concerning inquiry activities on part of the students are subsumed under the category "student-led inquiry".
	C12: Communication CL	Teachers' communication is matched to the needs and abilities of the group. The students are given feedback. The ressources are matched to the needs of the target group.		The category "Communication CL" subsumes text passages that give information about teachers' communication with students. Feedback behavior and the adaption of ressources to the needs of the target group on part of the teacher are considered as well.
	C13: Tasks	The tasks that are used center a problem. There are multiple solutions. Tasks are experienced as real and relevant.		The category "Tasks" subsumes text passages that provide information about the tasks that are used.

Indicator	Category	Descriptive account of the category	Examples	Coding Rules
PD	C14: Discussion	Discussions and debates are initiated/ faciliated by the multipliers. The multipliers built on teachers' prior knowledge or previous answers. The multipliers pose questions which inspire the teachers.		This category covers all text passages that shed light on discussions and debates held in the context on PD. Multipliers' questioning technique as well as their reference to teachers previous answers are considered as well.
	C15: Teacher-led inquiry	Teacher-led inquiry is provided by the multipliers. The multipliers give the teachers the leeway to find their own solutions. The multipliers foster and value teachers' reasoning. The multipliers encourage the teacher to use IBL tasks in their own class.		Text passages concerning inquiry activities on part of the teachers/participants are subsumed under the category "teachert-led inquiry".
	C16: Communication PD	Multipliers' communication is matched to the needs and abilities of the group. Teachers are involved in their own assessment and given feedback. The ressources are matched to the needs of the target group.		The category "Communication PD" subsumes passages of the text that emplaze multipliers' communication with the group. Feedback behavior and the adaption of ressources to the needs of the target group on part of the multipliers are subsumed as well.
	C17: Confrontation	Confrontation with contrasting teaching practices is considered by the teachers gainfully.		The category "Confrontation" comprises all text passages in which the confrontation with contrasting teaching practices is picked out as a central theme.
	C18: Teacher Interaction and Collaboration	Teacher interaction is desired by the multipliers. Teachers use each other for support and as ressources.		This category covers teachers' interaction in the context of the PD.
	C19: Dissemination	The teacher disseminate the concept of IBL in his/her school or for his/her colleagues.		The category "Dissemination" subsumes text passages that broach the issue of dissemination of IBL on the part of the teachers.

Appendix C
Questionnaire

Universiteit Utrecht

Primas

PRIMAS PD courses

This questionnaire concerns your participation in the PRIMAS PD courses. The results will be used as part of my educational research project which I am conducting at Utrecht University, The Netherlands. All responses are confidential.

1. How long have you been teaching and in which subject(s)?

_____

2a. Before your participation in the PD courses, did you involve EBL activities in your lessons?

□ yes □ no

2b. After my participation in the PD courses, I started implementing more EBL in my lessons.

Strongly agree	agree	neutral	disagree	strongly disagree
□	□	□	□	□

3a. The PD courses helped me develop my EBL skills.

Strongly agree	agree	neutral	disagree	strongly disagree
□	□	□	□	

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3b. The PD courses helped me develop my teaching practices.

Strongly agree	agree	neutral	disagree	strongly disagree
□	□	□	□	□

4a.Which of the following features were part of the PD courses you attended to?

- □ Collaborative working
- □ Discussion
- □ Reflection
- □ Feedback

4b. Which TWO of the above you consider to be the most effective/useful?

_____

4c. Which of the following modules do you consider to have been most useful?

- □ Student-led inquiry
- □ Tackling unstructured problems
- □ Learning concepts through IBL
- □ Asking questions that promote reasoning
- □ Students working collaboratively
- □ Building on what students already know
- □ Self and peer assessment

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5. I became more willing towards EBL after the PD courses.

Strongly agree	agree	neutral	disagree	strongly disagree
☐	☐	☐	☐	☐

6. The PD courses help me to better understand the benefits of IBL.

Strongly agree	agree	neutral	disagree	strongly disagree
☐	☐	☐	☐	☐

7. During the PD courses I had the chance to collaborate with my colleagues.

Strongly agree	agree	neutral	disagree	strongly disagree
☐	☐	☐	☐	☐

8. The PD courses were the incentive to collaborate with colleagues outside the PD courses.

Strongly agree	agree	neutral	disagree	strongly disagree
☐	☐	☐	☐	☐

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9. Below you will read about two cases of teachers participating in PRIMAS PD courses in the Netherlands. Please answer the question that follows.

Teacher 1.

This teacher was already implementing inquiry in his/her lessons so he/she had quite a lot of experience working this way. After the end of the PD courses, teacher 1 said that he/she became more aware of what IBL is, made changes in the repertoire because he/she learned more practical techniques of inquiry which were useful and the PD courses deepened his/her knowledge of how to approach inquiry.

What teacher 1 found particularly useful was the collaboration with other teachers and the reflection part during the PD, because it makes you think how and why you do things.

Overall, this teacher was content with what he/she learned from the PD courses and with the structure and organization of the PD courses. Teacher 1 became even more willing and positive towards IBL and changed some of his/her practices.

Teacher 2.

This teacher was not implementing inquiry in his/her lessons so much compared to the previous teacher. He/she had some experience working this way but rather limited. After the end of the PD courses he/she became more positive towards IBL and got some new ideas that could be useful for his/her lessons but did not have the time to practice them. Time was an important factor for this teacher because it is difficult to change parts of lessons. He/she said that you always have some things that really need to be done and implementing IBL has low priority.

Teacher 2 also found the reflection part during the PD useful, because you have the chance to see what other teachers are doing, what difficulties and

problems they are facing and what the obstacles are. That helped him/her realize that he/she is not the only one facing particular problems.

Overall, teacher 2 was content but expected more tips and information about IBL in science. He/she found some of the sessions relatively general and not focused on science teaching but teaching in general. Teacher 2 became more willing and positive towards IBL but hardly changed his/her practices.

With which teacher do you relate? Please provide an explanation of your choice and/or add any additional comments.

□ Teacher 1

□ Teacher 2

□ Both

□ Neither

Thank you for taking the time to fill in this questionnaire.

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