DESIGN AND IMPLEMENTATION OF A TRAINING PROGRAM IN IBSE FOR IN-SERVICE ELEMENTARY SCHOOL TEACHERS, IN A DEVELOPING LATIN AMERICAN COUNTRY

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Abstract

The purpose of this study was to design a structured professional development (PD) program for primary science teachers, using as sources of information a theoretical framework in inquiry based science education, teachers perceptions about their instructional practices for teaching science and their students' performance, and classroom observations for documenting instructional practices after participating in the PD program. The theoretical framework, which also guided the evaluation of the data gathered through class observation, has into account four main dimensions: conceptual schemes, process strategies, epistemological frameworks and social processes. It was observed that even accent changes (as opposed to structural changes) in the PD program have impact on teachers' instructional practices. It was also observed that when introducing opportunities for teachers to learn about the nature of science, their performance is positively impacted. Finally, a structured PD program, derived from observing and interviewing 50 teachers trained over 8 years, and from analyzing the results PD programs in a yearly basis is presented.

Introduction

This proposal focuses in analyzing the design and implementation process of a training program for in-service primary school teachers in Colombia, aimed to contribute to the improvement of inquiry-based science teaching. This program of professional development is one of the components of the program Pequeños Científicos, an inquiry-based science education (IBSE) program, recognized by the Interacademy Panel (IAP). It has been training in-service primary teachers since 1998, responding to an absence of other training opportunities in IBSE. Consequently, during the past ten years, 1,171 teachers have been trained in 12 different Colombian regions, thus taking inquiry-based science learning to more than 46,000 children. Despite the Program’s continuing efforts to deliver quality training for in-service teachers, it has been observed that teachers show a marked difficulty in changing their instructional practice in meaningful, deep ways. Given this fact, a research question arises: what characteristics of a training program in IBSE for in-service teachers make it effective for them to adopt new practices that guide students towards proficiency in science?

This paper describes observed patterns in teachers’ IBSE instructional practices over 7 years, and analyzes how they responded to changes introduced to the professional development program. Data for this study was collected in public primary schools of Colombian urban peripheral zones of the cities of Bogotá, Pereira and Sincelejo. This population’s socio-economic condition is considered to be highly vulnerable. Pequeños Científicos’ teacher training efforts have thus been addressed to the public sector, trying to contribute to reducing the gap in education in
Colombia between the public and the private sectors. Finally, an updated, re-structured one-year training program, based on the analysis of the collected observations and our most recent conceptual framework, will be presented.

Rationale

Science education in Colombia is still below international standards (OECD, 2008). One of the causes for this low achievement can be attributed to the outdated instructional practices, since teachers can hardly access opportunities of professional development focused on innovative pedagogical strategies. Moreover, the few available programs get to early ends due to lack of support.

Taking into account that "no innovation will be sustained unless systematic and ongoing professional development is provided to support the changes required in the pedagogy of science teachers" (Osborne & Dillon, 2008), the quality of science education in Colombia depends more on the design of innovative, systematic and structured training programs than on eventual changes to the National Curriculum. Responding to these facts and research findings, Pequeños Científicos has designed a structured training program aimed to change instructional practices, so teachers will be prepared for educating children in the development of science thinking skills, and in the comprehension of basic science concepts that allow them to explain their world beyond superstition and speculation, thus taking informed decisions. In this sense, it can be said that sharing the experiences leading up to the design and implementation of this training program in IBSE with the academic community, is highly relevant to the country and to other countries looking for strategies for fostering science teachers’ professional development. Moreover, the proposed training program structure comes from a transformative, bottom-up approach, where “teachers understand the reasons for changes and are active in seeing how to implement them in their own particular working environment” (Harlen, 2008). In order to accomplish this understanding, it is necessary to give teachers structured opportunities to consider examples and approaches to change. Pequeños Científicos is designing such an opportunity for Colombian teachers.

Methods

This research is of qualitative and quantitative nature, for both grounded theory and descriptive statistics are used to analyze data. Class observations, semi-structured interviews and analysis of teachers’ portfolios were the techniques used for collecting data. The sample was composed of 50 teachers trained between 2002 and 2008 that explicitly accepted to be visited and to participate in this research. Since changes to the training program were introduced in 2008, teachers trained in this year constituted a separate group (n=17).

Techniques for data collection

- **Class observation**: participant observation in the classroom was selected as the methodological approach for this study, since it guarantees the collection of a large amount of data, for it seeks to describe what the teacher and the students do and say in the natural day-to-day class environment. The records taken by the observers were strictly descriptive: they took exact note of the instructions, questions and dialogues that took place among children and between the teacher and his students.

- **Semi-structured interviews**: data was collected through semi-structured interviews to a group of 50 teachers trained between 2002 and 2008, in order to establish what teachers understand as a good IBSE class, and what they consider their students are learning.

Instruments for data analysis: assessment instruments

Two instruments were used to assess different dimensions of teachers’ instructional practices:

- **IBSE class observation instrument**: This instrument was designed based on a careful analysis of IBSE proposals from different authors (AAAS, 2000; NSF, 2000; Duschl et al, 2007; Furtak & Ruiz-Primo, 2007; among others). On the grounds of this bibliographical analysis, 4 domains were established: social, epistemological, conceptual schemes and process strategies. The present instrument is thus composed of four domains, similar to those described by Furtak and Seidel (2007).
- **Portfolio assessment rubric:** This instrument was designed on the grounds of a bibliographical revision on the advantages of assessing instructional practices and fostering teachers’ reflections on their own practices by using teacher portfolios (Harland, 2005; Zeichner et al., 2000). The rubric’s categories were: selection of activities and moments that show teacher’s/student’s learning (use of evidence); teacher’s reflection on his own learning (metacognition); teacher’s analysis of teaching and learning processes; teacher’s decisions related to changes in his own practice.

Both instruments were divided into categories, expressed in the form of four different levels of performance, ranging from “beginner” to “expert”. A score from 1 to 4 was assigned to each of the performance levels.

**Data analysis through grounded theory**

Data recovered from the semi-structured interviews was analyzed using AtlasTi 5.0 software by building emergent categories. A total of 174 categories emerged from the whole sample. Only the denser categories (those that included at least four mentions) were taken into account for the analysis, except in the cases in which a category was very innovative with respect to the previous years. The denser categories were interrelated by building category maps.

**Data analysis through descriptive statistics**

All the class transcripts were analyzed using the categories of the IBSE class observation instrument, and scores were assigned. Two groups were established and compared: teachers trained from 2002-2007, and teachers trained in 2008. The average of the scores obtained by the 50 teachers in each of the instrument’s categories was calculated. Bar graphs comparing the averages per category per domain were built using Excel 2008, Version 12.0. Portfolios were also analyzed using this procedure.

**Data triangulation**

Data concerning teachers’ points of view (derived from the interviews), assessment of instructional practices (derived from class observation and teacher portfolios), and teachers’ abilities to reflect on their own practices (also derived from portfolios), was synthesized through triangulation. This approach was adopted in order to reduce the impact of potential biases.

**Results and analysis**

**Science classes from the teachers’ point of view (2002-2007)**

The most mentioned category was cooperative learning, which was perceived as an IBSE’s essential component by teachers trained from 2002 to 2007, but only as a strategy to support development of concepts and scientific social abilities, by teachers trained in 2008. Despite the fact that Pequeños Científicos' PD program has always included workshops specifically dealing with students’ prior ideas, conceptual development, learning objectives, etc. teachers trained between 2002 and 2007 perceive cooperative learning as a synthesis of IBSE. This can be explained by the fact that establishing cooperative working groups in the classroom triggers dramatic, observable changes (i.e. changes in the relationship between students, conversations between them about their observations, more active oral participation) much more quickly than other strategies related to IBSE (i.e.: conceptual change strategies, fostering the use of observations to build explanations, etc.), which demand the teachers’ constant self-assessment over a long period of time.

Three main categories concerning what students do in science class emerged from data: “Children’s conceptual development”, “Children’s active oral participation”, and “Direct contact with the phenomenon”. From 2002 to 2007, teachers report only two ways in which children reach conclusions: “concluding from experience and observation” and “concluding by testing their ideas”. These ideas are coherent with the reported strategies used by
the same teachers for fostering conceptual development: “taking into account prior conceptions”, “reaching conclusions during class closure”, “applying concepts”, “going deeper into research subjects”. These strategies all promote conceptual change through cognitive conflict. Though this is coherent with IBSE, there are many other effective strategies promoted by IBSE that these teachers are not using (the use of analogies, the use of examples, evaluating peers’ arguments, etc.) (Scott et al. 1991; Duschl et al., 2007). This is due, partly, to a lack of emphasis in these alternative strategies during the training workshops. As noted by Duit (2003), “there are clear limitations to taking a single position to understand conceptual change”.

The category concerning what students do in science class is “Children’s active oral participation”, which is strongly related to the dynamics that take place when working in cooperative groups, as well as to children’s motivation when working under this new dynamic. Teachers expressed that a change had occurred in their relationship with their students: children speak more than their teacher during class, and the teacher guides their interventions through questions. Added to this, it is interesting to note that according to teachers, children not only speak more in science class: they also make use of various elements which characterize productive participation in scientific discourse (discussing with arguments, formulating predictions, raising questions, using scientific vocabulary). According to teachers, children thus seem to be able to argument logically. Nevertheless, they are not saying that their children are capable of formulating explanations based on evidence, nor evaluating their peers’ and their own discourse to the light of evidence (Gopnik and Meltzoff, 1997; Samarapungavan, 1992, cited by Duschl, 2007). This is most evidently a weakness that needs to be dealt with within the teacher-training program.

The category “Direct contact with the phenomenon”. Included quotations related to children effectively designing experiments and making observations, but not a single one related to the reflection on the meaning of the data they recover, or on the relevance of the procedures they are implementing, nor are they identifying the variables that play a role in the phenomenon. Now, fostering the development of science skills is not accomplished just by assuring the interaction of children with the phenomenon, or by assuring the recording of their observations and results. It is necessary to apply specific instructional practices focused on the understanding that, experimentation and observation should produce evidence that must be interpreted and evaluated. In this sense, not just the action of recording results conduces to data interpretation. Children must learn to organize data in a way they can identify patterns and regularities, thus identifying evidence for solving the raised question about the phenomenon (Duschl, 2007).

Taking into account the above discussed elements, it can be said that teachers trained between 2002 and 2007 share a too limited vision of what science is and the implications of its nature in how it should be taught. This was definitely a sign that some changes in the PD program had to be introduced.

Assessment of instructional practices (2002-2007)

Along with the interviews for getting to know teachers’ perception about their own science classes, class visits were carried out in order to have an external vision and to gather information for assessing the classes with an observation instrument. The instrument’s first domain is “conceptual schemes”. The general average of all categories inside this domain was below 2. This means none of the teachers trained in this period reached the consolidated nor the expert level, in none of the following categories: a) Providing students with a sense of purpose about the unit/module, b) Promoting the application of concepts, c) Acknowledging students’ questions, d) Taking into account the relevance of patterns and regularities, e) Taking into account relationships among concepts, and f) Overcoming misconceptions. Among these categories, the highest average was presented in “fostering the application of concepts”. This can be explained by the fact that Colombian teachers’ colleges insist on putting concepts in context, so teachers are used to presenting situations related to students’ daily life for them to use the recently learned concept. Despite of this, these situations are usually designed taking into account circumstantial changes but not changes into factors that can affect the phenomenon under study. This is why there were no
observations of students formulating explanations about how the variables/factors changed in a novel situation, which is the expected outcome of an expert teacher’s group of students.

Moreover, teachers did not relate this category to the category “relationship among concepts”, which presented the lowest average (1.75). It was observed that teachers tackle one concept after another, without asking their students to establish relationships between them. Consequently, students and teachers were observed to work with fragmented explanations of natural phenomena. Considering this relationship is important for achieving conceptual development, so it is important to design strategies for teachers to relate concept application to relationships among concepts. This idea agrees with the most recent reports about teaching and learning. According to Duschl et al. (2007), “Proficiency in science involves having knowledge of facts and concepts as well as how these ideas and concepts are related to each other. Thus, to become more expert in science, students need to learn key ideas and concepts, how they are related to each other, and their implications and applications within the discipline. This entails a process of conceptual development that in some cases involves large-scale reorganization of knowledge and is not a simple accumulation of information”.

It is then necessary to check teachers’ prior ideas about conceptual development in science in order to tackle alternative conceptions during the training program. This aspect was not had into account in the 2002-2007 training program, as it was assumed that workshops about core scientific ideas and about dealing with children’s alternative conceptions would be enough for teachers to conduce a process of concept development that enabled children to make deep sense of natural phenomena by formulating evidence based explanations. Since data showed this assumption to be wrong, changes were introduced in the 2008 training program.

On the other hand, the category with the lowest average in the conceptual domain was the relevance of patterns and regularities (1.15). It was observed that students recorded some observations of the studied phenomenon, but those data constituted isolated facts not interpreted nor used for drawing conclusions based on evidence. So basically, observed teachers did encourage their students to gather data but then when trying to draw conclusions they rely on what children remembered about the experiment, on what they as teachers know about the phenomenon or on scattered texts students write when exploring phenomena. This fact makes difficult for students the process of using concepts for building evidence-based explanations, since they are missing the meaning of the gathered data. Building evidence-based explanations is a basic skill for being proficient in science, so an emphasis on this skill was needed along all the workshops that compose the training program.

Regarding the dimension Process Strategies, results showed also low teachers’ performance in all the four categories of this domain. In fact, averages were even lower than in the conceptual schemes domain (1.06 to 1.33). This was a surprising discovery, since teachers mentioned constantly in their interviews that their students learned to raise questions and to conduct experiments. Also, in fewer interviews teachers stated that their students learned to formulate predictions and to discuss using arguments. Therefore, higher scores in the categories “raising questions and making justified predictions”, “observing, collecting and recording data”, “identifying sources of error”, and “building explanations” were expected, since all these categories are developed when conducting experiments for solving a scientific question. It was indeed observed that children used materials on science classes, that they raised questions related to the procedures and that they tried to guess about the outcomes of a given experiment, although none of these activities were supported by evidence nor were obtained structured data from experiments/observation in order to answer a question. This may lead to conclude that teachers actually changed their practices by introducing spaces for children to explore and question but these new practices are limited by teacher’s beliefs about science and science teaching. According to Wallace & Kang (2004) “… studies confirm that teacher beliefs about the nature of knowledge, teaching science, and the mandated curriculum impede and “filter” innovative practice suggested by professional development... Yerrick et al. (1997) concluded that an intricate cognitive system of resolving and rationalizing mechanisms allowed teachers to believe they had incorporated reform practices without changing their core beliefs”.
One example of what Wallace, Kang and Yerrick state are the results obtained for the fourth category of this domain (building explanations, average = 1.24). Class observations shown that although the training program insisted on using data for drawing conclusion, teachers in fact leaded students to draw conclusions by expressing their points of view and reaching consensus. This can be explained by the fact that Colombian teachers do value democratic practices in the classroom. So, teachers’ beliefs about a democratic classroom permeate their science instructional practices. The point that teachers seem to be missing is that a logical explanation is not necessarily a scientific explanation: without evidence that supports it, this explanation is not yet scientific. A perfectly logical explanation can be completely overrun by a piece of new, contradictory evidence. In this measure, this is definitely a problem lied to teachers’ insufficient comprehension of the very nature of science.

Consequently, it is of great importance to explicitly talk about teachers’ beliefs of science when conducting a PD program. In that way, the variety of ideas regarding what a scientific question is, the characteristics of a scientific register or the characteristics of a scientific explanation can be acknowledged and used for fostering more solid IBSE teaching practices. Therefore, it can be seen that the process strategies domain is closely linked to the epistemological frameworks domain, so without real understanding of the nature of science it will be difficult to achieve the development of science process skills (Duschl, 2000).

Regarding social processes, classrooms were observed where children could debate by presenting their different points of view using scientific language that they understand and confronting them in order to validate their ideas. Even though, none of the observed teachers emphasized the primary role of data and evidence in scientific argumentation. This is why the category “discussing ideas” presents a low score (1.3). As it was expressed by teachers and confirmed with class observations, children greatly improved their oral expression and got engaged in the studied topic so participated actively. Even though, no class was observed where students communicated their ideas and results with charts, graphs or schemes. The communication of ideas was limited to short speeches and texts, so the score in the category dealing with this aspect is one of the lowest in the observational instrument (1.03). Despite of this fact, it then can be said that almost all the observed teachers overcame what Mehan described as the initiate-response-evaluate triad (Cited by Duschl, 2007), where teachers asks questions with an already known answer and students do not communicate any novel or debatable interpretation or point of view. In other words they have been progressing in teaching argumentation, but not of a scientific type. This may be due to the fact that PD program has been focused on the importance of the collective construction of knowledge, the importance of cooperative learning, listening to and acknowledging all ideas about the phenomenon under study and demanding justifications for those ideas.

Unfortunately, the justification process that should be based on evidence still seems secondary to teachers. They show enthusiasm about the new class dynamic they achieve; they reported a feeling of satisfaction because of the blooming of what they call “critical thinkers” on their classes, so they were not really carefully evaluating the quality of their students’ participation in terms of the characteristics of the scientific discourse. What it was observed was closer to socio-scientific argumentation rather than to scientific argumentation. It has been reported by Osborne et al. (2004) that it is indeed easier to develop argumentation in a socio-scientific context since children can rely on their own ideas, experiences and values for drawing conclusions meanwhile a scientific argumentation requires knowledge of the phenomena for being able to use and evaluate evidence.

Changes introduced in the 2008 teacher training program

By participating in the 2002 – 2007 training program, teacher showed marked progress in: 1) the changing of classroom dynamics, 2) a constructivist perspective that leads teachers to consider student’s prior ideas, 3) the establishment of cooperative learning practices, 4) the development of argumentation skills and 4) the design of varied opportunities for students to explore phenomena by experimenting and observing. But as it has repeatedly
shown, the deeper issues required for achieving students proficiency in science were missing: basically a lack of understanding of the nature of scientific knowledge prevent teachers from achieving this goal.

This let us know that a structured one-year PD program in IBSE fosters changes in instructional practices, even though its accents and contents should be assessed and changed in order to reflect more accurately what science is and consequently how should it be taught. This is why, after the above-presented evaluation some thematic shifts were introduced in the 2008 training program. It was decided to not change the number or sequence of workshops in this first attempt of changing. This decision responded to two main reasons: 1) since it was observed that evidence based explanations was the missing link, it was attempted to include this accent transversally in all the workshops, so evaluating the reinforcement of this idea and not being distracted by side effects derived from entirely new workshops or changes in the learning sequence. 2) There is a maximum number of hours allowed by school’s principals for teachers to participate in PD, thus the program is build under this restriction. Structural changes were introduced in the 2009 PD program according to 2008 results. The main introduced changes in the 2008 program were:

- Constant insistence on the necessity of asking for justifications when students predict or make claims.
- Discussing the characteristics of a scientific explanation and revisiting this idea along the workshops.
- Introducing the idea of factor control along the workshops dealing with scientific phenomena.
- A marked accent in the need that students develop skills for asking scientific questions.
- Workshops dealing with students’ prior ideas and conceptual development were enriched with topics addressing conceptual change, cognitive conflict and analogical reasoning.
- Constant insistence on the necessity of registering data in ways that allow identifying patterns and regularities (charts, graph).
- Class visits and feedback were carried out not by the professional developer by her own but teacher’s colleagues from her same school (and that were participating in the PD program) were asked to join him for observation and feedback.
- Reinforcement of the idea that learning modules support IBSE but are not intended to be seen as inflexible tools that should be strictly followed. In this way the idea of non-unique procedures for looking for answers to a question and the possibility for children to design their own ways for solving questions, were discussed along the workshops.
- Design of a reflective portfolio by teachers. In this way encouraging self assessment and providing the program with detailed information about the process of teaching and learning.

It was observed that teachers kept on perceiving the same sort of things about their practices and about their students accomplishments than teachers trained between 2002 – 2007. Anyhow, their vision was enriched. They started to mention new information; they were more critical and reflexive about their own practices and most important, they stopped equating IBSE with cooperative learning and started to identify it as a strategy that supports IBSE. Also, their performance in science classes was improved almost in all the categories of the observational rubric, except in the dimension of epistemological frameworks.

Regarding the teachers’ perception about their students’ performance, there were also new categories derived from 2008 trained teachers interviews. Nevertheless, all of them presented low frequency of quotation. This means that embedding some key ideas in the workshops is not enough for teachers to create new ways of understanding the processes of teaching and learning. It is then necessary to design workshops dealing specifically with these topics: 1) Formulating explications based on evidence, 2) Finding relationships between concepts, 3) Using graph and tables as a way for representing results, 4) Interpreting data, 5) Comparing students’ results with information in books or other sources, 6) Replicate experiments/observations to validate results and 7) Reflect on the procedures. Since these ideas undoubtedly permeated practices of 2008 trained teachers but the majority of them were not aware of it. This awareness is important because we have observed better science instructional practices by more reflective teachers. According to Fenstermacher (1994 cited in Posnanski, 2002) and Richardson & Hamilton, (1994 cited in Posnanski, 2002) “Through reflection teachers become better empowered to implement content and pedagogical
improvements into their instructional practice”, so definitely an IBSE PD program must include a reflective component and consequently should assess teachers visions about the processes of teaching and learning occurring in their classrooms.

Conclusions: The new proposal for an IBSE training program for in-service teachers

It can be concluded that changes introduced to professional development programs have important impacts not only on the discourse of the teachers but also on their instructional practices. In this way, it can be stated that changes in the structure or contents of this type of training programs should not be introduced without a process of validation of the results of the training program, through assessment of instructional practices and diagnosis of teachers’ views about science and science teaching. This information will throw light on the most appropriate learning progressions teachers need to change their beliefs, their practices and for guiding their students towards proficiency in science.

According to the analysis on teachers’ instructional practices and views of their own practices and to the results of the changes introduced to the 2008 program, a final PD program was re-structured as shown in tables 1 and 2.

Table 1. Final changes introduced to the professional development program (curricula for training in-service science teachers from primary school).

<table>
<thead>
<tr>
<th>SPECIFIC WORKSHOPS</th>
<th>LEARNING OBJECTIVES FOR TEACHERS</th>
<th>TYPE OF INTRODUCED CHANGE</th>
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<tbody>
<tr>
<td>Experiencing IBSE I</td>
<td>Identify some general elements of an IBSE session by experiencing a typical one.</td>
<td>- Identifying patterns, regularities and its relevance.</td>
</tr>
<tr>
<td>Experiencing IBSE II</td>
<td>Plan, execute and evaluate a class session on the basis of a session of an IBSE module (STC, Insights o FOSS).</td>
<td>- Exploring scientific phenomena - Conceptual change</td>
</tr>
<tr>
<td>Comparing IBSE proposals</td>
<td>Identify the common elements among some IBSE proposals and critically analyze their differences.</td>
<td>- Identifying patterns, regularities and its relevance. - Exploring scientific phenomena</td>
</tr>
<tr>
<td>Disciplinary workshops (x4)</td>
<td>Explore a few fundamental scientific ideas by recreating sessions/experiences of the selected module.</td>
<td>- Advantages and disadvantages of alternative forms of data display for communicating results.</td>
</tr>
<tr>
<td>Experimenting in science</td>
<td>Design and develop a scientific experiment, taking into account the hypothesis, predictions and/or explanations to be validated, and the variables present in the phenomenon.</td>
<td>- Conceptual change - Exploration of scientific phenomena</td>
</tr>
<tr>
<td>Closure and conceptual development</td>
<td>Reflect on the importance of the closure in a class session, emphasizing different strategies for conceptual development and conceptual change.</td>
<td>- Conceptual change - Exploration of scientific phenomena</td>
</tr>
<tr>
<td>Knowledge construction: preconceptions</td>
<td>Develop abilities to tackle children’s difficult questions or answers by reflecting on the role played by preconceptions in the process of knowledge construction.</td>
<td>Extended period of discussion about teachers’ results and literature on the topic through virtual forums along the year of training.</td>
</tr>
<tr>
<td>Cooperative learning</td>
<td>Identify a few strategies for cooperative learning that facilitate learning about how science knowledge is built through debate and argumentation.</td>
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</thead>
<tbody>
<tr>
<td>Learning objectives</td>
<td>Formulate learning objectives coherent with the activities proposed for a class session.</td>
<td>Discussing the role of evidence when evaluating learning objectives.</td>
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New Workshops

Table 2. New workshops introduced to the professional development program (curricula for training in-service science teachers from primary school).

<table>
<thead>
<tr>
<th>SPECIFIC WORKSHOPS</th>
<th>LEARNING OBJECTIVES FOR TEACHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formative assessment: class dialogues and the science notebook</td>
<td>Identify a few strategies that provide the teacher with information concerning his students’ learning, and that simultaneously promote conceptual clarification and/or new learning.</td>
</tr>
<tr>
<td>Designing a learning sequence</td>
<td>Acquire tools to design small didactic units on scientific subjects, coherent with Inquiry-Based Science Teaching.</td>
</tr>
<tr>
<td>Role of evidence in science and in teaching assessment (portfolio design)</td>
<td>Understand what constitutes evidence of instructional practices, evidence of students’ learning, and how to systematize this information by building a teacher portfolio.</td>
</tr>
<tr>
<td>Scientific questioning in the primary school classroom</td>
<td>Analyze the difference of scientific vs. non-scientific questions by putting them under experimental trial. Also, discussing specific strategies like scaffolding for help children to develop the skill of raising scientific questions.</td>
</tr>
<tr>
<td>Class visit workshop (fidelity of implementation)</td>
<td>Use class observation tools to support and assess teachers that develop IBSE practices during class visits.</td>
</tr>
<tr>
<td>Design of a short learning progression.</td>
<td>Design a learning progression for teaching one scientific concept. This workshop is supported by virtual forums along the year, so multiple feedback is received by teachers.</td>
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It has been observed that teachers do not automatically change their beliefs about science teaching or their practices just by assisting to workshops. In Harlen’s words (2008): ‘it may not be sufficient for teachers to acquire the skills of inquiry; without the beliefs, the skills fall short of full implementation’. Teachers are unlikely to develop these roles, beliefs and new practices through informal teacher learning routes; rather they require some structured opportunities to consider examples and approaches to change”.

This phrase closely describes the vision of professional development for in-service science teachers presented in this paper. The more structured the PD program was (2008 vs. 2002-2007) the better results in change of instructional practices were observed. This off course includes designing a learning progression for teachers to learn about science and about pedagogical strategies that is distributed in the time in the form of workshops that allow reflection, re-visitation of concepts and development of scientific reasoning. This type of curricular design for training in-service teachers, derived from years of validating workshops, observing science classes and analyzing literature on cognition, epistemology of science, teachers’ professional development, etc., has been supported recently by one of the most important universities in Colombia and by the National Ministry of Education, since they have seen results regarding real changes in what teachers do in their classrooms and in what children achieve.

Finally, this proposal also pretends to be informative to other countries trying to implement PD programs in IBSE and that face similar challenges to the ones presented in this paper.

References


