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Good Practices in Science Teacher Education for Schools in Disadvantaged Contexts: A Case Study from a School Improvement Program in Argentina

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Abstract: In many parts of the world, schools serving students from disadvantaged backgrounds are the norm rather than the exception. In science education, research has shown that within these schools, science is taught as a body of simple facts and that inquiry-based teaching methods are practically absent, despite being endorsed by national and local curricula. We analyzed the case of "Escuelas del Bicentenario" (Bicentennial Schools), a School Improvement Program that has been held since 2007 in 151 primary schools in unprivileged areas of 6 provinces of Argentina. This professional development program is composed of a team of 30 science facilitators who work with about 1800 class teachers every fortnight in their own schools with the goal of improving their science instruction. We conducted an open survey to examine facilitators' perceptions of the efficacy of different professional development practices in having teachers incorporate inquiry-based science teaching methods in their classrooms. An overwhelming majority of science facilitators identified the same strategy as the most effective, namely modeling inquiry-based lessons in the actual classroom, with teachers very own students. We found the value of this practice, chosen by over 90% survey responders, to be related to the possibility of building teachers trust and understanding. First, when teachers see successful inquiry-based lessons developed with their very own students, they begin to have trust not only in facilitators as skilled professionals, but also in the value of this teaching method as a way to develop student understanding and class participation. It also helps teachers trust their students learning capabilities. Second, it helps teachers to understand the nuances of implementing inquiry-based curriculum by themselves in the future, including how to handle student questions, a challenge that most facilitators reported as one of the biggest fear for teachers in adopting inquiry-based methods.

Keywords: Science Education, Teacher Education, Inquiry Based Programs, Disadvantaged Contexts

Introduction

The large, and by now well-established opportunity inequalities within the educational system is currently considered a major problem both in Latin America as well as in other regions of the world. In the teaching of science, this inequality becomes strikingly evident from international examination results, such as those of PISA (Programme for International Student Assessment) (OECD 2010) or SERCE (Second Regional Comparative and Explanatory Study) (Leymonié Sáenz 2009), which show significant gaps in science achievement between children from affluent schools and students attending disadvantaged-sector establishments (Duarte and Moreno 2009). The number of children affected is considerable, given the fact that in 2007, 28.9% of the population in Latin America was estimated to be living below the poverty line (Rivas et al. 2010). Because scientific literacy has been globally established as a key factor for successful economic and social development in modern societies (Osborne 2007), the existing scenario reveals just how imperative the need to improve science education in disadvantaged-sector schools has become.

In response to this concern, several school improvement programs and professional teacher development efforts have recently been introduced in areas of social and economic vulnerability throughout Latin America which aim to reduce the achievement gap between children in poverty

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and students from more privileged backgrounds (Gvirtz and Oria 2010; Gvirtz et al. 2007; Valverde et al. 2007). However, very few of these programs have been properly evaluated or accompanied by research efforts. These research efforts are necessary for policy makers and program developers to understand which practices work best, or improve teacher classroom practices and student learning, least of all for science education.

In this study we analyze the case of Escuelas del Bicentenario (Bicentennial Schools), a multi-site school improvement program started in 2007, and currently in practice at 151 elementary schools in disadvantaged areas in 6 Argentine provinces. Over the last 5 years, 1800 teachers have worked with a team of 30 science facilitators, meeting twice a month to work on science instruction practices (see Program Description for further details).

Particular interest was focused on understanding the kinds of professional development practices best helping teachers understand and put into practice inquiry-based science teaching methods in the classroom. These methods involve engaging students in guided investigations relating to natural phenomena in order to develop, both an understanding of the nature of scientific knowledge as well as a specific set of scientific skills (Harlen 2000; Minner et al 2010). Examples of science learning modules developed by the program team can be found at: http://ebicentenario.org.ar/ebooks.php.

This objective was selected because, although the importance of inquiry-based science teaching has been well established and incorporated to national and local curricula, as well as confirmed in different investigations (CFCE 2004; NRC 1996), our field studies and those of other authors have shown that in most underprivileged-sector elementary schools, science is taught by merely imparting a body of facts, to students participating in very undemanding activities that do not help advance science related thinking-skills (Furman and Podestá 2009; Oakes 2000). Supovitz and Turner (2000) found that the largest school-level influence affecting teacher practices and classroom culture was poverty. Teachers from schools with high numbers of students receiving free or almost-free lunches had, on average, significantly lower levels of classroom investigative culture and inquiry-based practices.

Along these lines, a recent review of science teaching practices in Latin America and the Caribbean by Valverde and Näslund-Hadley (2010) has shown that in the region, science lessons are mostly based on rote data memorization and rudimentary problem solving, and that teachers explain student failure as the result of a lack of effort, or lack of interest in science, or in learning in general. As Angela Calabrese Barton (2003) already pointed out, teachers working in disadvantaged-sector schools often hold preconceived notions of students as deficient, further contributing to lower teacher expectations on potentially attainable skills. This presents a major challenge to teacher educators.

Regional findings are not surprising, given the fact that despite high national and local science education standards, inquiry-based methods had yet to be extensively adopted by pre-service teacher education programs (Bitar 2011). A study of Argentine teacher-training programs revealed that teacher educators often taught science as encyclopedic knowledge (Adúriz-Bravo 2009). These programs often promote an unrealistic view of science, presenting it as a rigid set of steps, as opposed to a set of practices and discourses (ACITSM 2007).

Inquiry-based science instruction is extremely challenging for teachers who have had no prior experience with research projects themselves, or have not participated in inquiry-based lessons as students, since it requires considerable conceptual changes regarding scientific knowledge and how it is constructed, and forces teachers to set up new student participation paradigms in the classroom (Gellon et al. 2005). Closing the wide achievement gap in science for children living in underprivileged areas requires teachers to meet this challenge and offer all students a rich set of classroom experiences, engaging them in deep thinking as well as in a conceptual understanding of science. Therefore, adopting professional development strategies effectively introducing science teachers to inquiry-based teaching methods becomes extremely important, in order to both design and rethink teacher-training programs, and assist science teachers working at disadvantaged schools to improve their teaching skills.

In an attempt to contribute to this understanding, we looked at science facilitator perceptions in relation to professional development practice effectiveness. Effectiveness was defined as how well each practice worked in order to have teachers adopt inquiry-based teaching methods in the classroom. We also looked at facilitator perceptions in relation to the challenges faced by teachers attempting to make use of these practices.

To this end, we conducted a survey of the 30 science facilitators conforming the Science team of the Bicentennial Schools Program (namely, the science teaching specialists working inside schools helping teachers improve science education skills). We were interested in analyzing their experience after 5 years implementing professional development practices for 1800 teachers, in direct contact with both teachers and students.

Research Questions

> What professional development practices do science facilitators believe best help elementary school teachers incorporate inquiry-based teaching methods to their science classes, and why?
>
> What are the main obstacles that teachers face when adopting an inquiry-based approach to teaching science, in the opinion of the science facilitators?

Research Methods

Both quantitative and qualitative methods were selected to interpret science facilitator views, on professional development practice success at introducing inquiry-based science teaching in schools in disadvantaged areas. We focused our research on a case study of the Bicentennial Schools Program. The unit of analysis corresponded to the group of 30 science facilitators working within the program since 2007, with teachers from 151 underprivileged schools.

Program Description

Bicentennial Schools (http://www.ebicentenario.org.ar) is a program jointly developed by IIEP-UNESCO and San Andres University in Argentina to improve quality and equity of education in public elementary schools that attend underprivileged student populations. It also seeks to construct a body of evidence on good practices for school improvement and teacher education, that may ultimately contribute to further the development of educational policies at the state level (Gvirtz and Oría 2010). The program receives funding from both public and private sectors, including local provincial School Boards, local non-profit organizations and private companies. Launched in 2007, it is currently working with 6 Argentine provinces at 151 elementary schools, involving 1800 teachers and 60,000 children, attending 1st through 6th grade.

Participating schools are selected by local education authorities based on poor national examination test results and high education vulnerability indices. The latter are established taking into account local variables, including percentage of population unable to graduate elementary school, unemployment levels and inadequate housing conditions, among others.

Program interventions at each school last on average 4 and a half years and focus on three different academic areas: Literacy, Mathematics and Science, as well as on School Management. In this study, we present the Science program, specially designed and implemented by us since its inception.

The goal of this particular part of the program is to introduce teachers to inquiry-based teaching methods and help them become reflective practitioners. In doing so, we seek to generate a ripple effect spreading from the central science coordinator team under the direction of the

Program, all the way to the classroom. Science coordinators meet on a monthly basis with local science facilitator teams (30 in total) who, in turn, work with teachers at the individual school level. Most facilitators are former secondary school science teachers, or science graduates with experience in elementary school teacher training.

Facilitators meet with teachers every fortnight for at least two hours, engaging in a variety of professional development practices, such as analyzing student course work, planning lessons, discussing science content and pedagogy, reviewing reading material or designing assessment instruments, among many others. Facilitators may arrange classroom visits with teachers, or coteach to model teaching strategies for lessons on particularly challenging topics. Other times, facilitators may demonstrate science experiments similar to the ones teachers will conduct with students in the classroom.

Although all facilitator teams share a single goal, namely to orient teaching practices towards inquiry-based methods applying the same professional development resources and practices, each facilitator is responsible for deciding which practice to apply and when, based on their personal judgment and expertise.

Data Collection and Analysis

An online survey with both open and multiple choice questions was conducted (see Appendix) asking teacher facilitators to identify the 2 most effective professional development practices from the set of options offered by the program. Responders were required to support their choice, providing reasons and examples from their work. We also inquired about obstacles encountered by teachers incorporating inquiry-based teaching methods in the classroom. All facilitators (N=30) completed the survey.

Facilitator responses to each question were subsequently analyzed, looking for patterns identifying professional development practices deemed effective for inquiry-based science teaching, as well as common obstacles. We also examined qualitative data provided by facilitators on reasons for considering particular practices effective, and successful examples of work, selecting the most representative reasons behind these choices.

Survey results were further triangulated with both individual facilitator informal interviews and monthly facilitator reports.

Findings

Analysis of the survey yielded interesting results on what science facilitators viewed as best practices for science teacher professional development. Among the set of options available, an overwhelming majority of science facilitators identified the same strategy as the most effective, namely modeling inquiry-based lessons in the actual classroom. This practice, chosen by over 90% survey responders, was followed in second place by practicing adapting preexisting inquiry-based science curriculum together with teachers (chosen by 30%) and in third place, by teacher participation in inquiry-based activities playing the role of learners (18%).

Given the almost unanimous consensus in favor of the value of modeling inquiry-based lessons in the classroom, we decided to examine in greater depth the reasons behind the effectiveness of this professional development strategy.

Before further analysis, it is important to clarify that within the context of the program, the practice of modeling lessons in the classroom involves a fixed set of steps:

- Teachers and facilitators plan an inquiry-based science lesson together, often by adapting science curriculum contents offered by the program, to teacher goals and particular classroom context.
- Teachers and facilitators set a date for the facilitator conduct the lesson in the teacher's actual classroom.

- On the day of the lesson, the facilitator leads the class. The classroom teacher takes the role of observer or helper and records relevant aspects of the lesson.
- After the lesson, teachers and facilitators meet in order to reflect on lesson development and outcomes in terms of student engagement, learning results and possible improvements.
- The process is repeated once or twice over the course of the year. One month after the practical demonstration, teachers and facilitators set a date for a new lesson they plan together, this time reversing their roles, followed by a reflection meeting as before.

This approach is designed to allow teachers to observe an expert in action within an authentic classroom setting, and be slowly introduced to a new set of teaching practices, starting out playing the more peripheral role of observers, and subsequently shifting into the more central one, taking charge of the lesson.

What is the true value of this professional development strategy? As mentioned, 91 % of facilitators considered it to be the most effective, if teachers were going to be scaffolding into switching to this lesson modality on their own in the future. In the facilitators' experience, the significance of modeling inquiry-based lessons was related to teachers “seeing with their own eyes” the impact of inquiry-based teaching on student learning and participation, thus envisioning what it really meant in practice.

Further analysis of the survey revealed two main pillars behind facilitator belief in effectiveness of this professional development practice, namely trust and understanding, which we discuss next.

First, the modeling of inquiry-based science lessons in classrooms jointly with teachers establishes trust, not only in facilitator expertise, but also in the genuine value of inquiry-based teaching, and in their own students as learners. While witnessing inquiry-based lessons being taught to their very own students, teachers develop trust in professional facilitator skills, when these lessons are conducted effectively, in classrooms with large numbers of students described by teachers as “having learning problems”. It also increments trust the inquiry-based science activities promoted by the program, that actually increase student participation and learning. Finally, it permits the development of trust in their own students capacity to learn science in more demanding ways.

Along these lines, many facilitators referred to the importance of gaining teacher trust before engaging in any professional development process. As described by one facilitator:

> “A teacher said to me: ´I think everything you are telling me sounds great, but I also believe it's not as easy to put into practice as you claim. That's why I would love to see you do it with the kids first. So I went to the school, where we had set a future day for me to lead the lesson we had planned together. It was a positive experience, students were very excited. The most rewarding moment came at the end of the class, when the teacher acknowledged the success of the experience saying: Well, to tell you the truth, you were right. When I teach, I never ask all those questions or follow all the steps you proposed to the kids, I see now just how different it is from what I was doing and why children engage more”.

Facilitators also talked about the importance of modeling inquiry-based lessons in order to have teachers visualize (and therefore trust in) the impact of this kind of pedagogy on student learning and participation. As one facilitator pointed out, it is only after watching facilitators model inquiry-based lessons in classrooms and observing the effects on their own students that the teamwork with teachers really begins:

> “This professional development strategy is effective because it allows us to connect with teachers by discussing ´real teaching´ as opposed to just a theoretical approach to

> instruction. It helps us to bond with teachers because, by watching inquiry-based lesson outcomes in their own classroom, teachers start to see how their students can build ideas based on their own investigations of natural phenomena. It is only then that they begin to believe inquiry-based teaching actually works, and that's when the teamwork starts, because teachers begin to trust in us as professionals as they realize the approach we bring is not merely theoretical, and that it is really possible to have students acquire not only ideas but also science skills”.

Watching students respond to inquiry-based lessons allows teachers to reconsider their potential as learners, award greater confidence to their capacity to understand things in new ways. In the words of another program facilitator:

> “The teacher did not dare teach the class we had planned on her own, she thought her students would not respond to the activities prepared. Yet, when I modeled it for her, she saw how her students actively participated , in varying degrees. Even the shyest student contributed to the conversation. When the class ended, the teacher told me how impressed she was that her students had been able to answer all the questions correctly.”

These facilitator testimonials show us that in underprivileged settings, incorporating inquiry-based teaching methods requires teachers to review their own underestimation of students as learners, and suggest that watching their students actively participate in class fosters this change. For example, one facilitator reported how one of his teachers started to describe her students as “different people” after seeing them actively participate in an inquiry-based lesson:

> “Over the course of the lesson, students elaborated their own hypotheses, collected data and recorded findings in tables, were able to draw conclusions and explain what they had learned. Their teacher was very surprised because the same children who had a reputation for “bad behavior” or had been labeled as “slow” by the staff, were the ones who stood out most. He mentioned that after the lesson I modeled, these particular students changed their attitude in class and now appeared to be entirely “different kids”. Even other teachers at the school have had trouble believing this teacher when he tells them about what these students are now able to accomplish in science class.”

We also found that the value of modeling inquiry-based science lessons in the classroom requires teachers to understand what the method really means in practice, in order to envision themselves as capable of implementing the strategy. As mentioned, teaching science through inquiry involves putting students at the center of classroom dynamics and often requires teachers to tackle a wider variety of student questions that are difficult to predict in advance; something which, at first, teachers reject as “another utopia brought by teacher educators”. One facilitator explained it as follows:

> “I believe that it makes teachers see how to do something they have never done before. By watching another colleague (one of us) in action, they start to consider our proposal less utopian than in the past. It demystifies science education, helping teachers see the meaning and the value of learning science”.

Yet another facilitator reflected, "teachers find inquiry-based approaches to teaching so challenging because they themselves have rarely witnessed this kind of lesson in practice, either as students or as pre-service teachers":

> “At the beginning of the project, teachers are usually resistant to the of changes we propose, because they feel that working with science means engaging in experimental

> activities with students for which they have had no preparation, even during their years of teacher education. Modeling successful inquiry-based lessons for them allows us to break the ice and show teachers that, in the real classroom, things are not as complicated as they seem on paper. This makes them feel safe and leads them to adopt a more active role in lesson planning and to start thinking of new activities to develop with students-”

As in the quote above, many facilitators spoke about the importance of showing teachers the nuances of how an inquiry-based science lesson can be implemented in order to make them feel safe and trust in their own abilities. Then teachers start to understand what the proposed methodology is all about, and begin to envision in details how they might be able to teach in the same way themselves in the near future:

> “Once teachers can watch how the inquiry-based approach works ´live´, they begin to understand the different stages they need to go through to build a class, what kinds of questions they need to ask in order to guide student reasoning, and other important issues such as time management or key concepts to write up on the blackboard. Seeing the kind of classroom dynamics that inquiry-based teaching generates gives them more confidence and insight into the understanding they need to look for in a lesson.”

In this way, putting inquiry-based teaching into practice also contributes to building teacher confidence in themselves as professionals able to teach science in richer ways than before.

This is linked directly to the responses obtained to our second research question. When facilitators were asked to identify obstacles limiting inquiry-based teaching method application, many of them referred to teacher fear of losing control of the classroom (35%), both in terms of managing large groups where student behavior was an issue (39%), and in terms of having students pose unforeseen questions they did not know the answers to (57%). This last finding stands in apparent contradiction with the fact that teachers perceived students as deficient in terms of their ability to learn. However, as facilitators report, teachers fear of unforeseen questions is related to their lack of knowledge of the subject matter of science. Thus, even simple questions posed by students may present a challenge to them.

For teachers, losing the fear of applying a new and more challenging teaching method, required by national curriculum guidelines, but one they have never received specific training for, remains the issue. Therefore, watching examples of how these lessons can be successfully conducted with their own students, becomes an important tool in helping them envision both the problems and the possible solutions when confronting the challenge on their own.

Finally, many facilitators assigned great importance to engaging teachers in discussions on lesson outcomes, and reasons underlying successful results, after watching modeled lessons. This last step of the professional development modeling strategy we describe, allows teachers and facilitators to critically reflect on the kinds of teacher interventions that best promote student learning, and to think about ways to improve future lessons. As one facilitator reflected:

> “It is a very enriching experience, when the modeled lesson is seen as a practice laboratory of sorts. After observing and then coteaching a few inquiry-based classes, I find teachers become more reflective about what makes a lesson work and why. They become more aware of the learning goals targeted during each class and of how to introduce teaching scientific skills as well”

We and others have previously shown that the process of learning to teach through inquiry-based methods is a long and demanding journey, which requires a mix of careful planning and flexible improvisation (Furman et al. 2012). Inquiry-based lessons need teachers to put students at the center of the teaching process, without forgetting lesson goals, and allowing room for debate while incorporating student findings, in order to progressively build scientific knowledge.

This last step involves joint reflection, which is at the heart of the modeling practice, and is therefore essential to help teachers gain ownership of this challenging process.

Discussion

We have shown how the Bicentennial Schools program team of science education facilitators, almost unanimously chose on site inquiry-based lesson modeling as the most effective professional development practice, for teachers seeking to apply inquiry-based science teaching methods in class. This result underscores the importance of adopting a situated perspective when introducing teachers to a new and demanding instruction method that involves both a significant change in basic pedagogic concepts as well as a different approach to the teaching of the subject.

As Lave and Wenger (1991) observed, learning a complex task such as teaching requires learners to become part of a community of practice, that gradually allows them to take on more central roles while learning the standard norms and practices of the community itself. In this case, starting the professional development process by having more experienced others (i.e. science facilitators), adopt central roles in the classroom community of learning (in this case, leading an inquiry-based science lesson), and teachers accept initially a more peripheral role and gradually move back to the center, seems to be a key strategy in facilitating learning to teach in new ways.

We have found that modeling on site inquiry-based lessons in classrooms by teacher trainers, helps teachers build both trust and understanding. Building trust involves developing teacher confidence both in science facilitator expertise (key for establishing a real community of practice, where novices must trust experts in their roles as such), and in the benefits of the method proposed (i.e. that it will actually increase student learning and participation); and confidence in their own students as learners as well (abandoning the deficient model held by most teachers of students from disadvantaged schools).

Building understanding involves having teachers comprehend what the proposed method actually implies in the context of a real classroom, including the nuances of putting it into practice, and is also related to building trust, in this case in themselves as professionals capable of conducting an inquiry-based lesson with real students.

Our findings can be linked to those of Hilda Borko (2004) in her review analysis of different teacher education models, where in order to transform their teaching practices, the author believes teachers need “an existence proof” whereby strategies proposed by teacher educators are real and applicable within their own work contexts, and not just in some ideal school. Marilyn Cochran Smith (2000) has called them “proofs of possibility”, or evidence that the new teaching scenarios are really possible. As Lee Shulman (1983) pointed out, existence or possibility proofs are extremely important because they can “evoke images of the possible…. Not only documenting that it can be done, but also laying out at least one detailed example of how it was organized, developed, and pursued” (p. 495). This was especially true in our study, not only with respect to the potential application of a specific methodology such as inquiry-based science teaching, but also regarding the actual possibility of implementing it with students in disadvantaged settings, who are often described by teachers in our program as problematic, with learning difficulties, or deficient in other ways. Seeing individual students perform differently and better when offered richer lessons, fostered in their teachers greater trust in student abilities and as a result, the courage they needed to offer more challenging lessons.

This study is part of a bigger research effort that aims to identify best practices in science teacher education, especially for those who teach (or aim to teach) in disadvantaged contexts. We acknowledge that looking at facilitators views on effective strategies for teacher education has limitations, since their perceptions might be different from what teachers really understand as those training practices that help them transform their actual practice. However, we also understand that the meaning that teacher educators (i.e. facilitators) give to their practice can shed an interesting light in order to understand the reasons why some training strategies work better than others. Next steps of this study involve looking at teachers perception of the effectiveness of different training practices and at the ways those practices transform classroom teaching.

We believe these study results acquire greatest significance in relation to the designing of teacher education programs. Although the findings are not surprising in the context of a situated perspective on teaching and learning, which underlines the importance of engaging learners (in our case, practicing teachers) in authentic contexts, experiences of this nature, as mentioned in the Introduction to this article, are the exception rather than the norm in Latin America, both for pre-service and in-service teacher education. In most cases, teacher education is based on a theoretical approach, both to teaching and to the subject matter, in this instance, science. Our findings speak not only to the key value of having teachers see actual inquiry-based lesson plans in action and be able to reflect with more experienced others on the challenges of working with students following this approach, but also to the enormous possibilities opened by its use if we are to transform the kind of science currently taught in the region, and offer all children the possibility of achieving scientific literacy.

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Appendix: Survey for Science Facilitators

Dear team,

We are conducting a research study on professional development practices. We are interested in establishing which approaches work best in order to have teachers incorporate inquiry-based teaching methods in their classrooms. Please complete this online survey to let us know, in you opinion as Facilitators, which option most successfully helped teachers adopt inquiry-based strategies in their science class. Thank you!

1. Name:
2. Province:
3. Select the 2 professional development practices that, in your view, were more effective in helping teachers incorporate an inquiry-based approach to science teaching, and give an example of each strategy from your own work.

<u>Strategy 1:</u>
Example:
Why do you think this strategy works?
<u>Strategy 2:</u>
Example:
Why do you think this strategy works?
<u>Options to choose from:</u>

- Modeling inquiry-based lessons with students in teachers own classroom.
- Working with teachers to adapt inquiry-based curriculum provided by the program.
- Working with teachers to create inquiry-based lesson plans.
- Asking teachers to create their own lesson plans.
- Having teachers conduct experiments (in the role of learners) similar to those they will later perform with students.
- Explain conceptual science topics teachers may be unfamiliar with.
- Reviewing student course work together.
- Analyzing other teachers written lesson plans
- Watching and analyzing videos of other teachers' lessons.
- Discussing science pedagogy material together.
- Discussing particular science topics together.

4. From your perspective, which were the most common obstacles encountered by teachers trying to adopt inquiry-based science teaching methods? Select an option from the ones shown below.

- Lack of scientific knowledge.
- More time required for planning and preparation than a traditional science lesson.
- Difficulties obtaining materials needed.
- Lack of support from school authorities.
- Large classroom size.
- Student behavior issues.
- Teachers feeling the approach involved "little science content" and that they were teaching less than with their traditional method.
- Fear of losing control of the classroom
- Fear of unpredictable questions from students they will be unable to answer.
- Requires greater effort
- Other (specify)

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