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Harcharan Pardhan
Aga Khan University, Institute for Educational Development, Karachi

Sadia Muzaffar Bhutta
Aga Khan University, Institute for Educational Development, Karachi

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Harcharan Pardhan and Sadia Muzaffar Bhutta
Institute for Educational Development, Aga Khan University, Pakistan

Asking questions is central to intellectual effort; it is instrumental in bridging the gap between the known and the unknown. Questioning existed even before the time of Greek philosopher Socrates and still prevails in classrooms.

Questioning is a major teaching and learning strategy for teachers in Pakistan. Unfortunately, teachers' questioning overrules students' questioning, leaving neither space nor time to create an interactive environment that promotes curiosity and meaningful learning. Using an innovative approach, we attempted to implement students' questioning in an upper primary science classroom. The encouraging findings of our study and their implications are discussed in this article.

The Context

Despite government efforts since Pakistan's independence in 1947 to implement more effective and purposeful education, Pakistan has a literacy rate of only 35 percent (World Bank 1993) and one of the world's worst education records. Political, economic and social constraints largely account for the low standards of the public education system: the physical facilities and social environment are not conducive to learning.

A senior educator describes primary teaching in Pakistan as follows:

> In the primary schools, science is taught by the general classroom teacher, and there are more than 100,000 such teachers. Most of these teachers have done 10 years of schooling (equivalent to O-Level) with one year of professional training. At school, they have done either a two-year course in general science or two years of physics, chemistry and biology. At the one-year professional course, these teachers are prepared for the teaching of all the primary school subjects; thus, they have little time for a good grounding in subject matter and teaching methodology of science. (Sheikh 1977, 8)

A weak general background and limited exposure to effective professional development result in incompetent teaching, especially in science.

Pakistan teachers prefer a transmission approach to teaching science. The roles of teacher and pupil conform to Freire's (1972, 45) "banking concept," where "students are the depositories and the teacher is the depositor" and "knowledge is a gift bestowed by those who consider themselves knowledgeable upon those whom they consider to know nothing."

In terms of questioning, teachers follow Ur's (1996) Initiation–Response–Feedback (IRF) model, which is simple, linear and mostly one-way: the teacher asks a question (initiation), the students then respond and, finally, the teacher provides feedback. In this model, the teacher's questions dominate.

Theoretical Perspectives

Questioning is as old as speech, and the use of questioning as a teaching strategy is at least as old as the classroom. In the 19th century, questioning was discussed primarily by school inspectors (MacNamara 1980). Since the beginning of the 20th century, several studies on questioning have been conducted.

Steven's (1912) study on questioning reported that teachers asked most of the questions in the classroom (with one teacher asking approximately 400 questions daily). Of these questions, 65 percent were designed to make students recall textbook knowledge. Students answered the questions but asked few of their own.

Pate and Bremer (1967) studied teachers' statements about questioning. The statements emphasized the following purposes of questioning:

- To check knowledge and understanding (69 percent)
- To diagnose pupils' difficulties (54 percent)
- To recall facts (47 percent)
- To encourage pupils' thinking (10 percent)

None of the teachers emphasized students' questioning.

Kerry (1982, 5) writes, "Teachers ask 1000 questions per week." Most of the research on questioning, until recently, has placed more importance on teachers' questions than on students' questions (Watts et al. 1997) and has revealed that a teacher-centred classroom prevents students from exploring information and thinking creatively and reflectively.

Barnes (1990, 51) notes, "Teachers' questions do not always help learners to think. Since teachers do not have direct access to their students' thoughts, it is easy for them to ask questions which impede learning by directing attention away from the issue that students need to clarify." Feasey (1998, 48) asserts, "Teachers' questions play an important role in supporting children, but equally important is the need to develop children's abilities as a constructively critical audience, encouraging children to ask questions of and challenge each other."

Harlen (1992, 42) suggests that "curiosity [is] an active component in learning with understanding." Children are curious about the world around them; they need to construct personal understanding in a setting that encourages and nurtures questioning. Thus, questioning in the classroom should be a two-way process: teachers should ask questions to support children's learning, and students should ask questions to develop curiosity and, in satisfying curiosity, understanding.

Students' questions not only develop curiosity and understanding but also help teachers to plan and teach effectively. Paling (1982, 40) writes, "The questions children ask often indicate very clearly to the teacher the way in which they are thinking. They can also indicate whether a child really understands some new idea or his thinking about it is muddled." Similarly, Woodward (1992) argues,

> A reason for fostering children's interrogative skills is that, by posing questions, pupils are shaping and exploring their thoughts and, hence, opportunities will be provided for teachers to have some insights into children's thinking and conceptual understanding. Having questions asked by children can lead teachers towards making appropriate assessment of children's understanding or, alternatively, their misconceptions. Adequate information about the misconceptions of children about different scientific phenomenon will help the teacher to get an insight into where each pupil is.

Current research demonstrates the need for more students' questioning in classrooms; in practice, however, teachers' questioning still dominates. Research shows that children come to school with many questions, but in time their curiosity dies and they become silent listeners (Holt 1982).

Several researchers (Biddulph and Carr 1992; Brain 1998; Davis 1993; Harlen 1992; Holt 1982; Shipley et al. 1964; Watts et al. 1997; Woodward 1992) have provided reasons for this. They report that teachers are unable to cope with an overwhelming number of questions; lack skills, time and patience to provide encouraging, nonthreatening classroom environments through effective instructional planning and handling of students' questions; and feel insecure about addressing diverse and unexpected questions, fearing loss of respect and classroom control if their lack of knowledge is revealed. Thus, students' questions are ignored, deemed silly or given unsatisfactory treatment.

Furthermore, the beliefs that the teacher is the source of knowledge and that questions have right or wrong answers deter students from asking questions. Students develop anxiety about the subject (especially math and science), a fear of being mistaken and ashamed, and an attitude that undermines their ability to think. Thus, they become passive learners. Derry and Loughran (1997, 17) write, "Perhaps more [in science] than in other subjects, [students] also often see the teacher as a 'font of knowledge.' Because this view is often at the forefront of students' thinking about science, they often undermine their own ability to think and learn in ways that science teachers themselves consider to be much more important."

Many of the research findings discussed emphasize the teacher's role in the questioning process and the importance of students' questioning for developing reflective, critical thinking. To promote students' questioning skills, teachers need to provide opportunities for students to frame and ask their own questions. Students' questions

- help students gain better understanding of concepts and phenomena in science;
- provide the teacher with better insight into children's thinking and conceptual understanding, which helps them to identify problematic areas and plan appropriate teaching strategies and approaches;
- promote curiosity through reflective thinking; and
- encourage more inquiry in the learning process.

Goals and Research Methodology

The theoretical perspectives on questioning discussed in the previous section inspired us to explore students' questioning. We sought to achieve balance between the teacher's questions and the students' questions and to facilitate two-way communication in the classroom.

The study's focus question was "How can a primary science teacher promote students' questioning skills?" We adopted the qualitative approach to conduct research personally and contextually without prior assumptions and to suit the descriptive, interactive nature of the study. Three expert views guided our approach:

> Qualitative data are most appropriate when the question to be answered is a how question. (Northey and Tepperman 1986, 58)
>
> Qualitative research is a useful approach whenever the investigator is concerned with discovering or describing . . . and where there are no assumptions. (Seliger and Shohamy 1989, 124)
>
> Action research is a form of self-reflective enquiry undertaken by participants (teachers, students or principals, for example) in social (including educational) situations in order to improve the rationality and justice of their own social and educational practices, their understanding of these practices, and the situations in which these practices are carried out. (Carr and Kemmis 1986, 162)

Because of time constraints, only one class, from a representative public school, was studied. The students were 10–12 years old; the teacher had a bachelor of science degree and a one-year primary teacher certificate. Primary school was chosen for study for two reasons: the comfort level of the researchers, and the belief that primary children possess natural curiosity. For more detailed, in-depth study, a focus group of six students with similar socioeconomic backgrounds but mixed abilities was selected. Vockell (1983, 103) states, "In order to use such a group to make decisions about the larger group, the subgroup has to resemble the larger group as closely as possible."

Data was obtained from multiple sources, and the researchers played the role of teacher while the participant teacher (PT) observed. Patton's (1990) "empathetic neutrality" was exercised throughout the study to build "a relationship of confidant and confidante" (Abell and Roth 1994, 79) between the researcher–teachers (RTs) and the PT. The purpose of the study, the process of the study and the use of the study's findings were explained to the school head and the PT in advance. Parents were informed of the study through consent letters, and confidentiality and anonymity were maintained.

Findings and Interpretations

Data from the pre-intervention stage of the study was analyzed promptly to establish the

starting point for planning strategies for the intervention stage. In subsequent research, data collection and analysis was done almost daily in accordance with Northey and Tepperman's (1986, 69) advice: "Do not leave these notes and other materials for interpretation at the end of the project. Rather, examine them recurrently as you look for major concepts, themes, and symbols by which to characterize the complex reality you are observing." This helped us to monitor and plan for students' questioning progress and to recognize challenges and facilitating factors. Four themes emerged:

- Teaching as telling and learning as listening
- Facilitating change through innovation
- Challenges
- Facilitating factors

Teaching As Telling and Learning As Listening

> My duty is to read the text to the children, to write questions and answers on the blackboard, to ask questions to check their memory or to keep them on task, and to check their homework. (PT)

The PT's statement, recorded before the classroom observations, indicates that he views his role as a teacher and his classroom practice in terms of Freire's (1972) banking concept. Our classroom observations, the corresponding data and informal anecdotes from students verified this.

A Typical Classroom Scenario

About 50 students, sitting in rows, faced the blackboard. The PT stood in front of the class, reading from a textbook. Without using much eye contact, he read a whole chapter on animals in 40 minutes. The RT reflected, "Life cycles of the birds and the insects were mentioned as typical topics but [it was] just taken for granted that children already knew them." The students at the front seemed to be listening, but those at the back were off-task and making noise.

Occasionally, the PT wrote words (and their meanings in Urdu) or answers to questions from the textbook on the blackboard. Although he seemed to know that the students were not keeping up with him, the PT quickly erased what he had written on the board. Rather than allowing enough time for the students to write everything down, the PT told the students to write faster.

The PT's talk dominated the lesson, with the students contributing infrequent one-word or yes/no responses to the PT's questions.

Borko and Putnam (1995) argue that teachers' actions in classrooms are shaped by their beliefs. The PT's actions in this scenario were consistent with his beliefs about his role.

Questioning

> It is very difficult for them to ask or tell something. They are just innocent kids. They need our guidelines all the time to move further. Children start to ask questions [later]. Now they are too young to ask questions. (PT)

The PT's perception of children explains his belief in teacher-directed classroom practice with children as passive recipients. Questioning was the PT's main teaching strategy. Of the 118 questions asked in the three lessons observed, only 11 percent were students' questions. Table 1 summarizes the questions.

The PT's questions, mainly checking rote learning, overruled the children's questions, and the PT demonstrated inadequate questioning skills, such as wait time, reinforcement or corrective feedback, and distributing questions. Evidence was gathered from dialogues similar to the following:

PT:	Does a lioness lay eggs or give birth?
Students:	Gives birth.
PT:	Do plants need sunlight? Yes, Sana.[1]
Sana:	Yes, sir.
PT:	Why do some animals lay eggs? [He immediately reads the answer from the textbook.] Animals lay eggs because eggs hatch to give birth to their babies.

The PT's classroom practice seemed to have been influenced by the opinion he expressed in the statement that opens this section. He denied students both the right to question and the right to voice ideas and queries to satisfy their curiosity. A student shared the following in an informal conversation about students' questions:

Table 1
Summary of Questions

Question Type	Example	% of Total	Comments
Closed-ended	• Are plants living or nonliving? • Where do these animals live? • What is a human being? • What fixes the plant?	70	This type of question dominated and questions were predominantly on recall of science content, and there was only one right answer. Often children were required to give a quick, short answer verbally.
Open-ended	• How are seeds dispersed? (Tell me, what did we learn yesterday from the book?) • Why do some animals lay eggs whereas others do not? (Yes, this is what we have just read and you have just written the answer to it in your book.)	2	The teacher expected textbook answers and removed students' opportunity to think otherwise. Hence, the open-ended questions became closed-ended.
Procedural a) Teacher's	• Where is your journal? • Do you have a scale? • Have you finished writing? • Have you opened your book? • Have you done your homework?	12	In the interview, the PT said that the purpose of these questions was "to check whether or not students are attentive and doing work."
b) Students'	• Sir, which pen should we use for writing? • What is the date today? • Sir, on which page are we to draw the diagram? • Should we draw all diagrams? • Sir, what did you write on the blackboard?	9	Students usually asked these questions while doing written work because they saw these notes as being important to success on exams: "We could not understand [the teacher's] handwriting so it was difficult for us to copy. We had to ask for what he wrote on the board. To copy the exact words from the blackboard is important because we have to learn all that by heart for the exam. We have to use the pen which teacher tells us so we ask for that also."
Disciplinary	• Tell me the page I was reading from? • Which line was I reading? • What did the other child say just now?	6	The purpose of these questions was to maintain discipline, especially at the back of the class. While asking these questions, the teacher normally moved to the back of the class and closer to the student concerned. The PT said, "These questions help me to keep children on-task because they become scared that I could ask any one of them about the page number."
Permission	• Sir, may I go and get a chalk?	1	Students usually asked this question when the PT asked for chalk.

> Whenever we try to ask a question . . . our teacher gets annoyed because . . . we are too many . . . and teacher beats us . . . and asks us to sit down and keep quiet . . . so we avoid asking questions in the classroom.

Many other students chimed in, "Yes, she is right."

This remark reveals the students' hidden maturity and empathy for their teacher and signifies their cultural context. The initial interviews and observations informed us about the existing classroom realities—especially about the teacher's and students' thinking and ways of working—thus providing us with a theoretical base on which to plan the subsequent stages.

Facilitating Change Through Innovation

Given the conventional reality of the classroom—the teacher in authority and the students as silent listeners—the attempt to challenge this reality and promote critical discussion called for tact and thoughtful planning.

In interviews, the students had expressed interest in pictures: "I like science because we have pictures in our science textbook. I like to see these pictures. At home I also see pictures in different books . . . my older brother has." This interest in pictures was a natural starting point.

Questioning About a Picture

Students in small groups of seven to eight shared two pictures: (1) a boy holding a glass of milk and (2) three football players in action. They wrote questions related to the topic "Health and Nutrition" (a topic negotiated with the PT and from the syllabus). The RTs monitored and collected the questions.

Organizing the students into groups proved problematic because of the large class size (about 60 students), the limited classroom space and the students' reaction to their newfound freedom. The noise disturbed the class next door, and one group decided to move out to the hallway (which the school rules prohibit). During the process of innovation, many other challenges were experienced that simultaneously cautioned us and deepened our understandings of the context and cultural dynamics. Later, we will share some of these challenges. Here, we focus on students' questioning and follow the development of our six focus group students: Tarana, Sana, Ghazala, Raja, Farukh and Zohaib.

Our focus group came up with 40 questions including repeats (approximately 5 questions per student), which we categorized and interpreted in Table 2.

The students were able to write many questions, though these questions were random and mostly low-order. This was encouraging, and students were verbally rewarded for their efforts. However, students seemed unsatisfied by writing questions without answers. There are two possible reasons for this. First, the normal practice is to write answers and not questions. Second, students saw answers as being the most important (especially in terms of passing exams). At this point, our prime focus was not on the quantity and quality of questions but, rather, on providing the context for asking questions.

At the end of the lesson, the RTs shared some questions from each group with the whole class. Ghazala, realizing that her group's questions were related to sports rather than health and nutrition, said, "Madam, it was a difficult picture." This was her authentic explanation, but for us it was a lesson: teachers have a responsibility to select resources carefully, and even pilot test them before bringing them to class, so as to prevent digression from the topic.

Following this lesson, the progression of strategies used to question about a specific concept within the main topic being studied was as shown in Figure 1. For each strategy, key findings will be reported with an attempt to illustrate the sequential progress.

Figure 1: Progression of Strategies

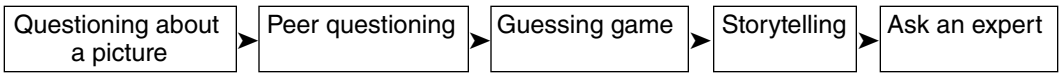


Table 2

Question Type	Percentage	Interpretation
Closed-ended • Who is the umpire in the game?	70	This is most likely due to the influence of existing practice (the teacher asked mostly closed-ended questions) (Morgan and Saxton 1991).
Open-ended • Why are the players' shoes alike, even though they are from different countries? • Why is milk white?	20	The first example is a discrepancy for students. Their notion is that different teams wear different uniforms (including shoes). The second question reveals children's innate curiosity, a desire to know about the unknown.
Procedural • Are we to write the answers, too?	5	These questions are related to usual expectations and questioning the writing of a question without an answer.
Statements ending in a question mark • Milk spreads diseases? • Packaged (sterilized) milk is good for health?	5	These questions represent the inability to distinguish between a statement and a question.

Peer Questioning

Early in the study, we had noticed students' natural urge to engage in talk. Though conversation had been discouraged, we recognized its potential as a meaningful learning opportunity. Students interviewed each other on the topic "Dietary Habits." Rules were negotiated: use a soft voice, and raise your hand if you wish to say something or answer a question. One RT initiated the task by posing the question "What do you eat for breakfast?" Students immediately got busy. In his journal, the PT wrote, "As soon as you asked them to interview each other they started at once . . . enthusiastically. They liked to find out about each other's dietary habits." The students asked each other what they eat for breakfast, lunch and dinner; a few even included teatime. The findings were pooled by the RTs and listed on the chalkboard under six categories: carbohydrates, proteins, vitamins, fats, minerals and water. We believe the interviews and the information on the chalkboard provoked students' thinking and engaged them in conversation through questioning.

Ghazala: Madam, I want to ask Farukh a question.
RT: Sure. Please go ahead.
Ghazala: Madam, I want to ask Farukh why he is so healthy. [Here, Ghazala seems to be linking food with health, thus linking this lesson with the previous lesson.]
RT: I think Farukh will not mind responding to your question. Besides, other students will also benefit from it.
Farukh: Madam, I eat spinach, rice, meat and fruits, and drink a lot of water. That's why I am healthy.
Tarana: Madam, I want to ask Farukh what sports he plays.
Farukh: Madam, I usually play cricket in the evening.

This spontaneous conversation surprised us for two reasons. First, we had not anticipated focused, relevant questions from the students at this early stage. Second, we learned

that real-life examples and stories about personal interests, generated by low-order *what* questions, can stimulate further interest and even *why* questions.

It is worth noting that students asked and answered questions through the teacher. In a journal, an RT wrote,

> Today children had a good discussion. They asked questions of each other, but they did not even once address each other directly. Why did they do so? Perhaps academic talk is just a new idea for them or maybe they are used to the teacher's authority. We have started to shift their role from mere listeners to active participants. They are not yet ready to ask each other questions directly. They need more time because change is a slow process.

Children's curiosity led them to ask further questions. For example, Raja pointed to the list of foods on the chalkboard and asked, "Madam, why are all those necessary for us?" Other students asked questions such as "Which vitamins does a mango have?" and "What will happen if we do not eat fruit?" These questions led naturally into the next topic, "A Balanced Diet." Thus, students not only had the opportunity to ask questions but also helped the teacher to segue into the next lesson. This eliminated imposition on the part of the teacher and enhanced students' interest, participation and contribution to curriculum.

Guessing Game

Games are an excellent vehicle for self-motivated learning. The students expressed their enjoyment of a Pakistan television program called *Kasoti,* which includes an element of guessing. This motivated us to design a game to introduce a topic that the PT had said was boring and difficult to teach.

A plastic pop bottle almost full of water was placed inside a cardboard box, and the box was closed. Thus, the box and its contents represented examples of a solid (the box and the bottle), a liquid (the water in the bottle) and a gas (the air in the bottle and the box). Children were to guess the contents of the box. The game rules were as follows:

- We will try to guess the hidden object in 20 questions.
- We will ask a question that can be answered with "Yes" or "No."
- One person will ask one question at a time while the rest of us listen carefully.
- We will not repeat a question.

In these rules, we used the words *we* and *us* to foster a feeling of togetherness rather than a tone of imposition.

The game started with a direct question: "Is there an apple in the box?" The RT shook the box so students could try to guess what the object was through sound. The next two questions were "Is there a ball in the box?" and "Is there a doll in the box?" Suddenly, Raja, Ghazala and other students asked the RT to open the box and show them what was inside: they had expected a quick answer and lost patience when they did not get one. Students wanted a straightforward answer whereas the RT expected them to analyze the problem from different angles. This proved to be difficult. The RT, noting the students' frustration, put the box aside for a moment and had students focus on a more familiar and interesting object: a new teacher. Using the same rules, students were to find out more about this RT by asking questions about her. Most of the significant questions are in the following conversation:

Sana: Is she tall or short?
RT: Should we accept this question?
All: No, madam.
RT: Why not?
All: Madam, because you cannot answer it with "Yes" or "No."
RT: All right. Would anybody like to help Sana to rephrase her question?
Sana: Madam, I can do that. [This is a sign of developing confidence.]
RT: Good. Go ahead.
Sana: Is she short?
RT: Now, this is a question according to our "Yes" or "No" rule. No.

This and similar questions helped students develop the concept of the game. When the RT sensed that the students were comfortable and willing, the mystery box was brought forward again and the game continued:

Tarana: Is it living or nonliving? Oh . . . is it living?
RT: Good—you reformulated your question yourself. No.
Tarana: Is it nonliving?
RT: Yes.

Zohaib: Madam, if it is not living, then it has to be nonliving. [This is an example of active listening.]

RT: A good point. This will save you a question. You only have 20 questions to ask to guess the object. [This was to reward active listening and reinforce good strategy.]

The RT reflected, "It was challenging to monitor and manage the discussion when students were arguing. I did not want to discourage the questioner, yet wanted to acknowledge the response as it was valuable to avoid repetition in questioning."

Having established that the object was nonliving, students wondered about its shape: "Is it square?" "Is it circular?" Next, they asked about its size:

Raja: Is it long?

RT: What do you think its length is?

Zohaib: Madam, this much. [He stretched his arms and moved them apart about 30 centimetres.]

The RT's reaction was as follows: "At this point, I had to ask Raja about his concept of 'long.' This incident made me realize the importance of probing to help children to formulate their questions in a more precise manner."

Now that the shape and the size were confirmed, the students asked questions about the material of the object:

Sana: Is it made of plastic?

RT: Yes.

Tarana: Is it a bottle?

RT: Yes.

Raja: Is there something in the bottle?

RT: Yes.

Ghazala: Madam, is there water in it?

RT: Yes, you got it! Very good! You all tried your best to defeat me and you have done it. Well done. Clap for yourselves.

The whole class clapped happily, as if rejoicing in a sense of reward and ownership. The RT opened the box, pulled out the bottle of water and asked, "What is in the box now?" Most of the students answered, "Nothing." Suddenly, the PT, who could not resist, raised his hand and replied, "There is air in the box." This was a rare event for the students. The RT reflected,

> Today when the PT answered the question, the students began to laugh and to tell each other in soft voices, "Look, sir is also answering the question." This reflected their thoughts of the teacher's role in the classroom as questioner not as respondent. They have started asking questions and arguing in my class, but they still think that the teacher is just to question, not to answer.

Though the children were frustrated at the beginning, they persevered and stayed in the game to solve the mystery of the box's contents. The RT reflected,

> Today children have enjoyed the game. Sana said, at the end of the lesson when the class was asked to comment, "Madam, I liked the game because we were playing together. You were also playing with us and we were learning as well."

Suchman Inquiry

Suchman Inquiry, an inquiry technique developed by J. Richard Suchman (1966), suggests using a puzzling phenomenon (a discrepant event) to build an intrinsic motivation and turn students into questioners. This was an appropriate extension to the guessing game, and a further challenge. It required students to observe more critically and pose questions to solve the discrepancy. The subtopic was "Air Occupies Space." The discrepant event selected was "Keep paper dry under water" (Liem 1987). A piece of paper was placed in the bottom of a glass and the glass was then pushed (vertically, upside down) into water until completely immersed. The inquiry model adopted was Predict–Observe–Explain (POE) and the guessing game rules were followed.

The RT asked, "Will the paper get wet?" The class's responses were split: about half said, "Yes," and the rest said, "No." This was fertile ground for discussion. Each group was asked to justify its response:

Tarana: Madam, as you push that glass into the water, water will rise and wet the paper.

Raja: Madam, I have done this experiment before. The paper did not get wet, so it will not get wet now.

RT: All right. Let's test it.

The paper stayed dry.

"Yes" group: We won, we won!
Tarana: All right, you are rejoicing your win, but how about explaining it to us.

Though Raja had provided a reason earlier, it was not good enough for Tarana. Hitherto, students had accepted answers, but, here, for the first time, a student challenged another student for a better answer. This signaled achievement and initiated further questioning and a search for an explanation. The dialogues that followed, in which students asked a series of questions, were encouraging.

Zohaib: Did the paper not get wet?
All: Madam, this is a wrong question.
RT: Not a wrong question, but it does not follow our rule. Let me write it on the chalkboard so we all can read it and keep it in mind.

Keeping instructions in mind and switching from getting answers quickly to searching for answers is challenging for students. They need to be given time and to be reminded and encouraged.

Sana: Madam, is there any drawing on the paper?
RT: Yes, also some writing.
Tarana: Madam, is this paper oily?
RT: No.
Zohaib: Can we make this paper heavier?
Farukh: Madam, if we soak it in water it will become heavier.
RT: Yes. Thank you, Farukh, for helping me. We will test it later.

The students' focus was on the paper, perhaps because paper was the main, visible object and also because the RT's initial question ("Will the paper get wet?") focused on the paper.

Zohaib: Madam, is this water special?
Sana: Madam, he is one of the water donors. Why is he asking this? He should know whether this water is special or ordinary.

The discussion about the quality of the water went on for a while. The focus had shifted from the paper to the water. Student–student interaction, active listening and making connections between water and paper were happening. Students were questioning, and students and the RT were responding. The challenge for the RT was to refrain from overcontributing yet maintain the game's momentum.

Raja: Madam, will this paper get wet in running water?
RT: Yes.
Raja: Madam, will this paper get wet in deep water?

The RT asked Raja to establish what she meant by "deep water."

Raja: Bigger container, with more water, in which glass will dip completely.
RT: No. (We will test it tomorrow.)
Zohaib: Madam, if we use another glass or bottle or water container, will the paper get wet?
RT: No.

Raja's second question was a discrepant event for the RT. It was only then that the RT realized that the demonstration had a flaw: the water in the larger container was not deep enough to immerse the glass completely—a required condition for this demonstration. Thus, the children taught us, too. The shared learning contributed to improving the investigation's design.

Ghazala: Madam, is there anything between the paper and the water?
RT: Yes.
Farukh: Madam, there is air . . . between the paper and water . . . and we learnt yesterday that matter occupies space.
RT: But is there really air between the paper and the water?
Farukh: Madam, air is also matter.
Tarana: Yes, madam, when we started the topic on matter, we had put air as a gas . . . and, madam, gas is matter.
RT: You people are real scientists, no question about it.

Now was the right time to explain the discrepancy because the students were attentive and ready. The discrepant event provided a context for the students to formulate questions. Though they initially got frustrated and expected a quick answer, the students learned to persevere and get to the plausible answer. Children are capable; we need to provide them with opportunities and time to demonstrate their capability.

Storytelling

This innovation resulted from a question raised by Tarana while the students were classifying assigned items as solid, liquid or gas: "Is glass a solid or a liquid?" Some focus group members were skeptical, and they debated. Finally, all but Tarana agreed that glass is a solid. The RT, who had recently learned that glass is a supercooled liquid, was intrigued by Tarana's doubt and stopped by the group to observe:

Tarana: Madam, is glass a solid or a liquid?
RT: What do you think?
Tarana: Madam, look. [She pointed at a glass full of water.] Both water and glass are transparent, so both are liquids.
RT: [She poured some water into another container.] Can glass flow like this?
Tarana: No, madam, it does not.

This was a critical moment for the RT, who had to decide whether to tell the students that glass is considered to be a liquid or to hold back and plan an experience from which students may learn.

She chose the latter strategy. She wrote, in a contextualized story form, a description of the findings that led to the theory of glass as a supercooled liquid.

> Hundreds of years ago, a building was built in a city. It was a beautiful building with large, stylish, colorful windows. Glass sheets were used in the windows. Some years ago, a team of archeologists visited the building and were fascinated by it. The archeologists explored the whole building, but what most caught their attention were the glass sheets of the windows. They found that the glass sheets were thick at the bottom and thin at the top. The team wondered why. They thought and they thought, trying to come up with an answer. Can you help the team by using your friendly words *what, why* and *how*?

The following day students closed their eyes and listened carefully to this story to imagine the situation. At the end of the story, students asked questions.

Zohaib: Madam, had all the glass sheets in the building become like that?
RT: Good question. You all are good listeners. Yes, all the glass sheets were like that.
Sana: Madam, did they make the glass sheets like that?
RT: No, at the beginning the glass sheets were the same thickness all the way.

Once it was established that all the windows had changed and there was a problem, the students became curious: "Madam, why did the glass sheets become thick at the bottom?" The students seemed ready to listen to the explanation to decide whether or not glass is a liquid or a solid.

Interestingly enough, the children asked three good questions. They were patient and curious. Teachers can make learning challenging and interesting for students by using imagination and creativity, which we all possess to some extent.

Ask an Expert

By now, the students had become comfortable with the new classroom dynamics: they felt free to ask questions to nurture their curiosity or as facilitated by the RTs. Now was the right time to have an expert come to class and answer the students' earlier question, "Why is milk white?"

The expert used an interactive approach (questioning and answering using simple activities) to explore how we see things—What color is light? Why do objects have different colors? This helped the students to ultimately answer their own question. Students were keenly interested and participated well, asking many questions.

While the expert was setting up a mirror in a dish of water to make a rainbow (to demonstrate the concept that light contains seven colors), a support was needed to keep the mirror in position (at an angle). The students provided the expert with a rock. As soon as the rock was placed in the dish, the students observed bubbles rising up in the water. This triggered their curiosity, and a host of questions emerged: "What are these bubbles?" "Where are they coming from?" "Are they from water?" "Why do I see bubbles?" Interestingly, this generated a dialogue in search of an explanation. The student who had picked the rock suddenly said, "I know. There are holes in the rock. Now there is water. The water went in the holes." At this moment, another student said, "I can tell . . . air came out." This was a big surprise for us. The children

were trying to make sense of what they had observed. Another student, using knowledge from a previous lesson, said, "Yes, madam, matter occupies space. Water went into the holes and pushed the air out to take its place."

This was enlightening. Students not only demonstrated their ability to ask questions but also went beyond. This was, for us, a fascinating experience and a result of our systematic progression of lessons as shown in Figure 2.

In this process of development, students passed through stages of confidence building, as the following anecdotes reveal:

> The way Ghazala defended her viewpoint was amazing. This girl would blush at the beginning of the study and would say, "[Madam, I cannot think of a question]." Today, she defended her viewpoint about the "shrinking balloon" amazingly. She took charge of her own thinking. She had the courage to stand up and disagree with the rest of the class and teacher by saying, "I had tied the balloon myself carefully. There is no question of air going out from its mouth." (RT)
>
> Gradually, the students developed their confidence. In the beginning they were shy, but with passage of time they began not only to ask questions but learnt to argue as well. (PT)
>
> Madam, I think of myself now as a scientist. . . . I have told my mother that I will take science in Class 9. . . . I can now do it. (Tarana)

Discussion

> Science is concerned with questions about the what, how and why of objects and relationships in the physical world. The most productive kind from the point of view of learning science are those which enable children to realize that they can raise and answer [questions] themselves. These are the questions which keep alive the close interaction between child and environment, between questions and answers. (Harlen 1996, 104–105)

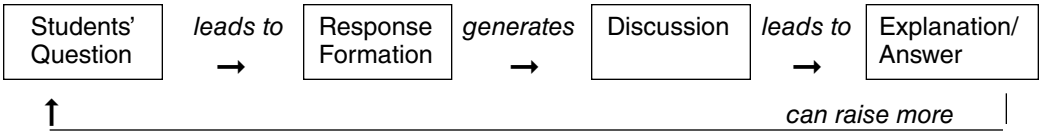
The purpose of our seven-week research study was to promote students' questioning skills in a primary science classroom. The results are encouraging, and we plan to pursue this practice in our classroom teaching. Through this article, we intend to share our findings with other practitioners in the hope that they may look for opportunities in their classroom teaching to tap students' curiosity and encourage them to "co-construct their learning" (Gallas 1995). This could provide readers with the opportunity to adapt some activities keeping in mind the facilitating factors and challenges or to take this research further, fill in the gaps or enrich it.

We began by considering the then prevalent teaching/learning practices in the classroom. We wanted to minimize imposing anything alien on the students. This is evidenced in the sequence of activities administered in the classroom, from using a picture to using Suchman Inquiry to storytelling.

Action research helped us to plan, teach, reflect and adapt innovative activities according to the level of development of the students' questioning skills. We used a variety of low- and no-cost, hands-on, minds-on activities at an appropriate level of difficulty. Gradually, children were given the freedom not only to ask questions but also to look for the answers to those questions. The classroom dynamics shifted from "power asymmetry" (Gallas 1995) to students taking control of their learning. This was enjoyable for the students, as is reflected in an RT's reflective journal entry:

> They view learning as a purposeful activity. As Zohaib said today, "Madam, we look for the answers to our own questions. . . . We ask questions and try to answer ourselves. . . . We enjoy our science class.

Figure 2: Curiosity Development Model



Gradually increasing the difficulty level of the activities, creating a friendly environment and appreciating students' efforts (Biddulph, Symington and Osborne 1986) helped students to overcome their fear of being wrong and nurtured their innate curiosity. This is reflected clearly in a statement made by the students in an informal discussion: "Madam, now we don't fear to say anything because . . . you told us that nothing is wrong in our class. . . . Madam, it was our great fear to ask any question . . . that teacher will be annoyed . . . if we would say something wrong."

However, challenges of this approach in the teaching and learning of science have been identified. A product-oriented education system, in which stakeholders (teachers, headteachers, parents and students) focus on quantity rather than quality, is a major barrier. This is clear in a headteacher's comments to an RT:

> How many chapters have you finished during this research period? I don't know whether you have taught something or just wasted our time. One day I passed by your class [and] you were doing something [she moves her hands up and down]. . . . I want a written report by tomorrow. . . . I have to answer to the parents, also. . . . If anybody comes and asks me about how much children have finished, I can show the written report that they have finished this much.

This statement demonstrates the parents' and school's demands for quantity and also reflects the headteacher's attitude toward teaching and learning in the classroom. It is perhaps strange for her to see a teacher doing something in the classroom other than writing on the blackboard. Looking into the RT's classroom when she was busy doing some activity made the headteacher skeptical about the RT's teaching.

The traditional expectation of pin-drop silence in the classroom was another challenge. Initially, getting children to talk was difficult, and, once they started, maintaining discipline became a challenge. However, the RTs made the class manageable by encouraging the children to raise hands, listen to each other and not interrupt when somebody is talking. Developing these rules encouraged shy students to speak up. For example, Zohaib said, "Madam, Tarana always interrupts. She always breaks the rule [of raising one's hand before speaking]. She hardly allows anybody else to speak." The class welcomed this reminder, and the RTs revised the rules from time to time to meet the needs of the group, which was just adopting the habit of scientific talk in the classroom.

Answering questions in an understandable and interesting way (Harlen 1992) was another challenge for the RTs. For some questions—Why are flowers red? Why does a comb attract pieces of paper after being rubbed on hair?—we had to read to strengthen our own content knowledge (Woodward 1992; Biddulph and Carr 1992). Using concrete materials and simple examples, and encouraging interactive dialogue, helped us to arrive at plausible explanations.

Our small-scale study, along with other studies and literature, indicates that primary science teachers in general and in Pakistan in particular need to review their roles in the teaching/learning process. Otherwise, any attempt to change the educational policy on science teaching would be useless. Teachers are responsible for promoting students' curiosity to help them become autonomous learners.

Note

1. To protect the students' anonymity, pseudonyms have been used throughout the article.

References

Abell, S. K., and M. Roth. "Constructing Science Teaching in the Elementary School: The Socialization of a Science Enthusiast Student Teacher." *Journal of Research in Science Education* 31, no. 1 (1994): 77–90.

Barnes, D. "Oral Language and Learning." In *Perspectives on Talk and Learning,* edited by S. Hynds and D. L. Rubin, 41–54. Urbana, Ill.: National Council of Teachers of English, 1990.

Biddulph, F., and M. Carr. "Developments in Primary Science: A New Zealand Perspective." *Evaluation and Research in Education* 6, no. 2 (1992): 191–98.

Biddulph, F., D. Symington and R. Osborne. "The Place of Children's Questions in Primary Science Education." *Research in Science & Technological Education* 4, no. 1 (1986): 77–88.

Borko, H., and R. Putnam. "Expanding a Teacher's Knowledge Base: A Cognitive Psychological Perspective on Professional Development." In *Professional Development in Education: New Paradigms and Practices,* edited by T. R. Guskey and M. Huberman, 35–65. New York: Teachers College Press, 1995.

Brain, M. "Students Are People." *Emphasis on Teaching* [online]. Available at <www.bygpub.com/eot/eot9.htm>. 1998.

Carr, W., and S. Kemmis. *Becoming Critical: Education, Knowledge and Action Research.* London: Falmer, 1986.

Davis, B. G. *Tools for Teaching.* San Francisco: Jossey-Bass, 1993.

Derry, N., and J. Loughran. "Helping Students Understand Their Own Learning Through the Use of Log Books in Science." *Science Education International* 8, no. 2 (1997): 15–20.

Feasey, R. "Thinking and Working Scientifically." In *Teaching Primary Science Constructively,* edited by K. Skamp, 29–63. London: Harcourt Brace, 1998.

Freire, P. *Pedagogy of the Oppressed.* London: Penguin, 1972.

Gallas, K. *Talking Their Way into Science: Hearing Children's Questions and Theories, Responding with Curricula.* New York: Teachers College Press, 1995.

Harlen, W. *The Teaching of Science.* London: David Fulton, 1992.

———. *The Teaching of Science in Primary Schools.* 2d ed. London: David Fulton, 1996.

Holt, J. *How Children Fail.* Rev. ed. London: Penguin, 1982.

Kerry, T. *Effective Questioning.* London: Macmillan, 1982.

Liem, T. L. *Invitations to Science Inquiry.* Chino Hills, Calif.: Science Inquiry Enterprises, 1987.

MacNamara, D. "Teaching Skill: The Question of Question." *Educational Research* 23, no. 2 (1980): 104.

Morgan, N., and J. Saxton. *Teaching, Questioning, and Learning.* London: Routledge, 1991.

Northey, M., and L. Tepperman. *Making Sense in the Social Sciences: A Student's Guide to Research, Writing and Style.* Toronto: Oxford University Press, 1986.

Paling, D. *Teaching Mathematics in Primary Schools.* Oxford: Oxford University Press, 1982.

Pate, R. T., and N. Bremer. "Guiding Learning Through Skilful Questioning." *Elementary School Journal* 67, no. 12 (1967): 417–22.

Patton, M. Q. *Qualitative Evaluation and Research Methods.* Newbury Park, Calif.: Sage, 1990.

Seliger, H. W., and E. Shohamy. *Second Language Research Methods.* Oxford: Oxford University Press, 1989.

Sheikh, A. Q. *The Problems of Implementation of Elementary Science Curriculum.* Government of Sind, 1977.

Shipley, C. M., et al. *A Synthesis of Teaching Methods.* New York: McGraw-Hill, 1964.

Steven, R. *The Question as a Measure of Efficiency in Teaching.* New York: Teachers College Press, 1912.

Suchman, J. R. *Inquiry Development Program in Physical Science.* Chicago: Science Research Associates, 1966.

Ur, P. *A Course in Language Teaching: Practice and Theory.* New York: Cambridge University Press, 1996.

Vockell, E. L. *Educational Research.* New York: Macmillan, 1983.

Watts, M., et al. "Promoting Teachers' Constructive Reflection: Pupils' Questions as Critical Incidents." *International Journal of Science Education* 19, no. 9 (1997): 1025–37.

Woodward, C. "Raising and Answering Questions in Primary Science: Some Considerations." In *Primary Science: The Challenge of the 1990s,* edited by L. D. Newton, 84–92. Clevedon, England: Multilingual Matters, 1992.

World Bank. *The East Asian Miracle: Economic Growth and Public Policy.* New York: Oxford University Press, 1993.