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Questioning in teaching of Early Mathematics: A Review

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"The teaching of mathematics should enhance a child's resources to think and reason, visualise and handle abstractions, formulate and solve problems."
— NCF, 2005

Abstract

Questioning is a powerful instructional strategy. Those interested in mathematics education have recognised the value of asking relevant questions for centuries. Classroom questioning is an extensively researched topic. Teachers use questioning fundamentally to check the understanding and knowledge of students to aid teaching, diagnose students' difficulties, recall facts, test their knowledge after the lesson is over, direct attention and maintain control. The high incidence of questioning as a teaching strategy and its consequent potential for influencing learning have led investigators to examine relationships between questioning methods and student achievement. The present review focuses on the importance of classroom questioning in the teaching-learning process in early mathematics.

Introduction

There is a growing body of evidence to indicate that early mathematics plays a significant role in education. From an analysis of six longitudinal studies, Duncan and colleagues have found that early mathematics skills are more powerful predictors of later academic achievement in mathematics and reading than attentional, socio-emotional or reading skills (Duncan, 2007, p. 1428). In addition, the differences in mathematical experiences that children receive in their early years "have long-lasting implications for later school achievement, becoming more pronounced during elementary

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school... and continuing on into middle school and high school" (Klibanoff, 2006, p. 59).

There are various learning theories in mathematics education. However, this paper focuses on constructivist theory for two reasons — one, school education in India is based on the National Curriculum Framework (NCF) – 2005, which endorses the constructivist approach; and two, questioning is one of the strategies followed in it. The constructivist theory expects students to be active in teaching-learning and teachers to guide the process. In constructivist teaching, a teacher's role is not to simply convey information, but to actively engage students in the process of acquiring knowledge. Teachers, who practise constructivist teaching, utilise various strategies to get students' views and understand their thinking. Questioning is one such strategy. When questions are used strategically by the teacher, socio-mathematical norms are established in the classroom. Teachers are able to evaluate students' thoughts. With this information, they can provide students with an opportunity to grapple with cognitively challenging problems as they guide them through the process of assimilation and accommodation in order to understand the problem. Questioning and discourse promote reasoning and intellectual development through social interaction. Teacher questioning assesses students' mathematical reasoning and provides needed information for scaffolding towards new understandings. In addition, questioning, requiring students' consistent engagement with constructivist theories, promotes student-centred learning.

Questions asked by a teacher that are related to ideas embedded in the curriculum will excite students' curiosity, promote critical thinking, elicit reflection and help them construct their own meanings for the mathematics they are studying. The responses will help the teacher assess what the students know and what the next instructional steps could be. Developing skills in questioning for understanding and content knowledge evolves over time and like anything else requires practice. The pay-off is significant in terms of students' conceptual understanding.

Research on the importance of questioning as a teaching and learning strategy is well documented (Almeida, Pedrosa de Jesus and Watts, 2008, Chin and Osborne, 2008; Graesser and Olde, 2003). It suggests that teachers spend up to 50 per cent of the class time on questioning and ask 300–400 questions a day (Levin and Long, 1981), while each student asks, on an average, one question per week (Graesser and Person, 1994). Surprisingly, teachers do not seem to be aware of this discrepancy. Several studies also rely on the kind of questions asked by teachers and students, concluding that these are, usually, procedural and fact-based (Brown and Edmondson,1985).

Characteristics of Questioning

Viewing one-to-one teaching of mathematics as an interactive communication is central to the literature being discussed here. In this section, four characteristics identified in the larger study are outlined — pre-formulating and reformulating questions, vague or ambiguous questioning, post-question wait-time, and questioning and prompting. A necessary feature of these characteristics is that they can be generalised across settings and tasks.

Pre-formulating and reformulating questions: Cazden (1986) cites the work of French and McClure (1981) to identify two interactive strategies, which serve as guidelines for children as they attempt to arrive at the answers teachers want. The first strategy is called 'pre-formulating'. Cazden reports that teachers, when pre-formulating questions, "preface a question they want the children to answer with one or more utterances, which serve to orient the children with the relevant area of experience and establish as shared knowledge between herself and the child and the materials essential to answer her question" (Cazden,1986). The second strategy is called 'reformulating'. Cazden argues that reformulating occurs when the initial answer is wrong. Reformulations vary depending on how the teacher makes the original question more specific. The important issue with reformulating is to what extent the teacher inadvertently or knowingly decreases the cognitive level of the task.

Vague or ambiguous questioning: According to Brophy and Good (1986), "Students sometimes cannot respond to questions asked by the teacher because the questions are vague or ambiguous, or because the teacher asks two or more questions without stopping to get an answer to the first one". A teacher's questions do not always get a response if they lack clarity or because s/he asks two or three questions without waiting for students' responses.

Wait-time: Wait-time is essential for student thinking. By wait-time, we refer to the time a teacher allots for student reflection after asking a question and before a student responds (wait-time I) and to the pause after the student has a responded (wait-time II). In her investigations, Rowe (1986) found that the mean wait-time was, on an average, one second or less. If a student did not answer in one second, the teacher would repeat or rephrase the question, ask another question or ask another student to respond. After receiving a response, the teacher waited for approximately 0.9 seconds before asking another question. Rowe trained the teachers to increase their wait-time to 3–5 seconds and found that both the quantity and quality of students' answers improved significantly. Students gave longer responses, cited more evidences to support their ideas, drew conclusions,

speculated and hypothesised more. Besides, more students participated in the process. The students asked more questions and talked more with each other.

Questioning and prompting: According to Lyons, Pinnell and Deford (1993), questioning and prompting take much practice and experience. They found that a teacher of mathematics recovery, an early intervention programme for students who are 6–7 years old and in their second year of schooling (Wright, 1994), becomes more aware of a child's learning and previous experience and micro-adjusts her/his teaching accordingly. In any case, a teacher needs to be sensitive to a child's learning and make crucial decisions based on her/his observations of students.

Types of Questions

According to the NCERT (2010), various studies have categorised the types of questions that teachers ask in the classroom. Some of these categories are summarised below. Each item lists a question type, giving a brief description and examples.

Gathering information: These questions are, usually, closed and may involve checking students' factual or procedural knowledge, checking for a method, leading students through a method, or rehearsing by asking students to state known facts or procedures. For example, by using different shapes, a picture is drawn on a blackboard. The teacher asks questions like—How many triangles are there in the picture? What is more—triangles or squares?

Introducing or recalling terminology: These questions are useful when ideas are under discussion and the teacher wants the students to use correct mathematical language to talk about them. For example, in Class II, the children try to explain why when you add 43 + 4, you cannot add 4 + 4 and get 8. The children say that a single digit number should always be written on the right. The teacher asks, "What does '4' in '43' mean?" She wants them to recall the place value terminology and realise that adding 4 tens and 4 ones does not give 8 tens.

Probing: These questions are aimed at getting students to explain, clarify or elaborate their thinking for their own benefit and for the class. For example: When asked what is 6 + 4, a child says 10. Probing questions could be like: How did you get 10? Can you explain your idea?

Exploring mathematical meanings and relationships: These questions point to underlying mathematical relationships and meanings and establish links between mathematical ideas. For example: A child is solving a subtraction problem by taking one ten from tens column. The teacher asks: Why did we rewrite '3' as '13' and why did we change the '2' to '1'.

Linking and applying: These questions focus on the relationship among mathematical ideas and between

mathematics and daily life or other subjects. For example: What do we say for half of half kilogram (kg)? How many quarter kgs make 1 kg?

Extending thinking: These questions are aimed at extending an idea so that it can be used in another similar situation. For example: If a pattern is visible in the table of 3, can you see the similar pattern in other tables? Another example could be—If there are six leaves and we arrange them in pairs, nothing is left. Does this happen for all numbers?

Orienting or focusing: These questions help the students to focus on key elements or aspects of a situation in order to enable problem-solving. For example, in the table of 3, we find that odd and even numbers alternate: 3, 6, 9, 12... Is there a similar pattern in other tables?

Generating discussion: These questions help in starting or carrying forward a discussion. For example, is there any other way of doing this? Has somebody done it differently? (Don't worry whether it is correct.) Can we do it with addition instead of subtraction? These are, particularly, helpful in involving learners, who do not participate actively in the class to contribute and comment on ideas being discussed.

Conclusion

Researches on teachers teaching mathematics indicate that the characteristics of questioning determine the extent to which learners are provided with opportunities to participate actively in the teaching-learning process, and construct mathematical meaning. In recent years, one-to-one teaching programmes have come to the fore with a renewed focus to see that all students have a reasonable chance of being successful in school, and to assist children who are at a risk of failure. Better pre-service training in the art of posing classroom questions, along with in-service training to sharpen teachers' questioning skills, have the potential of increasing students' classroom participation and achievement. Increasing the wait-time and the incidence of higher cognitive questions, in particular, have a considerable promise for improving the effectiveness of classroom instruction.

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