

Student Questioning in Student Talk
Understanding the process and its role in doing science

A Thesis

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by
Gurinder Singh

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research
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Declaration

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort has been made to indicate this clearly, with due reference to the literature, and acknowledgements to other researchers, peers and colleagues who helped at different levels and in different capacities in shaping and completing this work.

The work was done under the guidance of Dr. Karen Haydock and co-guidance of Dr K K Mishra, at the Tata Institute of Fundamental Research, Mumbai.

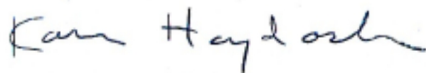

Gurinder Singh

In my capacity as supervisor of the candidate's thesis, I certify that the above statements are true to the best of my knowledge.



[K K Mishra]

Date: 23/09/2019



[Karen Haydock] (Feb., 2014 to Feb., 2016)
(retired in 2016 but continued to guide without pay until present)

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Abstract

This study is aimed at understanding the nature and dynamics of middle school students' questioning process and its role in learning and doing science. For this we have looked at student discourse in classroom and out-of-classroom contexts. In classroom contexts, students were observed and recorded while being taught by their regular science teachers. In out-of-classroom contexts, students were observed and recorded while they worked in groups observing and investigating some physical stuff, with researchers acting as teachers. In the informal contexts, teachers' control was minimised by letting students work on their own with very little teacher intervention - researchers giving least instructions, and sometimes with no prior instructions. Here the purpose was to record students' spontaneous talk and questioning. Using conversation analysis methods, we transcribed and analysed teacher-student and student-student discourse to understand the process of questioning in the discourse. As we followed an emergent research design, our methods of recording, data collection, transcription and analysis evolved with the progress of our study.

We found that in comparison to classroom contexts, students talked and asked much more in the informal contexts. We also found that most of the student questioning in the informal contexts was authentic with students asking a large number of investigable questions. We found that in classroom discourse, dominated and driven by teacher or textbook questioning, students hardly had agency to meaningfully participate and engage in the discourse. In contrast we found that in the informal contexts students had agency in matters like, turn-taking, allocation of turns, use of language, and exploring the stuff. In these contexts, student-student relations and their roles were dynamic and fluid, which kept changing and evolving during the discourse.

Furthermore, we found that student questioning in informal contexts evolved and progressed due to various kinds of conflicts and disagreements between students and between students and stuff, which classroom discourse generally suppressed. In the informal contexts students spontaneously engaged in various aspects of scientific inquiry to investigate their own questions. We discuss how and why the students engaged in a process in which questioning, observing, arguing, investigating and other aspects were integrated and interdependent. We also describe how doing science in these contexts could help students reflect about the nature

of science. Furthermore, we describe how bringing certain elements of such a discourse in classrooms can help give student questioning a central role in doing science in classrooms.

1

Introduction

While interacting with children, especially younger children, we all have noticed amazing questions asked by the children with sometimes unending long chains of questions. Here is one example of my experience of talking to my 10 year old niece Savy, while showing her pictures of the moon that I took using my camera and she asking some very interesting questions.

Savy: ये telescope से planet के अंदर भी देख सकते हैं क्या ? उसके पेड़ वगैरा ? मिट्टी वगैरा ? (Can the inside of the planet also be seen with a telescope? It's trees etc.? Soil etc.?)

Savy: अगर suppose करो दूसरे planet पे लोग रहते हैं तो वो भी हमें देख रहे होंगे ? (Suppose if there are people living on another planet, so can they also see us?)

Savy: जैसे वो छोटा सा तारा है तो हमारा planet भी उनको छोटा सा तारा दिखता होगा ? (Just like that tiny little star, so do they also see our planet like a tiny star?)

In another example, a 7 year old asks her grandmother:

Shana: Why am I I?

And while children having a discussion around clothes with teacher, a boy asks:

Boy: कपडे पहनने का रिवाज़ इन्सानों में ही क्यों है, जानवरों में क्यों नहीं ? (Why do people have the custom of wearing clothes but animals don't?)

In Deepa Dhanraj's documentary film, Young Historians, while a group of children were asking their elders about the history of the village, and what the British Security forces did before Independence, we heard:

Granpa: They could arrest people and put them in jail. People would be so scared they would pay their taxes.

Boy: But Granpa, you said each village had 400-500 houses. What if 4 or 5 villages refused to pay taxes?

These questions show not just the curiosity and keen observations of children about their physical world but also their questioning of status quo and power structures within the social setup. But in schools, do we really encourage or allow them to raise such questions?

Or, do we always think of telling them, making them memorise things, feeding them with answers, answers for questions asked by adults? Do we listen to their questions, or think they can be really critical and can ask challenging questions?

We all ask authentic questions not just at our workplaces but also in our day to day lives when we have some problems to solve. For example at a bus station we may ask other people, which bus will go to the city centre, seeing large number of police on roads we may ask ourselves what's going on, when we are preparing food we may ask after how many whistles will the dal will be ready, ... etc. We continuously interact with the surroundings in our outside world and in order to understand it and solve problems, we ask questions.

Asking questions is one of the primary ways of knowing about the world around us and one of the primary reasons for communicating. Any kind of discourse, whether everyday or institutional, informal or formal, unstructured or structured, involves questioning. It's hard to have a discourse without having questions. However in the sphere of school, questioning seems to be less predominant, especially student questioning. If this is true, then why is it so? What does it reveal about the actual aims of education? These are some of the questions that motivate us to study student questioning.

1.1 Coming to HBCSE

In March of 2011, I came to Homi Bhabha Centre for Science Education (HBCSE), Mumbai, as a teacher to attend an exposure camp in the Physics Olympiad programme. At that time I was working at an elite private school as a Physics teacher in my hometown, Ludhiana, an industrial town in the Northern state of Punjab. All of my previous education till my post graduation in Physics, I completed in Punjab only. Before coming to HBCSE, I hardly knew about the institute. I had skimmed through some of the Small Science textbooks published by HBCSE while teaching. Only in that context I knew about HBCSE. After spending 4 days at

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HBCSE during the camp, I got to know more about HBCSE and its work. Back home I read more about HBCSE and the PhD programme in Science Education at HBCSE. I found it interesting that the PhD programme required candidates who are passionate about teaching and have a flair for teaching apart from other requirements. I decided to give a try and appeared for the entrance test. I was quite confident that if I would clear the entrance test, I will surely clear the interview. And that's what happened. But joining for the PhD at a scholarship, almost half the pay I was getting while teaching, was quite challenging, especially convincing my parents. That also when I was 32 years old and divorced. Being an Indian parent, nothing can be more worrisome than having an aged unmarried child. My family comes from a lower middle class belonging to OBC caste with both the parents being educated and retired as school teachers. With both working parents, we had financial stability. So coming from an educated family, with financial stability, it was actually not as difficult to convince my parents about my decision to join the PhD program. Though my decision to join at HBCSE was unusual, but I really think that it was a worthwhile decision, which gave me huge opportunity to learn and change my understanding about the world, society and education.

1.2 My experience as a school teacher

Before joining HBCSE as a research scholar, I had about 8 years experience being a science teacher mostly teaching Physics at secondary and senior secondary level in some of the elite private schools of Ludhiana.

All across India, education is becoming privatised. There are a variety of private schools catering to people of various social and economic classes. There are low socio-economic private schools that cater to lower middle class people and there are rich elite schools catering to upper middle classes and in between one can find all range of schools for people from lower middle classes to very rich classes. However, most people come from lower classes and lower castes and send their children to government schools.

In terms of salary also private schools have a range of salary structures with very poorly paid teachers to highly paid teachers with very few private schools paying more than what government school teachers are paid. In general, private school teacher salaries are poorer than government school teacher salaries. So teachers teaching in government schools

generally belong to middle classes and send their own children to private schools. However, in recent times government appointments have decreased and lot of appointments are done on a contract basis or on probationary period basis with teachers being paid less than the permanent teachers. Furthermore, with neo-liberalisation policies of the governments, education has become more of a commodity rather than a fundamental right.

The private schools in which I taught were mostly elite schools and were giving me handsome salary though less than those of permanent government school teachers.

My initial motivation for doing a PhD study in the area of science education came from my interest in teaching. While working as a teacher I did not realise the importance of student questioning, although I also do not remember any instance in which I discouraged student questioning. But like most of the teachers, I was the one who was asking most of the questions in the classroom.

Furthermore, as a teacher I hardly remember any instance when students worked in groups and had discussions among each other. Most of the time I lectured to the students while explaining or discussing the topics with them. Even when I demonstrated some activities in the classroom, students watched and listened to me. Though, I definitely changed as a teacher during my 8 years of teaching, from being a boring didactic teacher who always lectured, to a teacher who tried making teaching lively by doing demonstrations and activities with the students. I did demonstrations and activities so as to make the students understand the concepts and explain them using everyday examples of phenomenon. I even designed activities and made my own material to do demonstrations. I myself liked to fool around with different kinds of materials in my spare time at home. While teaching, I began to realise that videos, demonstrations, and bringing things into the classroom was important. But I did not completely realise the importance of students' hands-on and group work until I left my teaching job and started reflecting about teaching while studying science education as a PhD student.

Before I started teaching, in my Bachelor of Education (B.Ed.) study, a mandatory pre-service course for working as a teacher in India, we were trained to focus on concepts. It was stressed that teaching aids such as charts, models, and physical objects are very important, and children learn better when these are used. However, the role of these teaching aids was for explaining the concepts through demonstration rather than for students' hands-on

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investigations. The emphasis was majorly on training pre-service teachers on how to teach theory or concepts in a more lively manner.

Furthermore, In my experience as a teacher, I noticed that teachers, students and parents tended to consider that laboratory (practical) work is separate from, and less worthwhile than ‘theory’ or science concepts. This is particularly true for higher classes where the syllabus is vast, and marks and competitive exams become more important. The most important exams are set by state or national school boards, and consist mainly factual and recall type questions and problems to work out using prescribed methods. Tests and homework set by teachers also follow similar patterns. Students consider ‘learning’ to mean mainly ‘memorising’, and in extreme cases they memorise answers word-by-word without much understanding.

1.3 How the topic of my study emerged

The story till now describes my progression as a teacher and how I began my Journey as a PhD student. But it does not describe how I got interested in student questioning, the topic of my PhD study. Actually my interest in student questioning emerged only after my field work during the PhD coursework at HBCSE. My field work project was to conduct a survey and semi-structured interviews of Class IX school students and teachers to explore how laboratory work is carried out and assessed and what are the problems that affect learning in the school science laboratory. One of the main conclusions drawn from this study (Singh & Khaparde, 2013) was that a cook-book approach is followed in conducting the practical work where the teacher defines the problem and tells the students the ‘recipe’ of what to do, step-by-step, including even the expected observations and results. Getting ‘right’ or ‘expected’ results remain the primary objective of the laboratory work. Despite its advocacy by researchers, educators and policy makers, students do not get any opportunities to define or frame their own problems and design experiments to solve those problems as part of their classroom or laboratory work. So I thought of trying out something with students in which students may pose their own questions/problems and solve for themselves by designing and doing their own experiments. In my eight years of teaching, I had never tried something like this in my own classroom. But I had some experience of conducting open-ended activities with visually impaired children during the days of my PhD coursework.

At a very close distance from HBCSE, there is a school for blind, which is a National Association for Blind (NAB) centre. Here children of all ages with varied degree of impairment come everyday after attending their regular school. Here they study, play games, learn music, learn dance, go for trips, go for trekking and do various other kinds of activities. A lot of teachers come here voluntarily. Some research scholars from HBCSE were also going to this centre every Saturday for 2 hours. During my coursework, I started going along with other research scholars to this centre. We would play music, do book readings and do maths, science and other activities with children. Without using any textbook or typical classroom problems, we tried teaching about 15-20 children of varying ages. Activities were carried out on topics related to day-to-day experiences like size, weight, mass, density, sound, vibration, length, area, measurement, force, etc. The observations in the activities were done by children mostly through auditory and tactile sensations. The mode of carrying out activities was quite open-ended in which children asked a large number of questions, gave answers, gave explanations, predicted outcomes, hypothesized, proposed experiments and did experiments to test their hypotheses. Due to the open nature of activities, children were not result oriented and they manipulated and explored the objects in various possible ways. This experience at the school for blind gave me encouragement to experiment my ideas about student posing and solving their own question/problems.

Also during the time of my PhD coursework I participated as a mentor in some teacher professional development (TPD) workshops for DIET teachers happening at HBCSE. Some of the sessions in the workshops were on investigatory projects. In these projects, teachers would come up with their own questions or problems to investigate and design and carry out experiments to find out the answers to those questions with the help of mentors. While doing these investigations teachers themselves had to take decisions like choice of apparatus or material for investigations, what kind of data to collect, which variables to keep constant and which ones to measure, how many measurements etc. One of the main focuses of these activities with teachers was to have them better understanding about the nature and processes of science, which is neglected in most schools. While working as mentors in such activities, I thought of trying similar projects with students to find out how students who may not have much prior understanding of the scientific method would respond to such activities.

So thinking about all these ideas and trying out something with students, I met Karen to guide me in writing the proposal for my PhD study and discussed my plans. At that time Karen

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along with Kranti (a project assistant working with Karen) were planning some activities with middle school children in order to have some photographs of children performing activities to write an article for a teacher's magazine. Karen initially thought of just inviting some students to be photographed. However, Kranti suggested having a workshop with school children. The idea of the workshop emerged after Kranti had seen a variegated bhendi tree in the garden of HBCSE that she thought was strange because not only does it have leaves which are completely green, it also have leaves which are partly green and partly white and even some leaves which are completely white. Thinking that plants make their food by photosynthesis, and leaves are green because they contain chlorophyll, Karen and Kranti wondered how without chlorophyll, photosynthesis can occur, how white leaves can survive and will the white leaves have stunted growth.

After talking to Karen about my plans of looking into students' investigations of their own questions for my PhD work, we decided to have a workshop with middle school children. The plan was to collect students' questions, then discuss those questions with them inside classroom and then let them choose a few of those questions in groups and then design and perform some investigations for answering those questions.

Initially I had a very rough and vague idea about my research questions. However, the preliminary analysis of the data from this workshop proved very useful in framing research questions for my proposal and the overall plan of the proposal for my PhD study.

1.4 Emergence of my ideological and philosophical position

Being a science teacher, I hardly critically reflected about the status of education and how it is related to larger existing social, political and economic conditions. Though I enjoyed doing activities with students and believed in more active participation of students in the classroom, I never realised the importance of student questioning.

Before joining as a PhD student, coming from a middle class family, I had ambitions of doing a job having a 'respectable' salary. Though I was satisfied with my teaching job, but I was also looking for opportunities for my career growth. At that point I had political thoughts that questioned the rich and poor divide in the society but I never reflected about the hidden power structures within society and how such power structures are playing a role in education to create a society full of divides.

Working as a PhD student, I had the chance to read a lot of stuff on education, its philosophy, the nature of science, philosophy of science, etc. as part of the PhD coursework. Though these readings were useful in shaping my ideas about education and about science, but more worthwhile were the informal discussions that happened within and outside HBCSE.

At HBCSE we would have long discussion during tea times, during lunch and dinner times, around the issues of education, capitalism and communism as well as current events. Sometimes we had informal reading sessions to read articles around nature of science, nature of education, the caste divide in India etc. A number of times we would screen documentaries related to various social, economical and political issues and have discussions. Being in Mumbai, a city where everyday, film screenings, documentary screenings, lectures, seminars and protests are happening, I had a chance to listen to and interact with various kinds of people. Also we would have long discussions, mostly among research scholars during our post dinner gatherings (D plus). All these informal forums provided opportunities to reflect on various issues and explicate my ideas around these issues.

Not to forget, our (mostly HBCSE research scholars) long discussions with Karen at her home during dinners and informal reading sessions, with disagreements amongst us, were also important in reflecting on my perspectives around various issues.

Furthermore, presently there is a political discourse around imposition of hegemonic Hindutva ‘culture’ and the single idea of ‘nationalism’ on a very diverse and dynamic populace. And this has led to a debate on the current social, political and economic situation in India. This discourse was influential in shaping my views about the various political ideologies.

For a researcher in education, it is important to ponder upon questions like ‘What is the purpose of education?’ ‘What is the purpose of schooling?’ ‘How and why the present education system and schooling is structured?’ And without understanding the social, economical and political context, it would be difficult to reflect about these meta questions. Every researcher will have his/her perspective about all these meta issues, though it may be implicit and the researcher may not have explicitly reflected upon these issues. However, the kind of research done by a researcher will be influenced by these perspectives.

Furthermore, our perspectives keep changing as we are always in the process of changing and evolving and so are our beliefs. So I am not saying there is some best understanding or the

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understanding that everyone should have, but that one should be more explicit about his/her perspective and need to ponder upon that. Furthermore, knowing a researcher's perspective on these issues would help understanding the work of the researcher.

1.5 Structure of the thesis

Reading through this thesis, it may seem that this study might have progressed chronologically or linearly, from the first chapter to the last chapter. However, the reading of literature, raising or refining of research questions, looking at data, drawing conclusions etc. all happened in a complicated non-linear, interdependent way. Though it all started with some broader questions in mind after my field work, but my questions kept evolving and refining with greater understanding from the data and literature. With some analysis of the initial data, we realised that we need to modify our methods of collecting data and must focus on particular things while we observe and record students interacting with each other. Furthermore, our methods of transcription and analysis also kept evolving during the course of our study.

This thesis has been divided into eight chapters. Chapter 1 is the introduction, describing how and why we started looking into student questioning and how our understanding about student questioning changed and evolved during the course of this study. This chapter sets the story of the journey of this study which began in 2011.

Chapter 2, critically reviews the literature around student questioning by looking at the kind of issues or questions that previous research has addressed and raises some important questions which previous research has not been able to ask. We do so by discussing some important philosophical perspectives around the nature of questioning, which previous research fails to address.

Chapter 3 describes our methods of collecting, transcribing and analysing student-student and student-teacher discourse and how our methods evolved during the course of our study. This chapter describes the schools and classrooms we were going into for our research. At the end of this chapter, we outline our research questions.

In Chapter 4 our observations of classroom teaching of three different science classroom have been reported. We have analysed the student and teacher questioning in these classes being taught by a regular science teacher.

As it is difficult to get much of student-student talk and student questioning inside the classroom from regular teaching, we conducted workshops with middle school students in informal settings. These were exploratory workshops in which students performed some tasks and activities which were relatively less structured, with researchers acting as teachers. The purpose was to let students have spontaneous talk among themselves as they worked in groups doing different activities or tasks. Chapter 5, 6 and 7 report our analysis of data from these interactions with students in informal settings.

Chapter 5 describes our identification and analysis of types and functions of students' questions in their spontaneous talk..

Chapter 6 describes our analysis of the nature and dynamics of discourse among students in the informal settings and our understanding of the evolution and progress of students' questioning process.

Chapter 7 looks at the role of student questioning in doing science. We do so by looking at the interconnections of questioning with other aspects of scientific inquiry such as observing, arguing, comparing, analysing, hypothesising, investigating, answering etc.

Though chapters 5, 6 and 7 are based on the analysis of data from our workshops with students, but this analysis is not entirely independent of our observations about classroom discourse.

In the last chapter, chapter 8, we summarise our conclusions and describe the implications of our study for classroom teaching as well as for research in student questioning. We also describe possible future directions of this work.

1.6 The problem of open access of research literature

It is not easy to find literature related to some topic of research done in India as there is a lack of comprehensive online database that manages various research studies done in India in large number of universities and other research institutes. Some of the premier research

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institutes or universities do manage their own database, but a large amount of research done in other places is hard to locate. There is a need to have a common database of all the research work done in India where at least abstract of thesis and bibliography could be available. There is one unified portal by UGC namely INFLIBNET started in 1991, but it has very limited data and lacks in many aspects.

Most of the studies done in India that one could find out are those published in high ranked international journals. But access to these journals is very expensive (sometimes single article costing \$ 50) and most of the students in India would never be able to spend that huge money. However, I being in HBCSE, a premier institute, had much better access to costly foreign literature than most of the Indian universities. But still there is huge literature which is beyond the access of HBCSE especially the books. However there are a few websites which provide access to journal articles and books but those websites are being called 'illegal' and they are repeatedly closed down as they are being attacked by the governments and the big publishing houses. It is shameful that knowledge is being commodified and becoming means of amassing wealth for such publishing houses. This leads us to ask some crucial questions. Why is the access to knowledge restricted and controlled for certain corporate interests? Does knowledge belong to a single person or small group of people? Why do we not have open access even when research is publicly funded? With these questions we begin our study by first looking at previous research in the area of student questioning.

2

A Critique of Previous Research on Student Questioning in Student-Student Discourse: The need to ask new questions

Humans have well developed language communication tools and questions are an inherent part of all human languages (Boudier, 1988). In the classification of human speech acts by Searle (1975), questions have been classified as a sub-category of directives, one of the five main categories of speech acts. In his work on the history of questioning in human race, C.E.M. Struyker Boudier (1988) wondered whether it is the question asking ability of the humans that led to the development of languages in humans or it is the language tool present with humans that led to question asking among humans. Whatever may be the case, question asking is an essential part of human language and communication and this process starts at a very young age even before we have learned to speak or verbalise.

Although, the mysteries about the origin and evolution of questioning among humans remain unsolved, but in our study, we are primarily concerned with the questioning among school students and its role in doing science. In this chapter we will look at some of the research studies on student questioning and our focus will be primarily on four aspects of student questioning:

1. Student talk and student questioning: some observational studies
2. Forms and functions of students' questions
3. Students not talking and asking in classrooms: understanding reasons and efforts to encourage student questioning
4. The need to understand the process of questioning and its role in doing science

2.1 Student talk and student questioning: some observational studies

Though there is widespread recognition of the importance of student questions in education in general and in science education in particular, classrooms generally lack student questioning and student talk, with domination of teacher questioning and teacher talk. Though we have not found many research reports on student questioning in India, but what we have found supports our own observations that students generally do not talk and ask questions in classrooms and it is the teacher who does most of the talking and questioning (Kumar, 1989; Madhu, 2015; Sarangapani, 2003). Krishna Kumar (1989), in his observation of a senior secondary history classroom in a school in India, says,

Teacher-questioning and pupil-answering are routine pedagogical norms. The opposite, namely pupil-questioning and teacher-answering, also takes place but not so frequently. When students do ask a question, it is mainly in order to seek clarification. A student-question which points towards new dimensions of the topic at hand is an extremely rare event. (ch. 3)

Even outside India the reports on questioning show a lack of student questioning as part of the classroom discourse (Almeida & Neri de Souza, 2010; Barnes, Britton, & Rosen, 1971; Corey, 1940; Dillon, 1988b; Good, Slavings, Harel, & Emerson, 1987; Susskind, 1979). In his review of classroom observation studies on student questioning, Dillon (1988b) reported that in some classes student questions were as low as one question per month per student. In his observation of 27 high school classrooms in 6 different schools, Dillon found that only one percent of all the students asked topic related information seeking questions and other 99 percent did not ask any topic related information seeking questions. Furthermore, he reported that more than 62 percent of teacher talk was in form of questions and only 6 percent of total students' talk was in form of any kind of questions, and also students talked much less than the teacher. The few student questions that are heard are usually asked by a very small number of students, with most students virtually never heard asking a single question.

Do teachers realise that they talk and ask much more than their students? In his study to encourage teachers to encourage student questioning, Edwin Susskind (1979) interviewed

school teachers about their perceptions of teacher and student questioning in their classrooms. It was found that teachers thought that, in their classes, students are asking at an average of 10 questions per half an hour class, whereas teachers are asking 15 questions per half an hour class. However, the actual rates for student and teacher questions in these teachers' classes as recorded by Susskind were 2 and 50 questions per half an hour class respectively. So teachers were completely unaware that they were asking many more questions in the class than their students. Maybe, making teachers realise this fact can help teachers improve and encourage student questioning.

In a study of question asking among college undergraduates during communication courses, Pearson and West (1991) observed 15 different classes of an hour each having a total 331 students. They reported that all 331 students during 900 minutes of observations asked a total number of 49 questions, merely 3.3 questions per hour by all the students together. And if we calculate the rate per hour per student in each class, then it will come out to be just 0.15 questions/hour/student. Similar observations were made by Arthur Graesser and Natalie Person (1994) for an undergraduate class, where they reported an average of 0.17 questions per student in each class. The classroom observation studies reporting lack of student questioning have been conducted across various countries for various subjects and various classes and the general conclusions seem to be quite universal: students are asking very few questions.

Although there are fewer recent classroom studies on student questioning, but the situation regarding teacher and student questioning inside classroom does not seem to be very different from what it was 30-40 years back (Almeida & Neri de Souza, 2010). In their study on teacher and student questioning Patrícia Almeida and Francislê Neri de Souza (2010) from Portugal have reported that the classrooms are still very much teacher centred, dominated by teacher questioning and student answering, even when teachers tried to use more student-centric pedagogies. In a very recent study (Stains et al., 2018) on STEM teaching practices in undergraduate classes in North American Universities, researchers found that classes were largely dominated by teacher lecturing with student questioning being the least practiced behaviour among students.

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Irrespective of whether it is a school, college or university, a typical classroom discourse involves an IRE pattern where teacher controls and dominates the entire discourse (Mehan, 1979). In such a pattern discourse gets initiated by the teacher asking a question to students (Initiation), students answering the teacher's question (Response) and the teacher evaluating or giving feedback on the student's response (Evaluation). There are reports by other researchers which confirm that in classrooms students hardly get opportunities to initiate sequences of classroom conversations (Barnes et al., 1971; Ramadas & Kulkarni, 1982). This restricts student questioning and their engagement in discussions. Even If students do discussions and ask questions, it has to be according to certain rules and procedures which are very different from informal talk outside of the classroom: to raise hands and be called upon by the teacher before speaking, not speak out of turn, talk one at a time, stick to the topic, not sound stupid, etc. (Dillon, 2004). All too often the teachers and/or the textbooks also give the expected answers, which the students are supposed to memorise. All this trains students at answering than asking questions and students in very early years of their schooling implicitly learn these rules of classroom talk. As rightly pointed out by Dillon (1988a)

.....Children around the world are schooled to become masters at answering questions and to remain novices at asking questions. Thus does questioning in school mirror and serve questioning in society.” (p. 115)

Is this phenomenon, the lack of questioning and lack of talking among students, restricted only to classrooms and schools or is it universal, observed in out of school contexts as well? Do parents and other adults talk more and ask more and children only answer questions posed to them?

There have been a few studies to understand children's talk and question asking behaviour in informal contexts. In a longitudinal study in the city of Bristol in the UK, Gordon Wells (2009) recorded and observed conversations of 32 young children for a period of about 45 months. The children were first observed as young as 15 months old at their homes and were observed until the first few weeks of their schooling. It was found that not only did children ask fewer questions at school than at home, they also initiated fewer conversations and spoke less at the school. He found that at school the teacher made about three times more utterances than the total number of utterances by all the 32 children in the class, and at home the

children and adults made almost the same number of utterances. According to Wells, this behaviour could be understood if we compared parents' and teachers' talk. In comparison to parents, teachers initiated many more conversations and asked many more questions in their talk with children. Wells concludes upon this by saying,

The result is that, at school, children are reduced for a much greater part of the time to the more passive role of respondent, trying to answer the teachers' many questions and carrying out their requests. (Wells, 2009, p. 96).

He claimed that this led to the reduction in the range and variety children's talk that he observed inside the class. So the passive role of children in school as answerers limits their potential use of language and rather than using language creatively, they end up mimicking the language of their teacher.

Though the Wells study described the relative differences in conversation patterns of parents and teachers, the study did not compare the question asking between children and parents in much detail. For example, Wells did not compare the question asking behaviour of different parents and how that had an impact on question asking among the children.

In a study by Tizard, Hughes, Carmichael & Pinkerton (1983), the researchers recorded and analysed the spontaneous conversations of 15 middle class girls and 15 working class girls, all attending a morning nursery school, for two mornings at school and for one afternoon at their home. Similar to the results of the Wells study, Tizard and colleagues also found that children asked many more questions at home than at school. Furthermore, working class girls asked fewer questions than middle class girls at school. Also children tended to ask fewer 'curiosity' and 'why' questions at school than at home. One of the reasons for this phenomenon was described as the difference in the nature of conversations at home and school. At school there were fewer one to one conversations between a child and the teacher than between an adult and a child at home. In school, the teacher mostly talked to the whole class or a group of students. Also at school, conversations between children and the teacher were short, lasting fewer turns, with the teacher dominating the discourse with his/her questioning. Also the topics of conversations at school were more abstract with very less opportunities for children to talk outside the ongoing context. Furthermore, at home children

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performed varied kind of activities whereas at school children did almost similar kinds of activities everyday. Another important difference between conversations at school and at home is that at school there is one adult interacting with a group of 30 or more children (in India the teacher student ratio in schools sometimes could be 1:80), whereas at home there could be one or more adults interacting with one child. This large student ratio per teacher itself reduces the time each child gets to converse in the class unless children are involved in some kind of group work.

It is interesting to note that even though the Wells study was a longitudinal study conducted over a period of three years and the Tizard study collected data only for a few days or a few hours, the results of the two studies regarding the questioning at home and at school are quite similar. Perhaps the nature of schooling, based on the factory model with an aim to transfer static information, with a domination of teacher talk and teacher questioning, is quite obvious and persists over most parts of our world. However, more research to substantiate such claims would be useful.

Furthermore, It is also interesting to note that in the above studies, the children being studied were very young and had just started going to school. Even at that early stage of schooling, children start learning the rules of not talking and not asking in the classroom. However the same children did ask more questions at home than at school. So does the nature of 'school talk' constrain student questioning in classrooms? Brice Heath (1982) reports that the kind of talk and questioning used by teachers, reduces students' active participation in talk and trains them at answering known information questions. This passiveness among children she even observed at the homes of some teachers who tended to be more like teachers than parents with their own children at home. She found that teachers as parents asked far more questions to their children at home than other parents. They thought questioning was a way of teaching or training their kids.

One might wonder here, what would happen if teachers start talking and asking less? Although teacher's use of 'wait time' has been found to be effective in increasing students' questions (Rowe, 1986), but a detailed study on teacher quietness or teacher asking and talking less to encourage student questioning is lacking. Also, more research is needed to find out how or whether the kind of questioning children do - or should do - in school differs from

the kind they do outside of school or in more naturalistic situations - either with regard to topic or type of questioning.

Although, schooling does limit students' question asking inside classrooms, but it is not clear whether this leads to a permanent change in children's question asking behaviour and impacts their question asking in outside school environments as well. But it is widely thought that before they start going to school, very young children tend to ask large numbers of questions (Falk & Margolin, 2005) and as children grow older they ask fewer questions (Berger, 2014). Berger points out that one of the main reasons for decline in questioning is the reward for answering rather than questioning in our schools. However, on the contrary, Yamamoto (1962) found that on an average the fluency or number of questions asked by students increased from grades 1 to grade 12 with some declines in grade 4 and grade 7. However some other research suggests that starting from kindergarten upto grade 12, students ask similar numbers of questions in the classroom (Good et al., 1987). These contradictory reports raise more questions about the change in question asking behaviour among students with increasing age and their class grades. The differences in results in these studies could be due to the differences in methods of collecting questions and methods to identify and classify questions. A larger study across different schools in different contexts with more standardised methods of identifying and analysing questions could shed more light on this issue. The observation studies on students questions generally report quantitative data about frequency of student questions (as a function of grade, age, gender, classroom size, etc.) and about the types of questions, with questions being analysed in isolation from the physical and social contexts in which questions emerge. To identify questions and understand the meaning of questions, we need to look at the contexts in which questions emerge (Barnes & Todd, 1977; Cifone, 2002).

There is a need for more qualitative studies in student questioning. More in depth case studies could be useful in understanding how and why changes occur in the questioning pattern among children with age and grades.

Though there have been studies looking at students' questions addressed to teachers, parents and other adults, but there is very little research that looks into students questions asked to students, where students address each other directly. We think that one of the main reasons

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for the lack of student questioning is the lack of opportunities for students to have spontaneous conversations where they address each other directly and address their questions to each other rather than teachers or other adults. And this is an area which has been quite neglected in student questioning studies. If we want to increase acts of student questioning in our classrooms, we must provide opportunities for student-student conversations where they raise and answer questions among themselves. For student questioning to acquire a central place in classrooms we must first understand the process and dynamics of student questioning inside as well as outside classrooms.

2.2 Forms and functions of students' questions

In order to understand student questioning, we need to understand the forms and functions of students' questions, and this has been one of the key areas of study in student questioning research. In order to understand the forms and functions of students' questions in various discourses, one needs to identify and separate questions from other types of utterances in the conversations. Depending upon the context of the discourse or conversation, there can be different schemes or frameworks to identify questions in the conversations. In order to develop such schemes or frameworks, we first need to understand 'what are questions', what it means to ask a question and how our own philosophical and ideological perspective influences our understanding about this.

2.2.1 What are questions

A question generally appears to represent an intention on the part of the asker to seek answers or get some information which the asker does not have. Although we do find questions in most of our day to day interactions but not all questions are asked to seek answers or get information. The ones which are asked to seek answers or get information can be categorised as authentic questions (also called as 'real' (Alpert, 1987), true or genuine questions) in the sense that the asker is ignorant of the answer (Nystrand & Gamoran, 1997). Authentic questions are asked out of a genuine curiosity to find out the answers to the questions. But not all questioning is entirely authentic. Sometimes questions are asked not to seek some response or some information but for other purposes. For example, rhetorical questions are

asked to make a point or present an opinion rather than seek an answer. Look at the following conversation between two children:

Bhavu: Hey, see there is blue leaf.

Naman: When are leaves blue?

The statement by Naman 'When are leaves blue?' is actually a rhetorical question, asked to make the point that the leaves are never of blue colour and the leaf being talked about is not a blue leaf. So Naman here is not seeking any answer from Bhavu, but making his point about the colour of the leaf.

Another example of questioning which is not authentic is teacher questioning to assess or evaluate students. Teachers generally ask a question with a motive to evaluate whether students know the answer to the question, rather than seeking an answer to the question asked. The teachers already know the answer to their question. Also, sometimes questions may be asked to express commands or requests, such as, 'Tell me the time' or 'I would like to know if that is correct' or 'Can you pass that ball to me?' Questions can also be used for performing other tasks in conversations, for example giving invitations: "Why don't you come and see me sometime?", to complain: "Why is it that we have to go there?" (Schegloff, 1984). And, sometimes questions can be asked without any of question markers. For example, the question asked by B (utterance number 2) in the following conversation is such a question.

A: Did you manage to fill the form?

B: No....that's what I was going to ask you.

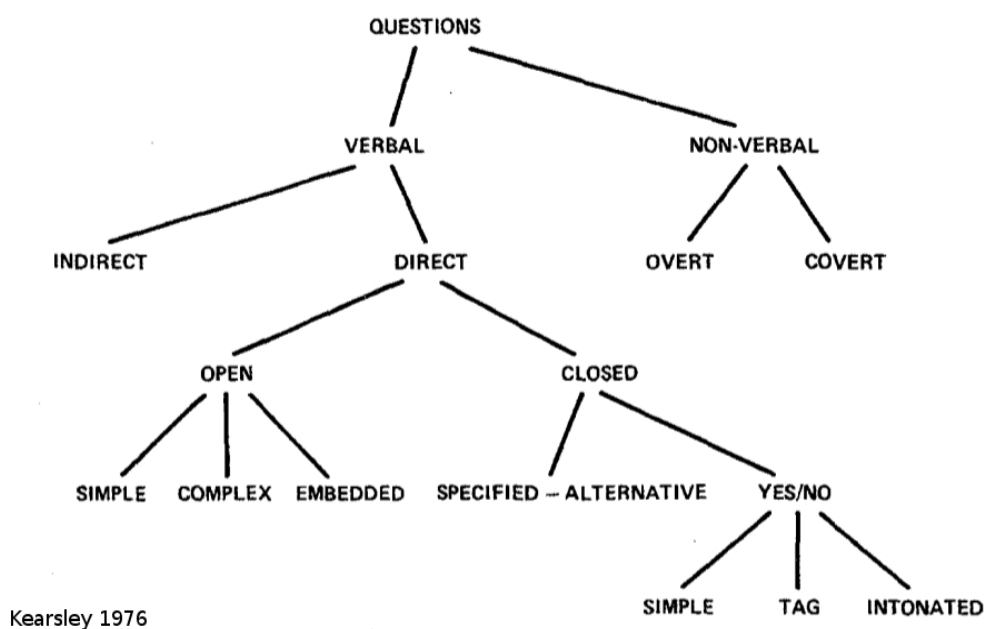
A: Actually it's pretty simple, let me explain to you ...

Whether to seek answers or to make a point or to serve any other purpose, questions are expressed mainly in two forms, verbal and non-verbal forms (Kearsley, 1976). When expressed verbally, questions could be either direct or non-direct. In a direct question, interrogatives are explicit, whereas in non-direct questions interrogatives could be missing or partial. For example, a student asking her teacher 'Teacher, I could not understand osmosis' is an indirect question without an explicit interrogative.

As categorised by Kearsley, non-verbal questions could be overt or covert (Figure 2.1). Overt questions are the ones that are expressed through gestures and expressions, whereas the covert questions are the ones that we ask and answer ourselves. Although Kearsley's categorisation separates verbal and non-verbal questions, but many a times gestures and expressions are also used in expressing oral questions (a kind of verbal question), where the meanings of questions cannot be understood without looking at gestures and expressions. Kearsley's categorisation does not treat such a category of questions as separate one.

Furthermore, Kearsley categorisation does not talk about the question forms when expressed orally and in writing. In a classroom context, questions expressed by students in oral and written form could be quite different in terms of their forms and functions.

Figure 2.1 Kearsley's categorisation of question forms



Questions, which are aimed at seeking responses or answers, exhibit perplexity or ignorance on the part of the asker. This perplexity is expressed in the form of questions, which may be verbal or non-verbal. There could be various gestures and expressions, through which perplexity could be exhibited non-verbally. Expression exhibiting perplexity could be in the form of a quizzical look indicated through kneading the forehead, raising eyebrows (perhaps just one eyebrow), opening eyes wider, glancing to the side, or by smiling, making a grimace, or opening the mouth, as in surprise. Gestures that may indicate perplexity could be such as

shrugging, raising and turning a hand inwards and palm upwards, raising shoulders, pointing, scratching one's head, putting a finger or a pen on one's teeth or lips, or various kinds of fidgeting.

As described by Dillon (2004) and Van der Meij (1994), perplexity is the beginning stage in the process of questioning, a step before a question has been verbalised. Van der Meij (1994), proposing a componential model of questioning, based on Dillon's model of questioning, describes the process of questioning in three stages:

Stage 1: The onset of questioning or the stage of experience of perplexity

Stage 2: Formulation and verbalisation of question or the stage of asking

Stage 3: Answering

It is interesting to note that both of them see the process of answering as part of the questioning process and not a separate process. Though in our analysis we will not be adopting one particular model of questioning, but our concern is with questioning as a process - a process situated within a particular social context and not isolated from answering. This is in close agreement to Michel Meyer's (1995) definition of questioning as a dialectical process, a process of interaction between questions and answers. According to Meyer, an answer can only be understood in terms of the question to which it refers. Questions devoid of answers and answers devoid of questions are meaningless. Whereas question/s is a thing, questioning is a process which is not something fixed but dynamic and changing with time. We will delve on these matters in greater detail in later parts of this chapter.

Questions being universal to all languages and domains of knowledge, questions and questioning has been studied by researchers belonging to diverse fields, with surprisingly little interaction between fields. For example, besides the studies on questioning related to science education, we find studies on questioning related to language learning (Meij, 1993; White, 1993), cognition, psychology, and child development (Chouinard, Harris, & Maratsos, 2007; Graesser, 1992; Vaidyanathan, 1988); linguistics (Portin, 1993), and philosophy (Hintikka, 1981; Meyer, 1995).

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A number of these researchers have pointed out the difficulties in defining and identifying questions in dialogues, speech, or other forms of communication (Cifone, 2013; Fahey, 1942; Piaget, 1923; Van Der Meij, 1994). In many languages, questions may be identified by the use of interrogative signifiers like 'WH' (who, what, why, where, how), word order, or by the use of a typical inflection or rise in intonation on a particular word, or with use of words like 'na' at the end of a sentence, all indicated by question marks when the questions are written.

Some authentic questions are not asked with any of the above indicators. Questions can be identified and defined in terms of forms and functions (Van Der Meij, 1994; Barnes & Todd, 1977), meanings, causes and effects, the intentions of the asker and/or the interpretation and response of the hearer - which may be very complex and difficult to discern.

Although there have been some schemes developed by researchers to identify and categorise questions (Kearsley, 1976; Graesser, Person, & Huber, 1992), implementing a particular scheme would require adaptation of the scheme according to the purpose and context of the study. Meanings and forms of questions can only be understood when seen in the context in which they emerge (Barnes & Todd, 1977).

In the studies reviewed here, researchers have defined questions from the point of view of the person asking the question. However, questions could also be defined from the point of view of the hearer. Suppose one person makes a statement that they do not think is a question and they are not seeking a response. The hearer may interpret it as a question and may think that the other person also meant it as a question, and they may give an answer. This may frequently happen with rhetorical questions. Even another observer may interpret the sequence as a question/answer sequence.

2.2.2 Forms and types of student questions

Identifying questions and categorising questions are quite interwound, with both being part of the process of defining questions (Cifone, 2002). As in the previous section, we could not define questions without describing about the forms and types of questions.

There have been some efforts by researchers to develop generic schemes or taxonomies of questions (Kearsley, 1976; Graesser et al., 1992). Kearsley, in his scheme, developed two

different taxonomies, one for forms (discussed in previous section) and another for the functions (discussed later) of questions. He based the taxonomy for question form on the syntactic criterion and for question function on semantic criterion. Though discussed separately here, the forms and functions of questions are not entirely separate aspects and are related to each other.

Kearsley defined a question as an interrogative utterance aimed at seeking a response from the addressee, and thus excluded rhetorical questions, and questions to give commands and convey requests, from the category of 'true' questions. However, at times a rhetorical question can be an authentic question, or at least semi-authentic. For example, let us say X wants to know whether Y is interested in going for the movie and X is doubtful about it as someone else said that Y may not come for the movie. So X asks Y 'Aren't you interested in watching the movie' Though it was a genuine question for X but the expression was rhetorical. Depending upon the context in which discourse occurs and the nature of replies that follow an utterance, the utterance may or may not be classified as a question. The ambiguities about identification and classification of questions are inevitable and are part of the complex process of understanding questioning.

Graesser, Person and Huber (1992) also devised a generic categorisation scheme, known as GPH scheme, based on the functional aspects of questions. Their taxonomy included both interrogative and non-interrogative questions which call for a genuine inquiry. The taxonomy has 18 categories of questions including verification, comparison, definition, procedural, quantitative and request questions.

Although researchers have developed few generic schemes to identify and categorise questions, but their use by other researchers in categorising students' questions has been very limited. Hardly any studies used an elaborate taxonomy, as the one developed by Kearsley, to understand student questioning in science education. We found only two examples of Kearsley's scheme being used by researchers (Cifone, 2002; Marx, Fuhrer & Hartig, 1999) to categorise students' questions. One reason that other researchers have not much used existing schemes or frameworks could be that, unless such schemes are adapted according to the context of the study and the context in which questions emerge, these may not be very useful.

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Many researchers, rather than using generic schemes, have categorised questions using empirical data from their studies for the particular purposes of their studies. We have listed some of these empirical works in **Table 2.1**. Though the categorisation in these studies is specific to a study, it is based on some kind of theoretical understanding about questions and questioning. Many of these studies categorise students questions on the basis of cognitive level of questions, where certain questions like recall or factual questions are categorised as lower cognitive level questions and questions related to real life phenomena, questions reflecting puzzlement and curiosity, questions asking for explanations and justifications, questions leading to investigation are categorised as higher cognitive level questions. Questions performing ‘lower’ cognitive functions have been grouped into categories like factual, input, basic information or closed questions. Whereas questions performing ‘higher’ cognitive functions have been grouped into categories like integration, output, wonderment, real life or open questions.

For example, Blonder, Mamlock-Naaman, & Hofstein (2008) in their study looked at students' questioning during an open-ended chemistry laboratory session and categorised students' questions based on three levels: (1) questions regarding subject matter; (2) questions related to scientific equipment and methods; and (3) questions concerning real-life phenomena. They reported that, “The highest level and the most complex questions are those at the third level that require an understanding of the subject matter, the instrument and measurement methods, and transfer this knowledge to real life situations.” They found that students rarely ask level (3) questions. This is contrary to the results of Kulkarni & Agarkar (1985) who found a large number of students' questions related to the real-life phenomena. It may be that in their study students rather than asking in the class wrote their questions on a paper and dropped them in a box. So this might have given them more autonomy to ask a wide range of questions.

Table 2.1 - Empirical studies on categorisation of students' questions							
Study	Purpose of study or Purpose of classification	Grounding for categorisation	Types of questions (examples of questions)	Settings or environment of study	How questions were collected	Questions posed to whom	Subject domain/ Grade
Piaget (1923)	Understanding child development	Logical functions	<p>Questions of reality (When or where did Y happen?)</p> <p>Questions of human actions and intentions (Will you come?)</p> <p>Questions of rules and usage (How is it written?)</p> <p>Questions of classification and valuation (What is this called? Is this more beautiful than that?)</p> <p>Whys of causal explanation - causal or finalistic explanation of a material phenomenon (Why do the balls always fall?)</p> <p>Whys of motivation - an explanation for a human action or psychological state (Why are you going away?)</p> <p>Whys of justification including whys of logical explanation - referring to the order or aim of a rule (Why is this word not spelled like that?)</p>	Informal school laboratory	Written notes by researchers	To children or researchers	Various/Kindergarten
Kulkarni & Agarkar (1985)	Understanding children's curiosity about Science	<ol style="list-style-type: none"> Questions asked by individuals depend upon their prior experiences and knowledge Differentiation of questions according to cognitive level and content area of questions 	<p>Text related questions - questions arising from textual content</p> <ol style="list-style-type: none"> Questions seeking meanings of difficult words Questions seeking additional information Questions seeking mechanisms and casual relationships Questions seeking guidance <p>Expericne related question - questions from everyday experiences</p> <ol style="list-style-type: none"> Enquiry about human body Enquiry about gadgets Enquiry about environment and incidences Enquiry about legends and supesitions 	Weekend - classes as part of talent nurture program for underprivileged children	Through question boxes placed in classrooms	To teachers	Science/ Middle school
Good, Slavings, Harel & Emerson (1987)	Understanding the effects of student achievement and gender on student passivity	Functions of questions	<p>Explanation (What would happen if you blew up the balloons?),</p> <p>Information (What is two plus two?), procedural (Where do I write my name?), confirmation (Isn't one plus one two?), clarification (Did you say that three minus two is two), non-task curiosity (Are we going to have a field trip in science this year?), off-task attention (Does it [a lost note] have an eyeball on it?), on-task attention (Mrs. X, ain't I the best reader in the class?), diversion (Mr X, what did you think of the Mizzou game this weekend?)</p>	Regular classroom teaching observed by coders	Coders taking notes	Teacher	Mathematis and Language arts/Kindergarten, Grade 1, 3, 6, 7, 9 and12
Pizzini & Shepardson (1991)	Understanding student questioning in large and small group problem solving instructional model	Differentiation of questions according to cognitive level of questions	<p>Input - recall questions (Name the parts of the flower?)</p> <p>Processing - Questions requiring use of data or information (How are pine trees different from oak trees?)</p> <p>Output - Questions requiring students to use data or information in new ways (If we continue to pollute our waters, what will happen to the aquatic life?)</p>	Classroom setting	Transcriptions of Students' oral questions during teacher instruction	To students and to teachers	Science/Grades 5 to 8

Table 2.1 - Empirical studies on categorisation of students' questions							
Study	Purpose of study or Purpose of classification	Grounding for categorisation	Types of questions (examples of questions)	Settings or environment of study	How questions were collected	Questions posed to whom	Subject domain/ Grade
Scardamalia & Bereiter (1992)	1. Understanding differences between text based and knowledge based questions 2. Whether asking educationally productive questions requires substantial prior knowledge	1. Questions depend upon one's prior experiences and knowledge 2. Differentiation of questions according to cognitive level of questions	Text based questions - questions asked about a topic after reading or studying some text material related to the topic Knowledge based questions - questions asked about a topic from experience without having read any material related to topic Basic information question - Textbook type questions asking some simple information (What are fossil fuels?) Wonderment questions - Questions that reflect puzzlement, curiosity, skepticism, asking for explanation (Does fossil fuels effect ozone layer?)	Formal and informal classroom settings	Written questions by students	To students and to teachers	Science/G grades 5 and 6
King (1994)	Comparing and understanding knowledge construction in two different teacher guided questioning conditions	Differentiation of questions according to cognitive level of questions	Factual questions - recall of facts or information Comprehension questions - asking to define or describe a term or a process Integration questions - Questions asking for explanations, justifications, inferences, relationships between ideas, etc. Investigable questions - questions which can be answered by collecting and analysing some data and doing hands on investigations (When does lime water turns chalky?) Non-investigable questions - which can be answered without doing some hands-on investigation (What is a mirror made of?)	Classroom setting	Transcriptions of oral questions from students' group discussions	To students	Science/G grade 4 and 5
Chin & Kayalvizhi (2002)	1. What types of questions students ask during open-ended investigations 2. How teachers can help students pose questions feasible for investigations	Difference in ways of answering questions	1. Verbal - General; Indirect; Direct open; Direct Closed Non verbal 2. Specific questions; Exploratory questions; Thoughts of doing something; Observations of what happens; Interest in accomplishing a practical aim; Attempts to resolve a conflict & consider alternatives; Consolidation of what is already known.	Classroom setting	Students told to write questions for investigations after they were given few examples	For themselves and teachers	Science/G grade 6
Cifone (2002)	Role of questioning in the learning process	1. Forms of question 2. Epistemic functions of questions	Level 1 - Questions regarding the subject matter (What is the exit order of alcohols from the column?) Level 2 - Questions related to scientific equipment and method (How does the temperature change affect the separation of the peaks in the chromatogram?) Level 3 - Questions concerning real life (When you take a mixture of water and alcohol, how does the number of distillations affect the % of alcohol in the mixture?)	Classroom setting	Transcriptions of video recordings	To students	Making models of classrooms/Grade 3
Blonder, Mamlouk-Naaman, and Hofstein (2008)	1. Identifying levels of questions in an open inquiry laboratory 2. To understand the relationship between the students' general ability and the level of their inquiry questions	Differentiation of questions according to cognitive level of questions		Laboratory sessions held at a university science Laboratory Center	Students' written questions posed for inquiry	For themselves and teachers	Chemistry /High school students

Table 2.1 - Empirical studies on categorisation of students' questions

Study	Purpose of study or Purpose of classification	Grounding for categorisation	Types of questions (examples of questions)	Settings or environment of study	How questions were collected	Questions posed to whom	Subject domain/ Grade
Almeida & de Souza (2010)	Understanding questioning patterns of secondary science classrooms and compare with reported patterns	1. Communication function of questions 2. Cognitive level of questions	Scientific - About science (Teacher, but is it an elementary substance?), Non scientific - Not about science (teacher, can you lend me a pencil?) Closed - single answer, Open - multiple answers	Regular classroom	Transcriptions of audio recordings of regular classrooms	To teachers	Chemistry and Physics/G grades 8 and 9
Hu & Chiou (2013)	Understanding student questioning in an online environment of three different kinds of question-stems	Epistemic functions of questions	What questions; Example questions; Why questions; How questions; Comparison questions; Influence questions; relation questions; Hypothesis questions; Perspective questions Beyond questions - beyond scope of students' science text, Invalid questions - incomplete or whose meanings are not clear	Online classrooms in the computer labs of regular school	Through specially developed online module	To students	Science/G grade 5

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There have also been efforts to train students at asking ‘productive’ or ‘better’ questions or certain kinds of questions. But in all these, there is an assumption that teachers know which questions are more important or significant for students. But for different students, in different contexts, different things would interest them or excite them or perplex them. What is more important is to let students ask those questions which naturally occur to them (Commeyras, 1995).

Teaching children to ask the questions we think important presumes that we know best which questions will help each child learn. If we take over all or most of the questioning, we miss out on learning with our students, and we deny them the experiences they need to hone their questioning ability. (p. 105)

As Barnes and Todd (1977, p. 120-123) write that a simple ‘yes-no’ question could be as higher order as a ‘why’ question demanding similar cognitive processing, whereas generally yes/no questions are usually thought of as being ‘closed’ and of lower cognitive order.

A similar point is raised by Kearsley (1976), who argues that questions, as seen part of a larger discourse, may have very different meanings from our theoretical understanding about the questions. He says that in everyday discourse, straightforward looking ‘yes-no’ questions are rarely answered with a simple “yes” or “no”.

As Cazden (1970) points out, the ‘wh’ questions puts cognitive burden on listener or respondent, where as ‘yes-no’ questions put cognitive burden on the asker. In this sense, the asker has to have considerable knowledge about the topic to ask a ‘yes-no’ question. For example, the following ‘wh’ question,

“What is it used for?” (looking at a sound recording device)

could be asked as a yes/no question,

“Can you record sound in this device?”

The asker of the second question had to hypothesize a possible answer in order to pose it as a yes/no question, which is more difficult. So in this sense, a yes-no question requires higher cognitive function by the asker. However, in differentiating questions on the cognitive level, researchers have generally looked at the expected answers to categorise the questions.

Also when certain questions will get labeled 'better' and when someone would ask a 'not so good' question, then that person may get discouraged to ask further questions. Thus we can question why more value should be given to 'wh' kinds of questions. Why there should be value in asking 'why' questions? More research in this regard needs to be done to investigate questioning from the perspective of both the asker and the responder.

In general there is a lack of research about critical questioning by students: the questioning which challenges the status quo, which challenges textbooks, which shows disagreements with authorities. Some researchers report on lack of 'quality' or 'productive' questioning among students and argue for encouraging such questioning. But we think, equally or rather more important is critical questioning among students.

Apart from higher order/lower order and productive/unproductive differentiation, questions have also been differentiated into scientific and non-scientific, investigable and non-investigable and text based and knowledge or experience based questions (see **table 2.1**).

Generally studies do the categorisation of questions in isolation from the discourse or context or expected answer or responses to questions, with questions being treated as independent entities. However, a more meaningful understanding of questions, and thus their categorisation, can only be made by looking into the overall discourse in which questions emerge. There are few studies (Barnes & Todd, 1977; Cifone, 2002) that explore student questioning as function of students-student discourse during students' group work. Most studies look at questioning as an individual quality which is more or less dependent on the performance or actions of an individual. This seems to be driven from ideologies of educational system that individualises performance and assessment of students. We wonder whether individualising questioning serves to maintain order in the classroom and safeguard the authority of the teacher.

With few exceptions (Cifone, 2002; Singh, Shaikh, & Haydock, 2018), hardly any studies look at students' spontaneous questions addressed to each other. Spontaneous questions are more genuine and can help in understanding students' epistemology and their cognitive process behind learning (Piaget, 1923). Piaget may have called his children's questions 'spontaneous', however the interactions between children were not very naturalistic, since the

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children in his study were in laboratory kind of setting, interacting with both teacher/researchers as well as other children.

Furthermore, very few categorisation studies focused on understanding the process of student questioning especially student-student questioning (Cifone, 2002). Maria Vittoria Cifone, who is a pioneer in the investigation of students' questioning in context, studied questioning in order to understand and explain what the students are doing, and how and why they are doing and learning. The context in her study was building of a model classroom by students. She identified questions "as the gestures, expressions, actions, or words which signaled the events in which the children's work showed a 'discontinuity' in the process that led to action or insight", and she then tried "to determine (a) whether it was the child's own question and (b) whether it conveyed an interrogative in connection to the child's own process of building."

In general there is a lack of studies in student questioning that look at the **process** of student questioning. We think that in order to provide opportunities for student questioning in classrooms, we must first understand the dynamics of student questioning: how and why questioning emerges and sustains. Since we are interested in the role of questions in the process of learning, we are more interested in the process of questioning than in particular questions as forms or entities in themselves.

2.2.3 Student questioning: its importance and its functions

As reviewed by Edwards and Westgate (1994), research has shown many advantages of students talking in class. Education is a social process that requires much more than individual, isolated students listening, reflecting, and writing (Vygotsky, 1966). Students must be engaged in activities and real discussions in which they ask authentic questions.

Several authors have mentioned the need to reawaken the quality of asking questions, which children seem to abandon as they grow older (Falk & Margolin, 2005; Rothstein & Santana, 2011). Students' questions are thought to be crucial for science education and as a basis to design educational programs (Joshi, 2007). In their review of research on students' questions in science education, Chin and Osborne (2008) reported that students' questions are important for (1) students' knowledge construction, (2) encouraging participation of students

in classroom discussions, (3) helping students to assess their own learning and (4) arousing epistemic curiosity. In addition, students' questions are also important because they help teachers in (1) formative assessment, (2) evaluating higher order thinking, (3) stimulating further inquiry and (4) fostering critical reflection on classroom practices.

On the importance of student generated questions in science inquiry, Falk & Margolin (2005) said that the main reason for doing inquiry is to let students explore their own questions. Other people also have observed the importance of encouraging students to ask questions and to have them find answers on their own (Biddulph, Symington, & Osborne, 1986; Keys, 1998; Roth & Roychoudhury, 1993; Watts & Alsop, 1995; Watts, Gould, & Alsop, 1997). According to Lock (1990), one of the important factors that determines the meaning and objective of an investigation is, who poses the question: teacher, student or a group of students. Students are generally more enthusiastic when they work on investigations stemming from their own questions. Students' questions give them a sense of ownership, thereby engaging them emotionally in the inquiry process (Roth, 1994).

The position paper on teaching of science (NCERT, 2006), also advocates similar position on questions or problems being meaningful to students (middle school level),

Apart from simple experiments and hands on experiences, an important pedagogic practice at this stage is to engage the students (in groups) in meaningful investigations -particularly of the problems they perceive to be significant and important. (p. 13)

Also the Indian National Curriculum Framework (NCERT, 2005) recommends that students should be encouraged to ask questions rather than only answering questions and they should be given opportunities to pursue their own question. According to the National Curriculum Framework (NCERT, 2005),

Teachers should also nurture their classroom spaces as places where children can ask questions freely, engaging in a dialogue with the teacher as well as their peers, during an ongoing lesson. Unless they can share their related experiences, clarify their doubts and ask questions, they will not engage with learning. (p. 82)

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Other curricular documents also have a similar position about the importance of students questions. As mentioned in ‘Science 5 - 13’, a guide book to help teachers across UK,

We have said that science involves exploration, and exploration involves the gathering of experience-a process that goes on throughout our lives. We can certainly help children to gather appropriate experience of their environment, and our convictions are that we must help them to ask their own questions and find their own answers by first-hand investigation as far as may be. (Ennever & Harlen, 1977, p. 5).

In the USA, asking questions has been recognised by the Next Generation Science Standards (NGSS Hub, 2013) as one of the key practices of doing Science and engineering.

Some researchers have suggested that one reason students should be encouraged to ask questions in class is that they are more apt to remember answers to their own questions than to questions posed by others (Ross & Balzer, 1975). However, we wonder whether remembering answers to questions is really a very important learning objective in a science class. It is well known that traditional, didactic teaching tends to over-emphasize the remembering of science ‘content’ (Foo & Looi, 2008; Scardamalia & Bereiter, 1992).

In our view, an important advantage of student questioning could be that it accommodates the different interests of students which the teacher may not be aware of. In turn this will help the teacher become aware of students' interests. This could address the problem of overly teacher centred pedagogy. In classrooms, which are less child centred, teachers often expect specific responses to their questions (Roth, van Eijck, Reis, & Hsu, 2008). This evaluation tends to obstruct students' own thinking as they try to guess expected answers. On the other hand, if a question is posed by the student, there is a good chance of uncertainty in the answer of the question to both teacher and student. In such a situation, the teacher cannot not be very evaluative. Such uncertainty can make teaching more effective by making students' experiences more authentic.

Students questions, especially their spontaneous questions, can help teachers as well as researchers understand them better. As said by Piaget (1923, p. 97), “*There is no better introduction to child logic than the study of spontaneous questions.*”

Teachers generally assess students from their answers to the teachers' questions. But the students' own questions may give a better understanding of the students' ideas and their learning. Asking questions involves learning what one knows and what one does not know, and trying to figure out what questions are more or less important or relevant (Chin & Osborne, 2008, p. 235). We might hypothesize that it is more important for students to (at least sometimes) ask themselves the questions 'What do I not know?' and 'Which questions are important?' than for teachers to ask (and decide), 'What do the students not know?' and 'Which questions are important?'

One of the most crucial functions of questioning, as considered by many educators (Postman & Weingartner, 1971; Freire & Faundez, 1989), is the construction of knowledge.

Consider, for example, where 'knowledge' comes from. It isn't just there in a book, waiting for someone to come along and 'learn' it. Knowledge is produced in response to questions. And new knowledge results from the asking of new questions; quite often new questions about old questions. (Postman & Weingartner, 1971, ch. 2)

However, very few studies actually explain the relationship between questioning, especially the student questioning, and knowledge construction in any detail. We will discuss this relationship in **Section 2.4** of this chapter, using Michel Meyer's ideas of Problematology.

Questioning is necessary for both critical reasoning and scientific investigation: in order to observe, analyse and evaluate evidence, justifications and explanations, as well as to make interconnections, postulate and test hypotheses and identify and clarify contradictions and doubts, and solve problems (Biddulph et al., 1986; Chin & Osborne, 2008). However, research in science education has looked at questioning in isolation from these different aspects of scientific inquiry.

In their review of research on students' questioning in science education, Chin and Osborne (2008) state what they think is the most important role of students' questions: "First and foremost, questions from students indicate that they have been thinking about the ideas presented and have been trying to link them with other things they know." However, rather than just helping students think about the ideas presented by teachers or 'fill their knowledge

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gaps', we wonder whether we should stress the creative potential of student questioning in forming new ideas, changing beliefs, and investigating new areas.

2.2.3.1 *Functions of student questioning*

Seeking information and settling one's epistemic puzzlement are seen as most important functions of questioning in conversations. But apart from these crucial functions, there are other important functions that questions perform. Understanding the functions or roles of students' questions can help us in understanding the reasons why students ask questions. Here we will look at some of the studies that describe functions of children's and students' questions. The functions of students' questions are closely associated with the importance of students' questions.

According to Kearsley (1976) questions perform four major functions in conversations, namely echoic, epistemic, expressive and social control. Echoic questions are a kind of confirmation question asked for repetition of an utterance or for confirmation that an utterance has been understood as intended. This category is similar to what Sinclair and Van Gessel (1990) called 'verbal incomprehension'. Epistemic questions are information seeking questions. Expressive questions perform the function of conveying attitudinal information to the respondent. Questions of social control are used to exhibit one's control over the discourse. Questions that are aimed at seeking attention are a kind of social control questions.

Kearsley's functional categorisation was based on the assumption that the purpose of all questions is to seek a response from the listener. As discussed earlier, however, we believe not all questions are asked to seek responses. But Kearsley's categorisation did not include such questions. Furthermore, as we discussed, Kearsley's categorisation was based on theoretical assumptions. But there are many empirical studies that looked at the functions or roles of children or students' questions.

In the study by Sinclair & Van Gessel (1990), to investigate the functions of children's spontaneous questions in a day care centre, they categorised questions according to various functions. Among others their categorisation consisted, teacher questions - questions to test others where speaker knows the answer; verbal incomprehension - requests for repetition like 'hein' when the listener is not able to hear or understand properly; solicit agreement to

comment - seeking agreement from others over a statement e.g. 'He has gone home, na?'; proposing future action - e.g. shall we play with this car and attract attention - to attract others attention e.g. Did you notice what I just did? Among all categories, they found the questions to propose future actions were largest in number asked by the children.

In a review to understand the forms and functions of children's questions Cazden (1970) described several important functions listed by the researchers. She found that children ask questions for various reasons like, to test someone, to seek permissions, to seek attention, for confirmation, for repetition among other reasons.

Cifone (2002) in her study (see Table 2.1) categorised students' questions according to various purposes of their questions. In her study, she observed that students asked questions to explore things about which they were curious, to see what is happening, to resolve conflicts and consider alternatives and for various other purposes. It is interesting that Cifone's categorisation for functions of students' questions is not generic and emerges from the purpose and the context of her study and the context of student discourse. These functional categories helped her understand the relationship between learning and questioning. Studies on similar lines would be more meaningful to understand the process of student questioning and its relationship to learning and doing science.

Freed and Ehrlich (2010) in their book, to understand questioning in different institutional settings, bring forth studies on questioning from many different institutional discourses, such as courtroom conversations, doctor-patient interactions, news interviews, as well as classroom conversations involving teachers' questions. They found that one of the functions of questioning in these discourses was the allocation of turn-taking, with the questioner having the authority or right to initiate and allocate turns by asking questions. Carlsen (1991) talking about the role of teacher questioning in classroom discourse, explains how the teacher uses questioning to maintain control over different aspects of the discourse. However, there has not been much work to compare the functions and purposes of teachers' and students' questions inside the classrooms, and how it affects the distribution and dynamics of authority inside a classroom.

There have been studies to understand the functions of children's 'why' questions by some researchers (Bova, 2011; Piaget, 1923; Isaacs, 1930). According to Piaget, children, from

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around 3-7 years age group, ask 'why' questions to seek some information for causal explanation or for some rule bound justification but not to seek the true explanation or logical justification. So their 'whys' are more affective than intellectual (see **Table 2.1**). However, Isaacs (1930), disagreed with Piaget and argued that children, even as young as 3 or 4 ask why not just for some casual information, but also for settling their epistemic unease or puzzlement. In somewhat agreement to Isaacs's finding, Antonio Bova (2011) found that the main functions of children's (aged 4 to 7 as reported in the study) 'whys' in family's dinner table conversations are, argumentative and explanatory.

Another important function of student questioning, which has been hardly explored by the researchers, is the construction of arguments through questioning. Questioning arises because of alternate or multiple views (Meyer & Cushman, 1982) and argumentation is a dialogical exchange between two parties having different points of opinion (Muller & Perret-Clermont, 2009)). Chin and Osborne (2010a; 2010b) in their studies found that students' questions helped them in initiating and constructing arguments. They found a strong correlation between students asking questions and their engagement in productive argumentation which involved reasoning, giving evidence, justifying, giving counter-argument etc. However, Chin and Osborne's analysis of students argumentation was based on Toulmin Argument Pattern (TAP), which has been criticised by researchers (Van Eemeren & Grootendorst, 1999), who argue that Toulmin like models present a traditional view of logic as syllogistic logic and ignore the recent developments of dialogue logic. Also TAP type models do not include questioning as an explicit element of argumentation. Furthermore, such an analysis does not look at the social aspects of talk, like gender, authority, emotion etc., which play a crucial role in everyday as well as scientific discourse. It has been argued that by reducing a natural discourse, which is generally very complex, to set of statements in terms of claims, evidences, justifications, etc., and by neglecting the social aspects of the discourse, we miss out the understanding of key aspects the discourse (Singh & Haydock, 2017). To better understand the student argumentation and its relationship with student questioning, one need to investigate student-student discourse in more informal settings using tools that accomodate different aspects of everyday and scientific discourse.

So apart from seeking information and settling their puzzlement or unease, children ask questions for various other reasons as well like, seeking attention, making requests, asking for

confirmation, seeking agreement, for testing someone, seeking permission, and seeking explanations and justification. Since many of the studies on functions of children's question looked at questions of very young children and that too from informal settings, a comparison with regular classroom teaching situations is needed. In classrooms, students motivations and purposes of asking questions are probably very different from the out of classroom situations. More research focusing on actual classroom teaching situations needs to be done to better understand the importance and functions of students' questions.

2.3 Students not asking questions: understanding reasons and efforts to encourage student questioning

As discussed in section 2.1, students are not asking questions inside classrooms and part of the reason is the teacher's domination and control of classroom talk. In this section we will first look at the nature of classroom discourse/talk in more detail and try to understand the reasons for students not asking. Furthermore, we will also try to understand the nature of schooling and education and how it impacts classroom questioning. With this analysis, we will then critically look at the efforts done by researchers in encouraging student questioning.

2.3.1 The nature of classroom talk and its relation to questioning

Let us first try to understand the nature and dynamics of classroom talk and in what ways this impacts student questioning.

2.3.1.1 *Formal classroom talk versus informal everyday talk*

In considering why students do or do not ask questions in classrooms, it is helpful to compare the situation inside and outside of the classroom, since students may be asking more questions in more informal settings, outside of the classroom. Kamil Özerk (2001) raises this point:

We all have experienced that children in natural settings ask a lot of questions. Contrary to our experience, however, it seems that children as 'students' do not ask so many questions in school. If we accept children's questions in their daily

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life outside school as a sign of their curiosity, we must ask ourselves why the school setting does not reflect the natural life of the children as it appears outside the school.. (p. 355)

It is clear that students, especially in India, do not talk to each other as much as part of the main classroom discourse, as they do in everyday settings. However, we find that there has not been much research on children's discourse in everyday, informal settings in India. We see the need for research that compares student discourse in and out of the classroom in order to understand children's questioning.

There are stark differences between the classroom and informal settings. The most obvious difference is the size and demographics of the group. There are probably very few cases where groups as large as 20 or 30 people (children or adults) carry on one conversation outside of a classroom or formal meeting of some sort. Rather, people carry on informal conversations in pairs and small groups of mixed ages. Unlike in the classroom, these are often fluid groups that form spontaneously, in which people are relatively free to wander off, change groups, split into sub-groups, etc.

Second, the rules guiding the discussions outside of classrooms and formal meetings are less rigid. The group dynamics will depend on power relations, but there may not be such a rigid binary of just one leader or 'teacher' facing all the other less privileged, as there is in most classrooms. People may not be as constrained to remain silent, take turns or wait until they are nominated to speak. Raising hands in order to be called upon would be very rare. Furthermore, in classrooms students are being assessed by the teacher, especially with regard to behaviour (whether the students are following the rules), and with regard to whether they give the answers that teachers expect (which we will discuss below). In informal groups, people may be assessing each other, but the types of assessment may be much more complex and multidimensional. In spontaneous informal talk, turn taking may happen with the speaker continuing to speak, or when the speaker pauses or chooses to give a turn to someone (Turnbull, 2003). Turn taking takes place more naturally and democratically with lesser demonstration of authority by the speaker in assigning the next turn.

Third, outside of the classroom, the environment may be much more complex: there may be various sorts of people, plants, animals, natural and artificial materials, various types of buildings, traffic, weather, etc - all of which are in constant motion, interacting with each other and producing a myriad of changing sights, sounds, smells, and feelings. In comparison, a typical classroom in India is a rather barren room (until it is crowded with students). The environment will affect (and be affected by) the conversations that occur.

As Gordon Wells (2009) mentions, the role of an adult is also very different in an out-of-school or pre-school context:

In the preschool years, as we have seen, talking and learning go hand in hand. Children talk about the things that interest them and try to increase their understanding; and, for much of the time, their adult conversational partners sustain and support their efforts, seeking, where appropriate, 'to add a pebble to the pile' (Brown, 1980). What is characteristic of such learning is that it is spontaneous and unplanned and, because it arises out of activities in which one or both of the participants are engaged, it is focused and given meaning by the context in which it occurs. (p. 74)

However in Indian classrooms this is not how learning takes place. Talking is rarely done by children, especially spontaneous talking grounded in the context as they explore something.

All of these factors affect the questioning that occurs in the conversation. And the most basic point is that in informal, everyday situations, the questioning that occurs, does occur as part of conversations. Until recently, the conversations would always be oral, face-to-face (except phone conversations which were restricted to pairs). Nowadays, people are beginning to carry on internet chats, which are usually in a written form. Although such conversations can be interesting to study, especially with regard to questioning in conversations, in our study we will mostly be concerned about face to face spontaneous oral conversations.

2.3.1.2 Monological teacher-student talk

In classrooms, most of the talk that is observed is teacher-student talk and not the student-student talk. Teacher-student talk that occurs, mostly occurs for the sake of passing

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information to students that the teacher already knows. Here students may not want or need to 'know' this information, or they may disagree with that information, but they have no chance to voice their disagreement. When a teacher acts as a knower, the talk is generally one-directional and monological in nature, in that its meanings and interpretations are predetermined and not open for other interpretations. This is in contrast to dialogic talk, or true discussion between the teacher and students, as Lemke (1990, p. 55) defines it, in which a teacher asks genuine questions, for which she does not know, and wants to know the answers. Lemke says such teacher-student discussions are more interesting than the usual teacher-student discussions in which the teacher asks known answer questions. However, in classrooms such discussions are generally very rare.

Atwood, Turnbull, & Carpendale (2010) refer to dialogical talk as being a "cooperative classroom interaction" in which the teacher allows the students to have considerable control over the discussion by encouraging students to initiate and terminate topics, present and justify arguments, and talk to each other as well as to the teacher. Student question asking has been found to be one of the crucial factors for initiating dialogic discourse in the classroom (Nystrand, Wu, Gamoran, Zeiser, & Long, 2003).

We wonder how the nature of the classroom talk will change if it occurs between students and students instead of between teacher and students. We think when students would directly address each other and debate among each other without the teacher, the talk may be more dialogical and students would have more genuine reasons for talking and asking.

2.3.1.3 *The dominant role of the teacher*

In our experience of schools in India, we have rarely observed students working in small groups or doing activities and having discussions with each other. Most of the talking in the class is done by the teacher. There is generally a lack of true dialogue. Science teaching pedagogies are mainly transmissive, which is apparently the case in other countries as well (Lyons, 2006; Newton, Driver, & Osborne, 1999). Despite its advocacy in Indian policy statements (NCERT, 2005) and textbooks, a constructivist approach is rare.

We have seen two dominant science teaching methods in India, which can be broadly categorised as (1) teacher-lecturing and (2) a pseudo-enquiry method. Combinations and variations of these methods are very common throughout a variety of types of schools.

In the most severe form of the teacher-lecturing method, students are expected to remain silent, but it is not uncommon to find lecturing interspersed with interludes in which textbooks are read out loud by the teacher or students (individually or in unison). Occasionally the teacher will perform demonstrations of the various activities which are suggested in the textbooks. The teacher and textbooks usually supply both 'questions' and 'answers', often without any student input, which the students are supposed to copy from the board or textbook, or record by dictation, and remember.

In the pseudo-enquiry method, which is also common in other countries (Cazden, 1988; Chinn & Malhotra, 2002), teachers rather than students do most if not all of 'enquiring'. Dillon (1988a), arguing for genuine inquiry questions by students says that though classrooms are full of questioning but lack inquiry,

As for education, it needs both a theory and a practice of asking problematic or inquiry questions. For, these are the very questions that stimulate thought and lead to learning, yet neither the learners nor the teachers are asking them. Those who ask questions in school - teachers, texts, tests - are not seeking knowledge: those who would seek knowledge - students - are not asking questions at all. Classrooms are full of questions but empty of inquiry..... (p. 115)

In pseudo-inquiry, teachers ask questions, and the students answer, with or without being called upon. Many a time the teacher would ask students to respond in chorus especially for short answers and for sentence completion. The discourse involving individual students is generally between the teacher and one student at a time. It is very unusual for one student to address another student, except in low voices or whispering, which the teacher may tolerate or try to prevent. As with the teacher-lecturing method, most of the time the teacher is talking. The pseudo-inquiry method is dominated by the IRE triad: teacher Initiation, student Response, teacher Evaluation or Elaboration, also called IRF, where the F is for Feedback (Mehan, 1979). The teacher Initiation is often in the form of a question. Researchers have

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extensively analysed teachers' use of the IRE triad and found many reasons why it is not a very satisfactory method (Edwards & Westgate, 1994; Shor & Freire, 1987; Van Booven, 2015), although some researchers support it (Kirschner, Sweller, & Clark, 2006).

In more 'advanced' forms of IRE, teachers reduce or eliminate the amount of explicit Evaluation they do, or use what has been called a "dialogic" rather than "authoritative" triadic questioning method. Dialogical questioning by teachers "can accommodate responses beyond those already known to or predetermined by the questioner" in order to "validate multiple voices or epistemologies" (Van Booven, 2015). Thus, a teacher initiated question may be followed by multiple responses from more than one student before the teacher gives verbal feedback or evaluation. Or, the teachers may respond to student responses in ways in which they try to conceal their opinions or assessments, e.g. by merely repeating or acknowledging. Even so, there is a lack of true dialogue between students except perhaps when students work in small groups without the teacher (Postman & Weingartner, 1971). Some researchers question whether teachers should try to focus or "restrict pupil participation to relevant, objective statements, and [use] them to develop an idea on which the teacher wishes to converge" because doing so may too tightly circumscribe what students are thinking (Barnes et al., 1971, p. 125).

There are several obvious reasons why classrooms are dominated by teacher-lecturing and pseudo-enquiry, and combinations and variations on these methods. In India one of the main reasons may be that education is confined by a number of systemic constraints, such as the severe shortage of teachers, inadequate infrastructure, and insufficient budgetary allocation (Govinda & Josephine, 2005; Jain & Saxena, 2010; Tewari, 2015; Tilak, 2008). In each classroom one teacher usually has more than 35 students - typically 40 to 60 and sometimes more than that. Nowadays teachers who have permanent government jobs are fairly adequately paid, but funds are often not being sanctioned to fill vacant government posts, and many extremely poorly paid contract teachers are instead hired to do the same work alongside their better paid colleagues. Teacher training is very inadequate for both pre-service and in-service teachers. Since there are a large number of languages and dialects spoken throughout the country, even within each district, most schools have an official medium of instruction (usually the official language of the state) which is different from the mother tongue of some or all of the students in the class. Conflicts of caste, class, and gender

between students are ubiquitous. Teachers also have many official duties outside of the classroom, and have very little time to plan, discuss, or reflect. With all of these constraints it is very difficult for teachers to encourage students to do activities, work in small groups, or carry on discussions in class. Educationists, teachers, parents, and children do make demands to change these conditions, but so far the government has not responded - except to try to privatise education, which results in worsening these problems (Nambissan & Ball, 2010). The implication is that there are unstated aims of education which are in conflict with the stated aims (Haydock, 2015).

2.3.1.4 Students' authentic questioning versus teachers' inauthentic questioning

As we have noticed in India, and as other researchers have noticed in other countries, teachers' questions are seldom authentic (Alpert, 1987). Since when an adult asks another adult an informational question, the one who asks is the initially 'ignorant' learner, and the one who answers is the 'knowledgeable' teacher, we might expect the learners in the classroom to be the ones asking questions to the teacher, and the teachers to be the ones giving the answers (Barnes et al., 1971, p. 44).

However, it seems clear that in India, as in many other countries, it is common for students to learn that in classrooms they are not supposed to ask questions to each other or to the teachers - the so-called questions are to be posed by the teachers and the textbooks. Students are supposed to answer the questions - but the answering is also according to certain procedures. All too often the teachers and/or the textbooks simply give the answers, which the students are to memorise. Paulo Freire and Antonio Faundez (1989) refuse to even call this questioning, since the answers accompany the questions.

Teachers ask inauthentic questions as part of what we call the 'school-school game' they are playing in which they try to get students to state answers which teachers already know. These answers are generally the 'facts' about the pre-defined science content. Most of the times purpose is to assess or evaluate the students, that's why teachers' questions are also called as test or exam questions (Sinclair & Van Gessel, 1990).

It is not clear whether or to what extent students learn to ask inauthentic questions by unconsciously imitating their teachers or textbooks. Van der Meij (1994) mentions that

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students learning to play a ‘game’ where they ask questions similar to the ones of textbooks or as asked by teachers. Such questions may not be valuable to their learning as they are not asked out of genuine curiosity.

Many authors have given reasons why teachers’ inauthentic questioning is problematic (Dillon, 1980; Freire & Faundez, 1989). But it has been pointed out that this form of discourse, in which the questions are usually closed, insures that the teacher maintains almost total control over the proceedings (Hanrahan, 2006; Lemke, 1990). This may be seen as an advantage or a disadvantage, depending on one’s point of view as to what the aims of education should be. Some researchers question whether teachers should try to focus or “restrict pupil participation to relevant, objective statements, and [use] them to develop an idea on which the teacher wishes to converge” because doing so may too tightly circumscribe what students are thinking (Barnes et al., 1971, p. 125). Others believe that students’ freedom to define their own problems for investigation should be limited by confining their questions to prescribed topics (content areas), “to ensure that student learning is basically in line with content objectives” (Chin & Kayalvizhi, 2002). In India, most teachers are required to teach a syllabus which is defined in terms of specific ‘science content’ rather than the science process. However, we wonder whether this unnecessarily restricts students’ questioning and learning. Are schools teaching children to stop asking questions?

2.3.1.5 *Students asking whom: teacher or each other*

An analysis of whom students address their questions to is an important aspect in student questioning which has not been given due attention in research. It is very different when students address (ask) their questions to teachers than when they address questions to each other. The research done in question asking among students generally has looked at questions asked by students in the classroom to the teacher, where the teacher will decide the next action upon the question. However when questions are asked by students among themselves the decision about what to do next are taken by students themselves. Since the progress of the discourse in such a case is decided by the students, it makes their involvement more engaging and meaningful. This is one of the reasons why student-student talk is crucial in students’ learning.

Perhaps students in classrooms do have a lot of questions which they do not ask because they are not allowed, or are discouraged, or because they are afraid of the kind of response from the teacher or the other students (Dillon, 2004; Good et al, 1987). The unsaid rules or norms of classroom talk which are very different from informal talk outside of the classroom like, being part of a large group, raising hands, being called upon by the teacher, not speaking out of turn, talking one at a time, sticking to the topic, not sounding stupid, etc. all constrain student talk and student questioning.

Van der Meij (1994) has discussed how students may need to “follow a code of politesse to moderate their chances of getting a negative response; they know they must persuade the other to respond favorably.” Rather than making a statement, which may expose their ignorance, students may pose a question. But even a question may expose their ignorance, especially if it could be construed as a rhetorical question or a leading question. So they may instead frame an open question. As Van der Meij (1994) explains:

Occasionally, a student may decide to frame the question differently or to pose another question for social reasons. For example, the questioner may begin with a foot-in-the door question in order to introduce the real question. Students may, for example, carefully construct a persuasive appeal, or ask a simple “May I ask you something ?” One could speculate that this explains why, even during seatwork, a student’s initial utterance in contacting their teacher is often an open question such as “I don’t know this” and “Can you help me?” (p. 150)

Alternatively, he points out, open questions may signal a lack of skill in formulating closed questions, or may be asked because of various social factors, such as the students’ need for approval from each other.

2.3.2 Does less knowledge increase or decrease questioning?

Besides the obvious power relations, the hesitancy of children to question adults - or each other - may also be due to differences in their perceived or actual experience, understanding, and content knowledge. There are differences of opinion regarding the possible correlations between students’ questions and their previous experience and/or their having been taught or

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their remembering domain-specific ‘content knowledge’. For example, some have claimed that, “In areas where they have no experience students cannot ask questions, except of the vaguest sort” (Dale, 1937). Miyake and Norman (1979) have reported that “it takes considerable domain-specific knowledge to ask good questions”.

On the contrary, other researchers have reported that middle school students (Grade 5-6) who had not been exposed to text materials asked better “educationally productive” questions:

When students produced questions on the basis of their own knowledge in advance of being exposed to any curriculum material on the subject of endangered species, they produced questions of generally higher quality than those produced by comparable students who had already examined resource material on the topic. (Scardamalia & Bereiter, 1992, p. 185)

They were judged to be better “in their potential contribution to knowledge, in their focus on explanation instead of fact, in requiring more complex information searches, and in being more interesting.” They also asked more questions which reflected political or social concerns. However, the same authors also suggested that this result may have been because the students were already familiar with the topic before coming to the class. For a topic with which they were less familiar, they asked more ‘basic informational’ type questions. Similarly, Van der Meij (1990) found that with increase in students’ prior knowledge, they asked less number of global questions but more number of specific questions. Furthermore, if it is true that asking good questions requires ‘domain-specific knowledge’, then why do very young children often ask such good questions? These and other questions regarding prior knowledge effects on question asking behaviour need to be researched further for better understanding on these issues.

2.3.3 Oral vs Written

Oral questions asked spontaneously reveal much more about the state of mind and inquisitiveness of the asker than the questions asked in written form. Oral questioning is all the more interesting as it includes active expression of the questioning in the form of gestures or expressions and through voice intonation. In our teaching, we have seen that students’ oral

questioning, expression, and discussion is much richer than what they express in writing, even with students in high school who are quite literate. However, we have not found research reports that focus on oral versus written questioning, and the generality of our observations have neither been verified nor falsified.

Much has been written about the 'oral culture' of India, and its comparison with 'literate cultures' (Ilaiyah, 2010; Rampal, 1992). One might argue that orature has some advantages over literature: it is more spontaneous and therefore perhaps more open to innovation; it facilitates communication within small groups and is less individualistic and less alienating; and it is more subject to evolution as it passes from person to person and group to group. This last point can also be a disadvantage, in that it may introduce spurious errors and contradictions between direct observations and reported observations. Scientific writing may allow people to more accurately communicate their observations, analyses, and conclusions. However, people may also make important modifications and additions as they orally pass on scientific discourse - resulting in the inclusion of more people in the orature. Orature is a process rather than a thing. It is more changeable, responsive, and 'living' than a relatively fixed, static piece of written literature. Perhaps because of this it may be more suitable for question asking. As Barnes et al. (1971) point out:

The disadvantage of writing as a means of making knowledge their own is that the reply to it may be both delayed and restricted to a general comment or assessment. It is in the give and take of reciprocal discussion that the pupil can best try out the new concepts and modify them in the response to the teacher's replies. (p. 30)

Nevertheless, there is no doubt that the written word is very important in doing science, and the importance of literacy is obvious. However, it becomes problematic when the extent of literacy becomes the major determinant of educational achievement in school (or even worse, when literacy in a language other than the student's mother tongue becomes the major determinant). As Gordon Wells (2009) writes:

What has emerged in the preceding chapters as the major determinant of educational achievement is the extent of a child's mastery of literacy. As children

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progress through the primary years, the content of the curriculum comes increasingly to be presented symbolically through uses of language that are more characteristic of writing than of conversation. Without the ability to cope with this literate form of language, therefore – that is to say, with the linguistic representation of ideas that are disembedded from a context of specific personal experience – children become progressively less able to meet the demands of the academic curriculum and, whether justly or not, are judged to be intellectually limited. (p. 213)

More research is needed to investigate the interdependent coexistence of orature and literature in and out of the classroom. For example, we suggest that oral discussions between students in classrooms need to be investigated - both formal discussions, as when students work in small groups, and informal ones, as when students ‘whisper’ to each other during a teacher’s lecture or, a demonstration, or during a presentation by other students. It may be interesting to compare classrooms in which teachers do or do not encourage or allow more frequent and louder ‘whispering’. Could some amount of validation of whispering result in a better atmosphere for learning to occur? We wonder whether even without teacher validation, whispering may sometimes have a positive role as a subversive activity that facilitates learning and teaching between students.

2.3.4 Is not-questioning inherent to the Culture?

We sometimes hear that even outside of class, children are quiet, docile, and obedient, because of ‘the Indian culture’ which teaches them to respect their elders and adhere to certain caste, gender, and class biases. For example, in a speech in 2016 on scientific temper in India, Hamid Ansari, former Vice-President of India, said:

In our family life, we do not approve of questioning. Most parents do not like children asking questions. In schools, from nursery to high school, teachers frown upon children raising questions. In colleges and universities, asking questions is often considered ‘cheeky’ and an attempt by the student to cast doubt on the knowledge of the teacher. The same holds good for social life. It is

considered 'disrespectful' to question an elder, a superior or a leader. (Ansari, 2016)

If teachers think children do not or should not ask questions, they may not encourage it. Research is required in order to find out whether the impression Ansari has stated is really correct, or whether children are questioning under certain conditions. Will students become talkative and start questioning if teachers are less authoritative, if the atmosphere is more relaxed, or under some other contexts?

In one study in the USA, teachers seemed to believe that their 7-8 year-old students were not 'good talkers' because of 'home influences', such as a poor socio-economic background, single parents, too much shouting at home, not enough discussion or use of 'good' language, too much time listening to TV and playing video games, etc. (Fisher & Larkin, 2008). However, in the same study the students reported that they were talkative outside of school but not in the classroom, and one reason the children gave was that they believed that the teacher does not like them to talk, or wants them to talk only at particular times, conforming to particular rules such as waiting to be called upon. Padma Sarangapani (2003) explains this authoritarian teacher-student relationship,

But in any case the school space is structured around authoritarian teachers and there is no mutuality between teachers and children. In this space, knowledge is represented (and experienced) as something to be received from authorities who deserve unquestioning deference and trust. (p. 214)

Educators (Kumar, 1989; Sarangapani, 2003) in India have expressed the general impression that children generally do not ask questions, especially to adults, because to do otherwise would be culturally unacceptable. Kumar (1989) argues,

Who has the right to ask questions and whose role it is to answer them, and what kinds of questions are supposed to be asked by whom, are related to the total cultural context of a society and to the conceptualisation of curriculum prevailing in its education system. Family norms in India do not encourage children to ask questions. Studies of adult-child interaction in Indian family settings indicate that questioning, criticism, and independent decision-making

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are not among approved and encouraged behaviours among children and youth (Narain 1964). Questioning someone older than oneself, such as a teacher, is certainly not an approved behaviour; it is perceived as an expression of one's disrespect for the adult's nurturant authority. (ch. 3)

It may be true that children's hesitancy to question adults is a general characteristic, and could therefore be called 'cultural'. But this begs the question as to why it is widespread or 'cultural'. And, more importantly, it leads us to ask whether by calling it 'cultural', the implication is that it is fixed and cannot easily be changed.

2.3.5 Does dominant ideology restrict questioning?

In their book, *Learning to Question*, Paulo Freire and Antonio Faundez (1989) discuss how the suppression of questioning is necessary in order to reproduce workers and reproduce the authoritarian ideology inherent in the capitalist mode of production. Paulo Freire says:

... work, as it responds to the demand for higher productivity in a capitalist setting, will be the more efficient the less workers ask questions, do not ask questions about themselves, and know little beyond the routine task assigned to them by mass production. ... Thus in the name of efficiency and productivity what we are seeing is the bureaucratization of workers' minds, consciousness and creative capacity. Brutalizing the workforce by subjecting them to routine procedures is part of the nature of the capitalist mode of production. And what is taking place in the production of knowledge in the schools is in large part a reproduction of that mechanism — although we could do the opposite. In fact, the more inventive and creative capacity of students is "brutalized", the more they are simply being conditioned to accept "answers" to questions which have not been asked ... The more students adapt to such a procedure, the more, ironically, it is reckoned that this is "productive" education. (p. 42)

They discuss how schools repress questioning by not allowing it or by "bureaucratizing" the act of asking questions. Antonio Faundez explains:

To find an example of this bureaucratized asking of questions we need look no further than the texts to which students are subjected. The questions are questions which already contain their answers. In that way, they are not even questions! They are answers rather than questions. Students have to know beforehand the answers to the questions they will be asked. On the other hand, if we taught them to ask questions, they would have to ask themselves questions, and creatively discover the answers for themselves — in other words, participate themselves in the process of discovery and not simply answer a particular question on the basis of what they have already been told. I would want to stress that education as it is consists generally in finding answers rather than asking questions. An education which consists in asking questions is, however, the only education which is creative and capable of stimulating people's capacity to experience surprise, respond to their surprise and solve their real fundamental existential problems. It is knowledge itself. (p. 40)

Faundez continues, explaining how questioning is risky, which is another reason why questioning is repressed:

The easiest way is precisely the pedagogy of giving answers, but in, that way absolutely nothing is put at risk. Intellectuals are almost afraid to take risks, to make mistakes, whereas it is the making of mistakes which enables advances in knowledge to be made. So in this regard the pedagogy of freedom or creativity should be an eminently risky enterprise. People should dare to take risks, should expose themselves to risk, as the one way of advancing in knowledge, of truly learning and teaching. I consider this pedagogy of taking risks very important, and it is related to the pedagogy of making mistakes. If we negate the negation, i.e. the mistake, this new negation will invest the mistake with positive quality: this transition from error to non-error is knowledge. A fresh mistake will never be a completely fresh mistake: it will be a fresh mistake in that the variable elements in it make it a fresh mistake, and this chain extends to infinity. If that were not the case, we would attain absolute knowledge, and there is no such thing as absolute knowledge. As Hegel said, the force of the negative is essential.

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*The force of the negative in knowledge is an essential part of knowledge, and we call it: making mistakes, taking risks, being curious, asking questions, and so on.
(p. 40-41)*

As discussed below (Section 2.3.6), we see some classrooms in which there may be a one-hour ‘question-and-answer’ period in the timetable, or, a question-box in the corner, or a particular assignment in which students are asked to ask questions. But why is it that student questioning is peripheral and bureaucratised?

2.3.5.1 Schools separate the hand and mind

In order to understand how and why schools suppress questioning we need to understand the objectives of education itself. Despite whatever the stated aims might be, we can determine the actual aims only by examining what goes on in schools. One of the most striking characteristics is that we see a separation of work with the mind from work with the hands. So-called ‘theory’ is emphasized and isolated from ‘practice’, which is separate, unimportant, and trivial. Intellectual activity is considered to be more worthy than physical activity. Most classrooms are hardly concerned with real-world activities, work, and everyday problems, despite some efforts to change this at the level of policy documents (NCERT, 2005), and even textbooks (Small science, 2019; Bal vaigyanik, 2019). Lectures and other didactic methods that require the mind (listening, remembering, thinking, reading) remain the dominant pedagogies rather than ‘learning by doing’, which requires the hands. The division between the hand and the mind, the material and the ideal, has also exacerbated the division between the real world and the artificial world of the school. In the real world, the two are inseparable. In Indian schools, hand-work is usually neglected. But even if it does occur, its connection with the mind work is problematic. Questions for investigation and problems for conceptual analysis do not usually arise from the work with the hands. This is obviously related to the caste structure of society, in which education is mainly aimed at upper castes, who delegate work with the hands to Dalit Bahujans (Ilaiah, 2009).

If questions are more apt to arise when the hand and the mind work in an integrated manner, their separation may inhibit questioning. If so, according to Paulo Freire’s definition of

human existence as an act of questioning (Freire & Faundez, 1989), this separation is a kind of alienation of people from their human nature.

2.3.5.2 Schools serve to maintain class structure

However, the division between hand and mind is not just a problem of caste, but also of class and the interaction between class, caste, creed, gender, and other forms of kyriarchy. It is related to the division of labour and class structure that is essential to capitalism. When formal education was developing in Europe at the beginning of the industrial revolution, it was not accepted by all intellectuals. Karl Marx (1887, ch. 14) writes how in manufacturing, capital is enriched by workers who use their hands without application of their minds, without reflecting or using their imaginations. He mentions that while Adam Smith advocated education in order to prevent “the complete deterioration of the great mass of the people which arises from the division of labour”, Adam Smith’s French translator Garnier objected:

Education of the people, [Garnier] urges, violates the first law of the division of labour, and with it 'our whole social system would be proscribed'. 'Like all other divisions of labour,' he says, 'that between hand labour and head labour is more pronounced and decided in proportion as society' (he rightly uses this word to describe capital, landed property and the state that belongs to them) 'becomes richer. The division of labour, like every other, is an effect of past, and a cause of future progress . . . ought the government then to work in opposition to this division of labour, and to hinder its natural course? Ought it to expend a part of the public money in the attempt to confound and blend together two classes of labour which are striving after division and separation?' (Marx, 1887, p. 484)

However, “the intellectual degeneration artificially produced by transforming immature human beings into mere machines for the production of surplus-value finally compelled even the English Parliament to make elementary education a legal requirement before children under 14 years could be consumed 'productively ' by being employed in those industries which are subject to the Factory Acts” (Marx, 1887, Ch. 15, p. 523). The children were required to produce certificates to prove that they had attended a school for a certain number

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of hours each week. To show the illusory nature of this 'education', Marx quotes an inspector:

In a second school I found the schoolroom 15 feet long, and 10 feet wide, and counted in this space 75 children, who were gabbling something unintelligible.' ... ' But it is not only in the miserable places above referred to that the children obtain certificates of school attendance without having received instruction of any value, for in many schools where there is a competent teacher, his efforts are of little avail from the distracting crowd of children of all ages, from infants of 3 years old and upwards; his livelihood, miserable at the best, depending on the pence received from the greatest number of children whom it is possible to cram into the space. To this is to be added scanty school furniture, deficiency of books, and other materials for teaching, and the depressing effect upon the poor children themselves of a close, noisome atmosphere. I have been in many such schools, where I have seen rows of children doing absolutely nothing; and this is certified as school attendance, and, in statistical returns, such children are set down as being educated. (Marx, 1887, Ch. 15, p. 524)

It is disturbing, to say the least, to note the similarity between this description and a large number of classrooms in India today.

But even in the 'best' of schools, what is it that children are actually being taught? David Harvey (2010, p. 147) discusses how one of the most things students are taught has been to learn to conform to a capitalist sense of temporality, including "a proper sense of time discipline". This is both a stated and unstated aim of education. In India it is historically related to colonialism. Colonisers would often complain that they could not get the indolent indigenous population to work a 'normal' working day - as defined by bells and whistles and definite starting and stopping times, with workdays of 10 or more hours. Marx describes how the regulation of work timings emerged as a result of class struggle, and is based upon the capitalist need to extract value as socially necessary labour time. Formal education thus plays an important role in the reproduction of the labour force. But what students learn about time is internalised - they learn to live by a sense of temporal discipline almost without even thinking about it. It is accepted without questioning, as if it were the only way to live.

It is not necessarily that someone has consciously designed schools in order to produce mindless, unquestioning workers. Rather, the need for such workers is inherent in the capitalist system, and when there is an educational system that happens to produce them, it is beneficial to the development of the capitalist system. A positive feedback develops in which this sort of education and capitalism reinforce each other.

Of course, this is not to say that education is not desirable or necessary. It is this particular type of education that is problematic. The point is that education does not have to be like this. Antonio Faurez discusses the advantages of alternative types of education;

Work is a creative process but, since the rationality of work is predetermined and with it the steps to be taken, workers are caught up in a process which is not educative and denies them any possibility of being creative. Think of the immense gain to human knowledge, the human sciences and society itself, if workers' creativity were given room to manifest itself. Even as it is, it does manifest itself, because workers sometimes solve problems' not foreseen in the way work is planned. But the rationality of work requires workers not to be creative. However, if it did allow workers to be so, it would be much more enriched through this capacity which workers have to be creative, particularly in the practical application of thought to actual situations. The whole rationality of work as propounded is in fact a rationality based on models. The great problem is the practical application of thought to actual situations. And in this regard the rationality of work requires workers not to respond creatively to the problems with which concrete reality confronts this abstract rationality. (Freire & Faundez, 1989, p. 41)

This underscores the connection between practice - work with both hands and minds - and creativity and problem solving. Creativity and problem solving cannot be confined to theory. They both depend on the recognition of problems, which requires questioning. Practice, questioning, problem solving, and creativity must operate in an interdependent, cooperative process, as opposed to a hierarchical process in which different people operate at different levels.

2.3.6 Studies on efforts to encourage student questioning

The reasons that students do not talk and ask questions are based not just on the nature of classroom discourse but also on the nature of schooling and educational system and its connection with capitalism. However that does not mean that nothing can be done to encourage questioning until the entire system changes. Education necessarily plays an interdependent role in making systemic changes. Educators can choose to either reproduce the dominant ideology or struggle against it. Investigating and understanding the system, its inner contradictions, and its interdependencies is one aspect of meaningful teaching/learning and education research that is needed in order to change the system. There are many ways in which students as well as teachers can and do begin to engage in questioning - including systemic questioning - even though the system represses it.

There have been efforts by teachers, educators and researchers to encourage student questioning using different ways. Here we will look at these studies, bearing in mind that researchers' efforts to encourage questioning depend on the reasons for the lack of student questioning, and as discussed above, we see many gaps in the research on the specific and basic reasons.

2.3.6.1 *Students working in small groups*

There are few studies (Barnes & Todd, 1977; Roth, 1994; Cifone, 2002) which look at questioning as part of collaborative group work, where questions emerge out of interactions between students and between students and physical staff.

As an alternative to both the typical monologic discourse by the teacher and the IRE teaching sequences between the teacher and the students, researchers have advocated the use of small group interaction as opposed to whole class interaction (Postman & Weingartner, 1971). One obstacle to learning is that students are confronted with a type of discourse in the classroom which is very different from the type of discourse they engage in outside of the classroom (Mehan, 1979). We wonder whether work in small groups allows students to engage in their out-of-classroom type of discourse, or whether they may adopt a monologic discourse style which is similar to that used by teachers. There are reports that small group work encourages dialogic communication in which, rather than just being respondents, students address and

respond to each other and share personal perspectives on particular topics (Haworth, 1999). In this work, Avril Haworth claims that the discourse which they observed in small group interactions is different from that of either normal monological classroom interactions or everyday conversation. She reported a tendency for a “playful, part-ironic engagement with language”. If this is to happen even when a teacher is present in the group, it may require the teacher to adopt a less authoritarian stance.

Although working in small groups of course encourages talk between students, there have not been many studies on whether it also encourages students to engage in questioning as part of their discussions, or whether this occurs in discussions without teacher participation. We hypothesize that student questioning and disagreeing are more likely in small groups. More research is required on this question.

2.3.6.2 Open-ended exploration and enquiry methods

Student questioning can be encouraged through enquiry methods and open-ended activities. However, as we noticed, the open-enquiry approaches in which students do their own hands-on work (Berg, Bergendahl, Lundberg, & Tibell, 2003) are usually not very open since the students are given considerable guidance in framing as well as answering their questions. The teacher is sometimes doing more enquiring than the students, who may be just trying to find what the teacher thinks the correct answers are. More research is needed to find out whether or to what extent students ask investigable questions, construct scientific methods, and find the answers to their questions without guidance from teachers, since some research indicates possibilities in this direction (Roth & McGinn, 1997; Roth, 1994). For example, Roth and Roychoudhury (1993) reported that when students were asked to define their own research questions in given contexts, they did do so, and were highly motivated. Without being explicitly taught, they also learned to use higher order science process skills to plan and carry out open-ended inquiries to answer their questions. Over a period of 14 months, their research questions became less broad, involving specific variables. However, Roth (1995, p. 127) has also written that asking students to frame their own questions was met with opposition from parents who expected the usual lecture mode of teaching.

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Research in science education is not unaffected by the social/political/economic climate of the time and place. Thus, many educationists are nowadays affected by a conservative backlash, and liberal and radical trends for ‘child-centred’, ‘activity-based’, ‘open-ended’ pedagogies which stress learning the process of science may be less favoured than ‘back-to-basics’ ‘teacher-guided’ pedagogies which stress remembering the content of science (Kirschener et al., 2007). Another argument against open-ended approaches is that they could be demotivating because students might find themselves directionless. They may fail to learn the scientific concepts and end up doing something which is not intended (Hodson, 1996). However, we question whether learning objectives should always be focussed on particular science concepts. When the intended goal is to reach the scientific concepts, the focus of assessing learning would be the child's conceptual understanding, where other learning outcomes are ignored. But it may not always be necessary for the teacher to define the learning objective beforehand or specify that students must ‘learn’ some particular concepts.

2.3.6.3 Using teacher-initiated activities

Open-ended inquiry methods may begin with various degrees of teacher initiation. Carolyn Keys (1998) has investigated the reasoning strategies that students use to create their own questions and design and carry out investigations to answer their questions. In this study, the students' projects were initiated by teacher-directed exploration activities – e.g. a demonstration which raised some open-ended questions. The students had also read and summarised some background information beforehand. Groups of students were then asked to frame research questions which they did either by modifying or extending the teacher-directed activity or by inventing their own questions in the same area, using the same equipment or materials. The author reported that students devised two different types of investigations: experimental and descriptive. While the former involved manipulating variables and exploring cause-effect relationships, the latter involved collecting data to describe the characteristics of the natural world. However, in our judgement, these two categories are not very distinct, and may not be very useful in practice. For example, given one student's question which the author categorised as descriptive, “How far can a voice travel?” the distance could be called the manipulated variable and the question could be seen as being experimental.

Another finding which was reported was that “The most important cognitive activities of the children during investigation planning focussed on transforming abstract ideas into physical objects and events” (Keys, 1998). We interpret her findings differently. The students began by observing actual objects and events in order to frame their mental ideas in the form of questions and hypotheses. The students did not translate semantic labels of the variables into physical objects, as the author concluded – rather the students observed variations (e.g. different materials they used as insulators) and constructed semantic labels for what they observed (manipulated variables). This sort of confusion points to the need for more study of how student questioning arises from their observation and manipulation of physical phenomena, and how their questioning affects their observation and investigation. Surely, questions do not just pop into students’ minds from their individual imagination. But it is not clear whether students require teacher-directed activities, or whether they can design and carry out their own activities in conjunction with their own framing of questions.

2.3.6.4 Teachers asking students to ask

Like Piaget (1923), Dewey (1909) recognised that it is important for children to ask questions and recognise contradictions and conflicts in order to learn. However, he realised that simply asking a child to ask questions - or to think - is futile. Children need genuine reasons in order to ask genuine questions.

Nevertheless, some research has been done that suggests that students’ reading comprehension can be enhanced if they are asked to ask various kinds of questions about the text (Koch & Eckstein, 1991; Pearson & West, 1991). Other research suggests that middle school students can be explicitly taught how to ask investigable questions by being shown examples and non-examples (Cuccio-Schirripa & Steiner, 2000).

Methods educationists have used to encourage students to ask questions include ‘guided cooperative questioning’, in which students are asked to formulate questions related to specific contexts using question ‘stems’ provided by the teacher, such as “What would happen if ... ?” or “Why is ... important?”. Alison King (1994) reported improved scores on comprehension tests when students worked in small groups to ask and answer such questions. Francisco Cano García, Garcia and Berben (2014) reported that similar methods resulted in

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improvements between pre- and post-intervention self-reports of metacognitive knowledge, self-regulation, and learning approaches. However, in both cases the students worked in questioning sessions which were separate from any activities, observations, or investigations, and they answered the questions by recall and reasoning. Although it was not reported, it is likely that many of the questions the students asked each other were not authentic questions, in the sense that the askers already knew the answers and were just quizzing their classmates. Also, rather than being concerned about whether or not students ‘acquire’ some particular ‘content knowledge’ or ‘comprehension’, we are concerned about whether students do science. Various methods to solicit student questioning have been criticised as leading to a ‘technification’ of learning in which students robotically follow formulaic procedures (Marton & Säljö, 1976; Arzi & White, 1986). We see a need for detailed analysis of questions students ask in settings which are more ‘naturalistic’. Most of the above studies focus on written rather than oral questions. They are also questions that are asked individually, rather than by a group of students. Because of this the types of questioning will be very different than what occurs in more informal situations.

2.3.6.5 *Through question boxes, postcards or letters*

One of the reasons why students do not ask questions inside class, is that they feel afraid of presenting themselves ignorant or being snubbed by the teacher for posing an ‘irrelevant’ or ‘stupid’ question. To overcome such a fear, a common strategy is to let students write their questions and put them in a question-box rather than verbally pose in the class. Post-card or post-box methods have been commonly used by educators to answer students' queries. A similar method was used by Homi Bhabha Centre for Science Education (HBCSE), Mumbai to conduct a programme in which students as well as any member of the public were invited to send their science-related questions and receive answers by postcard. There was an effort to avoid just giving matter-of-fact answers, but rather to guide and encourage the questioners to explore further for themselves. The collected questions were categorised and analysed (Wadadekar, Bhagwat, Modak, & Joshi, 1978). The questions were categorised according to the geographic area and age of the questioners and according to the distribution of questions in different subject areas. The researchers reported an eagerness amongst the public from both urban and rural parts of Maharashtra, to ask relevant, interesting science questions, This

is counter to the stereotypical perception that ordinary people, especially in rural areas, are meek, and do not have much tendency to question things. Even superstitions were commonly questioned.

Similar question/answer programmes by postcard or through newspapers or magazines have been carried out in different parts of India, and they have been very popular (Narlikar, 2001; Pal & Mishra, 2008). For example, in Madhya Pradesh, Eklavya conducted a “Sawali Ram” programme for many years in which people would send in questions by postcard, and they would receive answers in local magazines or by postcard (Joshi, 2007). In another program run by HBCSE for underprivileged children a large number of questions were collected from children through a box kept in the classroom (Kulkarni & Agarkar, 1985). Children would put their queries inside the box during each session. It was found that irrespective of being deprived of quality education, children posted a large number of questions. This indicates the natural curiosity of young children to ask questions.

Apart from India, there have been efforts by educationists to encourage student questioning using such methods. As an example, in a study by Cakmakci et al. (2012), researchers analysed Turkish primary children’s self generated questions posted to ‘Science and Children’ magazine and compared these questions with the questions collected from classrooms after students were asked to write a question that they wanted to ask a scientist. They found that in general children asked more questions related to the topic of biology with girls asking more biology related questions and boys asking more technology related questions. Furthermore, they also found that older students tended to ask more higher-order questions than younger students.

2.3.6.6 Using question stems

In order to encourage students to ask questions, some educationists have used ‘guided cooperative questioning’, in which students are asked to formulate questions related to specific contexts using question ‘stems’ provided by the teacher, such as “What would happen if ... ?” or “Why is ... important?” Alison King reported improved results on tests of comprehension when students worked in small groups to ask and answer such questions after teacher-led science lessons (King, 1994). The students answered the questions by recall and

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reasoning (and referral to books or other sources of authority), rather than by their own investigation. Although King calls this approach ‘constructivist’, the students are not doing experiments or other activities or making observations of physical reality in order to construct their ‘knowledge’. We think this limits its utility. If students get experience asking and answering their own questions through investigation, we believe that this may help them understand how science is done and it may also encourage them to do science throughout their lives (i.e. promote their scientific temper). This would be a more basic, and more important, learning objective than the aim of simply comprehending a teacher-defined ‘body of knowledge’. Nevertheless, it would be interesting to study whether teachers can suggest the use of question stems in order to help students ask more explicit questions while they are in the process of doing investigations of physical stuff.

2.3.6.7 Seating arrangement

In a study by Marx, Fuhrer & Hartig (1999), they found that when students were seated in semi circle arrangement, the frequency of questions asked by them increased in comparison to when they were seated in typical row and column seating. Researchers argued that in the semi-circular arrangement more students could interact or communicate with the teacher which resulted in increase in questioning. However, we wonder whether increasing interaction of students with teacher, really encouraged student questioning or there were some other factors? Also, we think, when given opportunities, students would ask each other many more questions than they would ask the teacher. More research is required to understand students’ question asking among themselves with lesser/minimised teacher interaction.

Furthermore such a seating arrangement may not work for a large class sizes of 50 or more than 50, which is very common for Indian classrooms. In Indian classrooms, reducing class size may be an obvious way to encourage student questioning.

2.3.6.8 Does answering encourage asking?

It is not clear whether teachers can encourage students to ask questions by answering their questions, or conversely by not answering. Researchers have given contradictory answers to

this question, perhaps because the number of students' questions is usually low in any case (Berlyne & Frommer, 1966; Ross & Balzer, 1975). These researchers have studied situations in which students ask factual questions for which the teacher can provide the answers. They also assume that a valid learning objective is that students hear and remember such answers. Whether hearing teachers tell the answers encourages students to ask more questions may also depend on whether students are in the habit of working individually or in small groups, competitively or cooperatively. Probably if a child's questions which are addressed directly to someone are continuously ignored the child will stop asking that person questions. But by supplying answers, a teacher may be inhibiting students from searching for their own answers. So a teacher may have to choose among answering, not answering, or choosing when to answer, after understanding the student and the context. However, research has not attended to these issues in greater detail yet. Furthermore, we have not seen any investigations of whether students' search for answers to their own questions (questions to themselves) encourages them to ask more questions.

2.3.6.9 Teachers' use of 'wait time'

'Wait time' is the term used to define the time for which a teacher pauses before and after a student responds to a teacher's question or statement. Rowe (1974) observed that teachers normally wait less than a second for a student's response after they had asked them a question or after a student has responded to the teacher's question. However, Rowe reported that when teacher's wait time is at least 3 to 5 seconds, students' engagement in the discussions increased with students asking a greater number of questions during discussions. Van zee (2000) report a similar observation regarding student-generated inquiry discussions, when a teacher consciously increased wait times and practiced quietness. However, with the teacher keeping quiet, teacher authority will be at stake, which may be a challenge within the existing education system. Further research, investigating the effect of 'wait time' on the distribution of teacher authority and dynamics of classroom discourse could be useful.

2.3.6.10 Teacher's model questions

Explicit strategies that have been suggested including direct teacher questioning to model student questioning, and dialogic classroom discourse (Alexander, 2008). Although some

have suggested such strategies (Alfke, 1974), it is not clear whether teachers' modelling of questioning is very effective. A number of researchers claim that, when teachers ask more questions in the classroom, this does not lead to increases in genuine dialogue or in the number of questions students ask (Hargreaves et al. 2003; Galton, Hargreaves, Comber, Wall, & Pell, 1999; Barnes et al., 1971). These researchers also claim that restricting questioning to teachers and discouraging student questioning serves to keep the teacher dominant and in control of the class. Whether question modelling is effective or not may also depend on whether the teacher's questions are authentic.

2.4 The need to understand the process of questioning and its role in doing science: Implications from philosophy of questioning and philosophy of science

In the previous sections, we reviewed some of the research done in student questioning and brought forth some old and emerging perspectives regarding student questioning. Here in this section, we will look at questioning from the philosophical perspectives which we think are quite important and have been relatively ignored by the researchers. Our approach will be in two parts

1. The need to understand the question-answer process: what does philosophy of questioning entail
2. The need to understand the role of question-answer process in doing Science: what does philosophy of questioning and philosophy of science entail

2.4.1 Need to understand the question-answer process

Although, some researchers (Dillon, 2004; Kearsley, 1976; Van der meij, 1994) have emphasised the need to understand the process of questioning and its role in learning specifically from the perspective of the learner, very few studies (Cifone, 2002) actually deal with such issues. Dillon (2004) argues that a question as a form or entity is the end product of a process, a process which starts with a percept (perception of something, a phenomenon or

proposition) and ends with the expression of question. Understanding the process would involve understanding the physical as well as psychological conditions under which questions arise and understanding the events of asking. This would help us in reflecting about the student-student discourse, student-teacher discourse, and the role of teacher and classroom conditions that can sustain student questioning. Furthermore it will help us in understanding learning in the process of questioning. Van der Meij (1994) in his review on questioning research has suggested that there is a strong need to understand the process of questioning in order to give student questioning a bigger role in education.

Dillon (1988a), while summing up about the issues concerning questioning in education, argues that in order to understand questions, there is a need to understand answers and the relation between questions and answers. In agreement, other researchers (Sinclair & Van Gessel, 1990; Barnes & Todd, 1977) have also argued that to understand questions and questioning, we must analyse and understand the answers or responses to those questions.

Furthermore, Dillon (1988a) argues that in order to understand all these issues, fields of philosophy and psychology could play a crucial role.

The overriding issue concerns the rising of problematic or genuine questions for inquiry. All fields stand in need of a persuasive account of how such questions come to be experienced, arise to mind, are formulated and expressed. Philosophy and psychology are promising, indeed essential, sources of such an account; yet none has been forth-coming. Philosophy of science should especially be able to contribute, and indeed requires such an account for its own purposes; yet analysis remains formalized where not mathematical, and restricted to logical and semantic relations. (p. 114)

However, the recent works on questioning especially student questioning have not yet explored the question-answer process both in formal and informal learning environments in any detail. As described in the previous sections, most studies focus on questions themselves rather than on the process through which questions get generated (Cifone, 2013).

Here, in our study, we will bring in an understanding about the process of questioning or the question-answer process, and its relation to the discourse and construction of knowledge from

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the ideas proposed by Michel Meyer. This will help in clarifying our criticism of student questioning research. Although, Michel Meyer does not explicitly relate his ideas to questioning in education, however his ideas on questioning seem very relevant to understand the process of questioning and answering. This will lead us to raise newer questions as proposed in the next section.

As said, in studies on student questioning, there has been a focus on the questions as products with questions being defined, categorised and analysed in isolation from their answers and from the discourse and the context in which questions emerge. Also there has been focus on producing 'certain' kinds of student questions, whose validity and meaningfulness is determined by the 'teacher' or the 'curricula' rather than by students or the particular discourse.

Furthermore, even in contemporary philosophy the role of the questioning process as a philosophising method has been sidelined. Michel Meyer (1995) argues that contemporary philosophy is based on the propositional model of reason where questioning has occupied a peripheral place and propositions or answers have become central. The very fact that the world is ever changing, means that the older experiences or assumptions cease to be true and get questioned. This is why Meyer thinks that questions rather than propositions are the basis of reason, thought and language.

Meyer (1980a) claims that to philosophise is to problematize. But historically, philosophy from the times of Aristotle, has shifted its focus from questions to answers. Meyer's theory of problematology, is derived from his interpretations of Socrates' dialogic questioning, in which Socrates challenges not just answers of his interlocutors but his own answers as well. This is in contrast with a common interpretation of Socratic questioning, where it is assumed that Socrates knew the answers to his own questions and was only trying to lead his interlocutors to his answers. The Socratic objective was to question authority. Meyer argues that with Plato and then with Aristotle, discourse shifted its focus from questions to propositions and answers. Meyer rejects the propositional model of reasoning and proposes an alternate model for reasoning based on questions and answers. Furthermore he claims that philosophy, science and language, all function through this model. Every discourse, whether

philosophical or scientific, involves language and progresses through dialectical interactions between questions and answers. Meyer (Meyer, 1988), rejecting the cartesian and neo-positivist epistemologies, argues that questioning is the only foundation upon which knowledge can rest.

This echoes with the Freire and Faundez's (1989) ideas of knowledge,

I would want to stress that the source of knowledge lies in inquiry, in questions, or in the very act of asking questions. (p. 37)

It's not that the ideas about questions and questioning, proposed by Michel Meyer are very new or rare. R. G. Collingwood, in some of his works first published in early twentieth century, had argued for rationality based on questioning. In 'An Autobiography' first published in 1939, Collingwood (1978) argued,

The Novum Organum and the Discours de la Methode began to have a new significance for me. They were the classical expressions of a principle in logic which I found it necessary to restate: the principle that a body of knowledge consists not of 'propositions', 'statements', 'judgements', or whatever name logicians use in order to designate assertive acts of thought (or what in those acts is asserted: for 'knowledge' means both the activity of knowing and what is known), but of these together with the questions they are meant to answer; and that a logic in which the answers are attended to and the questions neglected is a false logic. (p. 30)

Collingwood's ideas on questions and questioning and model of reasoning based on questioning quite resonate with Michel Meyer's ideas. Collingwood, like Meyer, argues that the meaning of a statement or utterance cannot be studied without studying the question (even if not explicit) in response to which it was uttered.

So unless we understand the process of student questioning, we cannot understand how students learn and create new knowledge.

2.4.2 Need to understand the role of question-answer process in doing science

Research in science education has not yet explored the relationship between the questioning process and the learning and doing of science and how such an understanding could help create better learning contexts for classrooms. Although, scientists, educators and science education researchers sometimes do acknowledge the importance of questions and questioning in doing science, but empirical work in this direction is lacking.

In our definition we see science as a method, a network of various interdependent combinations, orders and numbers of aspects or elements of a 'science toolbox' (Wivagg & Allchin, 2002). The various aspects or elements of the 'science toolbox' could include observing, asking questions, reasoning, justifying, hypothesising, predicting, arguing, experimenting, classifying, interpreting, comparing, evaluating, theorising etc. However, we see observing and questioning as more fundamental than other aspects and their presence being essential for the doing of science. Rather than trying to define a binary of processes which either are or are not science processes, we think it is more appropriate to talk about processes as being more or less scientific. For example, we may be acting less scientifically if we find answers by faith in authority and ignore observations of obvious physical evidence to the contrary. We may be acting more scientifically if we keep questioning our answers, modelling, making alternative hypotheses, and communicating collectively.

However generally in schools, a very orderly and systematized view of science, where doing science involves following certain well defined procedures, is projected. Students may have to follow a positivist 'scientific method' which is defined as having a particular set of steps in a particular order, and any deviation from these is discouraged.

But in actual practice science is much more untidy, unordered and unstructured in which processes are not just governed by some 'objective realities' but also by values, beliefs and relations of scientists among themselves as well as with society and with the state (Hodson, 1998).

Also, in science, more attention has been given to the answers than to the questions. The act of asking, the process of asking, the nature of questions and the relevance of questions (in terms of whose questions and questions for whom) has not been given due regard. Michel

Meyer (1980b) criticises such a positivist conception of science, where answers or results are seen as more important than questions and seen in separation to the process of questioning.

But, in classrooms, we project science more as a method of answering rather than a method of questioning. Also, people may define science as a body of knowledge, which is the product of the 'modern western science' done by professional scientists (Aikenhead & Ogawa, 2007). However, we claim that science is not just a body of knowledge, but a process - a process in which questioning is an essential aspect. Therefore we believe that science learning should not be focussed on remembering or understanding any so-called 'body of knowledge', but on doing the science process, which includes questioning. Schwarz (2009) described how in science classrooms, teachers' conceptions of science as a body of knowledge gets reflected,

As shown by several scientists that analyzed the language used in science classrooms (Lemke 1990 , Mortimer and Scott 2003), their implicit beliefs about science are reflected in their interactions with students in classroom discussions. Teachers commonly share the belief that science is constituted of a body of unequivocal and uncontested knowledge. As a consequence, interactions uncover control over turns, questions that invite short answers that are correct or not. In contrast, apprehending science as not being about absolute and certain knowledge induces more deliberative and dialogic talk in the classroom (Mortimer and Scott 2003). Adopting a new talk, more dialectical and dialogical, in the classroom is then not a matter of adopting a new vocabulary but assimilating new goals, and new epistemic beliefs. (p. 114)

Thus, in a view in which science is not seen as fixed or static, a dialectical and dialogical discourse could emerge, involving interactions between questions and answers in which one not just questions others' answers but also one's own answers (Meyer, 1995). According to Meyer (1980b) science is this process, a process of dialectical interplay between questions and answers.

The positivistic understanding of science does not describe the process of questioning, it only describes the process of answering (Meyer, 2010). What, how and why something is admitted as an answer is a function of justification of an answer or matter of logic (whether

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experimental or expository). Justification only tells about results but not about how they were discovered. Nor does it tell how and why questions emerge or get formulated in the first place or how newer questions emerge from older questions. It only describes the logic of answers but not the logic of questions. Meyer (2010) argues that, in a positivist view of science, research gets reduced to the justification process and to the matter of logic. But, in reality science progresses from questions to answers, answers which are both apocritical and problematological. The problematological nature of answers keep the inquiry open by giving rise to newer questions.

Such a theoretical model could be useful in understanding the progress of science: how new questions come about to be, how they get formulated and asked. However, empirical work on these lines, to understand science as well as science education is lacking.

We wonder whether it is this process of asking new questions, which results in knowledge creation or whether even without resolution of answers, knowledge could be defined as the process of questioning. In other words, rather than being a set body of knowledge, is knowledge just the continuous process of questioning and investigating.

2.5 Summary: Issues/questions that student questioning research needs to address

As we have discussed, there is a need for more qualitative, descriptive studies on student questioning. However, we can see that even though there have been several efforts by researchers to encourage, elicit or trigger students' questions, the picture regarding student questioning does not appear to have changed much in the last 30 or 40 years (Almeida & Neri de Souza, 2010). In India as well as in other countries, observational studies have reported that students are hardly asking questions in classrooms, and students very rarely carry on conversations in which they ask each other questions. Particularly in India, they are usually not even talking very much or carrying on conversations with each other as part of the main discourse. There may be differences in question asking behaviour depending upon class, caste, gender, etc, however research has not yet looked into such issues. So far it seems that either research has not had a sufficient effect on classroom teaching, or researchers have not

been able to raise important/relevant/fundamental questions about questioning in education (especially science education). As we discussed, probably both of these are giving rise to the present situation. It has been pointed out (Section 2.3.5) that there may be very good reasons why questioning is not really encouraged: questioning may be dangerous to the maintenance of capitalist society. If so, it would be convenient to have an educational system that does not encourage children to ask questions, despite whatever the stated aims of education may be.

More research needs to be done to study the disturbing questions: Do schools teach children not to ask questions? And while at school, do young children actually learn that the school-school game is not to ask but answer. Does schooling lead to a permanent change in children's question asking behaviour? Does questioning decrease with age, regardless of what happens in the classroom? Are some cultures inherently 'non-questioning'?

The importance of student questioning is widely endorsed in educational philosophies and pedagogies. However, as we have discussed, there is a lack of empirical studies to understand the functions and hence the reasons for student questioning in actual classrooms - and in student-student discourse. Also it would be interesting to compare the purposes of student questioning with that of teacher questioning to understand the dynamics of classroom discourse.

Student-student questioning is not well understood, and there is a lack of studies especially on their spontaneous questioning in more informal settings, at the level of middle-school and above. Students spontaneous questioning, being oral, could be live and more dynamic and can be helpful in investigating students' understanding and meaning making in greater detail.

As described (**section 2.3.1**), classroom environment in comparison to outside or home environment is very constraining such that the rules and norms of talk are rigid and controlled by the teacher. Researchers comparing school and home environments report that teachers in comparison to parents, do much more talking and maintain a control over the discourse. However, more research is needed to understand the relation between teacher quietness and student questioning. The home or outside classroom environment could be less constraining as children may have more agency in constructing the norms of the talk. As reported by Biddulph, Symington, & Osborne (1986):

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Suchman (1971) also commented on classroom environment with respect to children's inquiry. It seemed to him that when the environment was structured to reinforce success, achievement and visible end-products, as measured by external criteria and judges, children's genuine inquiry was inhibited. In his view, children's inquiry could develop only when children felt free to share their ideas without fear of censorship, criticism or ridicule. In short, the classroom environment should be naturalistic, not manipulative or judgemental. (p. 81)

We wonder whether, such an environment could provide students an agency to ask authentic questions and to control and guide their discourse. Or in a naturalistic environment without an adult, would children subject each other to censorship, ridicule, and manipulation - and not raise questions or engage in a dialogue? More research is needed on this question, in order to find ways of encouraging children to question each other in constructive, unoppressive ways.

As described, research has focused on engaging students in open-ended explorations or activities, whereby students explore the ideas or questions/problems presented to them by the teachers. However, we think perhaps students should be engaged in activities or explorations stemming from their own ideas and questions, whereby students initiate and lead investigations on their own. Such an approach will not just be open-ended but also what we call an 'open-beginninged' approach. The term open-beginning has been used by William (1998) and others (Greenes, 1997; Poddiakov, 2016) to define the openness of a problem/task in terms of its beginning state. According to them, if a problem is open for more than one interpretation by students or students have greater autonomy/freedom in interpreting a problem, it will be a more open-beginninged problem. Here we are using this term to define the autonomy given to the students to formulate their own questions and problems within a given context.

Categorisation studies focused a lot on lower vs higher cognitive questions although others have argued that such a differentiation is not very helpful in understanding questions as meanings of questions are very much discourse and context dependent. However we think, rather than encouraging 'better' or 'productive' kind of questions, we must enable our students to do critical questioning that challenges the status quo.

In addition to the above questions, based on our understanding of questioning and science, as described in Section 4, we would like to raise some important newer questions which have been neglected by researchers.

We see a disconnect between different research fields carrying out studies on questioning. In particular, science education research has failed to draw from studies in philosophy of questioning, in order to understand the dynamics of questions and answers in student-student discourse.

For a meaningful understanding, questions have to be analysed with regard to their responses/ answers and answers have to be analysed with regard to their questions. Also understanding questioning would require understanding social relations and the dynamics among interlocutors. So the researchers need to better understand how the dynamics of social power in a group affects the way questions are asked, understood and responded to.

Also, as discussed, questioning seems to play a crucial role in initiating and sustaining argumentation. However research on student questioning has not yet paid much attention to explore the relationship between student questioning and their argumentation. Furthermore, researchers have typically seen questions as individual acts rather than group or collaborative acts, thereby ignoring the argumentative properties of questioning.

Furthermore, questioning has been studied in isolation from different aspects of scientific inquiry. Specifically, science education researchers have not focussed on understanding the role of physical stuff in questioning and doing science. The process of questioning and its role in doing science has not been well understood as there has been more focus on answers than on questions. There is a need to try to understand the question-answer process and its relation to learning and the construction of knowledge.

3

Investigating Student Interactions to Understand Student Questioning: The emergent research design

In this chapter we describe our methods of recording, transcribing and analysing student-student and student-teacher discourse in classrooms and in informal contexts. We describe about the students and schools that we chose for our study. In the chapter we also discuss how our methods evolved as our study progressed. We list our research questions at the end of the chapter.

Our main objective in this study is to understand student questioning. In understanding student questioning, our immediate objective is not to find out how we can train students at asking certain kinds of questions, but to understand the dynamics of the process of questioning. Our main aim is not to categorise or quantify different types of questions, but to find various examples of questioning and try to understand how and why they occur in order to understand the process of student questioning.

In order to understand student questioning we needed to record students' questions. However, from our previous experience and according to the literature about student questioning, we were fairly sure that we would not find much of student questioning from inside the classrooms. In our experience, we had hardly even seen classrooms where students get opportunities to do activities and get engaged into discussions especially student-student discussions. So we wanted to find out that if they do not ask many questions inside the classroom with the presence of the teacher, will they be asking questions outside of the classroom in informal contexts, or when the teacher is not there, or when the teacher involvement gets minimised. Also, we wanted to record students' authentic questions which they would genuinely be interested in or curious about rather than the questions which the textbook or the teacher deemed or thought important. Furthermore, we were interested in understanding how students would answer their questions by designing and performing some sort of experiments on their own.

It was only afterwards that we decided to also observe questioning in science classrooms, to find out whether we were correct in thinking that students are not asking questions. For comparison, we also decided to look at some examples of teacher questioning in classrooms. Moreover, for whatever student questioning is there inside classrooms, we wanted to study how and why it occurs and how this can help reflect upon student questioning in informal contexts.

With these initial ideas, we wondered what methods we should use, how we should record and collect students' questions, their explorations, their experimentation, and how we should analyse the recorded data. Since we could not find much research on student questioning process, we had to come up with our own methods, which kept evolving and improving with the progress of our study.

So our research design is an emergent one, as described by Lincoln & Guba (1985), such that our frameworks, research questions, methods of collecting data, methods of transcribing and analysing data evolved with the progress of our study. This progression was not a simple or linear one but one having interdependencies between different aspects of our research. So our research questions evolved as our methods of analysis evolved and vice-versa. Furthermore, we do not claim to have acquired a 'specific design' with the completion of our study which could be useful for other researchers since only an emerging design could be useful for such kind of research. We started our study with some initial broader questions about student questions and methods of investigations, which evolved into more specific questions about students' questioning process with the progress of our study.

The initial motivation for our research methodology and for doing a naturalistic study in a qualitative paradigm came from Lincoln and Guba (1985). With the progress of our study and the kind of questions we were looking into, our focus shifted more towards students' spontaneous talk and conversation analysis methods. Though in our initial transcriptions, we did not refer to conversation analysis methods, but what we were doing was not very different. With some readings around conversation analysis methods (Roth, 2005; Ten Have, 2007; Wooffitt, 2005), we refined our methods of transcription and analysis.

As we transcribed and analysed student interactions, we understood more about our ways of recording and collecting data. The initial analysis helped us in improving our recording methods, improving ways of listening and transcribing, what to focus upon, what kind of

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interactions we were more interested in, refinement of our research questions etc. And this process was continuous.

The researchers also changed their interactions with students accordingly. After initial analysis, researchers realised that their talk, though it was minimal, interrupted children and presented the teacher/researcher as an authority. This led the researchers to be more quiet while observing and recording, allowing children to interact more directly with each other rather than with teacher/researchers.

3.1 Choosing the schools and students for our study

In order to understand student questioning, we have observed and analysed middle school students' student-student talk, their actions and their gestures. We chose to work with middle school students as they would have some experience of studying science as a subject in schools since science as a formal subject gets introduced from Class VI in schools in India. Furthermore, we were more interested in doing some everyday kind of science explorations with students which would involve less of abstract concepts of science, and middle school science content seemed to be suitable for that. In doing all such explorations with students, our main purpose was to engage students in talking among themselves and record and listen to that talk.

It is well understood that one's talk, actions and gestures are very much part of one's social and cultural sphere. So it becomes all the more important that we must let students express themselves using their own languages, if we wish to understand their meaning making and their thought process. With this in mind, we were inclined to study students talking in languages which they use both inside and outside the sphere of their school, that is their mother tongue. So rather than choosing English medium schools, we chose those schools where students conversed mostly in their mother tongue.

Our very first workshop, before framing of research questions for my PhD proposal, was with Marathi speaking children from Class VIII of **Shashtri Vidyalaya school**¹ nearby HBCSE. Shashtri Vidyalaya is a lower middle class government aided school with most of the students coming from nearby areas. The school is a semi English medium with textbooks of Science

1. In the entire thesis, as per the institute's ethical guidelines, we have used pseudonyms in place of the actual names of the schools, the teachers and the students.

and Mathematics in English medium. However, discourse in classrooms mostly occurs in Marathi. This school was chosen because it is close to HBCSE and that we could easily arrange logistics for conducting a teaching workshop at short notice with these children in our institute.

Since neither I or Karen could understand Marathi very well, we had to get the tapes transcribed from persons fluent in Marathi. These were Kranti Patil, Kalpana Sangale, Ankita Sawant and Swapnaja Patil, project assistants at HBCSE. But soon we realised that we have to ourselves look into the tapes sitting along with transcribers, as nobody other than us could better understand the nature and purpose of our study. Having more people who could understand not just the Marathi language but also the cultural nuances helped in transcription, translation as well as analysing the conversations.

We also realised that it would be better to work in Punjabi language which is my native language to understand the nuances of students' talk. Therefore, we decided to do the later workshops with Punjabi speaking students although Karen could not speak any Punjabi and could understand only a little. Also I chose to work in schools in Ludhiana because my home is in Ludhiana, and my family is still residing there and I am familiar with the schools and the community and the culture of the people living there. Since my father worked as a government school teacher for many years in different rural schools in Ludhiana, I had some idea about the culture of the schools and nature of their functioning. I wanted to use an 'insider method' (Kirpitchenko & Voloder, 2014) for both ethical and practical reasons. It would allow me to recognise and purposely consider my own identity and prior experience with regard to the students I am studying.

So we chose two rural government schools near my home town Ludhiana in Punjab. One of the schools is **Government Senior Secondary School, Fatehpur**, situated in the village of Fatehpur around 10 Km from the town of Ludhiana. This school is located on the outskirts of the village with large fields of paddy or wheat visible from the school terrace. The school does not have a playground in the campus, but the village ground, which is just opposite the school across the road, is used for school activities and games.

Fatehpur school has mix of students with students coming from both lower and upper castes. But the majority of students, more than 70 percent, come from lower castes and lower classes which also include children of migrant labourers from Bihar and Uttar Pradesh, settled in the

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village or nearby villages. All the children belonging to families of migrants are well versed in Punjabi and living in Punjab since their birth. The school has classes from 6th to 12th with classes 11th and 12th only for humanities subjects. Total strength of school is around 300 students with around 15 total teachers. Most of the students in this school come from Fatehpur village and Tibba village, nearby. There is a girls only Government Senior Secondary School near village Tibba with Classes VI to XII, which offers medical and non-medical streams to Classes XI and XII. So a lot of parents prefer to send their girl children to Tibba school instead of Fatehpur school. Due to this reason, Fatehpur school has less number of girls especially in higher classes.

The second school in Ludhiana where we did our interactions with students is **Government Senior Secondary School, Hazara** situated at about 20 km from the town of Ludhiana. My father got retired from this school as an English teacher in the year 2002. This helped me in establishing an easy connection with the school and knowing some basic details about the school even before visiting. Hazara is a large village with a population of over 5000. The school is fairly large with a total strength of students about 1000 for Classes VI to XII. More than 70 percent of children in the school come from lower castes and lower classes. About 20-25 percent of students belong to upper castes including those of land owning farmers and the business community. A large percentage of lower castes and lower class children studying in the school belong to migrant families from Bihar and Uttar Pradesh who have settled in Hazara and nearby villages. There is a total staff of about 51 with around 41 teaching staff and 10 non-teaching staff. Children studying in the school come from Hazara and a number of nearby villages. For classes XI and XII, school offers, science, humanities, commerce and vocational streams. The school has better facilities and amenities as compared to many other government schools. This school has its own big playground within the school campus (see **Figure 3.1**). If one comes out of the school's main gate and walk a few meters to the left side, one can see large paddy or wheat fields (see **Figure 3.2**). As part of our workshops with students, a few times we took students outside, near these fields, to engage them in various kinds of observations and explorations. School results are generally much better than the board results. Due to these reasons parents from even nearby villages prefer to send their children to this school. But the people belonging to middle classes or upper middle classes in the village mostly send their children to big private schools located in nearby villages and towns.

Figure 3.1 The playground area of Government Senior Secondary School, Hazara



Figure 3.2 Fields as seen from just outside of the Government Senior Secondary School, Hazara



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All the schools that we chose, were purposefully chosen to be rural or urban government schools or low socio-economic urban private schools. This is because we think these are the schools, which are representative of most of the schools across India. Furthermore, we purposely wanted to avoid working with more elite students since their educational problems are less urgent as they have much more class and caste privileges.

Apart from the above the three schools, I also did some classroom observations at **Krishna High School, Mumbai**. While assisting Himanshu, one of the research scholars at HBCSE, I along with Himanshu observed a few science classroom teachings of Class IX at Krishna High School between December 02, 2015 to December 10, 2015. Finding it interesting, I report one of the classes that I observed in this school in this study. Krishna High School is a semi-English medium, low socio-economic private school. The textbooks of science are in English medium, but classroom discourse occurs mostly in a mix of Hindi and English. However, students speak in Hindi amongst each other. The school is situated in a majority Muslim community area with most of the people living in crowded slums. The area is surrounded by India's largest dumping ground, the Deonar dumping ground.

For getting into the Ludhiana schools and doing classroom observations and workshops with students, prior permissions from the education department were required, which were obtained from the district education officer (DEO), Ludhiana. Furthermore, for video and audio recording students, prior consent and written permissions were taken from the parents of the students as all the students were minor.

3.2 Schedule of classroom observations and workshops with students

In this thesis we look at two kinds of data, one set of data comes from our observations of classroom teachings by the regular science teachers at the school and other set of data comes from various workshops that we did with students in the informal settings either at the school or at HBCSE. From April 2014 to February 2016, we did several observations of classroom teachings and workshops with students from the said schools (see **Section 3.1**) following the same students. These are summarised below.

Shashtri Vidyalaya School

- 3 day workshop at HBCSE from April 30 to May 02, 2014 with 11 Class VIII students
- One classroom teaching observation of Class IX (same students who came to HBCSE, now in class IX) on January 27, 2016
- One day workshop with same 11 students (now in Class IX) on January 30, 2016 at HBCSE

Krishna High School, Mumbai.

- Four classroom observations from December 02 to December 10, 2015 of Class IX.

Fatehpur school

- Two classroom teaching observations of Class VII on November 17, 2014 and November 18, 2014
- 4 day workshop with Class VII students at Fatehpur school from November 26, 2014 to November 29, 2014
- One classroom teaching observation of Class VII students on January 02, 2015
- 6 day workshop with Class VIII students (same students who were now in Class VIII) between May 21, 2015 and May 28, 2015

Hazara school

- Three classroom teaching observations of Class VII between November 15, 2014 and November 18, 2014
- 4 day workshop with Class VII students between November 20, 2014 to November 25, 2014
- One classroom teaching observation of Class VII students on January 01, 2015
- 6 day workshop with Class VIII students (same students who were now in Class VIII) between May 13, 2015 and May 20, 2015
- 2 day workshop with same Class VIII students from February 15, 2016 to February 16, 2015

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3.2.1 Classroom observations

The main purpose of doing classroom observations was to understand the process of student and teacher questioning inside the classrooms. Understanding the dynamics of the classroom questioning process helped us in reflecting about the dynamics of the process of student questioning in informal contexts. Furthermore, by providing actual examples student and teacher questioning of Indian classroom contexts, this study reduces the dearth of such research.

Though we did several classroom observations in the said schools, not all involved regular teaching. For example, at Hazara and Fatehpur schools, all the classroom observations that we did in November 2014 and December 2014 were revision classes as teachers had already finished the prescribed syllabus for the term. Generally government schools in Punjab get instructions from the Education Department on the month-wise division of syllabus, which includes which chapters to be finished on which months and time limits for finishing the syllabus and doing the revision work. Mostly teachers finish the syllabus earlier than required and do more revision so that students can learn all the question-answers of the textbook.

3.2.2 Workshops with students

In our workshops, we tried various explorations with students. Generally these workshops were 2 to 6 days long with 1-2 hours long sessions each day. For Ludhiana schools, all our workshops were conducted in the school and within the school hours. In all the workshops, researchers acted as 'teachers' and the regular teacher was usually not present there. We preferred for the teacher not to be there so that the students would talk more freely to each other, rather than being very quiet and 'well behaved'. However, in a few classes, regular teachers sat on their own and in one of the classes we asked teachers to participate in discussions on student questioning.

For all the workshops Karen and I would sit together and have discussions about our plans prior to conducting the workshops. We would come up with a rough plan of what to do and how to do it. Since our plans were centred around students fiddling and manipulating with the stuff, our focus was in choosing the kind of stuff which could engage students. Also, we wanted to have kinds of activities which students might find curious or contradictory. With rough ideas about the activities, we would list and arrange possible materials required for

doing activities with students. Most of the times we would first ourselves fiddle with stuff and reflect upon our own questioning and investigating. This helped us in understanding how students might respond to those activities and what kind of logistics we would need to do in order to conduct those activities. Many a time we had ideas of doing some activities, but upon discussion amongst us or after we ourselves had tried performing the activities, we did not select the activities to be conducted with students. For example, we thought of doing something around reflection with students and we tried fiddling with plane mirrors. But we observed that the kind of activities we were thinking about, might not engage students in spontaneous discussion. Also it seemed that students may not be able to fiddle much with the mirrors and may require more of teacher intervention to get engaged.

Our workshop plans were mostly flexible which kept changing and evolving with each day of our interactions with students. After each day of interaction we would sit together and reflect upon what happened during activities. We would also look at video recordings of the day to understand what happened on the day and what kind of questioning, discussions and investigations occurred. Most of the times we had to change our next day plans accordingly.

During all our first workshops with students we conducted warm-up activities with students in order to encourage the students to freely converse with each other. In these warm up activities we along with students played some kind of games after brief introduction with each other. We played the game in an effort to become relaxed and talkative and let students get accustomed to the cameras. For example, in one of the games that we played with students, each person (students and researchers) took turns to go off behind some bushes or out of the room and change something in their appearance (e.g. move a watch from the right to the left hand), and then the others would observe and discover the difference. The games were played in a fairly non-competitive manner, without mentioning winners or losers. Generally, there was a lot of laughter and the students did become talkative and playful.

In all the workshops our main purpose was to record students' talk as they explored different physical stuff or performed some tasks or activities while working in groups. Though initially we were more interested in science (or inquiry) questions but soon we realised that there are lot of other questions which are equally important in the discourse and cannot be seen separate from science or other kind of questions. Our initial plan, in the very first workshop held at HBCSE, was to note down students' questions as we heard them, talking and exploring, and then to present those questions to students for further investigations. After

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watching videos we realised that there are many more interesting and different kinds of questions asked by students than what we had noticed and noted down during the session. Also, our interest grew more and more in students spontaneous talk and spontaneous questioning, realising that investigating and answering was not separate from their questioning. So our workshops were planned with a purpose of giving maximum opportunities for students to talk as they did various explorations or activities in groups.

Some of the activities or tasks that we tried out with students during the different workshops are listed below:

- Let students observe a variegated bhendi tree by bringing them near the tree without any prior instructions
- Let students observe and play with an inflated and non-inflated balloon in groups
- Let students fiddle and play with different kinds of magnets and different pieces of iron, aluminium, plastic etc. in groups
- Let students observe and explore about ants in the playground of their school using different food items
- Let students observe and explore the free fall of various kinds of objects
- Let students make paper parachutes in groups
- Bring various kinds of flowers and leaves into the classroom and let students classify them into categories of their own
- Let students play in pairs a game of passing one magnet through a path (which students have first drawn for each other on A4 sheets) by using another magnet and without touching the first magnet
- Let students work in groups to explore various pieces of cloth of different textures, different colours and different knittings using water, scissors, lenses etc.

The purpose of recording student talk while they worked in groups was to look for any instances of questioning among themselves and understand the dynamics of the process. At times we also asked them to list questions of their groups in writing on A4 sheets. In some of the activities we also asked them to investigate one of their questions that they asked in their

group, by planning and doing some kind of investigation. However as we started analysing the tapes and other data of students' work, we got more interested in understanding the process of questioning among students. Thus our interest grew more and more into students' spontaneous talk in their groups.

3.3 Data reported in this study

We were not interested in conducting a survey in order to identify and/or find the frequencies of different kinds of questioning. Rather, we wanted to record lots of talk, both in classrooms and in informal contexts, so that we would have a large database from which we could select particular episodes to analyse in great detail and depth in order to understand the questioning process.

From the video and audio data of classroom observations and workshops with students, we transcribed only selected recordings in detail. And this is the data that we have analysed and reported for this study. Since we transcribed data using conversation analysis methods, even a small video of few minutes generated huge amount of data requiring several hours and sometimes several days for just transcribing. For the scope of this study, we identified the relevant and interesting parts of data and then transcribed only those parts in full detail.

For the classroom data, we selected three classrooms of the three different teachers from the three different schools and transcribed those recordings in complete detail. For choosing these three recordings, we watched and summarised all the recordings of the classroom observations that we had done. From those recordings we selected the ones which were being taught by the regular science teacher, and in which the teacher taught the topic for the first time (rather than revising some previously taught topic). Thus from the total of 12 classes that were recorded, I ended up transcribing three entire classes of about 25 to 40 minutes duration each.

The workshop data that we collected involved different kind of students' work like,

- Students having discussions with the teacher as teacher demonstrated something
- Students exploring some stuff and having spontaneous discussions in the group
- Students writing questions in their groups
- Students planning experiments in groups after they select a question to answer

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- Students performing experiments in groups

As described, with the progress of our study, our focus mainly shifted to students' spontaneous talks in groups as they explored some stuff or performed some activity. In our later workshops, we planned more time for students' spontaneous talks in groups. Also the kind of activities or stuff we chose, were such that the students could get engaged in some sort of discussions on their own without involving teacher. So for these reasons, we chose some simple the kind of stuff that might not be alienating for students and also at the same time might make students curious.

For the workshop data, we noted and summarised the parts of recordings that involved student-student spontaneous talk as they explored some stuff in the group. While summarising the recordings, we marked the relevant sections of the videos that needed to be transcribed in complete detail. The total data, from all the workshops, comprising student-student spontaneous talk was about 12 hours. However, not all of this data was relevant. Data that was not transcribed included the following: students doing individual explorations and not talking much, students' voices not audible or of poor quality, camera/s shifting between more than one group in short intervals of time and missing important parts. In order to select recordings for transcription and analysis, we made sure that they should represent the following:

- Different groups of students, including both girls and boys (usually in separate groups, as discussed below)
- Different kinds of topics, stuff, activities, context or setting
- Continuous discussion among group members at a length at least for 15-20 minutes
- Less or no involvement of teacher

So for the purpose of this thesis, we transcribed and analysed three selected recordings from the workshop data that we found most relevant for our study. Each hour of students' spontaneous talk that we transcribed, generated about 1200 utterances.

3.3.1 Classroom Observation data reported in the study

As said, in this study, we report our observations and analysis of 3 different classrooms. The analysis of this classroom observation data is presented in **Chapter 4**.

3.3.1.1 Shashtri Vidyalya class

This is Class IX that we observed on January 27, 2016 being taught the topic of work and energy by their regular science teacher. I and Karen sat on the back of the class and audio recorded the class using two audio recorders one placed in front and one towards the end. We also took written notes of our observations during the class. There were 54 students sitting in the overcrowded classroom with 23 girls and 31 boys. Most of the students, who had participated in Variegated tree sessions at HBCSE, two years previously, were present in this classroom. The entire class recording is of about 25 minutes.

3.3.1.2 Fatehpur school class

This is Class VII that we observed on January 02, 2015, being taught by the regular science teacher. The teacher was discussing questions from the chapter ‘Story of Waste Water’ in their science textbook. The class was video recorded by me using one camera kept in the front. I also took some written notes. There were a total of 18 students present in the class with 13 boys and 5 girls. This class was about 38 minutes long.

3.3.1.3 Krishna high school class

This is Class IX that I and Himanshu observed on December 03, 2015 being taught the topic of solid waste by their teacher. I and Himanshu sat in the back of the class and audio recorded the class using one audio recorder placed on the bench on which we were sitting. There were around 35 students sitting in the small sized classroom with 13 girls and 22 boys. This class was about 28 minutes long. Both Himanshu and I took written notes of our observations as well. The teacher teaching this class was a Teach For India (TFI) fellow on a 2 year fellowship. This was his second year in the school.

3.3.2 Workshop data reported in the study

As described above in this section, from the workshop data, we transcribed and analysed three selected recordings involving student-student talk. The context of the three recordings that we have transcribed and analysed for this study is described below. The analysis of these recordings is presented in **Chapter 5, chapter 6** and **chapter 7**.

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3.3.2.1 Exploring the variegated tree

This data is part of the first day of our workshop that we did with students of Shashtri Vidyalya school, Mumbai, from April 30 to May 02, 2014 at our institute. The complete workshop was divided into 7 sessions spread over three days. The plan was to first bring students near the variegated bhendi tree (*Talipariti tiliaceum*) in the garden of HBCSE and let them observe and talk without telling them or instructing them in any way. The sessions were planned as following:

Session (1) to let students' observe and discuss about the tree while researchers would notice their questions and write those questions on A3 sheets; Session (2) to post the questions in the classroom of our institute and ask the students how they might find answers to their questions (we also wanted to find out whether they would mention aspects of the science process without us telling them); Session (3) to ask the students to categorise their questions according to how difficult or how long it might take to find answers; Session (4) to ask small groups of students to choose one of the posted questions and write plans for how they will investigate it; Session (5) to let the students go back outside and conduct their investigations, and record their data; Session (6) to ask the students to come back inside and write reports of what they did; Session (7) to present their investigations to each other and discuss the findings. The data that we present from this workshop is 48 minute long session 1, involving students' observations and discussions about the tree. Before the session 1 on day one with the students we had played a warm-up activity for about half an hour with the students in another garden to let them get used to the camera and the environment.

This workshop was conducted in the summer break when the students had just completed Class VII. They were all 12-13 years old. The students' science teacher had already covered the topic of photosynthesis and chlorophyll in Class VII. None of the students had their own phone or home computer, and only a few had occasional access to the internet. After an open invitation to all the students of one section of Class VII (randomly chosen), six girls (Priya, Tanya, Ishita, Kavita, Trupti, and Janvi) and 5 boys (Nimish, Keshav, Hemant, Binod, and Suraj) obtained parental permission and attended the workshop.

Five researchers acted as teachers and as observers throughout: Gurinder, Kranti (Project Fellow), raised in a Maharashtrian village 3 hours from Mumbai, with degrees in agricultural sciences, Rafikh (a PhD student), raised in a small village in eastern Maharashtra, Karen (a

faculty member), from the USA, with a PhD in Biophysics and 30 years experience in science education in India, including about 10 years as a teacher of school students and/or teachers, and K.K. Mishra (HBCSE faculty and co-guide) from northern India, with a PhD in Chemistry. The cultural diversity of this group is notable, as indicated by the various places of origin, gender, caste, class, language, and religious backgrounds, and it is significant that only one of the researchers come from upper caste backgrounds, and at least three of us are from lower-middle class backgrounds.

Throughout, students spoke mainly in Marathi, which was the mother tongue of all of them. They were also able to understand, and to some extent speak in Hindi, but they were not able to converse in English. All researchers were fluent in Hindi and English, but only Kranti and Rafikh were fluent in Marathi (their mother tongue). Since we wanted to observe students interacting and conversing with each other in their mother tongue, we did not try to speak to them in English, and at first we did not say much in Hindi either. Researchers who could speak in Marathi (especially Kranti and Rafikh) did much of the talking with the students in the workshop. Our use of Marathi probably helped to somewhat lessen the power relations between us and the students. In hindsight, we think the researchers should probably have refrained from speaking in English to each other as well in front of the students since this emphasized our position of dominance and interfered with the students' conversations.

We chose to focus upon an ornamental shrub, variegated bhendi (*Talipariti tiliaceum* - formerly *Hibiscus tiliaceus*) in the garden of our institute due to its unusual look, which has leaves of various colours: completely green, completely white, white with asymmetrical patches of green, red, red with white and/or green, various shades of yellow and brown, and white with yellow patches (**Figure 3.3**). Knowing that leaves need chlorophyll in order to do photosynthesis to make food, and that the presence of chlorophyll is indicated by the green colour, we wondered how the white leaves could survive. Therefore, we thought that this tree might be an interesting context that would encourage students to ask such questions.

As said, initially we did not give any instructions to the students and just asked them to come closer to the tree. However as students observed and explored the tree, we planned to give them a set of instructions at different times during the complete activity of observing the tree. These set of instructions in chronological order are given below:

Figure 3.3 The variegated bhendi tree with leaves of various shades and colours



(1) The teachers (researchers) call students to the place near the tree, saying only “Come here”, otherwise not talking to the students.

(2) The teachers start looking at the tree so that the students get interested in the tree.

(3) The teachers start asking the students to look at the tree, with ambiguous exclamations such as, “Oh! look!”

(4) The teachers ask the students to ask questions about the tree.

The purpose of giving these instructions was that we wanted to observe 1) whether students would ask questions without being asked to ask or even asked to observe 2) Or if they would need some kind of explicit guidance or cues in order to ask questions.

3.3.2.2 Making paper parachutes

This data is part of the day five of our 6 day workshop that we conducted with Class VIII students of Government Senior Secondary School, Fatehpur in Ludhiana between May 21,

2015 and May 28, 2015. This 6 day workshop was mainly focused around activities related to free fall of various kinds of objects. On the very first day of this workshop, without telling students anything about what we are going to do, we started by demonstrating the free fall of a paper and a book. First we dropped them for few times separately and then dropped them together, with the paper kept over the book. The whole class sat on a mat on the floor of a big hall room and observed. The plan was to create some contradictions among students' thinking and engage them in some spontaneous talking without giving any prior instructions. As the workshop progressed we dropped various kinds of things like pieces of paper, nails, pen, paper board etc. so that the students could compare their fall. In all these activities the teacher tried to be quiet and let students observe and talk amongst each other. We also asked students to drop things on their own in groups and discuss and write their observations and questions in groups. We also asked them to perform an activity of dropping a sheet of paper and do something to the sheet so that they can make it fall slowest.

On day five of the workshop, we gave students the task of making paper parachutes using two A4 paper sheets to students. There were 20 students (19 boys and 1 girl) present out of total 22 students (20 boys and 2 girls) in the class on that day. Students were divided into 6 groups of either 3 or 4 students to perform the task of parachute making. All the conversations, either among students or students and teacher researcher, happened in Punjabi. For the entire task we focused on two groups using one audio recorder and one video recorder for each of the groups. A third video camera was also employed, which was randomly moving between different groups. All the groups worked in a big hall room, a multi purpose room, sitting on the mats on the floor of the room. This way of seating students on the floor was much better than students sitting on tables and chairs as students could interact better within their groups. Initially we tried doing group work inside classrooms but it was difficult for students to interact and do some hands on work while being seated. The benches were meant for seating 2-3 students with seats and table fixed on a single bench (see **Figure 3.4**). So we had purposefully moved away the chairs and tables from the room. The data that we have transcribed and analysed and included in this study involves the conversations of one of the two groups that we focused upon, comprising of three boys, as they planned and made their parachute. It's about 24 minutes of audio and video recording of the group.

I was the only teacher researcher present who interacted with the students for this task. However, the students' science teacher was also sitting in the room for some time, busy doing

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her own school work.

Figure 3.4 Students doing group work while being seated on benches inside classroom



Apart from me and the students, an assistant to help for video recording was also present in the room.

Students were initially explained the task, which was to design a paper parachute using a maximum of 2 A4 paper sheets, and scissors, thread and glue. Students were also told that after making their parachutes, they would have to test their parachutes and come up with their own ideas to test and compare their parachutes with each other's group. This whole activity lasted for about one hour. The data we report here is for the time for which one of the groups of three boys (Gurpreet, Jaskaran and Gurdeep) sat together, discussed, planned, designed and made the parachute (**Figure 3.5**).

Figure 3.5 Boys making paper parachute



3.3.2.3 Observing ants

This data is part of day one of our 2 day workshop held from February 15, 2016 to February 16, 2016 with Class VIII students of Government Senior Secondary School, Hazara. This workshop involved an activity of observing ants by students by using some food items. On day one there were 26 students (12 girls and 14 boys) present from a total 32 students (16 boys and 16 girls) in the class. The complete activity was divided into 3 sessions. Firstly students were brought into the playground of their school from their classroom and were gathered around the assembly stage in the playground. In the session 1 they were asked to find out places in the playground where there are ants. Upon being asked this, many of them actually responded by telling some places of ants. They were then told to look for all possible places of ants in the playground. Within 5 minutes, students found 4 places, where ants were there in the playground. All the students were then called back near the stage and were then explained the task for the session 2. The task for session 2 was to observe the ants and notice ants behaviour using different food items. For this task, students were divided into four

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groups with two girls groups of 6 students each and two boys groups of 7 students each. We just told them the number of students that should be there in a group, groups were formed by the students themselves. Mostly boys and girls would form separate groups. In our initial interactions, we did try forming some mixed groups, but it did not work out very well as boys and girls would work separately rather than in the group. After the group formation, we gave jaggery to the students of each group and asked each group to occupy one place where they saw ants. We purposely gave these brief and vague instructions so that the students could carry the assignment in various directions. Besides being open-ended, it was also open-beginninged in the sense that the students could define their own questions for investigation. Apart from jaggery, we had sugar, honey, butter, mustard oil and pieces of roti, which we gave to them later on. Karen and I each held a video camera in our hands and followed two groups, one of boys and one of the girls. For each of the two groups we also had put an audio recorder around the neck of one of the students. The session 2, lasted about 33 minutes. For the 3rd session, students were again called back near the stage and teacher researcher did discussions with the students about their observations of ants. For this study, we have transcribed and analysed the session 2 of 33 minutes of recordings of the group of 6 girls' (Disha, Kuldeep, Harmanpreet, Simranpreet, Sukhdeep and Manpreet) which was being followed by Karen. This group of girls observed ants moving in and out of an ant hole near the bottom of the trunk of a tree while sitting and standing around the hole (**Figure 3.6**). This tree, a Peepal tree, was on one side of the playground and hardly having leaves at that time of the year as seen in the **Figure 3.1**.

3.4 Methods of recording and collecting data

We recorded and observed students by videotaping, audio taping, taking notes, collecting students' work and taking pictures and photographs. For our very first workshop with students (exploring variegated tree) conducted at HBCSE, we used two handycams and one DSLR camera for video recording student interactions. This workshop involved recording students both in the out of classroom contexts (in the garden of HBCSE as they observed and explored variegated tree) and inside the classroom contexts. Most of the time video recorders were used simultaneously, focussed on different students or on the same group, but from different angles.

Figure 3.6 Girls observing ants while sitting around ants hole



But we did not realise the poor quality of the video recordings while we were recording and it became apparent only after we began viewing the recordings after the first day of our interactions. There were several problems with the recordings:

- (a) There was a lot of background noise, especially in the outdoor sessions, due to traffic noise.
- (b) Because of the distance of students from the camera in some episodes, the volume of the speakers was too low. In order to have a greater field of view, the camera was sometimes too far away. The more useful videos were recorded at about 1 metre from the students.
- (c) Some students tended to speak at lower volumes than others (sometimes even whispering to each other behind their hands).
- (d) Different students and different groups of students tended to often speak at the same time.
- (e) Researchers sometimes talked to each other over the voices of the students speaking at the same time (and their voices were louder since they were holding the cameras).
- (f) Researchers talked too much, often interrupting discussions between the students or not allowing a long enough wait time to allow students to speak more.

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(g) The students were constantly moving around in the outdoor sessions, so it was difficult to keep track of them.

(h) It was difficult to decide whether to film the students talking or the things the students were looking at and doing with their hands.

(i) The researchers who were filming often got distracted by what the students were doing and saying and forgot to pay attention to the filming, letting the camera film some less significant aspect (such as feet or headless bodies).

(j) Since some of the researchers who were filming were not able to understand the language of the students speaking, they may have missed important dialogues.

(k) Based on previous work videotaping other workshops, we purposely made several short videos rather than one continuous video. This was because we had previously had difficulty manipulating large video files. But now we found that it was difficult to chronologically organise the videos and find particular episodes.

After some reading around video and audio taping students' work (Roth, 2005)(Roth, 2005) and discussions amongst us, we took different measures to overcome the problems that we faced in video recording the students' work. One of the most useful changes was to use at least two voice recorders in addition to the video cameras. First we tried holding or placing a voice recorder on the table near a group of students which was also being video recorded at the same time. A further improvement was to hang a voice recorder around the neck of one of the students from the group. This allowed us to record the conversations even when the students of the group were moving around.

Also instead of recording several short videos, we preferred to record longer videos at least capturing continuous work of a particular group and the longer videos turned out to be more convenient at the time of data analysis.

Furthermore, we would identify at least two groups in the very beginning, which seemed interesting to us and focus entirely on the work of the two groups rather than randomly shifting between groups. This way we were able to track audio of at least two groups for the entire period of their work. Later on, for some of the recordings, we superimposed audio from audio recorders over the video recordings as audio from audio recorders was much more audible and clearer.

Also there were problems with recording several groups working inside a classroom, especially in small classrooms, as it would be too noisy to listen to conversations of a particular group. So either we chose a big hall room for our interactions or we did our interactions in an open space. In the village schools recording outside was comparatively better as there was hardly any traffic or other noise from outside the school. Also at times we tried recording one or two groups, which we found more interesting, by making them work in a separate room so that their conversations could be heard clearly. Other researchers (Barnes & Todd, 1977) have also reported similar kinds of technical problems in audio and video recording students' spontaneous conversations inside or outside classrooms. They describe the difficulties of transcribing data where multiple speakers talk at once, and of attributing names to speakers when voices are very soft or speakers faces are away from camera or their faces are not captured in the camera.

Another major change was that we became much more conscious of our own talking to each other, and we tried to minimise it. We also tried to talk less, and interrupt less, in order to allow the students to speak more, since it was their talk that we were interested in. Those of us who were not very fluent in the language the students were speaking were actually at an advantage here, since it was easier for the researcher to keep quiet, and even the students sometimes spoke less to us than to each other, thinking that we could not understand them.

Furthermore, in the case of the Ludhiana schools we had first visited few classes to informally talk to students and then to video record their classroom teachings before doing the workshops with them. This led the students to have some familiarity with us and the recording equipment.

For the group work, generally groups were formed with the teacher/researcher telling the number of students that should be there in a single group with students choosing the group members on their own. Initially we tried making groups completely according to our interest, but students would not stick to those groups and they would separate out.

3.5 Our methods of analysis

We analysed the data using Conversation Analysis methods (Roth, 2005; Ten Have, 2007; Wooffitt, 2005) in which we tried to analyse how social meaning was constructed through the conversation, activity, gesture, and interactions between people as well as between people

and the environment (e.g. the variegated bhendi tree, the ants, or whatever stuff was present). We included ourselves as well as the students as subject/object of study, analysing the effects of power relations and differences between the students' and researchers' perceptions and understandings. We tried to understand and interpret students' meaning, reasoning, intentions, emotions, and signs of doing science or exhibiting scientific temper, concentrating on the progression of the group conversation rather than analysing the utterances of individuals in isolation. We were always trying to understand what is it that makes a question a question and why students were asking questions. We tried to look at the connections between doubt, confusion, contradictions and questioning.

3.5.1 Transcribing the data

We used the audio and video recordings for an extensive transcription, translation from Marathi and Punjabi into Hindi and/or English, and as well as directly for analysis. Most of the transcription work was done by researchers themselves as they were better aware of the research questions and what to focus upon in the recordings. Also since researchers were present during the recordings, they knew about the events or episodes of recordings and it helped in the process of transcription. This also helped in analysing and marking important sections of the transcriptions during the transcription process. Even if initial transcription was done by others, researchers sat with transcribers and kept going back to the original recordings in order to revise the transcriptions and better understand their meanings. We have to hear tapes repeatedly several times even to produce the first set of transcriptions.

We used 'Easytranscript' software, a free software available online, to transcribe the tapes. The software provides easy typing at the same time while listening repeatedly to each section of the tape. From the initial set of transcriptions, we kept refining our transcriptions as we looked at tapes over and over again and got better understanding of students' interactions and their work. For our very initial transcriptions from the variegated tree interactions, we had to struggle a lot to hear, transcribe, translate, and analyse the tapes. Sometimes we spent an entire day listening to one minute of the recording. As described the quality of these recordings was very poor. However, with improvement in our recording and transcription methods, we spent comparatively much less time for our later transcriptions. Furthermore, as later on recordings were in Punjabi and I could understand Punjabi language and its cultural aspects, I could understand the nuances of the conversations. With these our transcribing

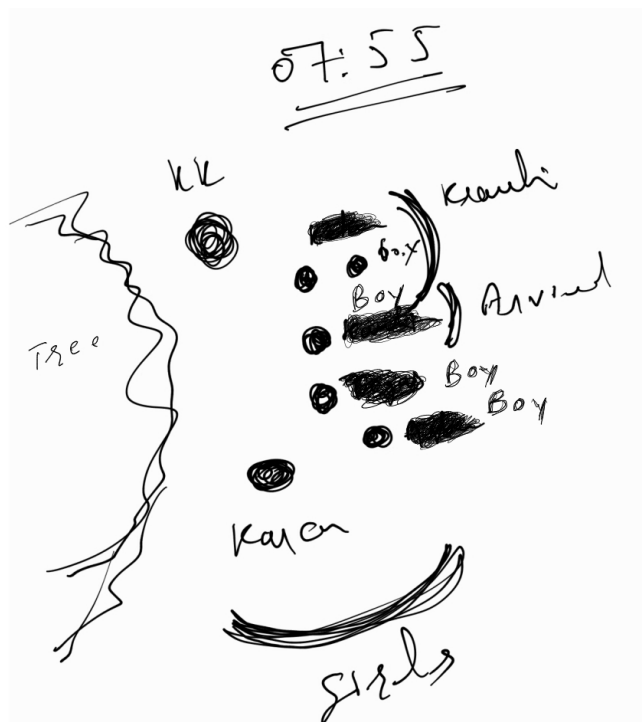
times for producing an initial set of transcriptions, reduced to 4-5 hours for transcribing 10 minutes of data.

Transcribing could be thought of as merely decoding spoken words into written words - the reverse of the decoding process that happens when we read text out loud. It is possible to mechanically decode written text by reading it out loud without (understanding) making meaning of the text. However, we think that decoding should not (and actually cannot) be done separately from understanding, either in reading or in transcribing. We need to try to understand what is being said at the same time as we try to decode it. Actually, we need to analyse and transcribe simultaneously.

The analysis required continuous referral back to the original audio and video recordings, rather than a complete dependence on the transcriptions and translations, which continued to evolve with repeated observation and analysis. Thus, the transcription, translation, interpretation, categorisation, and analysis were all interdependent and evolving throughout the research, requiring continual referral back to the data for verification of our interpretations (Lincoln & Guba, 1985). Doubts and disagreements were discussed and in some cases remained categorised as questionable, with alternative interpretations preserved. Photographs, and snapshots from videotapes were also used to analyse and understand students' meanings, expressions, and gestures. We also made several rough maps and sketches of student movements and their positions from the video recordings of their work in order to interpret their observations, discussions and activities. Since at many instances video cameras could not capture all the students who were involved in talking at one time, we tried tracking students movements and their actions through these maps and drawings. We also used these maps to understand the positions of different students at a time and figure out who was talking, when there were confusions regarding the speaker identity (**Figure 3.7**). At times, we went back to the actual site (for example the garden where the variegated tree was) along with these maps to identify students' actual positions in a particular episode to find out what they were looking at or pointing towards.

As we listened to the tapes, it was not easy to understand what is being said and assign meaning to that. Also there were difficulties in understanding the expressions like where a person stressed more or raised pitch of the voice. This was important in interpreting whether an utterance was a statement or a question.

Figure 3.7 A map showing students and researchers' positions around variegated tree at 07:55²



In order to address problems of listening, transcribing and assigning meanings, we had to

- (a) Listen to tapes repeatedly, sometimes in order to concentrate on each speaker separately;
- (b) Discuss, what was transcribed, amongst us and with others and make changes accordingly;
- (c) Listen to the discourse preceding and following an utterance to understand the meaning of the utterance;
- (d) Listen to different recordings (recorded using a different camera or audio recorder) of the same episode;
- (e) Pay attention to the body movements, gestures, and lip and face movement in order to decode, understand, and analyse what we hear.
- (f) Listen to the tapes at decreased speed and/or changing the frequency using an equaliser or noise reduction software.

2. Footnote - To conceal the identities of the students, we have darkened students' names in the drawing in Figure 3.7. We have used original names while transcribing and analysing the data and making the drawings.

As we were analysing the student interactions, we have to study more and look into greater detail about each of the topics, that is about the variegated Bhendi tree, about ants and about parachutes, to understand students' work, their conversations and their questions.

In case of data of variegated tree, we kept visiting the site of tree while we were transcribing and analysing the data in order to interpret the students' discussions, their activities and their movements. We also checked some literature about the bhendi tree, and other variegated plants in order to learn more about the biology of the tree.

While transcribing and analysing the students' tapes of their task of making a paper parachute, we ourselves tried making a parachute design, similar to that boys had made (**Figure 3.8**). This helped in us understanding the discussions of the group around parachute making and the kinds of problems students faced in making the paper parachute. This also led to a discussion between Karen and I about questions like; why boys chose this particular model, whose idea it originally was, did they intend to make something different but ended up making this model, etc.

At various stages we shared and discussed tapes, transcriptions, our interpretations and our analysis with other researchers at our and other institutes.

3.5.2 Transcription notations

In conversation analysis, transcripts try to capture not only what was said, but also the way it was said (Wooffitt, 2005). In doing so a certain set of notations are used to represent the oral characteristics of the talk, like pauses, change of pitch, stresses on words etc., which otherwise cannot be captured in simple transcription. We have used a transcription notation system which facilitates readability as a narrative. Though to some extent we have followed the conventional notation system, but for the purpose of our study and simplicity, we have also used some of our own notations as well. We mention times of the beginning of each utterance rather than using other notations to indicate overlaps and pauses. The time is indicated in minutes, seconds and sometimes deciseconds from the time audio or video recording of classroom or student interactions (in case of informal contexts) was started. For example in the following conversation,

01:36-3 TS: ***What is the other example of energy?***

01:38-1 S: Sound energy

Figure 3.8 Parachute model made by researchers and being tested for its flight by researchers



teacher began speaking at 01 minute 36 seconds and 3 deciseconds. In case of video recordings we have indicated the names of the speakers (pseudo names in case of students and teachers) before each utterance. Teachers names have been coded using letter T followed by the first letter of the school name. As in the above example, TS is the Teacher (T) of Shashtri (S) vidyalya school. In case of audio recordings, at times students' identities were not clear, so for such cases we have used generic identities for indicating students, like S for any student (girl or boy), Sg for a girl student , Sb for a boy student and Ss for multiple students (Ss) . In all the recordings the teacher researchers (Gurinder, Karen or others) have been indicated by their actual names.

When the identities of speakers are in doubt (due to the poor quality of the recording) we have put question marks after their names [e.g. Ishita (?)]. For the utterances, we use commas (,) to indicate very short pauses, single full stop (.) to indicate roughly one second of pause and two or more consecutive full stops (...) to indicate a pause of two seconds or longer. We have used question marks (?) for indicating explicit questions, and exclamation marks (!) for emphasis. A dash (-) immediately after an incomplete word without a space indicates that the speaker seemed to cut others off in the middle of their talk. However, a pair of dashes (--) following a word after space indicates that speaker has said something which is not clearly audible. If a word is spoken by the speaker by stretching the word it has been indicated by

repetition of letters, like ‘whoooo’ to indicate that speaker has stretched the sound ‘oooo’ while speaking ‘who’. We give all utterances in the language in which they were originally spoken, followed by translations into English in parentheses (). Translations are fairly literal, with explanations if necessary. In square brackets [] we describe actions, expressions, and gestures. Students’ questions are in indicated bold. All the teacher or teacher/researcher utterances have been put in italics. Also all the teacher questions are indicated in bold italics.

3.5.3 Making spreadsheets

Most of our initial transcriptions were generated as rich text format (rtf) document which were then converted into spreadsheets. Later revisions and modifications of the transcriptions were done in the spreadsheet itself. In each spreadsheet, we identified and categorised the students’ as well as teachers’ questions from all the utterances by colour coding them separately. Furthermore, apart from other things, we made separate columns for: identifying the categories of students’ questions; for identifying question-response sequence for each of the students’ questions; adding our own descriptions and comments for student as well as teacher utterances and marking important and interesting episodes; whom did speaker respond or ask.

Though we did not follow the same procedures or processes for generating spreadsheets for different transcriptions and analysing them, the whole process of making and analysing data sheets evolved with time and progress of our study.

3.6 Our ideological and philosophical framework: Nature of education and nature of science

Our understanding and analysis of student-teacher interaction, student-student interactions and student-real world interactions is governed by different frameworks. Our review of previous research on student questioning in chapter 2 highlights these guiding frameworks. Furthermore in **section 2.4** of chapter 2 we also describe the philosophical perspectives that guide our understanding about the process of questioning and process of science. Here in this section, we briefly describe the frameworks that guide our understanding about the nature of education and nature of science under respective headings so as to help readers to better understand our perspective and our analysis of work on student questioning in this study.

3.6.1 Nature of education and nature of schooling

Following Paulo Freire (1968) we see the value of (both natural and social) science education in its possible role to encourage students to work together in order to question the status quo and become more active participants in trying to create a better, more just and equitable world. Freire argues for critical education against the existing 'banking' model of education. From a critical education perspective, knowledge is seen as a process of 'problematization' whereby one questions not just one's natural realities but also one's cultural and historical realities. So in such a scenario we see an important objective of formal education as training children to raise critical questions and change the status quo.

However, the current schooling seems to be training students to be good at answering rather than questioning. In such classrooms we see silent students meekly listening to their teachers. However, to understand students and their consciousness, we must give them opportunities to talk, we must listen to them and we must understand their ways of talking (Shor & Freire, 1987). For this, the discourse in classrooms need to be dialogic, where teachers become learners along with students in the joint act of knowing. So in this dialogic act, teacher also rediscovers and relearns the material of study. When we have such a discourse in classrooms, then only we can think of education as liberating. Furthermore, classrooms should be places of critical discourse, where students, rather than submitting to authorities and the texts, become critical of authorities and texts.

We agree with Freire that education is a political process and seeing it as neutral is a fallacy (Freire & Faundez, 1989). In this political process, knowledge of those who are in power gets legitimised. To understand the process of education one has to understand the existing power structures and the social, economical and political context.

Rather than that students express their curiosity by act of asking, schooling has bureaucratized the asking of questions by subjecting students to questions whose answers they should know beforehand (Freire & Faundez, 1989). So questioning does not remain an act of curiosity or act of knowing. In schools, rather than having a pedagogy of questions, we have a pedagogy of answers. Freire and Faundez argue that such a pedagogy is anti-democratic and non-liberating as it restricts one's curiosity and freedom of thought. Such a pedagogy, based on standardisation, does not give a chance to engage in adventures and be creative.

3.6.2 Nature of reality and nature of science

Our understanding about the nature of reality is dialectical as described by Friedrich Engels (1886). As explained by Maurice Cornforth (2015) as well as Foster, Clark, and York (2010), this means that in physical reality, everything changes, and therefore things do not exist as things, but as things in the process of becoming something else. Thus we see the difficulties in thinking that a thing is identical with itself: because everything keeps changing and what is 'self' at one time no longer exists at another time.

Another aspect of nature which makes it dialectical is that there are inherent conflicts and inner contradictions in all things/processes which keep the whole in motion. Also, all things/processes are interconnected and interdependent. Following the interpretation by the marxist biologists Richard Levins and Richard Lewontin (1985), dialectical relations are opposing aspects that do not occur separately in time as causes and effects.

Furthermore, for us 'nature' means nature/society: the inseparable unity of the human (social) and the non-human living and non-living environment, in their complex interactions, interdependencies, and movement. This is in accordance with Marx's (1844, p. 143) description of the dialectical relationship between society and nature. Thus, according to this understanding, reality is the inseparable object/subject: we human beings are acting upon, studying, and doing science on a material world which is also acting upon us.

When we do (natural/social) science, understandings are probabilistic and can be challenged, questioned, investigated, requestioned, and reinvestigated. They keep changing as contradictory or new evidence is identified. New evidence keeps being found, partly because physical reality itself keeps changing. In doing science dialectically, we need to investigate how conflicts—inherent physical opposing forces—drive processes, rather than thinking that processes follow some basic, abstract 'laws' (Singh et al., 2018).

Furthermore, in agreement with many other educationists and scientists, we see the scientific method as consisting of a network of various interdependent combinations, orders and numbers of different aspects or elements of a 'science toolbox' (Wivagg & Allchin, 2002). Within the variability, we see questioning and observing as two fundamental aspects of the science process. In relation to process of questioning, we see science as described by Meyer (1980b), whereby it is a process of dialectical interplay between questions and answers. This process, the process of doing science, is necessarily subjective, influenced by emotions, and

interdependent with social, political, and economic systems. These interdependencies are complex, conflicting, and require attention from science educationists. However, contrary to actual practice of science, schools present science as systematic and orderly, independent of one's values and emotions and done by following certain pre-defined set of rules or procedures (**see section 2.4.2 for more details**). Such a science, as projected in schools is more a positivist science. Meyer (1980b) argues that such a positivist conception of science has led to more focus on answers than on questions. So in such a scenario, questions about questioning have taken a back place (**see section 2.4.2 for more details**). To understand the process and progress of science, we must understand the process of questioning, the process which leads to newer questions and we see Meyer's work (1980b; 1995) in this regard as very important.

Furthermore, there is a conservative trend to relegate the process of science to professional natural scientists, and to aim science education more at sifting and selecting students and teaching them to remember "the science content", using cognitivist theories argued by researchers (Kirschner et al., 2006) that prescribe some universal laws of development based on the cognitive structure of the mind. However, in agreement with Anna Stetsenko and Igor Arievitch (2002), we do not find any convincing evidence for universal laws of development, and anyway we are more concerned with those who are being sifted out. We see less need for people becoming walking encyclopaedias and more need for people to question, critically analyse, and find physical evidence for or against what the encyclopaedia says.

3.7 Theoretical framework to analyse the process of questioning in students' spontaneous talk

Although, we found that previously developed frameworks, like those that are based on IRE analysis of discourse, were useful in analysing teacher-student discourse in classrooms, but such methods could not be very useful to understand the student-student discourse especially in informal contexts. In comparison to classroom discourse between the teacher and the students, which is simple and somewhat structured, the everyday or the informal discourse is generally very complex and unstructured.

Furthermore, we are less interested in identifying and categorising questioning structures, and more interested in understanding the process of student questioning and how questioning

evolves and progresses in student-student talks in informal contexts. And for such an analysis we see value in using Michel Meyer's theory of problematology (Meyer, 1995). As discussed in Section 2.4, problematology, as Meyer defines it, is a theory of questioning, a unified model to understand philosophy, science, and language. The theory of problematology is built upon questioning as a fundamental property, which presents a new view of rationality in terms of questions and answers.

Apart from James Dillon (1988a), who has been a pioneer in student questioning, it seems science educators have not yet paid any attention to Michel Meyer's theory of problematology, which has been acclaimed by philosophers (Turnbull, 2015) as a radical new theory which puts forth a new foundation of logic or rationality for thought. It may be because very few science educators (with the exception of Dillon (2004), Van der Meij (1994) and Cifone (2002)), have actually tried exploring the process of student questioning. Though some educators like Barnes and Todd (1977), do not explicitly refer to Michel Meyer's ideas, but there seems to be some parallels in their ideas about questioning with that of Meyer's ideas. For example, in their study, Barnes and Todd (1977), found that social relationships among different interlocutors within a group determined how particular questions would be interpreted and understood. This is similar to Meyer's ideas (2010) about questioning as a characteristic of a group rather than an individual: the kind of questions one will ask, the kind of replies that will be generated are characteristic of the interlocutors.

Through his theory of problematology, Michel Meyer (1995) challenges the secondary status given to questioning in the thought process and argues for the overhaul of older propositional paradigms of philosophy, science and languages. The propositional paradigms, which are based on formal logic, give primary status to answers, ignoring the questions which those answers refer to. In place of a propositional model, Meyer argues for a question-answer model of rationality.

In his conception of question-answer rationality, Meyer explains that answers do not lend meaning independent of questions as opposed to propositional rationality. Answers are understood with regard to questions and questions with regard to their answers. The question-answer relation and its dynamics form the basis of this rationality.

While explaining the question-answer relation, Meyer argues that a question can generate two kinds of responses or answers, apocritical and problematological answers. The apocritical

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answers lend solution and gives a closure or end to the problem. Whereas the problematological answers bring forth alternatives, newer questions and hence keep the inquiry open. Furthermore, any answer, whether apocritical or problematological, could not be understood devoid of original questions. They lend meaning only in conjunction to the original question.

Furthermore, Meyer (1980b) argues that science is fundamentally a question-answer process and we need to understand science in terms of question-answer rationality than in terms of propositional rationality, to describe the process and progress of science.

We will be using Meyer's theory of problematology and his ideas to explain certain aspects of students' questioning process by analysing:

1. The question-answer relation in the process of questioning (Chapter 6)
2. The relationship of student questioning and argumentation (Chapter 6)
3. The role of students' question-answer process in their doing of science (Chapter 7).

3.8 Research Questions

Before I began this PhD study, I had a broad idea about doing research on student inquiries stemming from questions posed by students. The initial questions for this research emerged only after preliminary analysis of our first workshop with school students to study student questioning. These questions, asked during proposal of my study, were framed in order to investigate student questioning and their methods of investigating those questions. And we planned to look at these steps, whereby we assumed that first students would ask questions and then choosing a few of those questions, they would design and conduct some investigations. However, with further analysis of data, we realised that student questioning and student answering or investigating cannot be isolated and understood separately. This was further reinforced as we read more literature on student questioning. This led to refinement of our initial proposal questions, some of which we discarded and some we narrowed down with the addition of some newer questions.

Our research broadly focuses on understanding the process of student questioning. The understanding regarding student questioning that would emerge from our research can help to create classroom contexts where student questioning acquires a central place. Whereas we

would answer some questions through our research, we will also raise other relevant questions. This also illustrates how we understand the process of questioning in connection to the progress of knowledge.

More specifically our questions are

1. Understanding the questioning process in science classroom contexts:
 - a. What is the frequency and type of student questioning in actual classrooms and how is it similar or different to that of teacher questioning?
 - b. What is the nature and dynamics of discourse in classroom during student and teacher questioning?
2. Understanding the student questioning process in informal contexts:
 - a. What is the frequency and type of student questioning?
 - b. What is the nature and dynamics of student-student and student-stuff interactions in the questioning process. How and why does student questioning arise, evolve and progress?
3. Understanding the role of the student questioning process in doing science in informal contexts:
 - a. How is student questioning related to student investigations of physical stuff?
 - b. What is the interconnection between questioning and other aspects of scientific inquiry?
 - c. How questioning and answering are related in the process of science?

Although we have presented these questions in a certain order and separately, these cannot be understood in isolation from each other.

4

Observing Classroom Talk and Questioning: Understanding its dynamics

As discussed in Chapter 2, researchers report a general lack of student questioning and student talk in classrooms, especially as part of main classroom discourse. Most of these research reports are from non-Indian contexts and very few (Dillon, 2004) actually describe the nature of classroom discourse around student questioning. In this chapter, we will look into the nature and dynamics of classroom discourse around student as well as teacher questioning and try to understand the process of questioning inside the classroom. Although categorisation of students' questions is not our aim, we found that in order to understand how and why questioning occurred, categorisation was helpful.

To understand the discourse and the process of questioning inside the classroom, we will look into classroom observations from three different science classrooms from three different schools. Table 4.1 briefly describes the three classrooms taught by the three teachers, TS, TK and TF. In the previous chapter we have discussed about the three classes and the three schools in greater detail.

Table 4.1 Descriptions of the three classrooms that were observed

Teacher	School	Language of conversation	Language of textbook	Class Taught
TS	Shashtri Vidyalya, Mumbai	Mostly Marathi with some use of English words/terms	English	IX
TK	Krishna High School, Mumbai	Mix of Hindi and English	English	IX
TF	Government Senior Secondary School, Fatehpur, Ludhiana	Punjabi	Punjabi	VII

In all the three classes students were sitting on benches arranged in lines of 5, 6 or 7 benches with 3 or 4 such columns of benches. Each of the benches are generally meant for seating two students, but in some cases three students were also sitting on a single bench. Generally there was enough space left between two columns of benches for movement (see **Figure 4.1**). In all the three classes, the teacher most of the time was standing in front of the class facing the class, and sometimes moving in between the space between columns of benches.

Figure 4.1 Classroom seating arrangement of one of the classes



4.1 Teacher and student utterances

It's not always easy to tell where an utterance starts and where an utterance ends. Researchers have used different ways of defining an utterance (Barnes & Todd, 1977; Roy, 1981). We define an utterance as any talk made by one speaker at a length about one topic which is more-or-less not interrupted by someone else. A new utterance is marked if another speaker starts talking or the same speaker suddenly changes the topic and starts talking on a different

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topic. A single utterance could be a single word or a short sentence or sometimes a very long sentence, or several sentences.

Based on our past experience (e.g. walking around outside of school classrooms one tends to hear teachers' voices much more frequently than students' voices), we expected that the number of teacher utterances would be much greater than the number of student utterances. But this was not the case in the classrooms for which we tabulated this data (**Table 4.2**). As shown in Table 4.2, the number of teacher and student utterances are almost equal in number with the exception of TF's class.

Table 4.2 Numbers of teacher and student utterances

Class observed (teacher)	Topic taught	Total length of lesson (minutes approx.)	Total number of students (Girls/boys)	Total teacher utterances	Total student utterances (individual)	Total student utterances (in unison)
IX (TS)	Work and energy	23 min.	54 (23/31)	139	61	89
IX (TK)	Solid waste	28 min.	34 (14/20)	154	120	43
VII (TF)	Story of waste water	35 min.	18 (5/13)	185	68	27

However, this does not mean students were talking as much as the teacher. Generally teacher utterances were much longer and sometimes 40-50 words long (or more than a minute), whereas a large number of students utterances were very short (5 or less than 5 words). So it was clear that in all the classes we observed, teachers were, by far, doing most of the talking.

For one of the classes (TF's class) we have analysed the length of the teacher and student utterances (**Table 4.3**) to get an idea of how long teachers and students talked. The purpose is not to compare but to get an overall idea about the teacher and student talk.

Table 4.3 Lengths of student and teacher utterances for TF's class

	TF's utterances	Individual student utterances	Multiple student utterances
Total utterances	185	68	27
Total words	3199	307	77
Average utterance length	17.3	4.5	na
Length of very long utterance/s	40 to 70 words sometimes	maximum 16 words once	na

To better understand how long the teacher was talking and how long students spoke in the class, we present here one episode (**Episode 4.01**) as an example of teacher and student talk. In this episode teacher TS is asking students about the relation between energy and work.

Episode 4.01

- 04:02-4 TS: **area आणि pressure चा संबंध कसा जोडलेला ? area वाढलं की pressure? (How did you relate area and pressure? When area increases pressure?)**
- 04:09-6 Sg: कमी होत (decreases...) [softer voice]
- 04:08-3 TS: **area वाढलं की pressure? (When area increases pressure?)**
- 04:08-6 Sg: जास्त... (increases...)
- 04:10-0 Ss: कमी होत (decreases...)
- 04:10-0 TS: **कमी होत , मग त्याचप्रमाणे , energy आणि work यांचा संबंध सांगा , असे मी सांगते आहे ? (decreases, similarly tell me relation between energy and work, that is what I am telling you?)**
- 04:16-4 Sg: energy वाढली की work सुद्धा वाढणार आहे (When energy will increase work too will increase)
- 04:18-5 TS: **energy वाढली की काय वाढणार आहे ? (When energy will increase what will increase?)**
- 04:19-9 Ss+T: work वाढणार आहे (Work will increase)
- 04:21-2 TS: **बरोबर . म्हणजे जेवढी तुम्ही energy लावणार तेवढं काय होणार आहे ? work वाढणार आहे ? (correct? Which means depending on energy you put what is going to happen? Work is going to increase?)**
- 04:24-9 Ss: काम (work)
- 04:25-4 TS: **work वाढणार आहे (work is going to increase) [in unison with students]**
- 04:25-9 TS: **जास्त work करायचा असेल तर तुम्हाला ? (If you want more work then you?)**

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04:27-9 Ss: जास्त energy पाहिजे (need more energy)

04:28-5 TS: जास्त **energy** पाहिजे, म्हणजे **work** केवढं होणार, जेवढी तुमच्या कडे **energy** आहे, तेवढ्या प्रमाणामध्ये काय होणार? (**need more energy, which means how much work will be done, as much you have energy, what will be in that proportion?**)

04:34-1 Ss and TS: काम होणार (work will be done)

Generally students' responses were short, many a time only one or two words long. The longest utterance of a student that we could find in all the three classes is 16 word long and there was only one instance of such a long utterance. There are only a few student utterances longer than 10 words. However, teachers often spoke utterances longer than 10 words. So it was the teacher who was doing most of the talking of any kind. Most of the times students were either giving the expected answers to the leading questions or agreeing with teacher's claims. So, students were not engaging in much of argumentation with the teacher involving any kind of reasoning or justification. The above episode is one example, however throughout this chapter we have presented various episodes of teacher and student discourse and one can notice the difference between the length of teacher utterances and that of student utterances.

4.2 Identifying and categorising students' questions

In **section 2.2.1** we had done a detailed discussion on 'what are questions' and how questions are expressed verbally as well as non-verbally. In our analysis, we did not focus much on non-verbal questions. In our identification and categorisation of questions, we have only looked at verbal questions. However at times we have done some discussion around students' non-verbal questions appearing as gestures or expressions, but we have not included those in the list of questions.

In order to understand the process of questioning, we have to separate questions from non-questions. Actually it was not possible to differentiate a question from a non-question without understanding the context in which a question emerged, who asked the question, whether it was addressed to a particular person, who responded to it, and what was the response or sequence of responses following the question. This is also interconnected with trying to understand why questions were asked. In doing all this, we had to identify and categorise questions. So what we mean by analysis is an attempt to understand the interconnected

functions, forms, identification and categorisation of questions and answers in their social context.

Although, we did end up creating several types of categories of questions, but a lot of these are overlapping categories having blurred boundaries. As will be described below and shown in **Figure 4.1**, we have defined the following overlapping types of categories: (1) Implicit and explicit questioning, with blurred boundaries; (2) Authentic and inauthentic questioning, with blurred boundaries, using the definition of authentic that was given in Section 2.2.1; (3) questioning with various different functions; and (4) questioning with various different forms. Most of our categorisation focused on functions, but the difference between implicit and explicit questioning is on the basis of form rather than function. The categories of questions that we have developed may not strictly fall into one category. For example, a rhetorical question, generally inauthentic, may also be somewhat authentic. Furthermore, the meaningfulness of a category of question could only be understood when the question is seen in the context of the discourse. Figure 4.1, showing the relationship between different kinds of student questions that we observed, includes most of the types of students' questions observed in both the classroom as well as the informal contexts. Each type will be defined and discussed in Chapters 4 and/or 5.

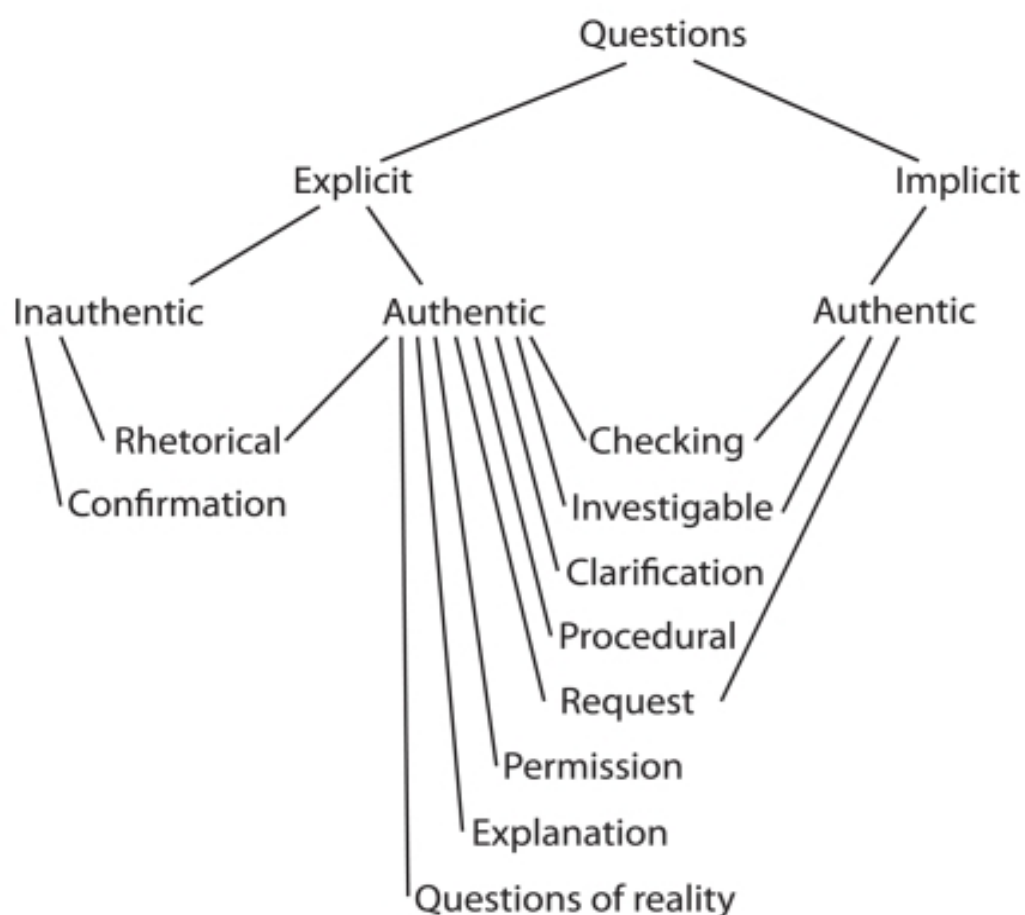
As we transcribed the tapes, we kept identifying questions by colour coding in our transcription sheets, using different colours to identify teacher and student questions. The process of identification and categorisation was actually not separate, with most of the times identification and categorisation happening simultaneously. All these were important in identifying and categorising a question. Understanding the responses following a question became especially necessary when questions and their categorisation was not very obvious. We went back and forth with our transcriptions, revised our categorisation and added or deleted the questions.

4.2.1 Explicit and implicit questioning

In the languages we have used in our studies (Marathi, Hindi, Punjabi, and English), explicit questions (also called direct questions) may be identified by the use of WH signifiers (who, what, why, where, which, how), word order, or by the use of a typical inflection or rise in

intonation on a particular word, all indicated by question marks when the questions are written.

Figure 4.2 Types of students' questions and relationship among different types



However, as we transcribed the tapes, we realised that there are many questions, which do not appear very explicitly involving any kind of the above question markers or indicators. Such questions represented perplexity, doubt or confusion on the part of the speaker but were not stated explicitly by the speaker. For example, in **episode 4.12** (see **section 4.3**), the question asked by Sajid at 09:01-9, 'वो तो काम आता है **(That is useful)**' is not explicit as it does not involve any interrogative indicator. But it definitely represent a doubt or conflict of Sajid about calling agriculture or garden waste as waste since that is actually useful. So we have categorised it as an implicit investigable question. We discuss about investigable questions in more detail later in the chapter.

All the questions that we identify in our data are either explicit or implicit. All the implicit questions have been identified using word 'implicit' before them. Any other question which

is not written by using the word 'implicit' is an explicit question. For example an explicit request question is identified as 'request' question whereas an implicit request question has been identified as 'implicit request' question and so on and so forth. Explicit questions have been indicated by a question mark at the end of the question whereas implicit questions do not have a question mark at the end.

4.2.2 What kinds of questions did students ask in classrooms?

In the three classrooms that we report here, we found various kinds of students' questions, mostly asked by the students to the teacher, but in some cases (like student whispering to each other) asked by students to each other. We discuss here each category with examples here.

4.2.2.1 Confirmation questions

These are the questions asked by someone to seek confirmation (seek agreement) of one's own response, procedure or task (Good et al., 1987). Generally a confirmation question is a statement with a 'na' or 'no' in its end, making it an explicit question. E.g. its complete, na? However sometimes a confirmation question can also be asked without using na or no like, You are going, aren't you? Its plastic, right? We call these questions as inauthentic questions (see **section 2.3.1.3** for more details on authentic and inauthentic questioning) because for these questions one already knows the answer and is only trying make other agree upon that answer. So in a way these questions are somewhat rhetorical and represent some assertion on the part of the asker.

In all the three classes, we found total 3 confirmation questions asked by the students, two of which were asked by the students to the teacher. Here is one example:

Episode 4.02

- 15:23-4 Sg: म्हणजे आपण गाणी लावतो ना, ती ऐकतो ना, आणि dance करतो, ती displacement (we play songs, we listen, and we do dance, that's displacement)
- 15:25-0 TS: मग **displacement** कुठे झालं त्याच्यामध्ये? (**Where is displacement in all this?**)
- 15:25-8 Sg: **Dance** झाल्यावर **displacement** झाली , ना? (**Did dance, displacement happened na?**)

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Here student had given example of sound waves as a form of energy, to which teacher asks but where is displacement in sound energy. Then at 15:23-4 student replies that when we play songs and dance, then there is displacement. To which at 15:25-0 teacher asks but where is displacement. To this student at 15:25-8 replies with a confirmation question that 'Dance is performed there is displacement, na?'

4.2.2.2 Clarification questions

These are the questions asked by a person when that person heard something being said but could not hear it properly or could not understand what was said (Good et al., 1987). For example, Did you say page 141?, Could you repeat that? And 'What did you say' are clarification questions.

These questions are also commonly asked by use of words like 'hun' or 'hain'. For example

T: What number did you get?

S: Forty three.

T: Hain?

S: Forty three

Like the confirmation questions, in our observations of classrooms we found very few clarification questions asked by the students. Here is one example,

Episode 4.03

22:55-6 TK: *Ok .. **can you quickly copy the question what are the effects of solid waste?***

23:08-7 S: **What are the effects of ?**

23:10-5 TK: *What are the effects of solid waste?*

4.2.2.3 Procedural questions

These are the questions about the classroom procedures or about procedures of some task (Good et al., 1987). In all the three classes together we noticed 17 procedural questions by students, making these as the most common type among all the kinds student questions. Here are a few examples of students' procedural questions from the three classrooms.

From TK's class, while the teacher is assigning homework, a boy asks at 22:40.4, '**Sir notebook** ਪੇ ਲਿਖਨੇ ਕਾ ? (Sir, is it to be written on notebook?)'

From TF's class, while students have a doubt about noting down the answer of a question, one boy Dalbir asks the teacher whether question number eleven's answer is to be written in the textboot itself.

Episode 4.04

- 24:31-6 Dalbir (?): ਕਿਤਾਬ ਤੇ ਈ ਕਰ ਲੈਣਾ ਆ ਜੀ ਗਿਆਰਵਾਂ ਵੀ ? (**Is eleventh also to be done on textbook?**) [teacher busy reading from the textbook and does not respond to the question]
- 24:34-0 Another Student (in a low voice): ਹਾਂ (yes)
- 24:35-5 Dalbir (?): ਵੀਰੇ, ਕਾਪੀ ਤੇ ਨੀ ਕਰਨੇ ? (**Brother, to be done on notebook itself?**) [students asking each other]
- 24:37-0 One boy: ਬਾਰਵਾਂ ? (**Twelfth one?**) ... [meanwhile multiple voices talking about question number 11 and 12 could be heard]

It is interesting to note that in this episode teacher does not respond to Dalbir's question asked at 24:31-6, as teacher is busy reading the textbook. This results in another student answering Dalbir's question, after which more students join in the discussion about this question. It is one of the very few instances when students directly asked and answered their own questions. Since the question was procedural, students may have felt that they had relatively more agency to answer the question than if it was a 'science' question. We wonder whether a similar strategy, where the teacher intentionally does not respond to student's question or pretends to not know the answer, will encourage students to ask among each other? But a teacher also needs to be careful that students should not feel that their question was neglected by the teacher as it may discourage them for asking in future. But it's also a dilemma, if students stop asking teacher, maybe thinking that the teacher does not know, will they start asking each other?

In TK's class we noticed three procedural questions of students, which were asked towards the end of the class when the teacher was assigning the homework to the students and students had questions about that.

We noticed a large number of procedural questions in TF's class, 14 of total 25 questions

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asked in the class. In this class teacher was dictating answers or writing answers of the textbook chapter questions on the board and students were noting down those answers. A number of times students asked questions about whether the answer is to be marked on textbook itself or written on notebook, and whether for certain questions (marked on textbook) they should leave space in their notebook or not. Also towards the end of the class teacher had discussion about the monthly test of the students and students had procedural questions regarding when the test will be conducted and what marks the test will carry, etc.

In TS's class we did not notice any of procedural questions. It may be because most of the discussion in the class was about the topic itself, which was being discussed orally.

4.2.2.4 Asking permission

These are the questions where students sought permission of the teacher for performing some task or action or asking permission to borrow some stuff from other students. A large number of permission questions (total 15 in all the three classes) that we noticed were asked by students to seek teacher's permission to respond to teacher's questions or participate in the classroom discourse. Here are two examples of these questions asked by students in TK's class

Episode 4.05

06:07-7 S: **Sir मैं बताऊँ ? (Sir shall I tell?)**

06:10-1 TK: **आपका बोला मैंने नाम ? (Have I asked your name?)** [rhetorically]

Episode 4.06

12:49-2 TK: **What happens in decomposition?**

12:48-7 S: **भईया ? (Brother?)**

In both the above examples students are asking teacher to respond to the question asked by the teacher.

4.2.2.5 Request questions

In all the three classes that we observed, we noticed one request question asked in TF's class. After dictating all the answers, TF at 29:13-9 asks students to note the questions and answers

in their fair notebook, since the usual practice by students is to note down on rough notebooks first. Many of the students have actually already noted the answers in their fair notebook itself. So upon being asked some students reply by saying that they have already done that and then at 29:20-4 a girl, Satwinder asks, 'ਜੀ **check ਕਰਲੋ ਜੀ (mam check it mam?)**' requesting the teacher to check the notebook, to which teacher replies by saying, 'ਕਰ ਲੈਨੇ ਮਾਂ (will do)'. As this request does not involve an explicit question marker, it is more of an implicit question, asking, 'Can/will you check our/my notebook?' If a similar utterance would have been made by the teacher (for example saying, 'show me your notebook'), then it may not be treated as a question and could be a command where the student has less of choice to reject that command.

4.2.2.6 Checking question

These are the questions that we found very unique in our classroom data. A checking question is generally a reply to a teacher's question, said in a doubting tone. The doubt is not epistemic one but doubt about it being the answer the teacher expects. Here the student would seek an evaluation of his/her response from the teacher. Students don't check if teacher agrees with their own belief - rather they check to see if they have supplied what the teacher believes. According to this 'school-school game', students are not supposed have their own beliefs but just believe' what teacher believes. Lemke (1990, p. 10) while discussing about students use of such a strategy in answering the teacher's questions argues that it provides students some kind of protection in case their answer is wrong. So student using intonation or doubtful tone expresses uncertainty in the answer thereby implicitly telling the teacher it may not be a correct answer. However, we could not find any studies which look into this kind of student questioning and its functions in some detail.

In our classroom observations, we found at least one checking question in each of the three classes. However, it was not easy to identify such questions as it involved very careful listening and understanding of change of intonation or tone of doubt in the utterance. Here is one example where Dalbir at 00:33-0 replying to the teacher's question implicitly questioning his answer. So it's an implicit checking question.

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Episode 4.07

- 00:31-0 TF: ਕੋਈ ਸੰਬੰਧ ਨੀ ਸਫਾਈ ਅਤੇ ਬਿਮਾਰੀ ਵਿੱਚ ? (**There is no relation between cleanliness and getting sick?**) [asking rhetorically]
- 00:33-0 Dalbir: ਹੈਗਾ ਜੀ... ਸਫਾਈ ਵਧੀਆ ਹੁੰਦੀ ਆ? (There is ... **Cleanliness is good?**) [starts with a louder voice but towards the end becomes very soft]
- 00:36-2 TF: ਸਫਾਈ ਵਧੀਆ ਹੁੰਦੀ ਆ ਫੇਰ ? (**If cleanliness is good then?**)
- 00:37-9 Dalbir: ਜੀ ਇਸ ਕਰਕੇ ਸਾਨੂੰ ਸਫਾਈ ਰੱਖਣੀ ਚਾਹੀਦੀ... (So we should keep cleanliness...)

4.2.2.7 Factual question

These are the questions which ask for factual information regarding a certain concept or topic as described in the textbook. Such questions generally have very well defined answers. All of the questions that we categorised as factual were asked in the TS's class where the topic of work and energy was being discussed. For example students asking, '**what is chemical energy?**' or '**what is an example of chemical energy?**'. We could not find any factual questions in the other two classes. It maybe because in the other two classes the topics discussed (solid waste and story of waste water) were less abstract and concerned everyday issues. Here are the examples of factual questions.

Episode 4.08

- 09:38-0 TS: ਤੇ ਨਾਹੀ ਏਤ ਟਰ ਦੁਸਰ, ਜੇ ਕਾਯ ਏਤ ਤੇ ਵਯਵਸਥਿਤ ਸਾਂਗਾ. ਉਦਾਹਰਣਾ ਸਕਟ. (*Tell me, if not this one, then another one, that you know well. With an example.*)
- 09:54-1 Sg1: **Chemical energy?** [whispering]
- 09:44-1 Sg2: **Chemical energy ਚ ਕਾਯ ? (What about chemical energy?)** [whispering]
- 09:50-1 Sg1: ਏਕ **electron** ਦੁਸਨ੍ਯਾ **electron** ਮਘ੍ਯੇ ਟਾਕਲਾ ਕੀ? (**One electron if added to another electron?**) [whispering continues but in a much lower voice]

Episode 4.09

- 13:10-7 Sg (to each other): ਉਦਾਹਰਣ ਕਾਯ ਏਤੀਲ **chemical energy** ਚੀ ? (**What will be examples of chemical energy?**)
- 13:21-0 Sb: ਆਪਲ੍ਯਾਕਛੇ ਜੇ chemical ਏਤ ਤੇ ਆਪਣ.. (the chemical that comes to us...) [not audible]

4.2.2.8 Explanation

These are the questions that request meanings or reasons to understand a concept, idea, phenomenon, task, procedure, or action (Good et al., 1987). In the three classes that we report here, we notice total three explanation questions asked by the students. Two of these

questions were asked by the students to each other, where as one of the questions was asked by a student to the teacher. In **episode 4.13**, described in **section 4.3**, the two questions asked by students whispering to each other are explanation questions as students are wondering about where is displacement in the example of light energy. Also in the **episode 4.12** at 09:04-8 teacher is saying that there is an important point raised by Sajid, which should be remembered, to which Salman asks, 'क्या ?' (**what?**), meaning what is that point. So Salman was asking the teacher to explain that point.

4.2.2.9 Basic questions of reality

Basic questions of reality are somewhat similar to Piaget's definition of questions of reality and history (Piaget, 1923). These questions deal with some simple facts about reality which are relatively non-investigable and have certainty about answers. These may be simple facts about which one could be wondering or perplexed. For example, 'Who brought this?', 'What is this', 'When is the meeting' etc. The facts asked in these questions are different than facts asked in factual questions as these are the facts related to events or actions rather than theoretical facts about some concepts. In the three classes we observed only two of these questions asked in TK's class but none was asked to the teacher. One of these was asked in the very beginning of the class to the researchers who were observing the class, when they had just placed the recorder for recording.

Episode 4.10

00:01-0 Sb (asking Himanshu and Gurinder): **ये क्या है ? (What is it?)**

00:03-2 Gurinder: ये recording के लिए. (It's for recording.)

The second question was noticed when two boys were whispering and having some discussion amongst them and at 10:01-3 one of them asks the other boy, 'कौन सा **mobile** है ? (**Which mobile is it?**)'.

4.2.2.10 Investigable questions

These are questions which are relatively open-ended and may not have a fixed or pre-determined answer. Investigable questions have been defined by Christine Chin (2002) as those that 'allow students to generate and collect some original data, analyse and interpret

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their findings based on these data, and finally make a conclusion that addresses the investigative question posed, on the basis of available first-hand evidence.’ However when we say generate and collect data and analyse and interpret data, we do not mean these as isolated steps being followed in some particular order. Rather we see these appearing in a complex network where one cannot separately distinguish the different aspects in time.

Also our definition of investigable questions is a little broad in the sense that the investigations required to answer such questions could even be very simple. For example, if someone asks wondering about a tree, what is this and nobody knows the name of the tree (as its not a commonly found tree), a small investigation looking into some book or on the internet about the tree could be done. It could be a question about the colour of something and different people calling its colour different (as the colour is shade of some primary or secondary colour), then by comparing with some standard colour spectrum or shade chart of colours, one can try to identify and even quantify it.

In all the three classrooms together, we found only three investigable questions, two of which are implicit. For example, in **Episode 4.12**, Sajid while wondering about the use of Agriculture and garden waste says, ‘बो तो काम आता है (That is useful)’. We see it as an implicit investigable question as one can always try investigating about different kinds of agriculture or garden wastes, whether and how they could be useful. There could have been an interesting discussion done in the class around this question, or some activities could even have been carried out in order to try to devise uses for various ‘waste’. The concept and definition of waste could have been further investigated. Larger questions such as why something is or is not called waste could have been discussed.

In another example, a student seems to be questioning the teacher conception that if somebody bathes using hot or fresh (lukewarm) water in winter, one would not feel cold. The student at 30:39-0 argues that even taking a bath with cold water, one may not feel the cold.

Episode 4.11

30:24-4 TF: मैं तुहाँ बर बर कहिनी बडी ताने पाणी नाल जां गरम पाणी नाल जे तुहाँडी availability हैगी आ, ना के आइआ करे। नाह नाल कदे वी ठंड नी लँगादी, ऐ बडे म न दे विँच वहिम आ ना के नावांगे तं जिआदा ठंड लँगेगी, नाह नाल ठंड नी लँगादी। (*I keep telling you that either with fresh water or hot water, whatever is your availability, you should come after having a bath. One does not feel cold on taking a bath, its your misconception that if you take bath, you will feel more*

cold, one does not feel cold on taking bath.)

30:39-0 Gurpreet: ਠੰਡੇ ਪਾਣੀ ਨਾਲ ਵੀ ਨੀ ਲੱਗਦੀ ਜੀ (**You don't feel cold even when you take a bath with cold water**) [student without asking TF's permission gets in discussion]

30:42-0 TF: ਠੰਡੇ ਪਾਣੀ ਨਾਲ ਨੀ ਨਾਣਾ, ਤਾਜ਼ੇ ਪਾਣੀ ਨਾਲ ਨਾਣਾ ਆ। ਠੰਡੇ ਪਾਣੀ ਨਾਲ ਤਾਂ --- (*You are not to take bath with cold water, you are take to bath with fresh water. With cold water ----*)

We think that Gurpreet might be wondering from his previous experience that when someone takes a bath with cold water, after a few mugs (or for sometime in shower), one starts feeling that the water is warmer. This is actually related to the concept of sensation of coldness and hotness, and one could carry out very interesting investigations related to this. However rather than taking up student's question for further discussion or investigation, teacher asserts her own opinion about the matter and closes the topic.

Furthermore, we find Gurpreet's agency to participate and disagree with the teacher being a little unusual as he responds to the teacher's claim without taking permission or being asked to do so by the teacher. This may have been because the teacher had finished doing the main course teaching and only some generic matters related to moral values were being discussed.

4.2.3 Numbers of student questions

In all the three classes that we observed, the number of questions asked by the students are much less than the number of teacher questions. The rate of student questioning that we observed in these classes is not very different from what is reported by other researchers (**see section 2.1** of Chapter 2). However, since our categorisation included wide range of questions and that we also report questions whispered by students amongst each other, the rate of student questioning that we observed may be slightly higher than that observed by other researchers.

It is important to note that a large percentage of students questions, more than 50 percent (52%) among all the total questions asked by students together in three classes, are in the form of procedural or permission seeking questions. If we compare questions asked by students (per student) and compare with questions asked by the teacher alone, then there is a huge difference in these numbers. For example, TS asked total 117 questions in the 23 minute class, whereas the total number of questions asked by all the 54 students during the same time

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are 13, making 0.2 questions asked per student in the entire class (see **Table 4.4**). Though, in TF's class the difference in the number of teacher questions (78) and student questions (1.4 per student) is least as compared to the other two classes, but still the number of student questions as compared to teacher questions is very very small.

Furthermore, we notice very less number of explanation or investigable questions asked by the students in the class and that too very explicitly. Although, we see these kinds of questions as being more important in learning of science than other kinds of questions (like procedural or permission seeking questions), but we do not see different kinds of questions in isolation for understanding the process of questioning.

Table 4.4 Total number of teacher and student questions and their rates

Class observed (teacher)	Topic taught	Total length of lesson (minutes approx.)	Total number of students (Girls/boys)	Total questions asked by teacher	Teacher questions per hour	total questions asked by all the students	Questions per student	Questions per student per hour
IX (TS)	Work and energy	23 min.	54 (23/31)	117	305.2	13	0.2	0.5
IX (TK)	Solid waste	28 min.	34 (14/20)	84	180	23	0.7	1.5
VII (TF)	Story of waste water	35 min.	18 (5/13)	78	133.7	25	1.4	2.4

4.3 Students' agency to participate in the discourse

4.3.1 Teacher interrupting students vs students interrupting teacher

In our observations we found that students were often interrupted by the teacher as they

spoke but the opposite, that is a student interrupting a teacher, was rare (except in whispers to other students). By interruption we mean someone speaking out of turn. For students, generally they were nominated by the teacher for their turn or they have to seek permission to take a turn to speak. Students have to seek permission to talk and to ask, which they sometimes did by raising their hands or calling the teacher. Mostly student responded when a teacher called name or gestured to select a student to respond. But teacher did not require permission to take a turn to speak.

However, it is interesting to see that in one of the examples, where a student interrupts the teacher, by speaking out of turn and that too without permission, he does so by raising a question and showing disagreement with the teacher (**episode 4.12**). Here the teacher is talking about different types of wastes with long sequence of alternate teacher and student turns. However, this sequence gets interrupted at 09:01-9, when a student Sajid raises a question about the agriculture and garden waste, saying how that can be called as waste since that is actually useful. At this, teacher cuts off from his topic and does a discussion about the usefulness of agriculture and garden waste.

Episode 4.12

- 08:11-1 TK: *आप लोगों ने nuclear plant सुना है? (Have you people heard about the nuclear plant?)*
- 08:12-5 Ss (multiple voices): हां (Yes)
- 08:15-1 TK: *Nuclear plant .. वो भाभा atomic plant जो है या तारापुर का atomic plant है, वहां पे nuclear reaction होते हैं। (Nuclear plant .. that Bhabha atomic is there or there is Tarapur's nuclear plant, nuclear reactions take place there. [students are saying 'haan' in the background as teacher continues])*
- 08:21-4 Ss: हां (Yes)
- 08:21-6 TK: *Nuclear reaction में जो waste product generate होता है उसको radioactive होता है, वो radiation से cancer हो सकता है.. [pin drop silence as teacher says this] so इस लिए वो radioactive waste बहुत harmful होता है.. So इन सबको hazardous waste कहा जाता है.. chemical .. इधर शिवाजी नगर में chemical factories का dumping होता है। (The waste product generated in the nuclear reaction is radioactive, that radiation can cause cancer .. [pin drop silence as teacher says this] so that radioactive waste is very harmful .. so all this is called hazardous waste .. chemical .. here in shivaji nagar chemical factories do the dumping.)*
- 08:38-7 Ss (low voices): हां (Yes)
- 08:39-5 TK: *शिवाजी नगर में chemical factories का dumping होता है, बहुत बड़ा problem है। (in shivaji*

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nagar chemical factories do the dumping, it's a big problem)

- 08:47-7 S1: हम भी nuclear -- में -- (We also -- in nuclear plant --)
- 08:47-7 S2: बहुत बड़ा है। (Its very big)
- 08:49-2 TK: *So that is hazardous waste. उसके बाद let's talk the next one, tell me उसके बाद क्या है?* (So that is hazardous waste. Then let's talk the next one, **tell me what's next?**)
- 08:55-5 S: Agricultural waste and garden waste [Perhaps reading from textbook]
- 08:57-9 TK: *जो agriculture या garden में produce होता है उसे agricultural waste कहते हैं। (One which is produced in agriculture or garden, is called agriculture waste)*
- 09:01-9 Sajid: वो तो काम आता है **(That is useful)**
- 09:03-4 Ss (in background): second -- भईया ? -- -- (Second -- **brother?** --)
- 09:04-8 TK: *एक मिनट, एक -- साजिद, आ सलमान, साजिद का एक important point था जो याद रखना जरूरी है। (One minute, one -- Sajid, aa Salman, Sajid has one important point which is important to remember.)*
- 09:12-8 Salman: **क्या ? (What?)**
- 09:14-8 TK: *Agricultural waste उसने कहा काम आ सकता है because that can be used as fertilizer or manure. (He said agricultural waste could be useful because that can be used as fertilizer or manure.)*
- 09:19-7 Ss: (low voice): हां (Yes)
- 09:22-5 TK: *तो point क्या है, की उसको आप waste को किस तरह से use करते हो, How do you use it उससे recommend होता है के वो useful है या waste बनता है। So अगर उसका ठीक से use किया तो काम आ सकता है। (So the point is that how you use the waste, how do you use it would recommend whether its useful or waste. So if you use it properly it can be useful.)*
- 09:33-0 S: **ऐसे -- कचरे का भी ? (Like this -- garbage also?)** [not clearly heard]
- 09:34-8 TK: **अच्छा उसके बाद next वाला, अख्तर ? (Ok, then the next one, akhtar?)**

Furthermore, many a times teacher was observed to interrupt a student who would be in the middle of his/her talk, but it was rare for a student to interrupt and start talking while teacher has not finished her talk. We could not find any instances of students interrupting the teachers TF and TS in their class. However, in TK's class at least at two instances we see that happening. There were a number of moments when students responded out of turn or without being called in TK's class, which was rare in other two teachers classes. TK's class was different than the other two teacher's classes as students were more talkative and rather than whispering, spoke out loud to each other. They even cracked jokes aloud in the class. For example at 07:11.2 TK asks, "**अच्छा hazardous word का meaning क्या है ? What do you mean by hazardous?**". To this one of the boys replies, "हज़ार बार दस" (Thousands times ten). Here the student simply broke the english word 'hazardous' into 'hazar', which sounds like

hindi word 'hazaar' meaning thousand and 'dous', which sounds like hindi word 'das' meaning ten. At other instances also students joked in the class. Actually, this teacher TK, was not a permanent teacher but a Teach For India (TFI) fellow, on a two year fellowship in the school. Also students did not call him teacher but rather called him 'Bhaiya'. Sometimes this teacher found it difficult to 'control' and 'discipline' the class as he thought the class was getting too noisy. These may be the reasons for a difference in the power relation between this teacher and the students as compared to the other two teachers, who are permanent teachers.

4.3.2 Whispering and illicit student talk

We have not found any research reports that focus on student whispering or talking to each other while the teacher is talking - which sometimes (but not always) the teacher tries to prohibit. We wonder whether in this talking the students may be more apt to relate the topics to their own lives and experiences, and ask the important questions to each other and to themselves. They may also talk about topics which do not seem to be directly related to what the teacher is talking about, but which nevertheless may be relevant and important learning experiences.

In the classes we observed, we found many instances of students whispering in low voices among each other. There were some interesting discussions that were picked up by the audio or video recorders among the students sitting near the recorders. Here is one such example of student whispering and talking among each other about the light as energy. In this example teacher is having a discussion about different forms of energy and is explaining energy as a form of work involving some kind of displacement. So when one of the girls whispers that light is an example of energy, the other girl asks her where is the displacement in light. It is interesting to note that in this whispering students raised questions to each other, which otherwise we did not notice in any of the classes as part of the main classroom discourse. Students never talked or addressed each other directly as part of the main classroom discourse.

Episode 4.13

11:30-8 TS: firli. फिरली म्हणजे displacement झालं. Work घडून आलं. पुढे. **अजून electrical energy चा वापर?** (Moving, moving means displacement happens. The work is done. Then. **more example of use of electrical energy?**)

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- 11:36-4 Gs1 (whispering): light
11:36-9 Another girl (elsewhere): light
11:37-4 Gs2 (whispering to Gs1): **displacement कुठे होत? (But where is the displacement in light?)**
11:39-6 Another girl (to whom who said light): **light मध्ये displacement कुठे होत?? (But where is the displacement in light?)**

In TF's class, sometimes teacher took long pauses and during there pauses students whispering increased. At number of occasions we noticed that students, when not sure about answers to the teacher questions, they whispered answers in low voices.

However in Krishna High School, we noticed less of whispering in comparison to other two classes. This may be because students in this class could speak out of turn without seeking permission.

4.3.3 Disagreement with teacher and textbook as part of main classroom discourse

In the three classes that we report here, we observed very few instances where students explicitly disagreed with the teacher though teacher often disagreed with the students. One interesting episode (**Episode 4.14**) involving student and teacher argument where a student actually disagrees with a teacher is the one with a few long utterances by a student.

Episode 4.14

- 08:19-4 TS: एक **solar energy**. बरोबर ? एक मिनिट, जर तुम्ही **solar energy** वापरलं तर दाखवा मला **work displacement**, उदाहरणासकट सांगा. **solar** ला **energy** का म्हणायचे ? कुठे **work** होत आणि कसं **displacement** होत ? (**one is solar energy. Correct? One minute, if you say solar energy then show me work displacement, with example. Why should we call solar, an energy? Where is work, and how is displacement happens?**)
- 08:32-6 Ss: [whispering] **solar energy... panel** मध्ये **energy**, पण **displacement** कुठे होतंय ? **[solar energy...energy is in the panel, but where is the displacement?]**
- 08:41-2 Sg: solar panel मध्ये solar ची जी शक्ती आहे ती panel मध्ये साठवू शकतो, आणि त्याचा वापर करू शकतो. (In solar panel, the energy of solar can be stored in the panels, and we can make use of that.)
- 08:47-6 TS: मला **displacement** दाखवा (**show me the displacement**) [Maybe rhetorically]
- 08:50-1 Sg: म्हणजे आपण ... (which means we...)

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- 08:50-7 TS: तुम्ही काय, तुम्ही काय केलय, energy च definition काय केलं आहे, energy is the work ... हम्म ... energy is the capacity to do? Work. म्हणजे work घडून आलेलं दिसलं पाहिजे तिकडे (What have you, what have you made the definition of energy, energy is the work..hmm..energy is the capacity to do? Work. Which means work done should be visible there.)
- 09:03-1 Sg (same student continues): म्हणजे solar energy च इथपर्यंत displacement झालं, solar panel पर्यंत, आणि त्याचा पुढे आपण वापर केला. (which means, solar energy has been displaced until the solar panel, and then we make use of that)
- 09:07-9 TS: solar ... हम्म ... ते displacement कस झालं? ती solar energy तू capture केलीस ना, मग त्या solar energy चा वापर करून तू काहीतरी displace करायला पाहिजे (Solar...hmmm...how is that the displacement? It is the solar energy that you captured, isn't it, then now you should displace something using that solar energy)
- 09:15-4 Sg: हा.. मग त्याचा आपण पाणी तापविण्यासाठी ... (Yes...then for heating the water....)
- 09:19-2 TS: [interrupting] मग पाणी तापवलं तर **displacement कुठे झाली आहे? (So if you heat water where is the displacement?)**
- 09:28-2 TS (softer voice): लक्ष द्या आणि व्यवस्थित उत्तरे द्या, आता पुन्हा सांगायला लावू नका. (Pay attention and give proper answers, Now don't make me say this again.)

What the teacher was doing was that she was asking for examples of energy and she had explained that energy is the capacity to do work and for work to be done something has to be displaced. So, for any example of a type of energy that students would bring up, she would ask where is work done and where is displacement. So when a student says solar energy, she asks where is work done and where is displacement. So first student says that we get energy from solar panel and we do work. But then she asks where is displacement in it. To this student responds there is displacement as energy has reached from sun to the solar panel. Here although teacher denies that there is no displacement, she seems to be not very sure about it and is not able to provide any justification for her denial. Ultimately without explaining or answering, she moves on to another question.

Both the students and the teacher are here confronted by conflicts which the textbook does not address. The teacher as well as the students seem to be confused. The textbook chapter presents definitions and abstract equations related to work, energy, power, etc, and teacher tries to make them less abstract by discussing examples from real life, such as people carrying weights and throwing balls, planetary motion, pendulums, water flow, solar energy, chemical energy, nuclear energy, etc. It is an impossible task to make all this seem as though it is clear and unquestionable, but that is what the textbook attempts. Examples like solar

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energy are too complex to understand simply in terms of something like work and displacement. Though such conflicts provide opportunities for students to engage in authentic discourse, confronting such conflicts (and addressing the questioning which arises due to the recognition of such conflicts) are actually not intended as teaching objectives. The teaching objectives are actually more concerned with remembering definitions, clarifying concepts, finishing the syllabus, and passing the exams. The pedagogy allows no time to realise that concepts may not be very simple and may not simply correspond to real-life situations.

This is an example where students try to move away from the set boundaries of the classroom objectives (learning concepts as defined by the text), however they could not go far and teacher brings the discourse back to the frame of the text. So students do try to take agency to move away from 'set' discourse, but it seems very difficult for them to go beyond the frame of text. But what we think would be more meaningful in terms of learning, is to challenge the set frame of text and move beyond it. As discussed in framework (**section 3.6.1**), Freire (1968) argues that unless classrooms become places of critical discourse, whereby students problematise set frames rather than conforming to these, we cannot think of education as 'practice of freedom'.

We claim that the potential for authentic learning may even have been enhanced because the teacher as well as the students were confused. If the teacher had not been confused, and had supplied seemingly non-contradictory answers to the conflicts, there is little chance that such answers would have been understood by the students. But the students may have given up and stopped their questioning and searching for answers, realising that the teacher has some understanding that is beyond their grasp.

In another example, in TK's class, students showed disagreement to the teacher regarding the use of agriculture and garden waste (Episode 4.12). As teacher says that the waste produced in the agriculture and garden is called agriculture and garden waste, then a boy Sajid at 09:01-9 somewhat tentatively claims that the so-called waste is not waste because it is useful, saying, "वो तो काम आता है" (**That is useful**). We classify this as an implicit question, as we will discuss later.

It seems that the students not just showed disagreement with the teacher but also challenged the textbook calling 'unused' material from garden and agriculture as waste. To Sajid's question, the teacher explains that such a waste can be used as fertiliser or manure and then

goes on to explain that whether something is called waste depends upon whether it is useful or not. Teacher says that the way you use it will tell whether it is useful or waste. So if you can use it rightfully then it can be useful. To this another student at 09:33-0 asks the explicit question: **ऐसे -- कचरे का भी ? (Like this -- garbage also?)**. But the teacher seems to have not noticed this question and moved forward.

Here in these three examples, it is interesting to note that students show their disagreement through questioning. This is how Meyer (1982) and Walton (2005) define questioning, to have disagreement or expression of doubt or having alternate point of view or opinion. In such a context we see the role of student questioning in classroom discourse being very crucial where they could challenge the teacher's frame and were critical about it.

4.3.4 Nature of topic taught and student agency

It is interesting to note that in two of the lessons, solid waste and story of waste water, the topic being more related to everyday phenomena, students participation was comparatively more and the teacher control was less. But in the case of topic of work and energy, the discourse was more around the concepts and facts as described in the book, so there was less of a chance for the teacher to move away from the textbook frame.

What we noticed about the discourse inside the classroom, generally teacher did follow the text in terms of topics, facts and concepts but did not follow the textbook word by word. Teachers would bring their own examples and use their own language and sometimes even ask students for their examples. This way discourse was very dynamic and not pre-defined. But depending upon the topic being taught teachers had more or less agency to move away from the textbook discourse. In case of more abstract topics, classroom discourse was more closer to the textbook discourse.

4.4 Understanding the structure of classroom discourse

In our observations of the three classrooms, the pattern of discourse among the teacher and students that we observed was mostly different forms and combinations of teacher initiation (I), student response (R) and teacher evaluation/elaboration (E, or teacher feedback, F) with the most prevalent being IRE triad. As we discussed in **Section 2.3.1.3** of Chapter 2,

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extensive research has already been done showing the prevalence and significance of the use of the IRE triad in classrooms in various countries. We will not delve into greater detail about IRE here as it will not be the focus of our discussion here because it has already been studied so much, and as it is focused around teacher questioning rather than student questioning.

In an IRE pattern of talk, the sequence of talk gets initiated by the teacher's question, with the teacher allocating the turn to a student to respond and keeping the control of the end turn of the sequence by giving the evaluation or feedback on the student's response.

Here is an example of a long sequence of teacher student talk from TF's class.

Episode 4.15

- 00:15-3 TF: ਹਾਂਜੀ . ਅਗਲਾ . question ਤੁਹਾਡਾ ਹੈਗਾ ਆ ... ਸਫਾਈ ਅਤੇ ਬਿਮਾਰੀਆਂ ਦੇ ਵਿਚ ਸੰਬੰਧ ਨੂੰ ਸਮਝਾਓ ?
(now . the next question is ... **explain the relationship between cleanliness and getting sick?**) [As she reads the question from the textbook] I
- 00:24-1 TF: ਫੇਰ ਸੈਨੂੰ ਇਹ ਦੱਸੋ ਸਫਾਈ ਤੇ ਬਿਮਾਰੀ ਦੇ ਵਿਚ ਆਪਸ ਚ ਕੋਈ ਸੰਬੰਧ ਹੈਗਾ ? (**Then tell me whether there is some relationship between cleanliness and disease?**) I
- 00:27-7 TF (rhetorically, after she does not get any response): ਕੋਈ ਹੈ ਸੰਬੰਧ ਕੇ ਨਹੀਂ ? (**Is there a relationship or not?**) I
- 00:31-0 TF: ਕੋਈ ਸੰਬੰਧ ਨੀ ਸਫਾਈ ਤੇ ਬਿਮਾਰੀ ਵਿੱਚ ? (**There is no relationship between cleanliness and disease?**) [asking rhetorically] I
- 00:33-0 Dalbir (sitting on first bench on right most line): ਹੈਗਾ ਜੀ .. ਸਫਾਈ ਵਧੀਆ ਹੁੰਦੀ ਆ (There is ... **cleanliness is good**) [starts with a louder voice but towards the end becomes very soft] R
- 00:36-2 TF: ਸਫਾਈ ਵਧੀਆ ਹੁੰਦੀ ਆ ਫੇਰ ? (**Cleanliness is good then?**) I
- 00:37-9 Dalbir (answering teacher): ਜੀ ਇਸ ਕਰਕੇ ਸਾਨੂੰ ਸਫਾਈ ਰੱਖਣੀ ਚਾਹੀਦੀ -- (So we should keep cleanliness --). R
- 00:39-3 TF: ਕਿਉਂ ਕਾਰਣ ਵੀ ਦੱਸੋ ? (**Whyy, tell reason also?**) [stresses on 'why' by stretching it while asking] I
- 00:41-2 Dalbir: ਜੀ ਸਾਨੂੰ ਬਿਮਾਰੀਆਂ ਨੀ ਲੱਗਦੀਆਂ ਜੀ (We do not get diseases) R
- 00:42-6 TF: ਕਿਉਂ ਨੀ ਲੱਗਦੀਆਂ ਬਿਮਾਰੀਆਂ ? (**Why we don't get diseases?**) I
- 00:45-0 Dalbir: ਜੀ ਜਿਵੇਂ ਪਾਣੀ ਖੜਾ ਉਹਤੇ ਮੱਛਰ ਪੈਦਾ ਹੋਊ (Like there is stagnant water, mosquitos will breed there) R
- 00:48-7 TF (Dalbir has not stopped at this point but the teacher gives her remarks as Dalbir continues speaking): ਹਾਂਜੀ (yes) E
- 00:49-0 Dalbir: ਜੀ ਉਹ ਕੱਟੂ ਤੇ ਡੋਂਗੂ ਹੋ ਜਾਊ (it will bite and then one will get dengue) R
- 00:51-0 TF: ਹਾਂਜੀ (yes) E

- 00:52-0 Dalbir: सदासी रँधंगे डेंगु रेडु नी (We will keep cleanliness, then there will be no dengue)
R
00:52-0 TF: रंजी (yes) E

Here we notice that the sequence is more complex than IRE,IRE,IRE.... It is rather, IIIIRIRIRIRERERE.

In another example from TK's class, we show a small part of a long sequence of IRE discourse happening between teacher and the students:

Episode 4.16

- 05:50-6 TK: **What is a second kind of waste? Industrial waste, right?** इधर लिखा हुआ है
[talking to someone in a softer voice] बाद में बताएंगे, **okay?** . **The second is?**
Industrial waste, right? तो अब आपका **industrial waste** क्या हो सकता है आपके हिसाब से ?
What can be industrial waste? (What is a second kind of waste? Industrial
waste, right? . Its written here [talking to someone in a softer voice] will tell later,
okay? . **The second is? Industrial waste, right?** . **So according to you what**
can be your waste? What can be industrial waste? I
06:07.7 S: **Sir मैं बताऊँ ? (Sir, shall I tell?)** [very explicitly asking for permission] R
06:10.1 TK: **आपका बोला मैंने नाम ? (Have I called upon your name?)** E
06:09-2 One boy: toothpaste R
06:10-1 TK: **haain?** [clarification] E
06:11-3 TK: -- -- -- Akhtar I
06:11-7 Akhtar: food R
06:14-9 Some Students: नहीं! . भईया ? (No! . **Brother?**) [asking for permission to answer] R
06:14-3 TK: Aditya (?) I
06:17.2 Aditya (?): जहाँ factories -- to throw the garbage outside (Where factories -- to throw
the garbage outside) [teacher starts without any wait or pause]R
06:20.4 TK: **So factories से जो garbage outside throw करके that could be? (So the**
garbage thrown out from factories that could be?) E,I
06:23.8 s: Chemical. [background oils, gases] R
06:24.6 TK: *Chemical and oils* E

Here the longer sequence is: IREIREIRIREIRE. In both these examples all the I turns and E turns were made by the teacher.

Though in both the examples the discourse is not a simple IRE chain but a variety of combinations of I, R and E, however, the turns of asking (I), responding (R) and evaluating

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(E) remained fixed and in the control of the teacher. So it was the teacher who decided about who, how and when someone will participate in the discourse and even for how long. By keeping hold of the two key turns (asking and evaluating) of the three part sequence, the teacher controlled the content of the discourse as well as the length of the discourse. Furthermore, the discourse at one time was between one student and the teacher, rather than directly between students. Even when two students spoke consecutively (at 06:11 - 06:14), they were both addressing the teacher. Also there were very few instances when two different students took consecutive turns in the sequence of turns.

Furthermore, it is interesting to note that student questioning at times disrupted the regular course of the discourse by breaking a long IRE sequence. For example in **episode 4.12** Sajid's question breaks and even inverts the regular discourse, by taking the turn of asking and thus implicitly passing the turn of responding to the teacher. So we see the turn of asking being critical in deciding the turn taking and turn allocation, thereby deciding the control of the discourse. Since most of the questioning was done by the teacher, the control of the discourse remained with the teacher. The students hardly had any chance to ask their own questions or make their own claims that were not in direct response to the teacher's questions.

Also with the turn of evaluation being in control of the teacher, the decision to end the sequence or topic remains with the teacher. Lemke (1990) argues that in situations where the teacher asks a question for which either teacher does not know the answer or there are many possible answers, then the evaluation part by teacher cannot occur and the typical IRE gets broken. Lemke calls such a dialogue as 'true dialogue' and says that the only cases when it occurs is around classroom or other matters but not science.

The IRE pattern of talk is found to restrict students opportunities to talk and ask in the class (Alpert, 1987), where teacher dominates and control the talk. Also such a talk limits the potential use of language as it lacks the dynamics and complexities seen in everyday or ordinary discourse. Though most of the talk that we observed in schools happened within the institutional context, but we wonder whether there were instances of 'ordinary' talk as well. Though in later chapters we talk more on this issue, but to address this question more research focusing on the structure of classroom discourse would be needed.

It may seem surprising that this IRE sequence is so ubiquitous and that teachers and students fall into their roles in IRE sequences so effortlessly, without even being fully conscious that

they are doing so. The large prevalence of IRE discourse pattern in classrooms can be possibly explained if we understand the nature of education and schooling, centred around memorisation of expected answers without questioning the questions, as described in framework in **Section 3.6.1**. In such a pedagogy teaching and learning functions to teach students to be obedient and submissive, rather than being critical or to challenge authorities. Thus it ends up reinforcing the existing social structures.

4.5 Teacher questioning

Teacher questioning is quite different from student questioning, because the reasons for which a teacher asks questions are (mostly if not always) not because the teacher does not know the answer but to elicit certain (predetermined) response from students. Unlike students, teachers do not ask questions because they are perplexed about what is being asked, but about what is being answered by the student. For example in **episode 4.16** at 05:50-6 TK asks “*What can be industrial waste?*” Teacher did not ask this question because he did not know what is industrial waste. He may think that he asks because he wants to know how the students will answer or what they believe or understand. But actually, he is probably unconsciously asking to find out whether the students will give the answer he (the teacher) thinks is correct. In any case, the functions of teacher questions are not epistemic (in the sense of finding and justifying an answer to the question, what can be industrial waste) but pedagogical. Due to these reasons, researchers have called teacher questioning as inauthentic and the questions asked by the teachers as ‘exam’ questions (for more details see **section 2.3.1.3**). The hidden or implicit question behind question asked by a teacher is whether student knows the answer, whether student understood it or how much the student has understood. So the authentic question in the teacher’s question is implicit, which is whether the student knows the answer to this question or not.

However, we wonder whether there are instances or examples from everyday life where questioning similar to this kind of teacher questioning could be observed. We wonder whether this also happens in informal contexts, e.g. does an adult or expert (or even other children) ask known-answer questions or elicit particular responses to ‘teach’ children? We wonder how discourse around learning occurs in apprenticeship models. Is ‘teacher questioning’ used by experts to train novices? Research looking into these questions could be useful in understanding whether there is any relevance of such kind of ‘teacher questioning’.

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Though most of teacher questioning in the classes we observed was ‘inauthentic’, But teachers did ask authentic questions like procedural or clarification questions, where the teacher actually did not know the answer. For example,

Episode 4.17

12:50-3 Dalbir: ਰੋਡ ਤੇ ਈ ਸਿੱਟ ਆਉਨੇ ਆਂ ਜੀ (Throw it on road only)

12:52-0 TF: **Hain?**

TF could not understand what Gurbanchan said and at 12:52-0 asks clarification by asking “**Hain?**”, meaning what did you say? Similarly, at 15:06-7 TF asks an authentic procedural question by asking whether students have noted down the answer from the board:

Episode 4.18

15:06-7 TF: ਉਤਾਰ ਲਿਆ ਸਾਰਿਆਂ ਨੇ? (**Has everybody noted down**) [asking about what she wrote on blackboard]

15:07-6 Some students: ਜੀ ਨਹੀਂ (No mam)

But there were very few teacher’s authentic questions about the topic being taught. For example we have discussed one such situation in **episode 4.14** where both the teacher and student seemed to have genuine conflict about the topic being discussed. And this actually led to interesting discourse between the teacher and the student.

In the three classes, we also noticed fewer teacher questions asking justifications or reasons or involving students in some kind of argumentation. Here is an example of an episode where TF continuously asks three explanation questions from Dalbir.

Episode 4.19

00:36-2 TF: ਸਫਾਈ ਵਧੀਆ ਹੁੰਦੀ ਆ ਫੇਰ? (**Cleanliness is good then?**)

00:37-9 Dalbir (answering teacher): ਜੀ ਇਸ ਕਰਕੇ ਸਾਨੂੰ ਸਫਾਈ ਰੱਖਣੀ ਚਾਹੀਦੀ- (So we should keep cleanliness-).

00:39-3 TF: ਕਿਉਂ ਕਾਰਣ ਵੀ ਦੱਸੋ? (**Whyy, tell reason also?**) [stresses on ‘why’ by stretching it while asking]

00:41-2 Dalbir: ਜੀ ਸਾਨੂੰ ਬਿਮਾਰੀਆਂ ਨੀ ਲੱਗਦੀਆਂ ਜੀ (We do not get diseases)

00:42-6 TF: ਕਿਉਂ ਨੀ ਲੱਗਦੀਆਂ ਬਿਮਾਰੀਆਂ? (**Why we don’t get diseases?**)

00:45-0 Dalbir: ਜੀ ਜਿਵੇਂ ਪਾਣੀ ਖੜਾ ਉਹਤੇ ਮੱਛਰ ਪੈਦਾ ਹੋਊ (Like there is stagnant water, mosquitos will breed there)

Here we see slightly longer responses and greater involvement of a student, with no predetermined answers. So these teacher questions led to more meaningful participation by the student in the discourse.

We see a difference in the kinds of questions asked by the teacher as compared to the kinds of questions asked by the students. This may be because of the difference in the functions of teacher questions, which are mostly pedagogic and the difference in the power relations between students and the teacher. For example, we noticed a number of permission seeking questions asked by the students to the teacher, however we could not notice permission seeking questions by the teacher. However, there were questions like procedural, clarification and confirmation, which we found both in teacher as well as student questioning. Also we found two kinds of teacher questions which were specific to the teachers only. We discuss these two types in detail here.

4.5.1 Complete the sentence questions

In all the three classes that we observed, we found one very interesting kind of teacher question, whereby the teacher would utter an incomplete sentence ending with rising intonation and students, generally in unison, would answer by completing the sentence. We have called this type of teacher question as ‘complete the sentence’ questions. Because of the rising intonation, this kind of question is explicit.

These questions are similar to other kinds of inauthentic ‘known information’ (Mehan, 1979) questions since the teacher already knows the answer (i.e. the rest of the sentence). In fact, usually as students would answer, the teacher would either say the answer along with students or repeat it after students, as a sort of evaluation, confirming that they were correct, there by completing the IRE sequence. However, in this kind of sequence, the evaluation part was not very explicitly emphasized. Most of the times students knew the answer for such questions. But in case students did not know the answer then teacher would herself first complete the answer and then again repeat her question to be completed by students.

For example, in a discussion on waste decomposition in TK’s class, we heard:

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Episode 4.20

- 13:57-7 TK: *quickly . right . decompose का मतलब क्या होता है . it will break into?* (*Quickly . right . the meaning of decompose is . it will break into?*)
- 14:05-8 Ss (in unison): *Smaller parts.*
- 14:06-5 TK: *Smaller parts.*

Here is another example from TS's class on work and energy:

Episode 4.21

- 00:38-6 TS: *त्यादिवशी आपण काय बघितलं ? work बघितला . (What did we see that day? We saw work.)* [without pause]
- 00:42-5 TS: *बरोबर ? work चा formula काय ? (Correct? What is the formula for work?)*
- 00:44-8 Ss (in unison): *Work is equal to force into displacement*
- 00:48-8 TS: *Force into?*
- 00:49-8 Ss (in unison): *displacement* [sound of writing on the board]

At 00:48-8 TS repeats her question, but by forming an incomplete sentence to be completed by the students. Here it was a kind of reinforcement using this questioning, where the answer has already been stated by the students.

Though we found these questions in all the three classes, but the number of such questions asked by the three teachers was quite different. One of the teachers, TS, quite frequently asked such questions.

Such questions were clearly meant to reinforce the 'facts' and help students memorise answers to questions that might later appear in examinations. This method is similar to the one used to help students memorise multiplication tables in schools.

This kind of questioning is similar to the "incomplete turn constructional units" reported by Lerner (1995). However Lerner's concern is mainly in understanding the structure of different kinds of utterance sequences between the teacher and students and how a particular structure provides or restricts opportunities for student participation. We are more interested in the nature of the student participation and whether it includes student questioning or supports learning of the process of doing science, which unfortunately it does not appear to do.

4.5.2 Teacher's rhetorical questions

As discussed in Chapter 2 (**section 2.2.1**), rhetorical questions are aimed primarily at making a point rather than at seeking a response. Generally in conversations these questions are used to convey a strong disagreement or rejection of another person's view or argument. It is interesting to note that we found a number of examples of these questions being asked by teachers, but we did not find a single example of students asking/saying rhetorical questions to the teachers. This could be because of the assertive nature of such questions and because students are lower in hierarchy than teachers and they could not explicitly challenge the teacher.

We here present a few examples of teacher's rhetorical questions asked inside the classroom. One of the ways teachers used rhetorical questions was to elicit 'expected' answers from students. For example here (**episode 4.22**) teacher TF first asks students whether there is any relation between cleanliness and diseases, but as nobody answers this question, she reframes it as 'Is there a relationship or not?' Again not getting the answer she puts it rhetorically as 'There is no relationship between cleanliness and illness?' From this last statement the teacher meant the opposite of the relationship stated in the sentence, i.e. that is there is a relationship between cleanliness and illness. So in a way after not getting any response from students, she gave a hint for the answer, but at the same time treating students' quietness as if they were conveying the wrong answer. Koshik (2005) in her study on functions of rhetorical questions, describes how teachers use rhetorical questions to convey criticism or disagreement with student's answer in form of evaluation and to provide a hint to students for self-correction of their errors.

Episode 4.22

- 00:24-1 TF: ਫੇਰ ਸੈਨੂੰ ਇਹ ਦੱਸੋ ਸਫਾਈ ਤੇ ਬਿਮਾਰੀ ਦੇ ਵਿਚ ਆਪਸ ਚ ਕੋਈ ਸੰਬੰਧ ਹੈਗਾ ? (**Then tell me whether there is some relationship between cleanliness and disease?**)
- 00:27-7 TF (rhetorically, after she does not get any response): ਕੋਈ ਹੈ ਸੰਬੰਧ ਕੇ ਨਹੀਂ ? (**Is there a relationship or not?**)
- 00:31-0 TF: ਕੋਈ ਸੰਬੰਧ ਨੀ ਸਫਾਈ ਤੇ ਬਿਮਾਰੀ ਵਿੱਚ? (**There is no relationship between cleanliness and disease?**) [asking rhetorically]
- 00:33-0 Dalbir (sitting on first bench on right most line): ਹੈਗਾ ਜੀ .. ਸਫਾਈ ਵਧੀਆ ਹੁੰਦੀ ਆ (There is ... **cleanliness is good**) [starts with a louder voice but towards the end becomes very soft]

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In the second example TS stretches the word 'ka' to sound rhetorical, there by telling the students that there is no difference between the two, energy and work.

Episode 4.23

05:18-0 TS: आणि दोघांमध्ये फरक आहे का? (**and is there a difference between the two?**)

05:19-9 Ss: नाही... हा... [softly]

In this example, it is interesting that although the teacher with her rhetorical question has already stated the answer - that there is no difference in the two - we do notice some soft voices actually answering in 'yes' which perhaps teacher could not notice.

In the third example, at 09:19-2 we notice teacher disagreeing by rhetorically questioning student's response.

Episode 4.24

09:15-4 Sg: हा.. मग त्याचा आपण पाणी तापविण्यासाठी ... (Yes...then for heating the water....)

09:19-2 TS: [interrupting] मग पाणी तापवलं तर **displacement** कुठे झाली आहे? (**So if you heat water where is the displacement?**)

09:28-2 TS: [softer voice] लक्ष द्या आणि व्यवस्थित उत्तरे द्या, आता पुन्हा सांगायला लावू नका. (Pay attention and give proper answers, Now don't make me say this again.)

After asking this, TS goes on telling students to give proper answers, which makes us understand that she did not expect an answer when she said 'where is the displacement' and has meant that rhetorically.

Interestingly, in the first two examples, teacher's rhetorical question does get a response, this is contrary to the general understanding of rhetorical questions. It is understood that rhetorical questions have obvious answer or answer in the question itself, that is why such questions do not get responded. But in classroom discourse, reasons for teacher's questions are different. Also in other examples of teacher's questions, like 'complete the sentence' questions, answers were very much obvious. So, even though teacher frames her question rhetorically, at times she does expect students to respond. For the reasons that rhetorical questions sometimes do get a response, Koshik (2005) uses the term 'reversed polarity questions' or 'RPQ' to refer to rhetorical questions with both, when asked, meant to assert opinions than asking any new information. An in-depth study of teacher's rhetorical questions could bring

forth some of the crucial aspects of classroom discourse, which have not been understood earlier.

4.6 Teacher's pauses and wait times

In our observations of the three classrooms, we noticed teacher would hardly pause after asking a question or after a reply from a student. This pause by the teacher after teacher's question and then after student's response has been defined as wait time and has been discussed in Chapter 2 (see **section 2.3.6.9**).

Generally if teacher would not immediately get a response from students she would either answer her own question or reframe her question. Also even when students responded, the teacher would immediately start talking, many a time even before a student has completed their response. But we also noticed that at times teachers did take longer pauses and it did result in students getting involved in discussions. For example in TS's class in **episode 4.08**, at 09:38-0 after telling students to give another example, she takes a longer pause. This gave the chance to the students to discuss about more examples amongst them, though they did so while whispering. TS also at times told students to answer by discussing among themselves by taking pause, this also lead to discussions among students.

We think teachers 'wait time' and pauses have pedagogical value, but unfortunately this practice is not very common.

Furthermore, we noticed teachers occasional use of pauses to indicate implicit questions. For example at 06:33-7 teacher repeats the student's response with evaluation and then takes a pause, indicating that the students should continue giving more examples of industrial waste.

Episode 4.25

06:20-4 TK: **So factories से जो garbage outside throw करके that could be? (So the garbage thrown out from factories that could be?)**

06:23-8 Ss: Chemical. [background oils, gases]

06:24-6 TK: *Chemical and oils*

06:28-7 TK: *I am happy a lot of students are raising their hands and not giving random answers. Akhtar?*

06:32-6 Akhtar: Gases

06:33-7 TK: Gases [said like confirming its the right answer] . *smoke chimney से जाता है..*

Though when teacher said ‘smoke comes from chimney’, it’s not a question but the evaluation to the previous answer. But the previous question about examples of waste from factories continues, with teacher indicating the question by pause.

4.7 Student answering in chorus

In all the three classes we observed student answering teachers’ questions in unison or chorus. Especially in TS’s class there was more of unison or chorus recall of answers by students, This is in addition to her sentence completion technique, which also involved choral answering, as we have discussed above. This kind of chorus recalling is mostly aimed at memorisation of facts and also used by teachers to keep the students alert and make sure they are listening and responding. So this kind of helped the teacher to do a formative assessment about whether students are involved and listening.

There may be some advantages to choral answering. It could be a way to more actively involve all, or a larger number of students, as compared to classroom situations in which students are made to sit quietly listening to the teacher talk. This could be especially important in classrooms with large numbers of students, where it would otherwise be difficult to give all students chances to speak. Also, it is well known that memory can be enhanced when one is speaking out loud, compared to reading silently. If text or answers need to be memorised, it is therefore advisable for students to speak out loud. However, such an answering style places focus on remembering where students passively participate in the discourse without having to think actively, critically analyse, or ask questions. This is an undesirable aspect of the ‘banking’ model of current schooling, which we have discussed in our framework in **section 3.6.1**.

4.8 Culture of rote memorisation of questions and answers

In TF’s and TK’s class, at the end of the class teachers assigned homework to the students. Since TF had finished doing the chapter, she asked students to memorise questions (and answers) number 1 to 7 at the end of the same chapter as their homework. Also, TK assigns

students to write down the question, 'What are the effects of solid waste'. He tells them that their homework is to find the answer on page 218 of the textbook and write it down in their notebooks.

So we see that in this type of written work, students do not have the freedom to compose their own questions or answers. Arguably, they had more chances to give their own answers in the oral discourse in the classroom or at least put answers in their own words.

In our experience of classrooms, in most of the schools we found neatly maintained notebooks with questions written in red ink and answers written in blue ink. The notebooks only had questions and answers written there, nothing else, with all the students have written the same questions and the same answers in their notebooks.

4.9 Summarising our classroom observations

In our studies of classroom observations, what we found regarding the frequency or occurrence of student questioning and student talk is similar to what is reported in previous studies by other researchers (reviewed in Chapter 2). Although, there are no studies specifically focusing on classroom questioning from Indian contexts, there are studies that report a lack of student questioning and students talk and the dominance of teacher talk and teacher questioning (Kumar, 1989 ; Sarangapani, 2003). In the three classrooms that we observed and analysed we did not notice much of student questioning in the classrooms. Even if students did ask questions, there were very few of those which showed disagreement with the teacher and the textbook or which led to further questioning or which engaged students critically. As described in framework in **section 3.6.1**, being critical and raising questions is opposed to the current banking model model of education, which is based on maintaining the status quo.

Though most of the discourse that we noticed did happen with alternate teacher and student turns, but the teacher was talking much more than the students. We found that the nature of discourse in classrooms was very rigid such that that the roles of teacher and the students were very much fixed and predetermined. Getting involved in the classroom discourse for students was not easy as most of the times they would have to seek permission of the teacher, wait for their turn and not speak out of turn. Similar observations regarding the students' participation in the classroom discourse have been reported by other researchers as well

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(Dillon, 2004). Furthermore, even if students got involved, mostly their responses were according to teacher's or textbook's frame. It was the teacher who posed the question and then decided what constituted a relevant and acceptable answer to that question. Barnes and Todd (1977) argue that the purpose of such teacher questions is to make sure that students are operating within the teacher's content frame rather than construction of understanding or exploration. Furthermore, they argue that way questions are asked, understood and responded to depends upon the social relationship between the asker and the respondent. So we wonder if the power relations between the teacher and the students in a class are altered, how it will impact the process of questioning and answering in the class.

In the classroom communities, students learn the implicit norms governing the social organisation of classroom. They learn the norms of participation in classroom discourse. Students get 'schooled' for certain classroom behaviours and learn the classroom meanings of talking, asking, answering, etc.

As we discussed in Chapter 2, other researchers have pointed out that much of teacher questioning is inauthentic, in that they already know the answers to their questions and we have found evidence of this in all the classrooms we studied. Actually teacher questions have the implicit question of whether students know the answer or not. A teacher could instead directly ask a student 'do you know this' and student may reply in yes or no. But will this let the teacher know what a student knows? Another way could be that teacher may listen to student talk, may look at their work, may observe them working in groups - this way teachers can try understanding students' understanding. Furthermore, the kinds of questions a student would ask will also reveal a great deal about student's understanding.

Apart from confirming what is reported by previous researchers, our study of classrooms also advances the understanding and categorisation of the nature of both student and teacher talk and questioning in the classroom. In our observations we found teachers using rhetorical questioning to elicit 'expected' answers. Also we have observed students whispering as one of the important means by which students take agency to participate in the classroom discourse. We observed a correspondence between student questioning and student disagreement with the teacher and the textbook. Also we noted the importance of students' implicit questioning, which has not been previously reported in the literature. Our research indicates that more in depth studies of all these aspects of classroom discourse and student questioning are required.

5

Students' Spontaneous Talk and Questioning: Identifying and categorising questions

In this chapter, we look at the frequency of student talk and student questioning in the three informal contexts. We also look at the types and functions of students' questions in these contexts. In these contexts, we found much more student talk and student questioning in comparison to classroom contexts. Also in these contexts we found certain kinds of student questions that we did not notice in classroom contexts.

But why did we notice much more student questioning in informal contexts. We think that one of the reasons for this was that there were many more opportunities for the students to talk with each other in informal contexts as compared to classroom contexts. Dillon (1983) argues that students engage in questioning and answering more readily with each other than with their teacher. Even if inside the classrooms, students had the chance to talk, they did so by remaining within the frame of the teacher or textbook. Karen Gallas (1995, p. 3) argues that a dialogue about the world and about the science among students can only begin when it occurs outside the theoretical frame of the teacher or the textbook.

I believe that when a community of learners begins with the act of dialogue about the world, and when that dialogue occurs outside of the theoretical or conceptual influence of the teacher, it moves more naturally and vitally toward theory and a readiness for instruction and study. This is the point at which the appropriation of the discourse of science begins. In this process the students take on the voice and the authority of scientists. They begin to bring their world of experience to the classroom in the form of personal narratives and important questions, realizing as they do that what they observe, wonder, and imagine has importance in a science classroom. In this way teachers and children move purposefully together toward an inclusive kind of talk about science where everyone is admitted.

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Furthermore, in agreement with James Dillon, Karen Gallas (1995, p. 100) argues that for listening to and understanding students' ideas and their naive theories, teachers have to learn to be silent. If teachers will keep interrupting students while they are talking or responding, rather than bringing forth their own ideas students will end up giving what the teacher believes as answer or ideas.

They will believe that their ideas are always being judged and are most probably not the right idea when they asked questions. They will search the teachers face for the right answer modifying their response at even the slightest nonverbal reaction. The answers they do provide will be the teacher's or text book's answer rather than their own.

But, for the purposes of understanding student questioning, how do we create such contexts where students talk without being judged or evaluated by the teacher or the textbook? We had this question when we first planned our workshop with the Shashtri Vidyalaya School students. Based on our prior experience, we thought of observing students in more informal contexts where students could have more opportunities for spontaneous talk and discussion. But we were not very sure how much of student talk and student questioning will occur in such contexts.

5.1 Why informal contexts involving student-student spontaneous talk outside classrooms?

We must clarify here that the classroom observation was not the first step in our study. From the very beginning of this study, we planned to investigate student talk and student questioning in more informal and unstructured contexts and this was the main purpose of our study. However, to understand and reflect upon the process of student questioning in informal contexts, we wanted to understand the process of questioning from inside the classrooms as well.

Only a few researchers had tried understanding the process of student questioning in informal contexts. Barnes and Todd (1977, p. 13), who studied student-student talk in similar contexts, argued that there is a need to withdraw students from classrooms, as inside classroom contexts we do not see much of group work and student discussions. Furthermore, in their

observation of the students talk in outside classroom contexts they found not just an abundance of student talk but quality talk as well.

In our own experience of classrooms as well as our observations of classroom teachings, we saw a rarity of group work and student-student discourse inside the classrooms. We wanted student-student talk not governed by some external motivations or by purposes set out by the teacher but talk driven by students' own motivations and purposes.

Actually, we realised that it's the student-student talk which is important for generating students' own questions. So we thought of providing different opportunities through different activities for students to talk. We got interested in those contexts where students talked freely among themselves without the teacher.

Some people may disagree with the idea of letting children loose to learn on their own. Such people would say that being in a group or community that includes an expert, such as a teacher, the experience of the expert can help less experienced or newer ones to learn. However in education, we have hardly explored the children especially their questioning when they are in their natural settings and are on their own, talking among themselves, arguing, discussing with each other. Studying children in these settings can tell many important things about their questioning process which could be useful in creating authentic contexts in schools for learning.

We also considered trying to investigate even more informal talk in which no adults are present. We thought of eavesdropping on children's conversations and activities as they are playing in the school grounds or at home, or as they are engaged in work and everyday activities at home. We considered doing this by asking a few children to wear voice recorders and leave them on when we are not present. But we thought it might be hard for the children to completely forget that they were being recorded and we still may not get to record their 'natural' talk. Though we could not try recording children at their homes, but a few times we did turn on cameras and recorders and then leave a group of students alone during the workshops with them. At times this did result in recording some interesting talk among students. But at other times this resulted in the students recording themselves singing and performing to the microphone. Maybe we should have left students alone with recorders for a longer duration. We think it would be worthwhile to make more attempts to record 'eavesdropped' conversations in various contexts. Of course, it requires getting students'

permission - and preferably recording students who are motivated to be co-researchers in this sort of endeavour, helping to listen to themselves and analyse their own questioning.

5.2 Did students talk?

In the three contexts from our workshops (variegated tree exploration, ants observations and parachute making), during the entire period of the recordings, as students worked in groups there were very few long pauses (more than 10 seconds) when students were not talking or not busy doing something. Most of the times students were interacting among each other with a continuous discourse happening amongst them. Often more than one student was talking at the same time. Due to this, transcribing these recordings was much more difficult and time consuming than the classroom recordings.

For example to give an idea of how much talk did happen among students in these contexts, we found about 370 utterances all together by Gurpreet, Gurdeep and Jaskaran in the parachute making in 24 minutes of their interactions. If compared to the classroom situation (**see section 4.1**), we observe much more talking happening in the informal explorations by students. In the other two contexts, the ants observations and variegated tree observation, the amount of student talk was even more than what we observed in the parachute making task.

However, there were of course differences between students: some particular students talked more and some asked more questions than others. For example in the parachute making task Gurpreet almost spoke double (186 utterances) than either of the other two students, Gurdeep (80 utterances) and Jaskaran (103 utterance). However, this just gives an overall idea, as there were differences in the lengths of utterances. Furthermore, the length of student utterances in informal contexts was generally longer (almost double) as compared to the length of student utterances in the classroom contexts.

But these differences in the talk among students are not as large as the differences observed between the teacher and the students in the classroom observations. For example in Parachute making it was Gurpreet who talked more than Jaskaran or Gurdeep. In the beginning, he was kind of leading and doing much more of the talking by telling the other two what to do and how to make the parachute. However his domination did not sustain for long and Jaskaran and especially Gurdeep who was more quieter in the beginning, did challenge Gurpreet's

domination and got more engaged in the activity. These dynamics of the group we describe in detail in the next chapter.

Similarly in the ants observation, we noticed differences among the six girls regarding who talked more and engaged more in observing or exploring the ants. The girls who sat close to the ants hole for all the time did more talking than others who were standing behind them. Though these positions were not fixed and many a time the girls who were at back moved forward. However one of the girls Manpreet, we noticed, did the least of talking and engagement. From the very beginning the other five girls did not seem to involve her more and kind of neglected her. This may be due to their relationships among each other inside the class or their classrooms status as being more 'ਹੁਸ਼ਿਆਰ (brilliant)' students than Manpreet. We delve more upon these power relations within a group in the next chapter.

It is interesting that although there were a few students who were not as talkative or active in the tasks, there was probably not too much boredom. When students became disinterested in what others were doing, they had the freedom to wander off and do something else. At times, some students engaged in activities that were not 'desirable', because they were off-topic, too noisy, or unruly. We even witnessed the beginnings of a few physical 'fights'. In other words, they were fooling around and behaving as they behave when they are not in school.

Compared to the classrooms we observed, student engagement in the informal contexts was more dynamic and variable over time. Even if some students were less involved and engaged at some times they were more engaged at other times.

5.3 Working and talking in groups

In all the three interactions that we report here, students worked in groups (without chairs or tables) and outside of their usual classrooms consisting of rows of desks facing the teacher. This setting we think was very crucial and led to interactions between the students. Particular arrangements of desks, chairs and tables are well known to individualise and confine students in particular ways—and may signify an alienated culture to students who may be more comfortable sitting on the ground in informal groups. Furthermore, in all the three contexts students were relatively free to roam around without seeking any permission.

Group work seemed to have played an important role in engaging students in discussions

among each other. Even though these students hardly had any school experience of working in groups and having discussions in groups, but in these workshops they readily engaged with each other in groups and did talking and exploring of stuff. We discuss these group dynamics further in the next chapter.

5.4 Did the students ask questions spontaneously without teacher guidance?

In our workshops with students we found much more student questioning as compared to the classroom contexts. **Table 5.1** describes briefly the number of questions asked by the students working in groups in each of the three informal contexts.

Table 5.1 Numbers of student questions found in informal contexts

	Parachute making	Ants observation	Variegated tree observations
Number of students	3	6	11
time for which recorded (min.)	24	33	48
Total questions asked	66	97	162
Questions asked per student	22	16.1	14.7
Question asked per student per hour	55	29	18.4
Question asked by all the students per hour	165	176.4	202.5

It is interesting to note that in the three contexts, the three groups we recorded, we observed all the students in the groups asking questions, although there were differences in who talked more and who asked more. However in the classroom observations we found only a few students in the entire class asking questions. As described in **Table 5.1**, the frequency of questions asked per student that we noticed in these contexts is almost 10 times as compared to what we noticed inside classrooms as reported in the previous chapter (see **section 4.2.3**).

This table shows questions of only those students who were part of the groups that we recorded, though we also observed some questions asked by students who were not in these groups (e.g. in parachute making and ants observations). Though we had compared the three contexts and calculated the questioning rates, but it may not be very meaningful to draw generalisations about student questioning as each of the activities was very different from others in terms of the tasks, nature of interactions and dynamics of the interactions.

To exemplify how and when students started asking questions, we present one episode from the students' explorations of variegated tree involving the very first student conversation that we recorded. After students had performed the warm up activity of playing a game, they were asked to move to another garden near the variegated tree (see **section 3.3.2.1**). In the very initial seconds of students reaching close to the tree, they start having discussions about the labels put on the trees in the garden (the labels were not part of our plan and the bhendi tree did not have a label). Gurinder asked the students to come close to the bhendi tree, but without mentioning the tree. Two boys, Suraj and Keshav, wandered past the bhendi tree to a casuarina tree about 5 metres away. Apparently they were attracted by the label attached to its trunk. The label contained the common name of the tree in Marathi (which is the same as its Hindi name) and in English, "Mast tree", followed by the scientific name "Casuarina equisetifolia" and "Family: Casuarinaceae" (see **Figure 5.1**).

Figure 5.1 The label on 'Mast' tree near the variegated tree



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Episode 5.01

- 01:26 Suraj: सुरु. मास्त tree. (Suru. Maast tree.) [reading from the label in Marathi and English]
- 01:27 Keshav or Hemant (?): काय आहे हे ? **(What is it?)**
- 01:28 Suraj: मास्त. (Maast.)
- 01:28 Keshav: [looking at the label] Mast tree. [pronounced मस्त, like the english word 'must']
- 01:29 Suraj: [after looking up to the top of the tree] मस्त tree! (Intoxicated tree!) [as he touches the tree trunk, loudly, jokingly, and smiling turns to the camera]
- 01:30 Keshav: मस्त tree! (Intoxicated tree!) [He smiles, then Hemant looks up to the top of the tree]
- 01:33 Suraj [Suraj again looks up]: तिथे कुठे ? **(Where is it?)**
- 01:35 Gurinder: [some distance away] इधर आ जाओ. (Come over here.)
- 01:38 a boy (Suraj?): मस्त! (Intoxicated!)
- 01:39 a boy (Keshav?): मस्त! (Intoxicated) [Suraj, Keshav and Hemant all look up]
- 01:40 Kranti: मस्त tree! (Intoxicated tree!) [gesturing to the Casuarina, then Suraj again looks up]
- 01:46 a boy: ये हिंदी का हे ? **(Is it Hindi?)**
- 01:46 a student: चढायला येत का ? **(Can you climb?)**

Thus, in the students' very first conversation, without being asked to ask questions or look at the bhendi tree, they did ask some questions, which were about the casuarina tree. Our open-beginninged effort resulted in a situation in which the students did not 'perform' according to our expectations: they did not at first focus upon the topic we had planned. In the students' first conversation, they did ask some questions, but contrary to our plan, they were about the Casuarina tree rather than the unusual variegated bhendi tree.

Thus, the boys collectively observed both the label and the tree top, and explicitly asked four authentic questions, without any teacher direction. The first explicit question, 'काय आहे हे ?' **(What is it?)** arose when the asker observed the label and/or heard Suraj read it, but realised that he did not understand what it was. Then they smiled naughtily, clearly because in their process of interactively decoding the text, they were confronting an amusing conflict between the English name and the similar sounding word in Hindi that means overjoyed, carefree, or intoxicated. This conflict between beliefs as to whether the word was Marathi, Hindi, or English was expressed as the question 'ये हिंदी का हे ?' **(Is it Hindi?)** at 1:46. It is interesting

that the first thing that attracted them was this label—an artefact, rather than nature. From the student interviews (not reported in this study) at the end of the workshop, we found out that there were no gardens anywhere around some of the students' homes. Thus it may not be surprising that the bhendi tree was not initially particularly curious to them—the entire garden was new and interesting.

When Suraj asked, 'तिथे कुठे ?' (**Where is it?**) he was probably trying to see the top of the Casuarina tree, which was quite high. We think there was a conflict between his belief that the treetop was there and his observation that the treetop was not easy to distinguish amongst the other treetops. He probably looked up because he wanted to find out what the tree was, through direct observation, and its leaves were all at the top.

5.4.1 Did student ask on being asked to ask?

In all the three workshops, at some point or the other we did ask students to either ask or write their own questions. In the variegated tree observations, at 29:52, Karen for the first time explicitly asked girls to ask questions by saying, "और भी प्रश्न है इसके बारे में ?" (**Any more questions about this**). At 30:15 Karen repeated her question and asked Ishita if she has any questions. Interestingly, upon hearing this Ishita started looking at and prying apart some leaves, but when Karen directly asked her again by saying, 'Hmmm?' she investigated a little more and then stopped and said 'No.' and walked away.

However, Priya reacted differently when she was asked to ask. She generally appeared to be more confident of herself and talkative, even as she tried to speak in Hindi, which she was not able to do very well.

Episode 5.02

- 31:22 Priya: [clicks her finger as if she got an idea] Ant उस पान को eat करती है। (Ants eats that leaf.)
- 31:26 Karen: *Hmm*
- 31:29 Priya: ये देखो -- छोटी छोटी मुंग्यां आहेत।(See this -- small small ants are here)
- 31:32 Karen: तो प्रश्न है इसके बारे में ? (**So, is there a question about this?**)
- 31:36 Priya: **Leaves को ant eat करती है क्या ?(Do ant eat leaves?)**

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Priya may have clicked her finger because she suddenly put two observations together—her previous observation of small holes in the leaves and this observation of ants. Although she has stated it explicitly upon request, we don't know whether the question of 'whether ants eat leaves' is an authentic question in her mind. Although students did ask questions on being asked to ask, but they were not spontaneous questions. When they were asked to ask questions, the student–student interactions decreased and rather interactions between one teacher and one student increased, and the student work became more individual, as described in the case of Priya. Their questioning seemed to be separate from their discussions. Perhaps their focus became on asking questions for the sake of asking questions, or to ask questions that they think the teacher wants them to ask rather than questions they really want or need to find answers to.

Furthermore, towards the end of this variegated tree session, the boys were asked if they had any more questions. Upon this they began dictating their questions quickly one after another to the teachers. Some of these questions appeared to be recollections of questions which had previously been asked during the spontaneous discussions. The students were still standing right next to (or inside) the tree, observing and touching it, which must have helped them remember or frame new questions.

Some of these questions did not appear to be related to each other. For example, (at 43:13) Nimish dictated the question: 'या झाडाचे रंग वेगवेगळे कसे काय?' (**How is it that the plant is having different colours?**). Immediately afterwards, (at 40:20) Suraj glanced at the base of the bhendi tree and dictated: 'या झाडाची मुळे अशी बाहेर का आली आहेत?' (**Why do the roots come out above ground?**). There was no further discussion on this topic; immediately afterwards Keshav showed Suraj a leaf bud and Suraj asked a question about it. These questions do appear to be authentic, although some of them appear to have been framed in order to satisfy the teachers' specific assignment rather than as part of a process of investigation.

In other cases, one student's question seemed to have been influenced by other students' questions. For example, questions about whether leaves were one colour or another colour had gradually evolved, and probably later led Nimish (when he was asked to ask questions) to state the question (at 44:25): 'ये झाडावर जास्तीत जस्त किती रंगाची पाने अस्तात ?' (**How many different colours of leaves can grow?**). Perhaps this is what then led Binod to state the

rather different question (at 45:12): 'हे झाड जेव्हा वाढतं तेव्हा रंग का बदलत ?' (**Why does this tree change its colour as it grows?**). The initial questions were quantitatively similar to each other: they differed only with regard to the value and number of colours (Is it golden? Is it brown?). But, although it is related to leaf colour, the question about why these colours change over time is a qualitatively different sort of question. This could be an example of a dialectic change: how the gradual, quantitative evolution of questions leads to a new question which is qualitatively different.

In the ants observation session and parachute making session, that we are reporting in this study, we did not ask students to either ask or write down their questions, as we intentionally did not want to interrupt student-student interactions. However, on different days in these workshops we did try asking students to write down their questions individually or in groups. We are not reporting this data on students' written questions in this study.

5.5 Types and functions of students' questions

As described in Chapter 4 (**section 4.2**) our analysis, identification and categorisation of questions was done simultaneously, by considering the functions of the questioning. Our methods of identification and categorisation of different kinds of student questions in the informal contexts are similar to what we have described in the previous chapter for our classroom observations. So our definition of the different kinds of questions, like Investigable questions, basic questions of reality, procedural questions etc. that we found in the informal contexts as well, is the same as what we have described in the previous chapter.

In comparison to classroom contexts, identifying questions (as distinguished from non-questions) and categorising them was more difficult in out of classroom contexts. In these contexts the discourse was generally very complex with use of language being more complicated and wider ranging, with a variety of meanings attached to it (classroom language use was much more simple and limited). Language in informal contexts outside the classrooms also involved greater use of expressions and gestures.

Identifying and categorising questions could not happen without looking into the whole discourse and sequence of talk. For example, the question asked at 06:18-0 by a girl in the ants observations about other girls sitting in the classroom at first seems to be a yes-no

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question. This girl asked “ਬਾਹਰ ਨੀ ਆਈਆਂ ? (They did not come out?)” to another girl. So if we just look at the question or listen to the question it may seem to be a simple yes-no question - or a basic question of reality. But the other girl replies by saying, “...ਪੇਪਰ ਆਉਣ ਵਾਲੇ ਨੇ ਤਾਂ ਨੀ ਆਈਆਂ (exams are coming that’s why they have not come)”. So, on analysing the response, its observed that question might have been about why the girls sitting in the class had not come out. So maybe it is an explanation question. So the process of identification and categorisation involved understanding the context as well as the discourse.

Some of the student questions that we notice in informal contexts are of different types and were not noticed in the classroom contexts. We will define these questions as we discuss them in this chapter.

Table 5.2 describes the different types of questions that we have found in the three informal contexts. The relationships between the different types of categorization of questions were given in **Figure 4.1** in Chapter 4. Some of the categories of questions are overlapping as a small number of questions appear in more than one category due to confusions regarding their categorisation. For example

Episode 5.03

- 31:52 Kavita: पण मुंग्या ह्याच्यावर कश्यासाठी येतात? (**But why do ants come on this?**)
31:55 Priya: राहण्यासाठी. तू घरात कशाला जाते? राहण्यासाठीच ना ? (To stay there..**Why do you go home? To live there no?**)

Question asked here by Priya has been put both into category of confirmation as well as rhetorical question as she asks it rhetorically but asks with ‘na’ as if she is confirming with Kavita. So we had a disagreement and confusion among ourselves about the category.

Table 5.2 Types of student questions found in the informal contexts

Question type	Parachute making (3 students recorded for 24 min.)	Ants observation (6 students recorded for 33 min)	Variegated tree observations (11 students recorded for 48 min.)
Investigable	10	22	73
Basic question of reality	11	20	16
Procedural	19	27	23

Clarification	3	5	22
Explanation	3	3	0
Command	2	3	0
Request	4	4	0
Questions of language	0	0	7
Asking evaluation or judgement	1	0	0
Permission	0	3	0
Confirmation (inauthentic)	3	3	10
Rhetorical (inauthentic)	13	34	25
Not categorised	2	2	0
Total	70	115	162
Implicit	10	19	25

It is interesting to note that investigable questions, basic questions of reality, procedural questions and rhetorical questions together comprised a large percentage of all the questions asked in each of the three informal contexts. We will talk about these four types in more detail later in this chapter.

We noticed permission questions only by the students in the ants observations and did not notice these in the other two contexts. For example in the ants observations at 12:52-9, Kuldeep asks Karen permission for pouring honey to which Karen vaguely replies by saying 'hmm'.

Episode 5.04

12:52-9 Kuldeep (asking Karen): ਜੀ ਸਹਿਦ ਯਾ ਕੇ ਦੇਖੀਏ ? (**Mam, shall we try putting honey?**)

12:54-0 Karen: *hmm . hmm*

In another example of permission question which has also been put in the category of request question, Sukhdeep at 31:10-1 asks Karen whether they can teach Punjabi to Karen. There was disagreement about the category of the question whether it is a request or they are asking

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permission, as this act could have involved action on the part of both the asker and the listener.

Episode 5.05

31:10-1 Sukhdeep: **mam** हम आपको पंजाबी सिखाएँ ? (**Mam shall we teach you punjabi?**)

31:11-9 Karen: *hhunnhhhh...*

There are also a few explicit questions that we could not categorise in any of our listed categories as either we could not understand what was being asked in the question or could not come up with some category. So we have listed these questions as ‘not categorised’ in the table above. For example, in the ants explorations at 07:28-0 Sukhdeep asks ‘**ਕਿਵੇਂ ? (How?)**’, but it is not clear in what response she is asking this question. It may be that she was talking to someone else which could not be seen or heard in the recording.

Episode 5.06

07:26-5 Harmanpreet: ਹਾਏ ਰੱਬਾ (oh god)

07:27-2 Some girl (standing behind):ਨੀ ਹੈਗੀ ਲੱਗਦਾ (....I think its there)

07:28-0 Sukhdeep: **ਕਿਵੇਂ ? (How?)**

07:28-5 One girl: ਨਹੀਂ ਤਾਂ (Then.....).

In another example, that we could not categorise, Gurpreet at 06:48-3 in the parachute making activity asking another boy from a different group, “**ਆੜੀ ਕਿੱਥੇ ਆਂ ? ਬਾਈ ਠੀਕ ਆਂ ? (where are you friend? Are you fine?)**”. Though, here Gurpreet seems to be just joking around, but its not clear why he asked so.

In the variegated leaves explorations, we noticed some questions of language, a type which we did not notice in the other two contexts. These were questions mainly concerning meaning or translation of some words or if students could not find a proper word to express something. For example at 01:46 a boy wonders whether the word **सुरु** written on the label of a tree is in Hindi or in Marathi and asks the other boy ‘**ये हिंदी का है?’ (Is it Hindi?)**.

Another category of question which was unique in the sense that we noticed only in one of the contexts, is a question of evaluation or judgement. We noticed one such question in the making of parachute by the boys. As the three boys made parachute they also planned to

make a 'man' from paper that they might have thought to hang on the parachute. Jaskaran after making this 'man' at 09:31 asks Gurpreet, 'ਆਹ ਬੰਦਾ ਠੀਕ ਆ ? (is this man ok?)'. It is interesting that the tone of voice that Jaskaran used is different from what you might expect if he was asking the teacher, even though he seems to see Gurpreet as having some authority (e.g. he had just gone to get the glue when Gurpreet requested him to do so). Jaskaran's tone was soft and amicable, and the question may even have been somewhat rhetorical, meaning "Look at what a nice-looking man I have made." If he had asked a teacher, he might have been more submissive, more doubtful, and less rhetorical.

5.5.1 Implicit questioning

As described in the previous chapter (**section 4.3.1**) all the student questions that we noticed were either explicit or implicit. Utterances which did not have any explicit question marker or change of intonation but represented a perplexity, doubt or conflict on the part of the speaker/s, have been marked as implicit questions.

In our very first interaction, even before our classroom observations, with Shashtri Vidyalya school students in the variegated tree exploration we observed students tending to make statements rather than ask questions. However, later on, when we transcribed their conversations and started looking for questions, we realised that there were implicit questions behind their statements. For example, they were saying that the leaves are white, pink, brown, or that one leaf is thinner than another or that fallen green leaves become yellow as they become old. Behind these statements they seemed to be asking themselves, "Which colours of leaves are there?" "Is this leaf thinner?" and "Why are the leaves different colours? Do they change colour?"

However, with further detailed analysis of the tapes, we found that although it was sometimes difficult to determine which utterances were questions, there were certainly many more questions which were not explicit but represented questions. So it also became clear that we had to include a category of questions as implicit questions different from explicit questions.

In our classroom observations, we noticed implicit questions appearing with individuals having doubt or conflict. But in the informal contexts, apart from implicit questions of individual students, we also observed implicit questions of a group representing conflicts or doubts or hidden question/s among different members of the group. So the questions were not

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stated, but were implicit in the arguments or disagreements among group members, with argument or disagreement pertaining without much of resolution. We call this questioning as group implicit questioning or group questioning. Many of the implicit questions that we observed in student-student discourse in informal contexts were group questions.

Furthermore in some cases an implicit question became explicit and got verbalised by a student after a group had apparently spent some time discussing the same question in an implicit form. For example, students were discussing about the colours of the leaves for some time in variegated tree observations, observing and naming various colours and then Gurinder asked Trupti, “**What is it?**” when he did not clearly hear what she was saying. To this Trupti replied (at 10:24), “**बो पत्ते का कलर कौन सा है वहा पे ?**” (**What is the colour of that leaf there?**). This indicates that indeed this question had been in the back of their minds, and they continued to observe and name more colours. Perhaps the first time a student said, “There are white leaves” there was no underlying implicit question. But when students started naming one after another colour, it was clear that they were searching for colours, and were asking the implicit question. We will discuss more about the dynamics of implicit questioning becoming explicit in Chapter 6.

We here present two more examples of group implicit questions from student-student talk in informal contexts. The first episode is from the ants observations by the girls, who had different kinds of food items, and wondered what to put and how to put them.

Episode 5.07

- 13:41 Simranpreet takes some honey in pinch of her fingers [By this time Simranpreet has already taken the sitting position and has stuff in her hand.]
- 13:43 Simranpreet is perhaps wondering where to put the honey
- 13:43 Harmanpreet to Simranpreet: ਯਾਰ ਉਰੇ ਲਾਦੇ ਮਾੜਾ ਜਿਹਾ (hey, stick it here little bit) [Harmanpreet asks Simranpreet to touch her (Simranpreet) finger by touching herself there, just above the ants hole on the stem of the tree]
- 13:47 Kuldeep to Simranpreet: ਉਰੇ ਲਾ ... ਉਰੇ ਲਾਦੇ (**stick here...stick here**)
- 13:50 Simranpreet touches her finger to the stem of the tree to stick some honey there
- 13:53 Disha: ਉਹ ਤਾਂ ਚੋੜੂ ... ਨੀ ਚੰਗੀ ਤਰਾਂ (**it can fall down...do it properly**)
- 13:54 Simranpreet listens to Disha and again touched the stem with her finger soaked in honey, maybe to spread it properly
- 14:00 Kuldeep: ਏ ਚੀਨੀ ਨਾਲ ਆਉਣਗੀਆਂ (hey, will come with sugar) [as she opens up a packet containing sugar]
- 14:03 Some girl in background: ਏ ਰੁਕਜੋ (hey,stop)

Students' Spontaneous Talk and Questioning

- 14:04 Harmanpreet: ਚੀਨੀ ਨਾਲ ਆਉਣਗੀਆਂ(will come with sugar) [Kuldeep is opening up the packet]
- 14:05 Kuldeep: ਏ ਰੁਕਜਾ ਤੂੰ (hey you stop...)[perhaps some other girl is asking to get sugar from Kuldeep]
- 14:08 Kuldeep opens up the packet and puts her hand to take out some sugar
- 14:11 Harmanpreet telling Kuldeep: ਕੁਲਦੀਪ ਮੁਹਰੇ ਪਾਈਂ ਥੋੜਾ ਜਿਹਾ (Kuldeep put some in the front) [as Kuldeep is putting sugar Harmanpreet asks her to stop and not put more]
- 14:15 Kuldeep: ਚੀਨੀ ਤੇ ਬਹੁਤ ਆਉਂਦੀਆਂ ਨੇ (they come on sugar more)
- 14:17 Someone in background: ਚੀਨੀ ਤੇ ਵੱਧ ਆਉਂਦੀਆਂ (**they come more on sugar**) [agreeing to Kuldeep]
- 14:29 Kuldeep puts back the sugar packet into the bigger polythene containing other stuff and she is told to give back the stuff to teacher/other group and not to give anyone else
- 14:29 Harmanpreet: ਹੋਰ ਕੋਈ ਚੀਜ਼ ਹੈਗੀ ਆ ? (**Is there anything else in that**) [as Harmanpreet and others tried to see what's inside

At 13:43 - 13:47 we see that Harmanpreet and Kuldeep tell Simranpreet where to put the honey. This indicates that there is an implicit question: “Where should the honey be put?” This question arises as there is a conflict: there are various possible places to put the honey, possible differences of opinion as to where it should be put, and reasons why it should be put in one or another place. If there was only one place to put it, there would be no conflict and no question and no need for anyone to say where it should be put. The implicit question probably arises only when the students are already in the act of putting the honey. If they were just thinking about what to do, the conflicts may not arise. But in the act of doing, more specificity is required, and a decision must be made, more or less explicitly. The act of doing may make the implicit more explicit.

In the above episode, we see the emergence of two implicit questions. The first implicit question is, “How and where the honey should be poured so that it stays around the ant hole so that ants can eat it?” This is an investigable question since the students could (and did) try to answer it by manipulating variables and testing their effects. As Simranpreet took some honey on her finger, it stuck to her finger, and she wondered how to put it near the ant hole. As she tried sticking the honey on the stem of the tree just above the ant hole, other girls objected to her way of sticking the honey. They also tried suggesting to her the place where it would be more appropriate to put the honey. So there were disagreements among girls on

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how and where to put honey around the ant hole. We see this as an implicit group question, “How and where should we put the honey?”

The second implicit question, also investigable, which actually emerged over a longer period of time than this episode, is “Which food stuff would attract more numbers of ants?”. We know it is investigable because the students did investigate it. Although, the girls seemed to be somewhat confident that sugar would be the most attractive to the ants, they wondered about the other different stuff they had, and whether it might attract more ants. This doubt may have arisen especially because a number of the things were sweet: sugar, honey, and jaggery.

Implicit question/s may not be identified as a single utterance said at a particular time. As such question may appear or be identified over a larger period of time involving several utterances.

This episode on implicit questioning is an example of how in everyday contexts, questions sometimes are not explicit and emerge with interaction of participants among each other and interactions with the stuff. However the classroom discourse that we observed and analysed did not provide chances for such questioning to occur and emerge. Inside classrooms, if students asked questions they were mostly verbalised explicitly.

The second episode that we describe is also from the ants observations, when girls wondered about what size of jaggery is appropriate to give the ants.

Episode 5.08

- 01:20 One of the three standing girls (not Simranpreet): ਏ ਓਹਨੂੰ ਨਾ ਯਾਰ ਤੁਸੀਂ ਭੋਰ ਭੋਰ ਕੇ ਪਾਉਣਾ ਸੀਗਾ ! (You should have put it after breaking into smaller pieces!) [While the three girls who are sitting are looking at the ant hole]
- 01:23 Harmanpreet: ਆ ਦੇ... ਏਨੇ ਪਾਇਆ . (See ... she has put it.) [Harmanpreet slightly turns her head towards back and gestures her hand towards Kuldeep.]
- 01:24 Simranpreet (to Kuldeep): ਕੁਲਦੀਪ , ਸਾਰਾ ਪਾਤਾ ? (**Kuldeep, have you put all of that?**) [Simranpreet bends down and ask]
- 01:26 Kuldeep: ਨਹੀਂ ... (No...) [as she looks up towards Simranpreet]
- 01:26 Simranpreet: ਭੋਰ ਭੋਰ ਕੇ ਪਾਉਣਾ ਸੀਗਾ. (You should have put it by breaking in finer pieces.)
- 01:28 Disha: ਓਹੀ ਤਾਂ ਕਰ ਰਹੀਆਂ ਨੇ ! (That's what we/they are doing!) [looking up towards Simranpreet]

- 01:29 One girl (maybe Simranpreet): ਖਾਦਾ ਨੀ ਜਾਣਾ ਉਹਨਾਂ ਤੋਂ | **(They will not be able to eat)**
- 01:30 Harmanpreet: ਉਹ ਦੇ, ਉਹ ਖਾਂਦੀਆਂ ਪਈਆਂ ਨੇ (See - they are eating!) [Pointing her pen towards ants]
- 01:32 Kuldeep: ਹੌਲੀ ਹੌਲੀ ਖਾਂਦੀਆਂ ਨੇ . (They are eating slowly.) [looking up at Simranpreet]

Our interpretation of this episode is that it shows the evolution of the (unvoiced) implicit question, ‘What size should the jaggery pieces be?’ We have categorised this as an implicit investigable question. Initially, the size does not seem to be in question, as none of the girls voiced disagreement with Simranpreet that the jaggery should have been put in smaller pieces. Simranpreet seemed to be complaining and trying to place blame. Harmanpreet tries to claim her innocence and places the blame on Kuldeep. Simranpreet, who was standing in the back, asks if any jaggery is left, so that at least that can be put in smaller pieces and She gives a reason for that: the ants cannot eat large pieces. This indicates that the girls were probably wondering what is the best size of pieces for the ants, because their aim was to feed the ants. We claim that Simranpreet has made a hypothesis that the ants are not eating because they cannot eat such large pieces. But then Harmanpreet sees that the ants are eating the large pieces, contradicting the initial observation and the hypothesis. When Kuldeep justifies that they are eating slowly, she may be having a new implicit question in her mind, ‘Are they eating slowly because the pieces are too large?’ Later on the girls did break the jaggery into smaller pieces (though not very small), to see if the ants would eat it, in a further test of the same hypothesis.

We claim that the evolution of the main implicit question is based on observations which conflict with beliefs. The initial belief that the pieces should be small probably arose because the students had observed that the ants were not eating the jaggery and that the pieces were large, compared to the size of the ants. Then this belief was brought into conflict with the subsequent observation that ants were eating it, after all. Therefore the question became more prominent, although it was still not stated explicitly.

5.5.2 Authentic and inauthentic questions

As discussed in Chapter 2 (**section 2.2.1**), questions are not always asked for genuine or authentic reasons, they are sometimes asked for purposes other than to seek answers. We have defined questioning as being inauthentic if the asker knows the answer and has not

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asked the question to seek an answer. In Chapter 2 (**section 2.3.1.4**) we have described how teacher questioning is a kind of inauthentic questioning.

Most of the student questions that we noticed both in classroom contexts as well as in informal contexts were authentic, such that students did not know the answer to the question. For example in the variegated tree observations, at 02:08 Priya asked her friends the explicit authentic question, ‘What is it [the tree]?’ as she did not know its name (we later also confirmed this with her). As this particular question has been categorised as an investigable question in the category of question types, we call this questions as authentic explicit investigable question. So all the student questions that we have categorised are either authentic or inauthentic. However, this classification is not a binary—there is a range of authenticity, as for some questions the answer may be partially known and it may not be completely authentic or completely inauthentic.

In our observations of student-student talk in informal contexts we found two kinds of questions being inauthentic, students’ rhetorical questions and confirmation questions. We describe examples of rhetorical questions later on in this chapter.

A confirmation question is often a statement with a ‘, no?’ or ‘, na?’ appended to it, which makes it an explicit question. For example in the variegated tree observations, Tanya’s question at 02:44: ‘हो ना मग **show** चं झाड आहे, हा मग त्याला नावं काहीतरी असेल, ना ?’ (**Okay it’s a ‘show’ tree, but it should have got some name, no?**) is a confirmation question. Perhaps the last word is added in order to soften the statement or make the hearers more likely to agree—forming a leading question. Or, it could be an emergent question: the asker began to make a statement, but then decided to change it into a question as it was being voiced. At what point was it a statement and at what point was it a question—or was it always a statement in the process of becoming a question, or both, or neither a statement nor a question?

Both rhetorical and confirmation questions may have some implicit authenticity. Rhetorical questions may be requests, inviting the hearer to agree or react (Henkemans, 2009) (Henkemans, 2009, p. 16). Confirmation questions may be asked because the asker has some lingering doubt, or wants to check whether the hearer agrees. There seems to be a dialectical logic to such processes of questioning, and we cannot say categorically whether they are authentic or inauthentic.

5.5.3 Investigable questions

In the informal contexts we found many of the students' questions being investigable ones (according to our definition described in **section 4.2.2.10**), which were very rare in our observations of classrooms. In the classrooms students did not do any of the actual observations of the physical stuff and they hardly had any opportunities to talk with each other. We see these as the main reasons for lack of investigable questions inside classrooms. Furthermore, classroom questioning was more about the questions whose answers were very much pre-determined or 'known' to the teacher, whereas the investigable questions that we observed generally did not have a pre-determined or fixed answer.

For example, in the following episode we see an implicit investigable question about how to break the jaggery piece. The question can only be understood when we see the complete discourse happening around breaking of jaggery at that point. Initially, Disha tries to break the jaggery, but unable to do so she puts the larger piece as it is. To which Simranpreet objects and then Manpreet and Disha argue that it is not breaking. Upon hearing this Charanpreet, standing at the back, jokingly suggests to wet the jaggery piece to break it. This kind of clarifies that the question was an investigable one and students did try breaking it by hand and were wondering how to break it in finer pieces. They could have investigated more by trying out different methods than only using hands.

Episode 5.09

- 08:05-7 Disha tries to break the piece of jaggery into finer pieces by using using her thumb and fingers of the right hand and then puts the single piece as it is
- 08:06-0 Simranpreet: ਡਲੀ ਨਾ ਸਿੱਟਦੀ (Don't put the big piece)
- 08:08-4 Manpreet: ਕੀ ਕਰੀਏ ਭੁਰਦਾ ਈ ਨੀ ਉਹ (**What to do its not breaking up**)
- 08:10-0 Disha: ਭੁਰਦਾ ਈ ਨੀ ਉਹ (not breaking up)
- 08:11-0 Someone at back: ਲੱਭ ਤਾਂ ਗਿਆ (found it)
- 08:12-0 Charanpreet: ਗਿੱਲਾ ਕਰ ਲੋ ਓਹੋ ... (make it wet oh hooo....) [laughingly]

In one more example, in the variegated tree observations, Priya and Kavita were looking at the leaves on which Priya saw some ants. As they talked about ants coming on the leaves, at 31:52 Kavita asked, “**पण मुंग्या ह्याच्यावर कश्यासाठी येतात? (But why do ants come on this?)**” This is an investigable question because it could have led them to observe the ants for a

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longer period of time in order to figure out why they were coming on leaves and where they were going.

5.5.4 Basic questions of reality

As described in Chapter 4 (**section 4.2.2.9**), these questions are relatively non-investigable and seek simple facts about some physical stuff, some action or some phenomenon. These questions represent asker's curiosity, wonderment or puzzlement about some basic information. Most of times these questions got answered and that too clearly and uncontested.

For example in the variegated tree observations at 38:23-0 Kavita asked, 'कोणाला मिळाले हे ?' (**Who found this [the eggs]?**), to which Kranti replied by pointing towards Nimish. In another example from ants exploration, Simranpreet asks Kuldeep, who was opening a packet, 'What is this?', to which other girls replied saying 'It's sugar'.

Episode 5.10

14:07-0 Simranpreet (?): ਇਹ ਕੀ ਆ ? (**What is this?**)

14:08-5 One girl: ਚੀਨੀ ਆ (Its sugar)

In another example from the activity of making parachutes, Gurdeep asks Gurpreet 'What is today?' to which Jaskaran replies 'It's Wednesday today' ??

Episode 5.11

14:34 Gurdeep: ਗੁਰਪ੍ਰੀਤ ਅੱਜ ਕੀ ਆ ? (**What is today Gurpreet?**)

14:35 Jaskaran: ਅੱਜ ਬੁੱਧਵਾਰ ਆ (Today is wednesday)

14:37 Jaskaran: -- ਲਿਆ ਥੋੜੀ ਤਾਂ cheating ਕਰਨੀ ਚਾਹੀਦੀ ਆ (give it -- lets at least do some cheating)

14:41 Gurdeep: ਦਾਲ ਚੌਲ ਆ ਕੀ ਕੜੀ ਚੌਲ ? (**Its dal rice or kadi rice?**) [asking for the mid day meal in the break]

14:45 Gurpreet: ਚੌਲ ਈ ਨੀ ਅੱਜ (No rice today)

14:46 [Meanwhile Jaskaran is talking in a very low voice, maybe telling his plan of how to 'cheat' by finding out how others are making parachutes]

14:47 Gurdeep: ਰੋਟੀ ਆ ? (**Is it roti there?**)

Actually by asking this, Gurdeep wanted to ask what's there in the mid day meal today. So to

clarify his questions he asks whether there is 'dal rice' or 'kadi rice' for lunch today.

5.5.5 Procedural questions

It is interesting to note that both in the classroom as well as informal contexts we noted many of the student questions as procedural questions. We have defined procedural questions in Chapter 4 (**section 4.2.2.3**).

Here we discuss a few examples of students' procedural questions from informal contexts.

In one example from the Parachute making, when Gurpreet and Gurdeep were tying the threads, Jaskaran asked Gurdeep about how many more threads are to be tied to the parachute, to which Gurpreet replied by saying one more thread.

Episode 5.12

21:21-7 Jaskaran: ਕਿੰਨੇ ਕ ਰਹਿ ਗਏ ਇਹ ਗੁਰਦੀਪ ? (**How many of these are left, Gurdeep?**)

21:23-5 Gurpreet: ਇੱਕ ਬੱਸ ਹੋਰ ਕਰਨਾ .. ਉੱਚੇ ਲਾਢੇ (Will do one more .. put here)

In another example from the variegated tree observations, Tanya at 08:18 asks Kavita what they are supposed to do. Initially the students appeared confused about what they should do because the teachers (researchers) had purposefully not given them any instructions.

Episode 5.13

08:18 A girl (Tanya?): क्या करने का ? (**What are we supposed to do?**)

08:19 Kavita: Dance करने का (To do dance)

5.5.6 Rhetorical questioning

In Chapter 2 (**section 2.2.1**) as well in Chapter 4 (**section 4.5.2**) we have described about the rhetorical questioning. It is interesting to note that in the classrooms that we observed we did not notice a single rhetorical question by the students but we noticed many rhetorical questions asked by teachers. But in the student-student talk in informal contexts we noticed many rhetorical questions asked by students to each other.

Also, among themselves, students asked a large number of rhetorical questions, but they never asked rhetorical questions to the teacher researcher. This indicates that asking a

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rhetorical question may usually require that the one who is being addressed should not be in a position of too much authority over the asker. A rhetorical question is often meant to convince someone of one's opinion, knowing that the person may disagree. Perhaps students in classrooms do not feel they have the agency to present their own beliefs or argue their positions.

In the parachute making, Gurdeep and Gurpreet were tying threads to the parachute one by one. At one point Gurpreet takes all those threads and tied them together. To this Gurdeep at 21:57-1 angrily objected and rhetorically asks why have you tied them yet. By this he meant Gurpreet that he should not have tied the threads yet. To this Gurpreet replies by saying just be quiet. To this Gurdeep again replies rhetorically at 22:03-6 saying Gurpreet whether he knows better. By saying this he actually meant Gurpreet that you do not know better. So Gurdeep here used rhetorical questions to disagree with Gurpreet and make his point.

Episode 5.14

- 21:57-1 Gurdeep: ਖੜਜਾ, ਹਜੇ ਕਿਓ ਬੰਨਤੇ ? . ਮੈਂ ਥੱਪੜ ਮਾਰਨਾ ਬਾਂਦਰ ਜੇ ਦੇ ! (Hey stop, **why have you tied them now?** Will slap you!)
- 22:02-3 Gurpreet: ਓ ਬਹਿਜਾ ਟਿਕ ਕੇ ! (Hey, you keep sitting!)
- 22:03-6 Gurdeep: ਵਾਲਾ ਪਤਾ ? (**You know more?**)
- 22:04-0 Gurpreet: ਹਾਂ (yes)

Interestingly, Gurpreet does give a reply by saying yes, meaning he does know better. It may be that Gurdeep challenged Gurpreet very strongly, to which Gurpreet does give a reply by challenging back Gurdeep.

In another example of rhetorical questioning, from ants observation, at 05:52-0, Kuldeep asks other girls of the group that why have you thrown the jaggery inside the ant hole. Actually by saying this she was kind of objecting to the girls and meant that you should not have thrown the jaggery piece inside ant hole. This contention becomes more clear from the reply of one girl who tries to justify her innocence by saying that ants themselves have pulled the piece inside (we have not done it).

Episode 5.15

- 05:52-0 Kuldeep: ਤੁਸੀਂ ਅੰਦਰ ਕਿਓ ਸੁੱਟਿਆ ਗੁੜ ? (**Why have you thrown jaggery inside?**)
- 05:53-2 One girl: .. ਗੁੜ ਲਾਹ ਲਿਆ ਉਹਨਾਂ ਨੇ .. (They pulled the jaggery)

Rhetorical questions are usually asked in order for the asker to build an argument, and therefore Dillon (1983) has called these types of questions 'expressive/argumentative', or when the asker also answers, 'self-answered'. In agreement with Dillon we find that these types of questions are very common—in some discussions they are even the most common type of question. Sometimes they may be addressed mainly to oneself, as if one is thinking aloud and considering conflicting ideas, which points to their dialectical and emergent nature: being statements and questions all at once.

5.6 Summary and discussion

In the three informal contexts we observed that students spontaneously got involved in talking and questioning without much of guidance by the teacher researchers. In these contexts we noticed much more student-student talk and student questioning as compared to the classroom contexts. In classrooms the only student-student talk that we had noticed was student whispering to each other, which was not part of the main discourse. In the informal contexts students asked questions spontaneously even without being asked to ask.

Furthermore, in the informal contexts we noticed a large number investigable questions asked by the students without much of teacher guidance. This is contrary to what other researchers (Chin, 2002) have reported - that students need explicit training in framing or asking investigable questions. We will discuss the reasons for students asking investigable questions in informal contexts in later chapters.

Another important category of student questioning that we noticed in our study is of implicit questioning. Though we did notice a few of the students' implicit questions inside classrooms, but those questions were mostly questions of individual students rather than the group questions as we noticed in informal contexts. Furthermore, in the informal contexts we observed students implicit questioning getting explicit as they interacted with each other and with the stuff. So we claim that an important role of student interactions with each other and with stuff is to make students' implicit questioning explicit. No previous studies have described about this kind of questioning.

Also in the informal contexts we observed students' frequent use of rhetorical questioning among themselves for making a point, showing disagreements, presenting a challenge etc.

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Other researchers have not yet explored students' rhetorical questioning both in the formal as well as informal contexts.

6

Question-Answer Discourse: Nature and dynamics of the student questioning process

In the informal contexts, we observed much more of student-student talk and student questioning in comparison to classroom contexts. But why could this happen in informal contexts? Why students spontaneously got involved into talking and discussions and asked questions? To understand the reasons, in this chapter we will look into the nature and dynamics of student-student discourse in informal contexts and try to understand the process of their questioning and answering.

Though in the previous chapter our focus was mainly on describing the forms or types of student questions in informal contexts, but that could not be done without situating questioning in the discourse in which it occurred and without discussing the functions of particular question types. But for a more meaningful understanding of the purposes and functions of student questioning, we must understand the nature and dynamics of the discourse around student questioning described in this chapter.

6.1 Understanding the nature and dynamics of student-student discourse

In the three informal contexts that we report here, students worked in groups, interacting with each other and with the physical stuff without much involvement of teacher researchers. Teacher researchers did not give any prior instructions on whether students should discuss in groups or talk with each other while they would do their observations. However, students spontaneously got involved in talking and discussions. Even in the variegated tree observations where no prior groups were formed, students themselves formed their fluid groups and did the talking.

It is important to note that their talk was spontaneous and not guided by the teachers. This freedom actually led them to assume and carry out important roles on their own, that were

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required to get involved into talking and discussions. In comparison to classroom talk, the talk in informal contexts was much more dynamic and complex. Here we will try to understand those dynamics and complexities of the student talk.

6.1.1 Understanding student agency in the discourse

6.1.1.1 Students' agency in turn allocation and turn taking

As opposed to the classroom talking, where turn allocation and turn taking was controlled by the teacher, in the informal contexts turn taking in student-student talk happened spontaneously. There was not necessarily any one person who controlled the talk, it was usually decided together by the participants. Nobody explicitly sought permission to seek the turn or change the turn, it was mostly spontaneous. The talk among students in the informal contexts was close to what other researchers (Wooffitt, 2005) have described as ordinary or everyday talk.

Turn-taking in ordinary conversation is a remarkable achievement. At the start of any period of interaction, neither party knows in advance how many turns they will take, what the topics will be or the order in which they will be addressed, how long each turn may be, whether or not someone else will join in, and if they do, how turns are to be allocated among the respective parties, and so on. Moreover, the length of a speaker's turn is not fixed at the start of the turn. Yet despite these and numerous other uncertainties, it is highly likely that turn transfer will be achieved in an orderly fashion: there will be very few periods where more than one party is talking, and these will be relatively short-lived, and successive turns will be built so as to minimise any gap or delay before the next speaker, indicating that there is an impressive degree of precision timing in the placement of turns in relation to each other. How is this degree of orderliness achieved? (p. 26)

Here is an example of a conversation that occurred during the ants observation:

Episode 6.01

15:59-5 Harmanpreet (talking to herself and Kuldeep): ਆਹ ਦੇ ਆਹ ਰੋਟੀ ਖਾਓ (See this, put roti)

16:01-0 Boy1: ਰੋਟੀ ਲੈਲੋ -- (Have roti) [may be talking to ants, jokingly]

- 16:02-6 Girl1: ਮੁੰਡਿਆਂ ਦੀ ਸਾਈਡ ਉੱਪਰ ਆ (Boys' side is there)
- 16:03-7 Kuldeep: ਕੁੱਛ ਨੀ ਆ ਰਿਹਾ (Nothing is coming) [upset that ants are not coming out]
- 16:05-0 Harmanpreet (pointing finger towards an ant that's coming out): ਉਹ ਆਗੀ . ਨੀ . ਆਗੀ ..
(It has come . see . has come ..) [very excitedly]
- 16:07-0 One girl: ਆਗੀ ਆਗੀ ਆਗੀ ਆਗੀ (has come has come has come has come)
- 16:08-2 Kuldeep (?): ਏ ਆ ਰਹੀਆਂ ਨੇ (Hey they are coming)
- 16:09-0 Kuldeep (as she raises her head to speak): ਏ ਚੁੱਪ ਹੁਣ ਕਿਸੇ ਨੇ ਰੌਲਾ ਨੀ ਪਾਉਣਾ (Hey quiet nobody will make noise now)
- 16:11-5 Another girl: ਵੀਰੇ ਅਪਣੀ ਕਲਾਸ ਚ ਜਾਓ (Brother go to your class)
- 16:12-0 Harmanpreet (to Karen gesturing towards the ant hole): mam ਧਛੱ ਆਓ (Mam come here)
- 16:12-6 Sukhdeep: ਏ ਆਗੀਆਂ ਕੀਤੀਆਂ (Hey ants have come)
- 16:13-0 Kuldeep to Karen (Pointing towards hole): ਜੀ ਆ ਦੇਖੋ (Mam see this)

This entire conversation of 12 utterance by seven different students occurs in less than 14 seconds. It is remarkable that the speaking is very quick, none of the students interrupt each other, and there are no gaps in which no one is speaking.

To compare the nature of informal talk with the talk inside classroom, here is an example of the discourse from TF's classroom. Here the teacher is trying to explain a point regarding the duty of Nagarpalika (Municipality) in setting up of dustbins at appropriate places in a town and the duty of common people to throw garbage in those dustbins. She explains this point by bringing the analogy that, like at home, parents buy and arrange the dustbins, but it's the duty of all the members of the family to maintain those dustbins by properly throwing garbage in them.

Episode 6.02

- 12:42-6 TF: ਹੁਣ ਘਰ ਦੇ ਵਿੱਚ ਆਪਾਂ ਡਸਟਬਿਨ ਲਿਆਨੇ ਆਂ, ਕੂੜਾਦਾਨ ਲਿਆਨੇ ਆਂ, ਉਹ ਸਾਡਾ ਕੀਹਦਾ ਫਰਜ਼ ਬਣਦਾ ਹੁੰਦਾ ?
(Now we bring dustbin at home, dustbin at home, **whose duty is it?**)
- 12:50-3 Dalbir: ਰੋਡ ਤੇ ਈ ਸਿੱਟ ਆਉਨੇ ਆਂ ਜੀ (Throw it on road only)
- 12:52-0 TF: **hain?**
- 12:53-1 Dalbir: ਜੀ ਉਹ --- ਕਰ -- ਦੇਖਣ --
- 12:56-3 TF: ਲਿਆਂਦਾਆਆ ਕੌਉਉਣ ਆਆ ਕੂੜੇਦਾਨ ਨੂੰ ਘਰ ਦੇ ਵਿੱਚ ? ਕਿਹਨੂੰ ਮਤਲਬ ਪਤਾ ਲੱਗਦਾ ਆ ਬਈ ਸਾਨੂੰ ਕੂੜੇਦਾਨ ਘਰ ਚ ਚਾਹੀਦਾ ਆ ? ਕੌਣ ਲਿਆਂਦਾ ਘਰ ਦੇ ਵਿੱਚ ? (**Whooo bringsss dustbin at home? Means who gets to know that we need dustbin at home? Who brings it?**)
[starts by speaking at a very low pace while stressing on words]
- 13:03-8 Dalbir has raised hand

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- 13:04-0 TF: ਹਾਂਜੀ (Yes) [giving permission to respond]
- 13:04-6 Dalbir: ਜੀ ਸਫਾਈ ਰੱਖਣ ਨੂੰ (Mam to keep cleanliness)
- 13:08-6 TF: ਬੇਟੇਦਾ ਲਿਆਂਦਾਮਾ ਕੌਣ ਆ ? (**My Sonnn who bringsss it?**) [using word 'beta' to stress her question? Teacher showing frustration as she is not getting her expected answer]
- 13:10-2 Dalbir: ਜੀ (Mam) [loudly] .. ਮੰਮੀ ਡੈਡੀ (Mother father [softly])
- 13:12-0 TF: ਹਾਂ (yes) [agreeing that this is the right answer]

In this example of almost 30 seconds we see the exchange of 10 utterances between the teacher and one student. While the teacher was still asking her (inauthentic) question, Dalbir signaled by slightly moving his hand that he wanted to answer. He gives his response and the teacher asks for clarification (as she could not understand his answer or maybe because he has not given the answer she wanted). Then he attempts to answer but again does not give the answer she wants. Again she asks, and this time Dalbir raises his hand for permission to answer. The teacher calls on him, and finally he gives the answer she wants, and she gives her evaluation of his answer. Here we notice a huge difference in the authority or agency of talking between the two parties. Here the discourse is steered by teacher's arguments, with control of turns as well choice of topics and arguments made by the teacher. This was the nature of most of the classroom discourse that we observed in the three classrooms.

In the classrooms most of the talk happened with alternate teacher and student turns following an IRE sequence as described in chapter 4 (**section 4.4**). But in informal contexts we did not notice any IRE pattern of talk whereby turns for asking, responding and evaluating are fixed and predetermined. In informal contexts, though during student questioning, question and response sequences did happen but those were very dynamic and without any explicit evaluation to the responses. In these contexts, the utterances were not all directed to particular person as they were in the classrooms. Even if a statement or question was directed to a particular student, we observed instances where other students would reply (see **episodes 5.11 and 5.12**). Bracha Alpert (1987), describes what she called active discussions in classrooms as against teacher-controlled and silent discussions (in which a teacher discusses with themselves, asking and answering their own questions, and students remaining silent). She argues that in active discussions students had much more agency in talking as there was no teacher evaluation. She observed that the features of active talk inside classrooms were very close to ordinary or everyday talk,

Examination of the differences between conversations in everyday life and classroom conversation indicates that the active discussions resembled conversations in everyday life, whereas the silent and controlled discussions had unique characteristics of typical classroom conversations. Lack of evaluation, various options in turn allocation, personal questions seeking information and opinions, and use of informal language, were features of everyday conversation that often appeared in active discussions, but scarcely in silent and controlled discussions. (p. 38)

In our classroom observations there were hardly any instances of the so called ‘active discussions’. Furthermore, the classroom talk involved very long utterances of the teacher where the teacher would speak at length, sometimes continuously for more than a minute. But in the informal contexts, we did not find such a domination of talk by particular student/s. There was not much of the difference in length of utterances of different students talking in a group. Also in the conversations among students (in non formal contexts) there were hardly any utterance by a student as long as 10 or more seconds.

6.1.1.2 Students’ agency in exploring the stuff

It is interesting to notice that in the variegated tree observations, in the beginning, when students were brought near the tree, many of them were reluctant and hesitant in touching or exploring the tree. At 02:26 when Suraj approached a green leaf with white patches, Nimish warned him saying ‘हात नाही लावायचा रे, कळत नाही काय ?’ (**Don’t you know that you should not be touching it?**). There were differences between how different students interacted with the tree, and how their interactions changed over time, wavering between passivity and agency (Roth, 2007a). Some, like Suraj, took the initiative to start observing and touching, others did so only after seeing other students doing so. However, by the end of the 48-minute session for exploring the tree, as a group the students were touching and manipulating the tree.

Perhaps the students’ inhibition to touch and handle the stuff could be coming from their school and everyday experience, where they are generally told by adults not to handle anything unless being instructed or being told.

But the reason for this difference could also be that students perceived HBCSE to be a ‘big’

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place where gardens are neatly maintained and plants trimmed properly, clean roads, with everything looking orderly and that one has to enter by permission. So in the beginning some of them did not feel the agency to explore the tree and other stuff. However, this engagement changed over time.

This contrasts with the workshops done at Fatehpur and Hazara, which were done inside the schools. In these, students were much more active and felt agency to touch, manipulate the things from the very beginning. We were even somewhat surprised that they were not at all hesitant to handle the things we brought, such as magnets, paper, cloth, glue, and other materials, and sometimes even pulled them out of our hands.

Furthermore, we also noticed that the difference in students' agency to explore the stuff depended upon the nature of the stuff as well. For example in the ants observations, the girls sitting close to the ants hole were more engaged in doing actions and doing more of the talking. Actually the place around ants hole was congested and only 3-4 students could comfortably sit around (see **Figure 3.6**). So for the group of 6 girls, there were always 2-3 girls who were at the back, mostly standing. However, the positions of the girls did kept changing, with girls at the back, at times coming in front and getting involved with the stuff.

However, in the case of the variegated tree, most of the students were having direct contact with the tree. The spaciality around tree allowed all students to have direct interaction with the tree, all at the same time (see **Figure 6.1**). All the 11 students (even if there could have been 20) could stand around the tree at the same time and approach the tree, touch it and explore it.

Maybe if there had been more ants spread over a larger area the situation would have been different - in this case there were not many ants because of the weather and the time of the year.

6.1.1.3 Role of language and students' agency

One factor that encouraged the students to talk and ask questions in the informal contexts was that they spoke in their own language. The language in these contexts was informal such that it involved the use of colloquial words, much more usage of gestures, expressions, sounds, etc. to express meanings. Though the language used in most of the classrooms that we

Figure 6.1 Boys and girls spread around the variegated tree occupying different locations while observing and discussing about the tree



observed was also students' mother language, it seemed to be more formal, literary and standardised with restricted use of words and sounds.

To understand the nature of language in the informal contexts, we discuss one episode from parachute making. Here, Gurpreet and Jaskaran were trying to explain to each other how the threads can be passed through the two cut out pieces of paper, one a ring shaped and other a circular shaped (see **Figure 6.2**).

Figure 6.2 Boys passing threads through two pieces of paper



Episode 6.03

11:29-8 Gurpreet: ਦੇਖ ਹੁਣ ਐਵੇਂ ਐਵੇਂ ਜਾਉ ਨੀ ? **(See now, like this, like this, won't it go?)**

11:30-4 Jaskaran: ਐਵੇਂ ਐਵੇਂ ਐਵੇਂ ਕਰਕੇ (like this, like this, like this) [making gestures of threading needle from upside to downside]

11:33-5 Gurpreet: ਹੁਣ ਐਵੇਂ ਜਾਉ ਨੀ ? **(Won't this go now likewise?)** [with rising intonation]

But they seemed to have difficulty in expressing this using proper words. So, to explain their ideas they used the so called non-standard words of Punjabi (like ਐਵੇਂ ਐਵੇਂ and ਐਵੇਂ ਐਵੇਂ) along with gestures of needling the threads. Lemke (1990) argues that meanings are situated in the use of language within a community and group who share certain beliefs and values. Since students used language which was much closer to their own everyday language, they could communicate even complex meanings in informal contexts.

Furthermore in the informal contexts students took the freedom to use non-academic language such that they even coined their own words for naming things. In the variegated tree observations we noticed students created their own words for naming colours and the tree, without asking for recognition of these terminologies from authorities. For example, in the very beginning when one of the girls asked about the variegated tree, another girl replied by saying, 'mixed colour ਕੀ ਜ਼ਾਡ ਆਹੇ (it's a mixed colour tree)'. Another girl, Priya, called the tree as 'show tree' and Trupti called it 'white ਪਾਨਾਚਾ ਜ਼ਾਡ (white leaves tree)'.

Also for naming of different colours of leaves, students made up their own words for colours. For example in identifying a shade of brown Priya said: ਘਰਾਂਨਾ ਅਸਤੀ ਨਾ colour ਤਸਾ. (The colour of the house - maybe referring to the building nearby). And Janvi said: ਆ ਘੋਡਯਾਚਾ ਬਘ ਨਾ ? ਘੋਡਯਾਚਾ chocolaty colour ਨਾ ਤਸਾ... **(It looks like a horse, no? A chocolaty horse colour...)**.

Letting students work in small groups on their own and have spontaneous discussions in their own language can help them build upon their out of school experiences and give them opportunities to appreciate their differences. Ann Rosebery and Cynthia Ballenger (Rosebery & Ballenger, 2008)(2008) have recommended that teachers should allow students coming from diverse linguistic backgrounds to use such styles of discourse, so that they can understand that their own languages and experiences are valid and important for learning and doing science.

In schools, the way language is used, there is more reliance on literary and written kind discourse than on oral discourse. Though in the classrooms we observed oral discussions, but the way students are tested and evaluated has heavy reliance on students' written work. Also inside classroom oral language was more formal and literary unlike out of classroom context. We have even observed many Class VII students having difficulty in writing in Punjabi even though it is their mother tongue. Actually with more emphasis on oracy, we can reduce the disadvantage that many children have due to their poor 'literary' backgrounds (Wells 2009, p. 164).

6.1.1.4 Dynamic and Fluid roles and power relations

As we have described, the classroom discourse was always between the teacher and one or more students, with the teacher being the one who initiated and guided the discourse. Thus the roles in classroom discourse were rigid and fixed. However, the discourse among students in informal contexts was very complex with roles being very dynamic and fluid.

For example in the parachute making activity, in the beginning Gurpreet was in control and telling Gurdeep and Jaskaran what to do and how to do it. Gurdeep was very quiet and mostly acting mechanically whereas Jaskaran did get involved in argumentation about the design and making of parachute from the beginning, though Gurpreet did not listen to him much. However, these roles changed with Gurdeep getting more and more involved in argumentation with Gurpreet and confronting and disagreeing with him.

In the beginning (see **episode 6.04**) Gurdeep was more involved in logistics and hardly participated in the discussion and most of the discussion was between Gurpreet and Jaskaran with Gurpreet dominating the discussions by being more assertive.

Episode 6.04

02:15-6 Gurpreet (explaining by drawing on notebook): ਆਹ ਦੇ ਇੱਕ ਤਾਂ ਐਵੇਂ ਹੋ ਜਾਣੀ ਆ ਗੋਲ . ਇਕ ਐਵੇਂ ਹੋ ਜਾਣੀ . ਆ ਇਕ ਐਵੇਂ . ਉਹ ਜਿਹੜਾ ਵਿਚਾਲੇ ਵਾਲਾ ਹੋਊਗਾ ਓਹਨੂੰ ਕੱਟ ਦੇਣਾ . ਦੋ ਬਣਗੀਆਂ ਆਹਾ . ਫੇਰ ਇਹਦੇ ਨਾਲ ਜੋੜ ਦੇਣਾ ਇਹਨੂੰ ਮੋੜ ਕੇ . ਐਵੇਂ ਬਣ ਜਾਣਾ ਫੇਰ ਆਹਾ . **ਲੱਗਗੀ ਸਮਝ ?** (See here one will become round like this . and one like this . one like this . and the one which is in the middle will be cut . so will become two . then we join with this by folding . then it will become like this . **understooddd?**)

02:32-2 Jaskaran: -- ਗੋਲ ਨੀ ਬਣੇ -- ਤਾਂ ? (**-- if these won't be circular then?**) [raising question that it would not be in circular shape]

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- 02:33-5 Gurpreet: ਉਹ ਮੋਅੜ ਕੇ ਬਣ ਜਾਣਾ (Will become circular by folding)
- 02:35-5 Jaskaran: [saying something not audible]
- 02:36-1 Gurpreet (to Jaskaran): ਐਵੇਂ ਬਣੂ . ਏ ਐਵੇਂ ਜੇ ਬਣੂਗਾ ਉਹ ਹਨਾ ? .. ਐਵੇਂ ਜੇ ਬਣੂ (Will become like this . **like this it will become right?** .. will become like this) [after explaining this to Jaskaran, Gurpreet takes a pause for about 3 seconds, maybe giving time to Jaskaran to react or respond]
- 02:38-1 Gurdeep: ਜੱਸ ਪ੍ਰਕਾਰ ਦੇਦੇ ? (**Ja**, **give me compass?**) [asking for compass from a boy of another group]

But as Gurdeep got involved more and more in making the parachute, he also started getting involved in the discourse about the design, raising interesting questions. That's how the roles changed. At around 13 minutes, we see a very different dynamics of the group with Gurdeep starting to take a lead role.

Episode 6.05

- 12:28-4 Gurpreet: ਉਹ ਜਸਕਰਨ -- ਪਾੜਾ .. ਓਏ ਓਏ ਜਸਕਰਨ ਕਿਓ ਪਾੜੀ ਜਾਨਾ ? (**Oh Jaskaran! -- Hey, hey, why are you tearing?**)
- 12:32-3 Gurpreet (to Jaskaran): -- ਇਹਨੂੰ ਮਜ਼ਾਕ ਲੱਗੀ ਜਾਂਦਾ (-- he thinks its funny) [suddenly there is quietness for few seconds]
- 12:41-2 Gurpreet: ਓ ਗੱਠ ਬੰਨੋ ਓਏ ਉਰੇ (O tie a knot here)
- 12:43-2 Gurpreet: ਇੱਕ ਮਿੰਟ -- ਧਾਗਾ ਤੋੜ -- ਕੈਂਚੀ ਲੈਕੇ ਆ (One minute -- cut the thread -- bring the scissors)
- 12:44-9 Gurdeep: ਕਿਓ? .. ਧਾਗਾ ਤੋੜਨ ਦੀ ਲੋੜ ਈ ਨੀ (**Why?** .. There is no need to cut the thread) [asking rhetorically]
- 12:46-7 Jaskaran: ਗ਼ਲਤ ਹੋ ਗਿਆ (its wrongly done)
- 12:47-6 Gurpreet: ਹੁਣ ਠੀਕ ਆ (Its right now)
- 12:48-2 Jaskaran: ਇਹਨਾਂ ਨੂੰ ਐਵੇਂ ਈ -- -- (These maybe like this -- --)
- 12:50-1 Gurpreet: ਤੂੰ ਗੱਠ ਬੰਨਲਾ (You tie the knot)
- 12:51-6 Jaskaran: ਤੂੰ ਸੁਣ ਤਾਂ ਲੈਂਦਾ (You should at least listen)
- 12:52-6 Jaskaran: ਗੁਰਪ੍ਰੀਤ ਇਹਨਾਂ ਨੂੰ ਗੁੰਦ ਲਾਕੇ ਐਵੇਂ ਛੱਡ ਕੇ ਯੇ ਇਹਦੇ ਵਿੱਚ -- ਪਾਈ -- (Gurpreet put glue to these by leaving these on side inside this -- put --)
- 12:57-2 Gurdeep: ਹੁਣ ਜਿਹੜੀਆਂ ਇਹਨਾਂ ਚੋਂ ਰੱਸੀਆਂ ਆਉਣਗੀਆਂ . ਉਹ ਸਾਰੀਆਂ ਥੱਲੇ ਕੱਠੀਆਂ ਜੋੜ ਦੀਏ -- -- (Now the ropes coming from these . will tie them together down there)
- 13:01-7 Gurpreet: ਇੱਕ ਮਿੰਟ ਓਹਦਰਲਾ ਹਿੱਸਾ .. ਚੱਕੇ ਦੇ ਵਿੱਚ ਪਾਉਣ ਦੇ (One minute that part .. let me put inside the ring) [maybe asking for the other end of the thread he is passing through the paper]
- 13:05-2 Gurdeep: ਰਹਿਣ ਦੇ ਇੱਠ ਈ .. ਆਹਾ . ਆਹਾ ਅੱਡ ਰਹਿਣਦੇ .. ਇੱਠੋਂ . ਪਾਕੇ ਥੱਲੇ ਆਲੇ ਚੀ ਇੱਠੋਂ ਉੱਤੇ ਜੇ . ਉਹ ਅੱਡ -- -- ਅੱਡ ਅੱਡ ਰਹਿਣ -- (**Let it be there .. this . be this separate .. through**

this . putting in lower side and this through upper side . that separate -- -- that separate separate --) [implicit question about how to put threads]

In the above episode, Gurdeep and Gurpreet are in the process of using a compass point to make holes in the paper parachute and attaching threads to it. Jaskaran while trying to help them grabs one of the threads from Gurpreet and pulls it. To this, at 12:28, Gurpreet rhetorically asks Jaskaran why he is tearing the parachute paper. Gurpreet asks this in order to tell Jaskaran not to pull the threads because it is causing the paper to tear.

Our interpretation is that the assertion by Gurpreet over Jaskaran here is not just because he assumes himself in authority (in order to establish dominance) over Jaskaran but also because of Gurpreet's involvement in the making of the parachute. He thinks that Jaskaran is interfering in the work and is not serious in making the parachute. On the other hand, Gurdeep has been quite involved in the making of the parachute. At 12:44-9, Gurdeep raises a question about the Gurpreet's idea to cut the extra threads. Actually after needling the thread from two pieces of paper there was extra thread (see **Figure 6.2** to notice this). At 12:57-2 gives his idea on how the extra threads can be tied together which would be used to attach some load to the parachute. Gurpreet likes the Gurdeep's idea and readily agrees to his idea. So, after about 10 minutes, we see Gurdeep's role becoming important, and Gurdeep challenging and questioning Gurpreet's ideas. Thus, the engagement in the work and the discourse and raising of questions, seemed to play an important role in the dynamics of power relations between the students.

Also in the ants observations and in the variegated tree observations, the roles of the students were fluid and not fixed, such that one or few students dominated or led the discourse or interactions. Students' roles and relations kept changing as they challenged and questioned each other, showed disagreements with each other, shared their ideas and points of view, did not simply believe others, etc.

It is interesting that in informal contexts students did have the agency to break or reverse their as well as other's roles. But, in the kind of classroom discourse that we observed, this probably would not happen.

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6.1.1.5 Teacher's quietness and student agency

When we watched videos of our very first workshop of variegated tree observations, we realised that though we planned not to talk much, but we did end up doing more talking and asking with students than what we had planned. More importantly, we noticed that whenever we were talking, students would become either quiet or whisper among each other. So our talking to some extent interfered and interrupted student-student talk. Though we intended to not act or behave as 'teachers', but it was not easy for us, especially in the beginning, to get away from our 'teacherness'. However, after watching and reflecting upon the videos we did succeed to some extent to break away from the usual teacher roles in subsequent sessions.

Later on in the workshops in Ludhiana, we were more conscious about being quiet and it did result in us talking less and students talking more. While it was sometimes difficult for Gurinder not to talk, especially when students addressed him directly, it was easier for Karen not to talk, because she could not understand or converse in Punjabi. Sometimes she pretended not understanding students, and was reluctant to let them know that she could speak to them in Hindi. This may be one reason why students talked very informally even in front of her. Nevertheless, these students tried to speak in Hindi with Karen though they were not very comfortable in speaking in Hindi.

Furthermore, many a times students asked questions to the teacher researchers, which teacher researchers did not answer. With teacher not answering their questions, the questions were debated among students themselves and at times got answered among themselves. For example, at 14:39-3 in the ants observations, Kuldeep takes out a small polythene kept inside the big polythene containing different food items. This polythene had a small packet of butter in it. She sees the polythene from outside and shows it to Karen asking 'What is this?' However Karen did not answer her question, but at the same time another girl replied saying 'It's something with a peel'. Upon not getting answer from Karen, she opens up the polythene and takes out the item inside it. She takes the item in her hand wondering what it is. She then actually peels off the cover on it and then shows to the other students. Upon seeing this a number of students reply saying, 'its ghee', its butter, 'its makhan' etc. Maybe these students have not seen such a packet of butter earlier, which is generally given in trains or flights during travel. So they wondered what it is. But they did find out the answer on their own by actually investigating it when Karen did not provide them the answer.

6.1.2 Understanding students' group behaviour

In the ants observations and parachute making, the discourse among students mainly happened within pre-defined groups, defined together by students and the teacher researcher. In the ants observations, there were many other students apart from the group of girls, who were standing nearby and observing the group. At times they even tried engaging in the ants observations. However, their suggestions or arguments were ignored and not taken seriously by the group members. For example, one boy suggested that the girls should make a hole and put some oil in it to attract the ants. However, nobody from the group responded to him or did what he suggested.

Also at one point, one of the boys, Charanpreet, who was for most of time standing and watching the girls and sometimes even getting involved in talking with the group, suggested to make jaggery wet in order to break it (though he said laughingly). However nobody even argued or thought about Charanpreet's idea.

In the parachute making and ants observations, we noticed that students had a sense of belonging to their group. So there seemed to an emotional attachment within a group. We also noticed a sense of competition among different groups as they performed these tasks. This even interfered with cooperation between different groups. So we wonder how constructive such competition among groups could be and how a teacher can encourage more constructive and cooperative group work. Here, we did not interfere to encourage cooperation among different groups as we wanted to record students' work with minimal possible intervention by the teacher. This was because we wanted to understand what students were doing on their own.

But in the case of the variegated tree, there were no pre-defined groups and students formed their own fluid groups which were dynamic and kept changing. This gave them agency to spontaneously engage in discussions with different 'groups' or students, as they were not restricted to have discourse among particular members. So students had more agency to roam around and have freedom to occupy any space around or near the tree rather than being confined to more fixed space for explorations if they were in pre-defined groups. This may have encouraged their questioning and investigation even without teacher guidance.

Though in variegated tree explorations, there were no 'fixed' groups, but for most of the time during their explorations around tree, students segregated themselves into two bigger

'groups' of girls and boys, occupying different places around the tree for most of the time. This could be due to their classroom culture in which boys and girls generally sit and work separately and are discouraged to talk to each other.

6.1.3 Students' 'studentness' and the 'school-school' game

Though in the informal contexts students behaved much less as 'students' as they did inside classrooms but it was not easy for them to break away from their typical role of being a student. In all the three informal contexts, to less or more extent we observed students trying to figure out what the teacher researchers wanted them to do and students trying to act, ask and respond accordingly. This could be due to the prevailing power relations inside the classrooms where it is expected that the students would act in certain ways.

For example in the variegated tree observations, in the very beginning students confronted a conflict when they saw that the teachers were not acting as they believed teachers should act. This could be because teachers did not tell them any instructions or any task to perform, neither teachers were lecturing or demonstrating something. This led Tanya at 01:53 to ask the explicit question, “काय ओळखायचं आहे ? (What should we identify/look for?)”. To which Kavita replies by saying, “मग ते काय ते तर वृक्ष आहे. (Well there is that tree there (to identify/look at).) [pointing to the Casuarina tree, smiling]” They began trying to identify the plants maybe because they had heard the boys talking about the Casuarina tree and they believed that plant identification would be an educational or science kind of thing that should be done in this context. They were trying to play their part in the 'school-school game'. This game may have temporarily prevented them from being more curious about more unusual things. However, the students gradually deviated more and more from the usual school-school game.

In another example in the ants observations, girls thought that their task was to feed the ants though we did not explicitly tell this task. In our instructions, we only told them to use food items and find out something about the ants. We never intended to assign some 'task' for completion as such. We gave them slightly vague instructions as we wanted that students should start from their own questions from the things that would interest them. We may have given more specific instructions like find out which food item ants prefer more or how do one ant pass message to other ants when it finds some food. But we thought it might constrain

their explorations and questions about ants. Moreover we were interested in listening to their more spontaneous discussions. However, with girls thinking their task was feeding the ants they seemed to be more concerned about feeding the ants and completing the task. And maybe they thought that this way they would prove their 'studentness'.

So we observed that at times it was difficult to sustain the natural discourse among students as they tried to act, ask and respond according to the expectations of the teachers and played the usual 'school-school' game. This seemed to be a hindrance to their inquiry process.

6.1.4 Understanding student argumentation in their discourse

As discussed in section 2.2.3.1 researchers have argued that argumentation is a dialogical and dialectical phenomenon involving critical engagement with opposing viewpoints through a social and collaborative process (Nielsen, 2003; Walton, 2005). Muller and Perret-Clermont (2009) says that argumentation occurs when there is plurality or multiplicity of ideas. Argumentation means confronting others ideas and not submitting to majority or authoritarian ideas.

Research on understanding students argumentation often focuses on understanding, categorising, and evaluating the logic, structure (form), and products of argumentation rather than the process (Nielsen, 2013), the context, the function, and reasons for argumentation. The dominant framework has been the Toulmin model and its variants called TAP (Toulmin Argument Pattern) models. These models have been used by various researchers to evaluate students argumentation by looking at the claims and warrants that students present. The content of the arguments is evaluated but the dynamics and development of the arguments and the role of the social context is sometimes not given much attention. There are various social aspects that need to be looked into - the relations between students and students and between students and teachers, including power relations, role of gender, role of emotions and conflicts due to social structures, however TAP models often fail to describe these aspects.

Duschl (2007) points out problems with the use of Toulmin and similar models for assessing student argumentation. He says,

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Augmentation of students' discourse to promote critical thinking and reasoning would benefit by a shift from an emphasis on deductive and inductive argumentation schemes to an initial emphasis on the more natural dialogue logic found in dialectical contexts. (p. 172)

Furthermore, Van Eemeren & Grootendorst (1999) criticises both the Toulmin and Perelman theory of argumentation as both the theories are not very different from the traditional syllogistic logic, though both theories claim to move away from syllogistic logic for understanding everyday logic.

Apart from these problems, researchers studying student argumentation have largely ignored the role of student questioning in construction of their arguments and vice-versa. Michel Meyer (1982), criticising propositional models to describe argumentation, argues for a question-answer model for describing argumentation.

Consequently, argumentation pertains to the theory of questioning. What is an argument but an opinion on a question? To raise a question, which is the essence of discourse, is to argue. The question being posed - the possibility of an opposed opinion or, more simply, of a debate - is posed along with it. But what questions are we referring to? If a question must be faced in a given context, the argument is the answer which occurs as a conclusion on the question. (p. 99)

Here in this section we will try to understand the student argumentation in student discourse by looking into the role of questions and social aspects like authority, gender etc. in their argumentation.

6.1.4.1 Questioning and argumentation

In the variegated tree observations, as the boys were exploring the tree, Nimish found some tiny eggs stuck onto a leaf (at 33:42) and was very excited about it. He went to show those to Gurinder, who was busy, so he showed them to the other boys. Then (**Episode 6.06**) he went triumphantly to show it to Kranti (at 33:48), saying, "Oh Madam! Eggs! Look, eggs!"

The girls, who were gathered around Kranti, wanted to see the eggs, and one girl (Tanya) made Nimish show her the eggs. At this another girl asked the explicit question, "**Whose eggs are they?**" and Ishita immediately answered, "Ants'."

Episode 6.06

- 33:48 Nimish: ओ मॅडम, अंडी बघा अंडी! (Oo madam, eggs see eggs!)
- 33:48 A girl: बघू, बघू ([let me] see, [let me] see)
- 33:49 Many girls (saying together): काय आहे ते? दाखव. बघू. (What is it? Show. [let us] See)
- 33:54 Kranti: **ए ती मोत्यांसारखी आहेत. ना? (hey those are like pearls . No?)**
- 33:55 Priya: wow
- 33:55 One girl (maybe Tanya): **कसली आहेत ती? (Whose eggs are they?)**
- 33:56 Ishita: मुंगीची. (Ant's)
- 33:59 Suraj: मुंगीची नाही ती | (They are not of ants)
- 34:02 Suraj: मुंगीची सफेद असतात, एवढु एवढुशी | (Ant's eggs are white, tiny tiny)

Then Suraj disagreed, saying, “They are not ants’ [eggs]”, and without being asked to give evidence, he continued, “Ants’ eggs look white and are much smaller.”

Here a disagreement by Suraj about the answer to an authentic student question led Suraj to present justification for his disagreement. However, this argument was temporarily left aside while a few students raised other questions about the eggs, such as where they were found (not answered) and how many eggs were there on the leaf.

Kranti had been recording students’ questions on large sheets of paper and the girls had been watching her do this. Although she did not intend to re-initiate the argument, when the students heard Kranti repeat the question at 35:30 (see **Episode 6.07**) ‘whose eggs are they’, as she was writing, they took it up again. It is important here to note that the question ‘whose eggs are they’ asked by the student, which led to interesting arguments among students, is an investigable question.

Episode 6.07

- 35:30 Kranti: **कसली अंडी आहेत? (Whose eggs are they?)** [reading/writing]
- 35:34 Tanya: मुंगीची. (Ant's)
- 35:34 Shrusti [speaking at the same time]: कसली पण अंडी असतील (might be any kind of eggs)
- 35:35 Nimish: **मुंगी तरी एवढी मोठी असते का ? (Are ants even that big?)** [rhetorically]
- 35:36 Tanya: Eh! (with an expression of discounting Nimish)
- 35:38 Nimish : **मुंगी तरी एवढी असते का ? (Are ants even that big?)** [repeating himself]
- 35:40 Kavita: ए दाखव ना! (Show me!)
- 35:41 Tanya: काय बघायचं आहे एवढे त्यात? **(What's so special about it?)** [rhetorically]

With Kranti reading the question, Tanya replies by saying “Ants”. To this Nimish replies by rhetorically saying, “**Are ants even that big?**”. When Nimish asked the rhetorical question he presumably thought the answer was, “No, ants are not even that big.” In our observations we noticed that rather than using statements, students often used rhetorical questions for emphasis and emotional impact. Actually with his rhetorical question, Nimish not just rejects Tanya’s claim but also gives evidence for the same that these cannot be ants eggs as ants are not that big.

With Nimish’s complete disagreement with Tanya’s answer, argument between Nimish and Tanya became more emotional and Tanya replied “Eh” telling Nimish that she did not want to hear him. To which Nimish repeated his rhetorical question with the same intonation. At that moment Kavita asks Nimish to give the eggs and Tanya says, “**What’s so special about it**”. Tanya showed her disdain by saying that the entire subject was unimportant. She also used a rhetorical question to do this, with an implied insult to Nimish’s pride at finding the eggs. However, perhaps Nimish was successful in making his point that the eggs were too big to be ants’ eggs because no one argued against this point.

Actually students used rhetorical questions for various kinds of arguments like showing disagreements, making a point, presenting challenge, making claim and giving justification. Students’ use of rhetorical questions in student conversations especially in their argumentation has hardly been explored by the researchers and as suggested by the above examples, this is an interesting aspect to further explore.

Apart from making claims, giving justifications etc. students also used questions to become cognizant of what they do not know, to get others to consider contradictions, and to become meaningfully involved in the discourse, which we see as important aspects for involving in argumentation.

6.1.4.2 Power relations, authority and emotions: understanding ‘rationality’ in student argumentation

Being critical of others’ opinions irrespective of their social position is an important aspect of argumentation and doing of science. However, in classrooms and in everyday life, we can

find numerous examples when one's arguments get accepted or rejected because of one's authority or social position.

For example in classrooms that we observed we found very few examples of students being critical of teacher's arguments and disagreeing with those (see **section 4.2.3**). Like our observations, Kirch (2007) in her study also found students being less skeptical of authorities than of each other.

When facts are not given equal weight because of a social structure for respecting authority this influences how we decide something to be true. In the present study, students were typically accepting and much less skeptical of information from authoritative sources. This was in direct contrast to their treatment of classmates of whom they were much more skeptical and close-minded. (p. 811)

We found that, both inside classrooms and in the informal contexts, students showed more disagreements among each other and were more skeptical of each other than they were with teachers. In informal contexts we did observe students sometimes challenging authorities and a few times disagreeing with authorities, though teacher researchers spoke much less with students as compared to their regular teachers inside classrooms.

In informal contexts, students at times did treat researchers as teachers, asking permission to get stuff or asking about the task itself. For example in **episode 6.08**, during ants observations, at 09:43-3 Disha asked Karen whether their task is complete and whether they can go now. Although here Karen did not say anything verbally, but maybe Karen's silence and gestures indicated girls that they cannot go yet.

To this, at 09:49-0, Disha tried to argue with Karen saying that they can go as ants have eaten some jaggery that was fed to them, and they might not be eating the rest of the jaggery. Here Disha shows resistance and actually challenges Karen with her rhetorical argument.

Episode 6.08

- 09:43-3 Disha: जी अब खा . बस चलें अब जी ? (Mam now eating . **shall we go now?**)
[Charanpreet and others start laughing. Maybe the way Disha was speaking in Hindi they found it funny]
- 09:48-0 Disha: जी अब वो सारा थोड़ी खाएंगी ? (**Mam they won't eat all of this?**) [Rhetorically]

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- 10:00-0 One girl (in Hindi to Karen): **Madam चलें ?...चलें? (Madam shall we go? .. Shall we go?)**
- 10:03-0 One girl: **Madam चलें ? (Madam shall we go?)**
- 10:05-0 Another girl: **Madam चलें ?(Madam shall we go?)**
- 10:05-5 Kuldeep: **Madam चलें ? (Madam shall we go?)**
- 10:06-0 Disha: **Madam चलें ?(Madam shall we go?)**
[With Disha asking Karen whether they can go, other girls also start asking to go. Suddenly all of them wanted to go. But its not clear whether all of them really wanted to go or they just followed what others were saying.]
- 10:07-0 Karen: **aaan पता नहीं (Aan don't know)**
- 10:08-8 Some girl: **जी वो उधर हैं sir .. (Mam sir is there ..)**
- 10:08-6 At this point Disha is looking at karen with a very confused face. Maybe she could not understand whether they can go or not.
- 10:10-0 Meanwhile Manpreet stands up from her place and Kuldeep follows her.

With Karen saying that she does not know whether they can go, the girls immediately asked about asking Gurinder. Perhaps with Karen saying she does not know, they thought Gurinder might be knowing and they can get permission from Gurinder. They might have thought of Gurinder as more of the teacher than Karen. Actually it was Gurinder who explained the task to them and gave instructions and conversed with students in Punjabi.

Though they seemed not to be treating Karen as an authority figure, but they found Karen's presence around them to an extent restrictive. For example, at one point Karen goes to see the other group who were continuously calling her their place to see the ants. As Karen leaves, the girls start singing songs as if they have got the freedom to do and say what they would have wanted. Some boys also join them in singing. They were intrigued by the audio recorder, and treated it as a device for recording their singing.

Even though students did challenge teacher researchers, their challenge was not as strong as with other students. But we did notice that for most of their questions they did not ask the teacher researchers for the answers thinking them as authority which can provide answers, but argued and investigated their questions on their own.

Among students also, there were complex dynamics of authority and power relations, which were seen being challenged as students argued among themselves. We found some examples in which a student thought of another student as an authority and asked them to answer their questions, but the arguments or answers of the authority were not able to satisfy the asker.

For example in the variegated tree observations (**episode 6.12**) Trupti saw some buds on the tree which she thought as flower buds. To verify she asks Priya her question. But why did she go and ask Priya, who was standing a distance away, in the first place rather than asking anyone else? It may be because she wanted to verify that Priya has a certain authority. Meyer (2010) has suggested that verifying authority (rather than getting an answer to the explicit question) is the aim for some kinds of questioning. Some questions can be answered to the satisfaction of the askers if the authorities answer by imposing themselves as authorities, even if they do not provide satisfactory answers with logical reasoning or evidence. If this was the case here, then even if Priya did not provide a rational answer with evidence, she may have been able to verify her identity as an authority and this may have provided some sort of satisfaction to Trupti - which could bring her problem to a satisfactory end. Alternatively, even if Trupti was not satisfied by Priya's answer, she may have been so dominated by her authority that she could not bring herself to question it.

We suspected that Trupti may view Priya as an authority because Priya was one of the 'toppers' in the class, she was talkative and outspoken, and she was also physically dominant (much taller than the others). Although none of the girls were 'upper caste', Priya was from a slightly higher caste than most of the other girls, including Trupti and Janvi.

But actually Priya gave a simple, direct answer: "No. There are no flowers." It seems that Priya treated the question as if it was a Yes/No question which could be answered in this simple and definitive way. But Trupti did not accept Priya's simple no and pursued her question. Also upon hearing Trupti's question and Priya's answer, other students also join in discussions with their own different opinions. This may have helped Trupti to investigate her question further.

If Shrushti accepted Priya as an authority, she may have been satisfied by her answer, even though she did not give any explanation, reason, or evidence. Or, if she was dominated by her authority, they may not have dared to question it. However, we do not see this happening. The other girls were also not satisfied with this answer, and they voiced their questioning as well.

The above examples show how students were 'more rational' in their arguments and did not accept arguments of others just because of their authority. However, at other times we

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observed students being ‘less rational’ in their argumentation and being influenced by their egos and emotions.

For example in **Episode 6.07**, presented in the previous section, our interpretation is that the argument between Nimish and Tanya may have been partly a ‘girls vs boys’ argument and/or an ego conflict. In the episode Nimish used a rhetorical question to make his point, maybe because it sounded stronger that way. Perhaps the logic and the need to resolve the question under dispute was secondary to Tanya’s need to challenge the social hierarchy.

Further evidence for this interpretation is that much earlier there was an argument between the boys and the girls about whether or not there are golden coloured leaves on the tree. When the boys were slightly away from the girls (at 10:18), Nimish had said that there are golden leaves. At 11:08, probably after seeing that Kranti had written the question “What colour leaves are there? Golden...”, Priya said that there were no golden leaves. The other girls stated their agreement with Priya on this point. Then at 12:35 (**Episode 6.09**) the girls used a sarcastic rhetorical question to make fun of Nimish’s statement that some leaves were ‘golden’:

Episode 6.09

- 12:29 Nimish: golden colour आहे (It is golden in colour)
12:32 Priya: नाही golden (Not golden)
12:34 Nimish: हा बघ golden (See, it’s golden.)
12:35 Other girls: **हा काय golden आहे ? (Is this golden?)** [rhetorically]
12:37 Nimish: थांबा तुम्हाला चष्मा आणून देतो (Wait, let me give you eyeglasses.)
12:38 girl: दे, हा जा. (Okay, bring them)
12:39 Girl: **काय बोलला तू (What are you saying?)** [rhetorically]
12:42 Kranti: अरे भांडू नका (Hey don't fight) [laughingly]
[Nimish leaves to join the other boys.]

Although it began as a concern about whether or not there were golden leaves, when Nimish stated that there were golden leaves, the girls, knowing they were all in agreement with each other, challenged him. So the whole argument about colour probably was less to justify the claim or seek evidence for the claim but more a chance for girls to score a point over a boy.

At other times we noticed that conflicts arising from emotional and power relations dominated to an extent that it inhibited student questioning and their meaningful engagement in the discourse. We specifically found this in the girls' observations of the ants. Much of the argumentation was directly or indirectly about social relations and power dynamics within the group and between the group and outsiders: who should be where, who should or should not do or have done something, whether someone else agrees. The following **episode 6.10** gives an example of argument ensuing between girls in the ants group and boys from another class, one grade lower. The girls objected to other students standing close to their group. Actually there were many other students crowding around them.

Episode 6.10

- 01:43-5 One girl: **ਆਪਣੀ ਕਲਾਸ ਚ ਨੀ ਜਾਣਾ ਤੁਸੀਂ ? (Won't you go into your class?)**
[Rhetorically]
- 01:44-4 Disha: ਬਤਮੀਜ਼ ਜੇ ਨਾ ਹੋਣ (Stupid) [abusing boys]
- 01:49-0 Simranpreet (?): **ਏ ਸੁਖ ਹੁਣੀ ਆਪਣੇ ਗਰੁੱਪ ਚ ਨੇ ? (Are sukh and others in our group?)**
- 01:51-0 One girl (responding to Simranpreet's question): ਨਹੀਓ (No)
- 01:52-5 Disha??(asking the boys of the other class): **ਤੁਸੀਂ ਕਿਹੜੇ ਗਰੁੱਪ ਚੋਓ ? (Which group are you in?)**
- 01:54-5 Disha: ਜਾਓ ਆਪਦਾ ਕੀੜੀ ਲੱਭੋ (Go and search for your own ants)

So the discourse among the students persisted or continued not just for some logical or rational reasons and/or because of some logical arguments, but also due to different spontaneous acts or responses which were guided by emotions and social power relations. In another example, we noticed Nimish being quite possessive about the eggs he found and at points he treated the eggs as if he owned the eggs, especially in front of the girls telling the girls to be careful not to hurt them (see **Figure 6.3**). His this behaviour actually led to a whole new line of discussion (**Episode 6.11**) giving rise to some interesting questions:

Episode 6.11

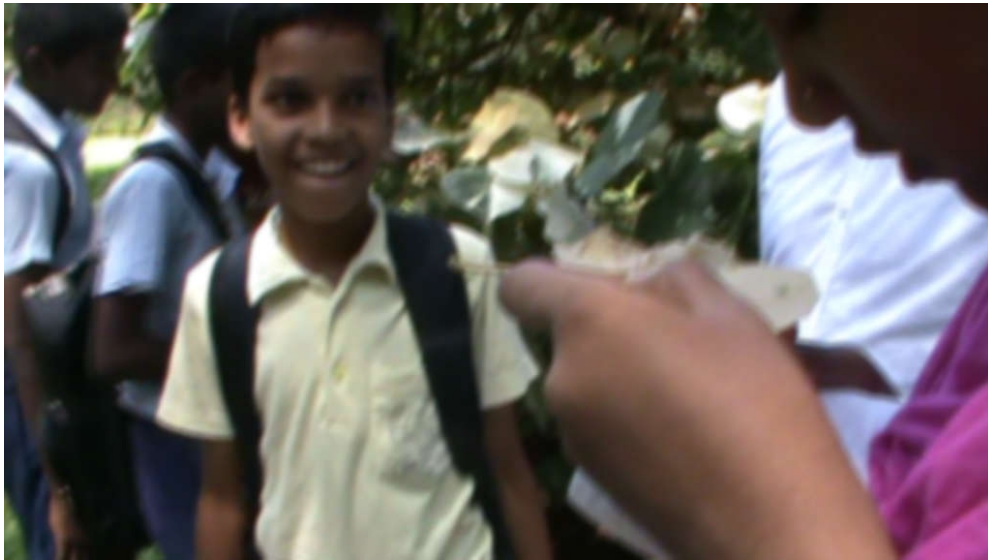
- 36:49 Ishita: **ਕਾ, ਤੂੰ ਘਰੀ ਖੇਝਨ ਜਾਯਾਰ ਆਵੇਸ? (Why? Are you going to take them home?)**
- 36:51 Nimish: ਪਾਠਯਾਰ (Raise them.)
- 36:53 Kranti: *ਲਿਆਕੂਨ ਪਿਲ੍ਹੂ ਬਾਹਰ ਯੇਯਾਰ ਆਵੇ. (Baby is going to come out.)*
- 36:55 Ishita: ਫੁਲਪਾਖਰਾਬੀ ਅਸਤੀਲ. (Maybe butterflies.)
- 36:58 Kranti: *ਫੁਲਪਾਖਰਾਬੀ (Maybe butterfly's)*

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- 37:00 Nimish: फुलपाखराची पण एवढीच असतात पण एकच असतो (Butterfly also has this much big eggs but they has only one egg.)
- 37:01 Ishita: फुलपाखराची एवढी छोटी? मोठी असतात. (**This much tiny butterfly's?** They are bigger.)
- 37:02 Kavita: ह्याच्यासारखी असतात ती गोल गोल (They are like these round ones.)
- 37:04 One girl: फुलपाखराची अंडी मोठी असतात. (Eggs of butterflies are bigger.)
- 37:05 Kranti: फुलपाखराची नाही. ते तुम्ही रेशमी किड्याचं बघितलं असेल... तो एवढा मोठा moth असतो (That is not a butterfly egg. Maybe what you have seen is a silkworm... It gives a big moth.) [gestures for large]
- 37:09 Nimish: फुलपाखरांचं एवढं मोठं असत. गोल गोल असत. ते फुटतात आणि फुलपाखरू बाहेर येत. (Butterfly's are bigger and round, it breaks and butterfly comes out.)
- 37:13 Kranti: हा ते अंड नसत, तो कोष असतो, ती अळी बनवते, आणि मग तो कोष फोडून फुलपाखरू बाहेर येतो (Yes, that is not the egg... You must have seen a cocoon. The larvae makes it and when cocoon ruptures butterfly comes out.)
- 37:16 Kavita: ते मणी सारखे आहेत. पानावर चिकटलेत. हलत पण नाही आहेत. (These are like beads, stuck on the leaf . they are not moving.)
- 37:26 Kavita: हे ते magic ball असतात ना कुठे पण चिकटतात (This is like the magic balls they stick anywhere)
- 37:42 Student: अरे ठेऊन दे जिथे होते तिथे, त्यांची आई शोधत असेल त्याला (Keep it where it was, its mother will be searching for it.)
- 37:46 Kavita: दाखव ना ? (**Show me na?**)
- 37:48 one of the girls: त्यांची आई शोधत असेल तिला (their mother will be searching for it (her))
- 37:52 Kranti: ती येऊन मारेल हा तुला, अंडी चोरली म्हणून (The mother will come and hit you - because eggs are stolen.)
- 38:06 Kavita: असं काळ काळ आहे आणि हात लावला तरी पडत नाहीये (It is blackish in colour and it did not fall down though we touched it.)
- 38:17 Kranti: ह्याला आपण सूक्ष्मदर्शकाखाली बघुयात, आपल्याकडे आहे एक microscope (We will see this under microscope, we have one.)
- 38:19 Priya: **transparent** आहे की नाही ते बघू. (**We will see whether it is transparent or not.**)
- 38:23 Kavita: कोणाला मिळालं हे ? (**Who found this?**)
- 38:23 Kranti: [gestures towards Nimish]

It is interesting to note that this episode involving conflicts, questioning and argumentation resulted because of Nimish's possessiveness towards eggs. We notice examples of four different types of questions asked by the students in this episode. At 37:46, Kavita adds the “, no?” to her request to be shown the eggs, making it a confirmation question. Probably she did this in order to make her request more polite, and to make it more likely that others would show her the eggs, implicitly suggesting ‘Why not?’

Figure 6.3 - Nimish's possessiveness about eggs while he shows eggs to other students



Kavita's question at 38:23 is just a basic question of reality, with a simple answer which is not too hard to find. But the answer, by the teacher, had an important emotional effect; it may have drawn positive attention to Nimish, increasing his pride and quashing the girl's efforts to deny him satisfaction.

So the students' beliefs and their replies were not just guided by their 'rational' thoughts and observations of physical stuff but also by collective interactions, emotions and social power relations. Kim and Roth (2018), who looked at argumentation as a social process, also describe how arguments get constructed in a group as a collaborative process. However these researchers do not delve into issues of power relations and emotions within the group. We wonder whether efforts to individualise learning, and stifle (or deny the relevance of) social relations, may inhibit discourse and the process of doing science.

6.1.4.3 Role of observation of physical reality in students' construction of arguments

In the variegated tree observations, students could not resolve the question about the eggs as to what kind of eggs they had found. At the end different students seemed to have different opinions and some students were very unsure of the answer. A number of students were enthusiastic about doing various things to further investigate this question:

keeping the eggs as pets and waiting to see what hatches

breaking an egg open

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looking under a microscope (with or without dissecting)

However, interestingly, none of them suggested looking in a book or on the internet, and none of them directly asked or suggested asking a teacher (maybe they assumed that if one of the present teachers knew, they would have offered the answer). All their suggestions were related to making more observations and doing science.

It is also interesting that there were a range of variables the students considered when giving evidence for their claims as to what sort of animal did or did not lay eggs on the leaf:

the size

the colour and shininess

the shape

the number of eggs

All of these reasons are concerning the physical features of the eggs.

Here is another example to understand the role of observations of physical stuff in students' argumentation - from the ants observations. While giving jaggery to ants, Disha and Simranpreet accused Kuldeep of putting large pieces of jaggery by saying: "You should have broken it down into fine pieces and then has put it". At this, Kuldeep did not respond back to their accusations. When Harmanpreet tried to break the jaggery into smaller pieces, and said that she is unable to make very fine pieces ("It's not breaking up"), Kuldeep immediately took up her argument and justified it, saying "That's what I was telling, you people are not listening". So until Harmanpreet herself tried to break the jaggery, she (as well as others) was not able to understand Kuldeep's argument.

These episodes show how students' arguments were guided and shaped by their observations and actions upon the physical stuff. Students' argumentation was based more on their observations and experience than on logical reasoning. This supports our belief that science is based on observations of physical reality, and that argumentation in science requires a recurrent concern for physical reality, for the formation of both questions and evidence. The point is that, as Eleanor Duckworth (2012) says, "In science, the stuff is the authority".

6.2 Understanding the process: How questioning arose, evolved and progressed?

In this section, our focus would be to understand how questioning arose, progressed and sustained by looking at the specific question-answer/response sequences. However, this cannot be possible without understanding the nature of student discourse, the dynamics of power relations, and the nature of student argumentation, discussed in the previous section. Questioning evolved and progressed as a result of complex group interactions between students and between students and physical stuff, which were dependent on factors such as nature of physical stuff, gender, agency, social hierarchy, caste, class, and numerous types of conflict and misunderstandings. When we observed and analysed the questioning process, we did not find any set of steps in some order or set of aspects that are necessarily present. We think that questioning did not arise as a result of any series of logical steps because there are too many variables: the people, the stuff, the language, and interdependencies among these, etc.

We found that spontaneous discussions do not have a particular 'structure' - they are by nature more unstructured and complex. Therefore, we cannot identify structures in them as we can in the classroom talk that is dominated and controlled by the teacher. Informally, we did not find anything like an IRE type structure. We will discuss about the 'unstructured' student-student discourse in the informal contexts while explaining the process of questioning in this section.

6.2.1 Explaining the question-answer relation using Meyer's theory of problematology

In order to understand the questioning process and question-answer relation, we will here analyse one episode of sequence of students' questions and responses from their observations of variegated tree.

This episode gets initiated by a question about flowers on tree, verbalised by Trupti. As Trupti and Janvi were looking at and handling the leaves on the ends of the branches of the tree, they spoke to each other in soft voices which were not audible in the recording. Then at

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15:40 Trupti stepped over to Priya and the following conversation occurred:

Episode 6.12

- 15:40 Trupti [directly to Priya]: झाडाला फुल आहे का? (**Does the tree have flowers?**)
- 15:42 Priya: नाही. फुल कुठे फुल नाहीये. (No. There are no flowers.) [as she looks at the tree from a distance]
- 15:43 Ishita: फुल कुठे? (**Where are flowers?**) [hardly glancing at the tree, from a distance]
- 15:44 Tanya: सगळे झाडाला फुले असतात. (All plants have flowers.) [with her back to the tree]
- 15:46 Trupti: अरे, आहे वाटत ! (Hey, I think it [a flower] is there.) [still looking at the tree from a distance]
- 15:47 Kavita: नाहीये. ([A flower] is not there.)
- 15:48 Priya: अरे, नाही, नाही, प्रत्येक झाडाला फुल अस्तात नंतर मग फळ येत. (Arre, no, no, all plants have flowers and then they turn into fruit.)
- 15:52 Trupti: हा. असत. (Yes. [All plants] have [flowers].)
- 15:55 Ishita: आणि बिना फुलांचा झाडा -- (**But the flowerless plants --**)
- 15:58 Kavita: हे सुरु आहे! सुरु! (Oh there is the suru! Suru!) [looking at nearby Casaurina tree]
- 16:00 Ishita: हां ! (Yes!)
- 16:01 Another girl: ...सुरु...[inaudible]
- 16:04 Tanya: काय ? (**What?**)
- 16:11 Trupti: अरे, आहेत के नाही फुले? (**Hey, are there flowers or not?**) [to Janvi, who has a disinterested expression, as Trupti turns to look towards the tree]
- 16:13 Ishita: नाही शपथ. केस खराब झाली. (I swear there are not [flowers]. My hairdo is getting spoiled.)
- 16:15 [Trupti pulls Ishita by her hand towards the tree - Ishita makes a complaining expression.]
- 16:16 Trupti: घरी जाऊन टीवी बघन अपेक्ष हे चांगलं आहे ! (This [workshop] is better than going home and watching tv!)
- 16:18 Tanya: बग न. (see it.) [without enthusiasm]
- 16:20 Trupti : आ इकडे ये ना. हे फुल आहे ना? (Hey, come here . **These are flowers, no?**) [to Ishita, pulling her by the hand]
- 16:22 Ishita: काय आहे? (**What is it?**)
- 16:23 Trupti: हे फुल आहेत, ना ? (**See these are flowers, no?**) [showing closely]
- 16:26 Trupti: परत इथे पान आहेत (There are leaves here as well) [as she takes hold of a branch]
- 16:29 Tanyai: कुठे आहे फुल? (**Where is the flower?**) [Trupti, Ishita, and Tanya all look closely at a branch, pulling the leaves apart to see the bud]

- 16:31 Ishita: [clicking her tongue to mean no] **येई ती फुल आहे कि छोटी छोटी पान आहेत ? (this is flower or this is leaf?)**
- 16:33 Kavita: पान आहेत ती. (They are leaves.)
- 16:33 Ishita: -- छोटी -- (-- small --) [inaudible]
- 16:40 Tanya: **ए प्रिया ती फुल आहेत ना ? (Ee Priya they are flowers na?)**
- 16:42 a girl (Kavita?): ये पत्ता है. (This is a leaf.)
- 16:46 another girl: पत्ता है. ([It] is a leaf)
- 16:56 a girl: हां, पत्ता है -- (Is leaf...)
- 17:06 a girl (maybe Tanya): **ये पाना है ना ? (This is a leaf, right?)** [asking the teacher]
- 17:06 Trupti: फुल आहे (It's a flower.)
- 17:08 Priya: छोटी छोटी पान आहे (It's a little tiny leaf.)
- 17:08 Kavita: पान आहेत (They are leaves.)
- 17:08 Kranti: *हम्म* (Hmmm) [from the tone, this sounds like an ambiguous yes]

In this conversation there appear to be two main questions under consideration by the girls, and they may be shifting between these two questions. Both of these questions are what we call as investigable questions. The question which Trupti initially asks Priya is probably whether this tree has flowers, or whether this type of tree is a flowering tree. The other question is whether the buds that look like flowers are really flowers. It is clear that this is the question in Trupti's mind when she tries to get other girls to closely observe the buds. Trupti first verbalises her question loudly to Priya. At this Priya said, "No. There are no flowers." The way she phrased the answer makes it clear that she interpreted the question as referring to this particular tree, not this type of tree. She also treated the question as if it was a Yes/No question which could be answered in this simple and definitive way. However, Trupti as well as the other girls, who were listening to Trupti and Priya, were not satisfied with this answer, and they voiced their questioning.

At 15:48, after Tanya argues that every tree has flowers, Priya changes her earlier reply of 'no' and agrees that all trees have flowers. She also adds the point that flowers turn into fruit, which provides further evidence, since they all might have observed fruit on trees. Priya did not just treat Tanya's statement as something requiring a simple Yes/No agreement or disagreement. Rather than saying, "Yes, I agree.", or just repeating what Tanya said, she built upon it. So a reply from one student guided the other to analyse, further develop, and verbalise the argumentation. Priya's statement that all trees have flowers reinforced Trupti's questioning, making it more possible that if all trees have flowers, this tree also has flowers,

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and the buds she saw may actually be flowers.

However, Ishita does not agree and at 15:55 argues that there are flowerless plants as well. Here she may not be sure about her reply, she may be wondering and thinking out loud. But building upon Ishita's reply, Kavita brings in an example of a flowerless tree, which the students had observed a few minutes earlier, just next to the bhendi tree.

With Kavita citing the example of flowerless trees, the deductive argument, that every plant has flowers and therefore the tree in question will also have flowers, became questionable. It is an example of how in doing science, deductive arguments are not really independent of inductive arguments. There is a dialectical relationship between inductive and deductive argumentation. By this we mean that induction and deduction are opposing aspects which are inherent to the unity of their relationship in the argumentation process.

With this, Trupti again starts doubting whether the tree has flowers, indicating that she was probably convinced by the argument she heard that some trees have flowers and some don't. So we can see Trupti continuously challenging her beliefs. This is what we expect from student questioning -- challenging and questioning of one's own beliefs.

Trupti continued to ask other students to look at the buds more closely in order to answer her question. Her persistence indicates a challenge to Priya's authority. Her insistence on direct observation indicates that she did not consider this to be a simple Yes/No question. Up to this point Trupti and Janvi had spent much more time handling and looking closely at the leaves than Priya had. And yet, Trupti did not pull Priya to the tree, She pulled Ishita, who seemed to be the one who was least interested and most reluctant (she had just complained about her hair getting spoiled). We do not know whether caste or class differences or some other factors (e.g. friendships, personalities) may have been important here.

Ishita does finally handle the leaves, takes a close look, and then immediately claims that they are not flowers. Rather than just saying that they are 'non-flowers' she declares that they are something else - leaves. By stating that they are small leaves (rather than petals), she has also made an implicit distinction between leaves and petals. However, she does not explain why she makes this distinction. It could be that she thinks they are not flowers because she does not see any stamens, anthers, or carpels. But she does not state this either, so we have no way of knowing whether her thinking is really based on observation or on wanting to side with one of her friends.

The tree did have something that resembled flowers (**Figure 6.4**). What the students were examining were not petals, but they were not exactly leaves either. The branches of the tree ended in buds which were actually stipules enclosing developing leaves, but they resembled flower buds.

Figure 6.4 The stipules resembling flower buds



Finally, the teacher is brought into the scene and asked about the buds. With teacher being called in seemed to bring an end to the question-answer process, which may have continued longer, and maybe some more and different arguments could have emerged among students. But it seems that Trupti was still not satisfied by the answer of the teacher. Perhaps it was because she developed some kind of ownership and emotional attachment with the question; and no authority figure gave reasoned arguments with evidence.

This whole sequence of questions and responses, originating from Trupti's question, occurred in a very dynamic and complex way, with arguments proceeding at a more social, collaborative level than at a personal level. Both the questioning and answering was collaborative.

For the whole of the episode, discourse was centred around the two main questions - whether this tree has flowers or whether the bud-like things are flowers. However there were other questions which emerged during the course of discussions among students like - whether all trees have flowers (implicit question), what could be an example of a flowerless tree (an implicit question by Ishita at 15:55), where are the flowers and whether the buds that look like flowers are small leaves. Some of these questions do not seem to be questions unless we look at the surrounding discussion. Using Meyer's (1995) ideas on question-answer relationship, we analysed possible questions in the context of their replies and vice versa.

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Only when we look at the discourse in the context of both, the so called questions and replies, we can make a meaningful understanding of the discourse.

Furthermore, it was not a simple q-a sequence in the sense that there was one question raised and answered and then another question and another answer. But rather one question, without being resolved, led to other questions. But how did these new questions emerge? They emerged from the problematological nature of the responses. This is shown for example, when in the reply to Priya saying 'Arre, no, no, all plants have flowers and then they turn into fruit', Ishita says, 'But there are flowerless plants.' Although independently neither of these statements appear to be problematological, but when the two are seen with respect to other questions/replies preceding or following these, they become problematological giving rise to the question of whether all trees have flowers. Actually it is difficult to say whether each of these statements in their isolation are answers or questions.

The problems/questions are not resolved or answered completely. They persist. So this nature of discourse cannot be understood in terms of 'problem solving' in which the problems become eliminated or closed, but in terms of problematology in which problems are partially resolved and partially unresolved (hence they persist), explaining the rise of newer questions.

That, as a group, students did not come to a resolution on the question/s, questioning persisted. So this non-resolution or problematological answering gave rise to questioning. And answers were problematised with the questioning of answers. Using the Meyer's (1995) theory of problematology, one can understand the progress of discourse through problematological answering. Problematological answers perform dual function by describing two questions - one, they correspond to the question which is resolved (apocritical) and two, they correspond to the question which is raised (problematological). This problematological questioning/answering explains the emergence of newer questions and thus the progress of the discourse.

In some cases discussions began with an explicit question, but this was not always the case. We also saw examples of discussions which were centred around implicit questions (Episode 5.07 or Episode 5.08), or questions that became explicit quite late in the discussion (Example of question about colour of leaves discussed in section 5.5.1). Furthermore, as we observed, questioning occurred because complex interactions between students and between students and stuff. So the act of questioning was collaborative not individual.

It may not have been important that the questions were resolved or not. It was less important that the students found out whether the tree had flowers or not than that they raised the questions and engaged in the process of observing and investigating, recognising conflicts, and realising that the questions are difficult to answer and that each question raises more questions. The act of raising questions is itself the most important thing the students were doing.

6.2.2 How questioning got initiated, sustained and progressed: Role of conflicts and disagreements

According to Meyer (1982), to question something is to evoke alternatives. A question only arises when there are multiple views or opinions. Showing disagreement or conflict with some opinion is to evoke an alternate opinion.

In our observations of student-students talk in the informal contexts as well as classroom contexts, we found disagreements between student and student, between student and teacher, between students and physical stuff and between student and himself/herself. These disagreements gave rise to questioning. Also it was not just that disagreement or conflicts led to questioning, questioning in turn also led to conflicts, disagreements or formation of alternate opinions and that's how the discourse and questioning sustained (Singh & Haydock, 2018). Since both of these processes may occur simultaneously and interdependently, questioning is a dialectical process.

For example, in the parachute making activity (**Episode 6.13**), Jaskaran shows his disagreement with what Gurpreet was doing by saying that the shape will not be round. So Gurpreet does not simply say that it will be round or disregard his opinion but rather gives an explanation that we can make it round by folding it. So Jaskaran's question actually made Gurpreet think about the design, which he otherwise himself might not have realised.

Episode 6.13

- 02:32-2 Jaskaran: -- ਗੋਲ ਨੀ ਬਣੇ -- ਤਾਂ ? (-- **if these won't be circular -- then?**) [raising question that it would not be in circular shape]
02:33-5 Gurpreet: ਉਹ ਮੋਅਤ ਕੇ ਬਣ ਜਾਣਾ (Will become circular by folding)

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Furthermore, students not only showed conflicts and disagreements with others but also with themselves. Here is one example from variegated tree observations (**Figure 6.5**). This 10 second episode presented through snapshots, shows the verbal and facial expressions of Tanya. It shows how a conflict arose from other students' observation and how it leads Tanya to question her own belief about the presence of thorns on the tree and then her observation of the tree, leading to a change in her earlier belief. Here Tanya demonstrated genuine critical thinking by doubting what she heard her friends say because it was contradictory to her own observations. This led her to investigate by looking more thoroughly for thorns, finding them, and then changing her belief. If the circumstances had been less conducive to the expression of scientific temper, she might have just believed what her best friends were saying without looking. In this and other examples, the students demonstrated good observation skills and authentic discovery.

Figure 6.5 Tanya questioning others' as well as her own belief and changing her belief through her observations



These and many other episodes present examples of different types and combinations of confusions, oppositions and negotiations among students. But in all these episodes we see questioning as a crucial aspect of the discourse. According to Meyer (2010), questioning is what drives discourse and communication. Furthermore, questioning was sustained because of conflicts and disagreements, not just between each other but also with one's own beliefs. This aspect of questioning, to challenge others as well as one's own beliefs, we believe is central to doing science and this is what we expect of the discourse in science classrooms to include.

Though there were expressions of power between students and between students and teachers with differing amount of authority, but at times, we see students challenging this authority. In our observations, students generally did not believe what they were told but instead called

attention to counter-examples and showed disagreements with their peers and their teachers. One of the reasons for such disagreements could be students' emotional attachment and ownership to the questions and the discourse.

6.2.3 Evolution of one question into another

In our observations we noticed questions getting evolved or shifted into other questions due to various reasons apart from the non resolution of questioning or problematisation of answering.

For example, in the **episode 6.12** described in the previous section, there appear to be two main questions under consideration by the girls. One of the questions is whether the tree has flowers or whether this kind of tree is a flowering tree. The other question, which Trupti was asking about is, whether the buds are flower buds. In their discourse, girls seem to be shifting between these two questions. The question which arose in Trupti's mind initially seems to be about the buds she saw and was whether those buds are flower buds. However when she poses this question to Priya it gets evolved into a different question. This maybe because when she poses her question to Priya, who was standing slightly away from the tree, she did not mention the buds which perplexed her and asks whether the tree has flowers. So rather than being a specific question about the buds it becomes a more abstract and philosophical question followed by a discussion whether all trees have flowers or not. However when Trupti pulls Ishita and others to see those buds, the question evolves into the question of buds being flowers. At this, the question becomes very specific and arguments occur as students physically handle and observe particular buds.

Furthermore we noticed a shift in questions from being quantitative in nature to being qualitative in nature. For example, in the variegated tree observations, students were having questions about different kinds of colours of leaves on the tree. These questions about whether leaves were one colour or another colour gradually evolved, and probably later led Nimish (when he was asked to ask questions) to state the question (at 44:25): 'ये झाडावर जास्तीत जस्त किती रंगाची पाने अस्तात ?' (**How many different colours of leaves can grow?**). Perhaps this is what then led Binod to state the rather different question (at 45:12): 'हे झाड जेव्हा वाढतं तेव्हा रंग का बदलत ?' (**Why does this tree change its colour as it grows?**). The initial questions were quantitatively similar to each other: they differed only with regard to

the value and number of colours (Is it golden? Is it brown?). But, although it is related to leaf colour, the question about why these colours change over time is a qualitatively different sort of question. This could be an example of a dialectic change: how the gradual, quantitative evolution of questions leads to a new question which is qualitatively different.

It may be difficult to say that a question occurs at a particular moment, since it may be formed in the inner-mind before it is expressed in any way, and also it may evolve over a period of time (e.g. the question “What colours of leaves are there?”, as we mentioned above). Explicit questions may exist implicitly before they are made explicit.

6.2.3.1 Evolution of implicit questions to explicit questions

In Section 5.5.1, we gave an example of how an implicit question about the colour of the leaves evolved into the explicit question. Here we discuss the dynamics of this process.

Implicit questioning is an example of ‘unconscious collective consciousness [which emerges] from the embodiment of experiences in an inherently social and material world’ (Roth, 2007b) i.e. it emerged from the group physically interacting with the same material.

Implicit questions can be included in what Vygotsky (1966) called unvoiced, internal speech, which he distinguished from two types of audible speech: private and external, depending on whether it is directed primarily to oneself or to others. Vygotsky also identified a process by which learners hear external speech (perhaps of a teacher) and then personalise it by talking aloud to themselves, and finally internalise it fully by ‘self-verbalising’, talking silently to themselves. This is a dialectical process, in which the personalisation includes implicitly or explicitly confronting conflicts. We propose that in the process of student questioning, this sequence may sometimes be reversed. One example we found of this was in variegated tree observations when Tanya seemed to have a conflict when she heard others saying ‘काटे (thorns)’. The conflict arose because of her disbelief about the presence of thorns on the tree. The implicit question first appears as a conflict expressed nonverbally through fidgeting and an expression of doubt and frustration (see **Figure 6.5**). Immediately, she verbalises it saying काटे ? (Thorns?) with a rising intonation. Here she is asking herself aloud ‘How come thorns be there on this tree?’. However, without asking others, she herself observes the tree and concludes that there are thorns present on the tree.

As Piaget (1923, Ch 1) also pointed out, people, and especially young children, have a tendency to sometimes use an audible 'internal' speech, in which they 'talk to themselves' rather than to communicate with others, even though an audience may be required. We noticed many examples in which students appeared to be asking their questions to themselves. We think this is an important part of the process of making implicit questions explicit - or going further to actualise the dialectical relationship of being implicit/explicit. Perhaps forcing students to be silent or quiet, inhibits this process. In the classrooms that we observed, students' implicit questions did not evolve into personal or explicit questions because students were not allowed to talk to themselves or to each other. Attempting to individualise, internalise, and cerebralise the inherently social and environmentally interdependent process of learning may be self-defeating. Does such individualisation necessarily increase as teachers take on more explicit teaching roles in the classroom - or is there some way that teachers can try to circumvent it?

6.2.4 Nature of physical stuff: its role in the questioning process

The outdoor environments, for example the variegated bhendi tree and the ants, were themselves dialectical. In our framework in the **section 3.6.2**, we have discussed this dialectical nature of reality. The tree was inherently contradictory: in addition to green leaves, it had leaves which were white and of colours other than green, even though green pigment is required for photosynthesis; it had root/thorns; it was a 'flowering tree' without flowers; etc. Even the colours were not what they appeared to be: they depended on the light and the environment, and even on social factors. We claim that this obvious contradictory and dialectical nature of the tree led the students to observe more closely, and observation led them to become more aware of the dialectical nature of the tree. The dialectical nature of the tree was the basis which gave rise to the students' dialectical conflicts which in turn gave rise to interactions, discussions, and questioning.

In the observations of the ants, there was continuous conflict regarding whether ants are eating and whether the items were food or not. Perhaps ants were too small to be observed by the students to see them eating. Since the stuff was considered by the students to be food, it was likely that ants would also consider it to be food. But, if the ants did not eat it, was it food? The ants were moving over the stuff, and if the stuff was food, maybe the ants were eating it. Also students were continuously arguing about the size of the jaggery pieces, since

they could not observe ants very clearly that how ants were eating the jaggery, they could not come to a resolution about the appropriate size of the jaggery. So maybe the food was food only if it was a particular size.

6.3 Summary and discussion

In our observations of student-student talk in the three informal contexts, we observed students taking agency in various aspects of discourse like turn taking, initiating and terminating turns and topics, exploring the stuff, use of language, shaping roles and relations within a group etc. We see these as crucial roles to be performed by the students to participate more meaningfully in a discourse. So the discourse in informal contexts was guided and shaped by the students themselves collaboratively. In comparison classroom discourse, as discussed in chapter 4, was much more different as it was guided mostly by the teacher. Barnes and Todd (1977) argue that for a more meaningful discourse in the classrooms students must be given authority for making important decisions in the talk. Van zee (2000) arguing on the role of the teacher in such kind of discourse suggests for a distributed teacher authority where the teacher acts more as an organiser or context setter.

In the three informal contexts that we report here students worked in small groups, at times forming the groups spontaneously and having discussions with very little teacher guidance. Working with each other in pairs and small groups probably helps students form questions, because conflicts between different students' statements and observations are apt to arise since students have different perspectives and experiences. A student exploring more individually may be more apt to think a question is resolved before it is even explicitly stated. Without confusion or without realising there is a conflict, an authentic question will not arise.

We see conflicts and disagreements with others as well as oneself as one of the important reasons for questioning to occur. This aspect of questioning, to challenge others as well as one's own beliefs, we believe is central to doing science and this is what we expect the discourse in science classrooms to include.

Also the question-answer process in the informal contexts we studied was very dynamic, which progressed in a complex fashion involving sequences of questions and replies. Questioning and discourse progressed on account of problematological nature of replies and problematisation of previous questions and answers/replies. This problematisation happened

as a result of conflicts arising due to varied students' experiences and their dynamic and complex interactions among each other and with the physical stuff. Also the process of student questioning was not isolated from their observing, arguing, investigating and answering. We discuss these interrelationships in more detail in the next chapter.

We also noticed that student argumentation was closely tied with their questioning. Questioning arose because of difference in opinions and conflicts. So the very reason that argumentation could emerge and sustain was questioning. Furthermore questioning was used by students to present different kinds of arguments like claim, justification, counterclaim, disagreement etc. However, in studies of student-student argumentation, the role of questioning has been completely ignored by researchers. Also students argumentation in the groups was more at a social level than personal level where arguments got constructed spontaneously in a collaborative manner. Also student argumentation was not just driven because of some rational choices but also due to complex interplay of power relations, gender relations, emotions etc. within a group.

Since we see science as a process, and we are interested in helping students to practice this process throughout their lives, we are also interested in questioning as a part of this process, rather than seeing questions as static ideas or ends in themselves.

Our study provides evidence of the temporal nature of questions. We found that it is not easy to identify a moment in time when a question exists in a student's mind, or amongst a group of students. Implicit questions may gradually or suddenly become explicit, and may evolve over time, depending on the interactions between the students, and the interactions between the students and the real-world context - the stuff they are handling. Questions may appear and disappear - and even suddenly become replaced by transformed questions.

7

Understanding the Role of Student Questioning Process in Doing Science

In an effort to understand the role of student questioning in doing science, we have looked at the interrelationship between questioning and various different aspects of doing science like observing, arguing, investigating, etc. in this chapter. In our analysis we found that all these different aspects are interdependent in complex ways. We describe these complexities and dynamics between different aspects in this chapter. We do so by addressing the following research questions (as listed in section 3.7 of our research question).

- a. How is student questioning related to student investigations of physical stuff?
- b. What is the interconnection between questioning and other aspects of scientific inquiry?
- c. How questioning and answering are related to the process of science?

As described in Chapter 2 (**Section 2.4.2**) and Chapter 3 (**section 3.6.2**), we see science more as a process than a body of knowledge, a process consisting of various elements or aspects of the ‘science-toolbox’, occurring in various orders and combinations. Furthermore, we also described how we see science as a questioning process, a process of dialectical interaction of questions and answers. The role of student questioning in doing science that we would describe in this chapter can only be understood by understanding the nature of science that we have described in much detail in these sections.

Furthermore, in order to understand the role of student questioning in doing science we have to understand the nature and dynamics of the students’ questioning process as described in Chapter 6.

This leads us to now discuss the role of questioning process in doing science.

7.1 Students' investigable questions and their investigations

In the three informal context that we report in our study, we observed students asking many investigable questions (**Table 5.2**). These are the questions whose answers were relatively more contentious. These questions required, or could lead to, some kind of investigation on the part of students for answering (see **section 4.3.2.10** for our definition of investigable questions). In our observations, we also noticed students performing investigations on their own to answer many of these questions.

In the parachute making activity we noticed that students asked fewer number of investigable questions as compared to ants observations and variegated tree observations. We noticed more number of investigable questions by students in the variegated tree observations. Though it is very difficult to say why these differences were there, because each activity in its own was very different and cannot be compared with each other. Furthermore due to the dynamic nature of discourse and relations among students and students and the stuff, it may not be very meaningful to compare or contrast the three contexts. However in terms of nature of activities or structure, there were of course some differences. For example parachute making activity was more a design and make kind of activity with a more structured and focused task. In comparison, both variegated tree and ants observation activities were more exploratory activities involving continuous observations of physical stuff. However, even among the two there were differences in terms of structure and prior instructions. Whereas white leaves was most open and least structured as there was initially no prior task or instructions given to students, ants activity had some structure and vaguely defined prior task. This lack of structure could be one of the reason that students asked more number of investigable questions in the variegated tree observations.

7.1.1 Nature of discourse following an investigable question: students' confusions, conflicts and questions

In our observations we found that the sequences of dialogues initiated by students' investigable questions were interesting, in that they were involving different kinds of confusions, conflicts, questions, agreements and disagreements among students. We identify initiation of a sequence of dialogues when any utterance, either a question or non question,

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introduced a new topic of discussion by either cutting the previous topic off or temporarily suspending the previous topic of discussion. For example in the **episode 6.13** when at 15:40 Trupti asked the question, ‘Does the tree have flowers?’, students were previously discussing about the colour of some leaves on the tree. But with Trupti asking the question, students suddenly switch from the topic of colours to the topic of flowers and do a discussion around the topic of flowers for almost one and a half minute. So this one and a half minute of sequences of dialogues around the topic of flowers gets initiated by Trupti’s investigable question. Even in cases when initiation was not with an investigable question but by some other question or statement, the sequences of dialogues following the investigable question were more interesting.

Furthermore, many a times investigable questions did not get resolved completely and this at times led to long argumentative sequences of questions and responses by students. We have discussed one such long argumentative sequence of student discourse initiated by Trupti’s investigable question on flowers. In this episode, students not only tried investigating the question of flowers, but at the same time got involved into observations, comparisons, hypothesis formation, asking questions, doing deductions, doing justifications by giving evidence, etc. And all these different aspects of doing science occurred in a dynamic and complex fashion with student-student and student-stuff interactions being central (or crucial) to the process.

Here we present another example of student-student discourse following some investigable questions to understand the nature of such a discourse in more detail. In this example, from ants observations, a conflict occurs between the girls about whether the ants will get afraid of their actions or movements or sounds near the ants hole and whether this will prevent ants from coming out of the holes and eating jaggery. We have called this conflict as an implicit group question as nobody explicitly stated the question but as a group they wondered about the behaviour of the ants. This episode starts with Disha picking up a small wooden stick at 02:34 from the ground.

Episode 7.01

02:34-0 Disha: [picks up a wooden stick from ground]

02:36-0 Harmanpreet: ਹਾਏ ਚੱਬਾ ! ਇਹ ਨੀ ਟੁੱਟਦਾ (Oh god! it's not breaking) [First she tries to break the piece in the pinch of her two fingers and she then presses the piece against the stem of the tree to break it]

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- 02:37-4 Disha: ਕੱਢਾਂ ਮੈਂ ਬਾਹਰ ? **(Shall I bring them out?)** [Rhetorically, as she is holding the stick in her hand and trying to move it towards ants hole]
- 02:38-0 Harmanpreet (while pushing Disha's hand away with her hand): ਏ ਨਹੀਂ ! (Hey, no!)
- 02:38-9 Kuldeep: ਚੁੱਪ ਕਰ (keep quiet) [asking Disha to not disturb ants]
- 02:39-0 Harmanpreet: .. ਖਾਂਦੀਆਂ ਪਈਆਂ ਨੇ .. (.. they are eating ..)
- 02:40-4 Disha: ਇਹਦੇ ਵਿੱਚ -- -- (Inside this -- --)
- 02:40-4 Kuldeep (pushing Disha's hand away from ants): ਡਰਨਗੀਆਂ ਯਾਰ (will get afraid) [little louder to stress her argument]
- 02:41-1 Disha [even on being opposed by Kuldeep to not scratch sand using stick, Disha puts back her stick near the ant hole]: ਇਹਦੇ ਵਿੱਚ ਵੀ ਆ ਦੇਖ . ਦੇਖ ਮੈਂ ਤੈਨੂੰ ਕੱਢ ਕੇ ਦਿਖਾਉਣੀ ਆਂ (See its here as well . see I will take out them and show you) [she starts scraping sand]
- 02:46-0 Harmanpreet: ਉਹ ਦੇਖ ਇੱਕ ਆਗੀ ਤੂੰ ਸੈਡ ਹੋ .. ਹੱਥ ਕਰ (See one has come you get aside .. your hand)
- 02:47-7 one girl (mybe Harmanpreet): ਏ, ਰੁਕਜਾ(Hey, stop)
- 02:48-2 Disha: ਉਹ ਦੇਖ (see there)
- 02:48-5 Someone standing: ਇੱਕ ਆਗੀ (one has come)
- 02:50-0 One girl: ਨੀਚੇ ਕਿਉਂ ਸਿੱਟਦੀ ਆਂ .. (why are dropping it on the ground ..)
- 02:52-0 Kuldeep: ਤੂੰ ਹੱਥ ਨਾ ਲਾ (You don't touch) [moving Disha's hand away]
- 02:53-0 Kuldeep: ਡਰ ਜਾਣਗੀਆਂ (Will get afraid)
- 02:53-5 Disha: ਖਾਉਗਾ ਉਹ (It will eat)
- 02:54-3 Kuldeep: ਡਰ ਜਾਣਗੀਆਂ ਉਹ (They will get afraid)
- 02:55-4 One of standing girls: ਓਹਨੂੰ ਭੋਜਨ ਖਵਾਣਾ ਕੇ ਮਾਰਨਾ .. ਦੱਸੀਂ ਜਰਾ (Want to feed them or kill them .. tell me)
- 02:57-4 Disha: ਉਹ ਵਿਚਾਰਾ ਖਾਉਗਾ ਗੁੜ (This helpless will eat)
- 02:59-1 Kuldeep (not in agreement with Disha's way): ਉਹ ਆਪੇ ਆਜ਼ਗੀ, ਆਪੇ ਆਜ਼ਗੀ (It will come itself, will come itself)

Actually before this there was argument among girls whether more jaggery should be needed to feed the ants or not. This conflict was partly because some girls thought that the jaggery pieces which were put, were of large sizes and ants could not eat those pieces. Though some girls tried breaking jaggery but it was not easy to break into very small pieces. For example, at one point Harmanpreet tried breaking the jaggery by pressing a small piece of it against the stem of the tree but was unable to break it and she says 'Oh god - it's not breaking!'.

Though some girls argued for bringing more jaggery, Disha and Harmanpreet thought that there was enough jaggery that has been put and ants will come and eat that jaggery. However, Disha seems to have some doubt that ants will come out on their own. So she may be

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wondering that it's not more of jaggery but something else that could make ants come out. Or maybe that since she has said ants will come out she thought that she should make sure that they come out. With these questions and confusions in her mind she may have made a plan to push the ants out, and since there happened to be a stick very close to her hand that was close to the ant hole, she immediately picked it up and moves it towards the ant hole, almost at the same time that she was making the plan - if it can even be called a plan. She voiced her 'plan' only after she had picked up the stick. However it is not very clear what her initial plan was. It seems that she wanted to put the stick inside the ants hole and maybe take a bunch of ants out since after picking up the stick she bends and looks inside the ants hole. However, as soon as she tries to move the stick towards ant hole by announcing her plan, she is prevented from doing so by Kuldeep and Harmanpreet, who push her hand back. At this Harmanpreet says they are eating. Maybe Harmanpreet meant to Disha that ants are already eating and you might disturb them. However Disha again brings back the stick and this time with a changed plan saying, 'see it's here as well .. see I will take out them and show you'. And she starts scratching the sand near the ants hole to see if there are ants beneath the sand. It is interesting that at this, Kuldeep and Harmanpreet change their minds and do allow Disha to scratch the sand near the ant hole (maybe because it was not exactly inside the hole). Perhaps they got interested in Disha's small investigation and wondered whether there are ants under the sand. But Disha was not able to bring any ants out from beneath the sand. However suddenly Harmanpreet sees an ant moving over the tree trunk and tells Disha to move her hand away. After this Disha using the stick tries to move this ant onto the sand where jaggery was poured saying that the ant will eat jaggery over there. However Kuldeep and Harmanpreet object to Disha and tell her the ant will itself go near the jaggery and eat it. It is interesting that Disha thought the ants are not able to identify jaggery on their own and they need to be moved near to the jaggery. Whereas the other two girls thought that ants will themselves find out jaggery and eat.

It is interesting to note that girls showed varied emotions towards ants as they observed and investigated ants. While some, like Disha, did not mind touching and physically handling the ants, though they might not have intended to 'hurt' the ants, others thought that such actions could hurt or even kill ants and showed 'empathy' towards ants by not letting others touch the ants.

In the above episode we see a number of confusions and questions among the girls: Whether ants will get scared by their actions?, Whether their actions would kill the ants?, Whether ants can be taken out using the stick?, Whether there are ants beneath the sand?, Whether ants will find jaggery on their own or they need to be fed the jaggery pieces (like children need to be fed)?

Actually throughout the ants observations girls had conflicts regarding whether ants will get scared of their sounds, or whether ants will get scared of their movements and actions. On the next day, when students were asked to write their questions about the ants observations, a number of them wrote questions about whether ants can hear or talk, and whether ants can see or not. It is interesting that after hearing their questions about whether ants can hear or not, we tried investigating more about these questions by looking into resources on the internet and found that there is still a lot of research happening around these questions.

In our classroom observations we noticed that there were hardly any investigable questions asked by the students as part of main classroom discourse. Furthermore, there were no investigations. Though there were instances of argumentative discourse in classroom but those were very few and always occurred between the teacher and one student with teacher asking most of the questions. Furthermore the classroom sequences of argumentative discourse were relatively short.

7.1.2 Understanding student investigations: An illicit experiment

Many a times students investigable questions involved some sort of investigations by the students. A number of times, these investigations were very spontaneous and immediately followed the questions or occurred alongside the question. However, in one of the instances we noticed a very interesting investigation carried out by a student who first carefully planned it with the help of his friend and then carried it out.

The episode is a part of the variegated tree observations by the students. This episode involves an 'illicit' investigation by a boy called Suraj to answer his explicit question, which he asked out loud at 02:26. We call this investigation illicit because this is what Suraj thought about it. At 02:26, Suraj standing along with another boy Keshav went closer to the tree and touched a leaf which was mostly white with a little green and said, 'रंग तर गेला नाही ना? **(Hasn't the colour gone?)**.'

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Upon seeing Suraj touching the leaf of the tree, another boy Nimish, standing slightly away from the tree said, 'हात नाही लावायच रे, कळत नाही काय? (Don't you know that you should not be touching it?).' With Nimish telling Suraj to not touch the leaves, Suraj moves back. Thereafter, Suraj did not do or say anything about his question until 06:26, when he tried to investigate the same question about the fading away of the colour of the leaves. The complete episode of Suraj' investigation is presented below:

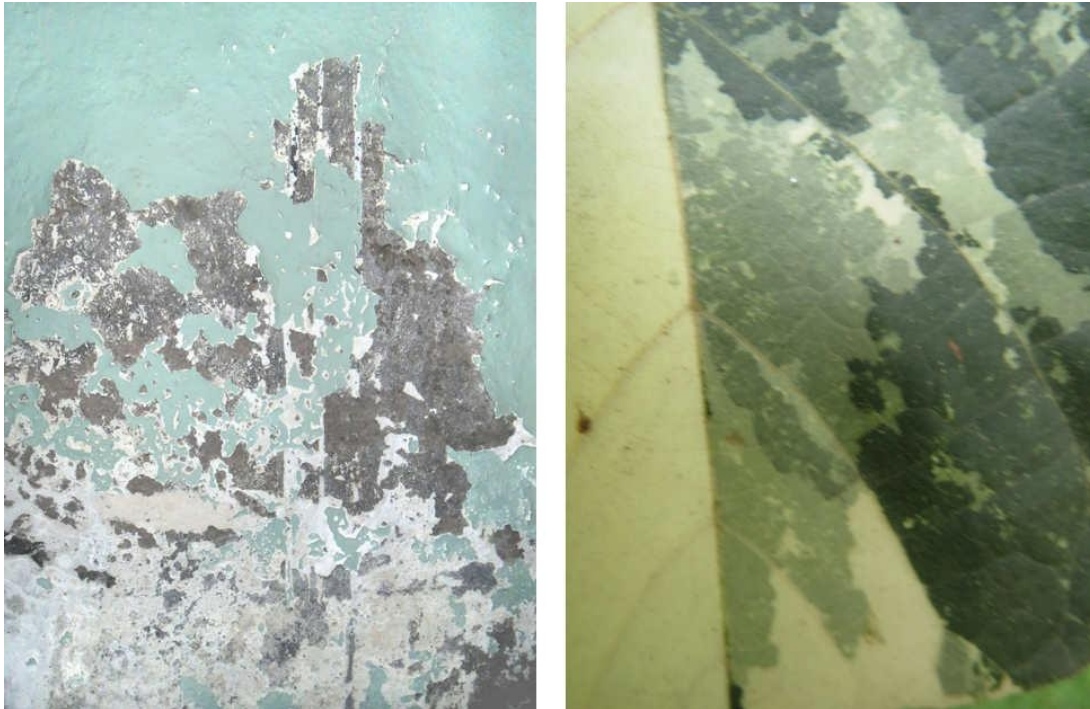
Episode 7.02

- 06:26 Suraj stands with his arm around Keshav, within 2 metres of the bhendi tree, both looking intently at its leaves.
- 06:28 With one hand holding the video camera which is focussed on the boys, one of the teachers (Karen) looks closely at the bhendi leaves, without touching them, and puts her finger to her cheek with an admittedly overacted, puzzled look (in order to encourage the students to look at the bhendi tree - but without actually asking them to look).
- 06:29 Suraj knocks Keshav's head to turn it away from the tree, towards Karen.
- 06:30 Suraj points towards Karen.
- 06:41 Suraj makes fun of Karen, mimicking her gestures in a humorous way, (but without paying much attention to the bhendi tree), and they both laugh.
- ...
- 07:35 Suraj keeps looking at the bhendi leaves.
- 07:42 Suraj: अरे पुढे बघ (Look in front) [to Keshav, as Suraj reaches out and scratches the green part of a bhendi leaf which has both green and white areas.
- 07:44 Keshav: [leaning out from behind Suraj, seeing Karen filming them] थांब ! (Stop!) [softly, to Suraj]
- 07:45 Suraj quickly withdraws his hands from the leaf and then turns to the camera.
- 07:46 Suraj stares at the camera, while Keshav turns his head down and away.
- 07:47 Keshav: क्या है ? **(What is it?)**
- 07:48 Suraj (as he again touches a leaf): सफेद, हरा (white, green) [Keshav nods his head in agreement]
- 07:51 Keshav: [looking at and touching the leaves] Three colours.
- 07:53 Suraj: Three नाही four colours (not three four colours)

This episode is an interesting example of a student investigating his own question without being guided or told by the teacher to do so. Furthermore, this episode provides us a window to the students' ideas of what it means for them to learn or do science. For Suraj the entire investigation seemed illegitimate, which was not being allowed by the teachers, although we (the teachers) never intended this and rather wanted the students to ask and investigate on

their own. Perhaps Nimish's objection to Suraj touching the leaves could have inhibited Suraj in carrying out his investigation. But we wonder what prompted Nimish to object to Suraj touching the leaves. This objection occurred in the first few minutes of students reaching the garden. In the later part of the session, students were observed to be less shy in touching and handling the tree and its parts.

Figure 7.1 Paint is chipping off a wall compared to a leaf of variegated tree



It could be that the variegated leaves might have reminded Suraj of the way a wall looks when its paint starts chipping off (**Figure 7.1**), and by analogy he hypothesized that the green colour was chipping off the leaves. He wanted to test this hypothesis by performing an investigation: scratching the leaf with nail to see if the green colour comes off easily. However, he had been warned by Nimish, and he was afraid that he might get in trouble if he touched or disfigured them. He did not think that his question or investigation was valid or was considered to be science in the eyes of teachers.

Suraj did not give up on his original question and planned to do an investigation. At 07:42, more than 5 minutes after he first posed the question, when Nimish was some distance away, he joined his friend, Keshav, and asked him to watch the teacher (Karen) and tell him if she looks at him while he scratches a leaf. Maybe Keshav knew Suraj' plan and was a partner in the investigation to help Suraj. As Keshav keeps an eye on teacher, Suraj goes closer to a leaf

and scratches it (**Figure 7.2A**). As Karen turns around, Keshav softly tells Suraj to stop. At this Suraj pulls his hand behind (**Figure 7.2B**). After this, they each pretended in their own way that they were not doing anything wrong: Keshav looked down and away, and Suraj definitely looked straight at Karen, with an expression of contrived innocence (**Figure 7.2C**). After all this, Suraj and Keshav tried to behave themselves by returning to what they thought (or what they thought the teacher would think) was a more innocent activity—of just naming and counting the colours of the leaves—which is actually a less adventurous science investigation of the implicit question, ‘What are all the colours of the leaves?’ Interestingly, they also switched from Marathi to Hindi and English, as they conformed to the supposed requirements of ‘school-school’. This reminds us of an episode Shirley Brice Heath (1982) reported of a young boy internalizing his teacher’s inauthentic questions by asking, e.g. ‘What colour dat truck? What colour dat car?’ on the way home from his first days at nursery school, rather than the authentic questions such as, ‘How da firemen know where dey going?’ which he asked during his pre-school-going days.

Figure 7.2: A) Suraj scratching the leaf while Keshav keeps an eye on Karen from behind Suraj, B) Suraj on being warned pulls his hand backward, C) Suraj and Keshav pretending with an expression of innocence



In this episode we see how the observation of dubious physical reality, made Suraj confused and curious, led him to ask an investigable question and then take a ‘risk’ to investigate and answer his question. It explains an interesting aspect of asking questions and being curious, which is taking of ‘risks’. Here in order for Suraj to investigate his question he had to take the ‘risk’ of being ‘caught’ by the teacher, though teachers never intended so. Asking questions and being curious sometimes could be a risky affair especially when questioning involves challenging the status quo or those who are in control or in power. So the way Suraj pursues his question so fervently makes us wonder why students in classrooms become so passive, why they are not so curious.

In informal contexts we observed students asking many investigable questions and performing investigations. However, Christine Chin (2002) in her study of student questions and investigations, reported that most of the questions students asked are not amenable to their own hands-on practical investigation. Similar to our study, Chin studied 'novice' middle-school students who had not been previously requested to pose questions for investigation in school. She reported that when individual students were asked to pose questions, some students were not able to formulate any investigable questions - or sometimes any questions at all - until the teacher gave examples of such questions and let the students work in groups. Maybe this points to the problems which arise when students are guided to follow steps in which asking questions is separated from investigation. In our study, unguided students worked in a more integrated style in which question asking was not separated from investigation. Perhaps as teachers, questioning especially investigable questioning can be encouraged among students by figuring out ways of student explorations of some physical stuff in which students are not given much of instructions and guidance. So students' explorations which are not just open-ended but also open-beginninged with minimal teacher guidance could encourage student questioning and investigation.

7.2 Interconnection between questioning and other aspects of scientific inquiry

In our study of student questioning we observed questioning was not separate from other aspects like observing, hypothesising, arguing, comparing, analysing, investigating etc. Each of these had a dynamic and dialectical relation. Although, all of these cannot be understood in isolation, here we will focus on a few of the aspects to understand their interconnections with each other and with questioning.

7.2.1 Student questioning and student observations

Here is an example of an investigable question asked by a student during variegated tree observations that led students to observe and investigate the tree to answer that question. This question was about the thorns on the variegated tree. Only much after the workshop did we realise that this is a very interesting question, because we discovered that the variegated *Talipariti tiliaceum* is unusual (and different from the unvariegated variety) in that it has

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small aerial roots which appear in the monsoon (June-September), some of which turn into thorns afterwards (**Figure 7.3**). So we ourselves wondered whether it is a root or a thorn? Can one thing be both a root and a thorn? When does it stop being a root and finish becoming a thorn? This is an example of an overlapping category: a root and/or thorn. This sort of classification is often ignored by school textbooks and teachers (Haydock & Patil, 2014).

Figure 7.3 Root thorns on variegated tree



The question in the workshop was initially stated at 14:14 by Trupti while whispering to Janvi that there are thorns on the tree. We call this an implicit question, but it became explicit gradually, with all five girls participating in the discussions as they investigated the tree:

Episode 7.03

- 14:14 Trupti: [indistinct] ह्याला **side** ला काटे आहेत (**thorns are here on sides**)
- 14:19 Karen: **hmm?**
- 14:20 Janvi: याला काटे पण आहेत वाटत छोटे छोटे. (**I think it also has tiny thorns.**)
- 14:21 Karen: **हान? क्या बोला? (yes? What did you say?)**
- 14:21 Tanya: काटे. (Thorns.)
- 14:22 Trupti: Colours.
- 14:23 Tanya: कुठे दिसतायत ग काटे? (**Where do you see thorns?**)
- 14:24 girl: ..छोटे छोटे ... (little tiny) [indistinct]
- 14:25 Karen: **हाँ? (yes?)**
- 14:27 a few girls: काटे आहेत ... काटे (There are thorns.)
- 14:27 Tanya: काट्यांना काय बोलतात ग ? (**How do say kate (in hindi)?**)
- 14:29 Priya: काटे ? . माहित नाही मला (**Kaate ? . I don't know.**)
- 14:29 Ishita: कांटे नाही कटते ये दिन ये रात ... [Ishita is smiling and singing a Hindi song, and she suddenly stops and looks worried when she sees the camera focused on her]
- 14:31 Tanya: [with a look of disgust] काटे ? (**Thorns?**)

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- 14:34 Tanya: [after turning her head slightly towards another part of the tree - but without moving closer or touching] आहेत! आहेत ! काटे. (There are! There are! Thorns.)
- 14:36 Trupti: एवढे नाहीत (Not many.)
- 14:37 girl: पण आहेत ना थोडे (They are leaves not thorns.)
- 14:38 Ishita: आहेत. आहेत. काटे आहे. (There are. There are. There are thorns.)
- 14:40 girl: काटे आहेत.
- 14:41 Janvi: एवढे नाही लागत आहेत काटे (Don't feel those thorns much)
- 14:43 Trupti: नाही ग एवढे नाहीत काटे . (No,there are not that many thorns.)
- 14.46 Priya: अरे त्या तिथे बघा, त्या तिथे बघा, कसे डाग आहेत, काट्यासारखे काटे आहेत. (Arey see there, see there, how are those black marks, they are thorns like thorns...[maybe she meant like bigger thorns])
- 14.51 Janvi: आहेत , आहेत.

Here we see that Janvi and Trupti, working together as a pair and observing the tree closely, made a statement, which became tentative. In this context we can consider it to be a hypothesis. Others agreed or disagreed and tried to find thorns. Janvi and Trupti then doubted whether there really were thorns, as shown by the way they felt the branch. If they had been sure that there were thorns, knowing that thorns may be very sharp, they may not have touched the branch as they did. Investigating whether the protrusions were sharp and hard was a way to verify that they were thorns. Since they actually were not too hard or sharp, the question was not so easy to answer. On the other hand, Tanya also wondered about the thorns on the tree after hearing this question, but did not go closer and touch the tree. She may have been afraid to touch and quicker to agree. However, she also demonstrated genuine critical thinking by doubting what she heard her friends say, leading her to use visual observation to find out whether the tree had thorns. So here Tanya questions her own belief about the presence of thorns on the tree and then goes on to the observation of the tree leading to a change in her earlier belief. The small episode of 10 seconds, presented through snapshots of Tanya (**Figure 6.5**), shows how questioning arose, progressed and 'resolved' through the observations of physical reality.

With Tanya and other agreeing that there are thorns on the tree, one might think that this would serve as an apocritical response, so bringing the question of thorns to an end. However with Janvi and Trupti still not sure about the presence of 'thorns' as can be seen from the continuation of the conversation, the presence of the thorns remained problematological. The question which was implicit initially was explicitly formed towards the end. Probably not all

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the girls agreed that it was a question - some were fairly certain that there were thorns, despite the uncertainty of others. We present this episode as an example of how seeing, touching, observing, hypothesizing, communicating, and questioning evolve simultaneously in an interconnected manner in a small group. This emphasizes our contention that science is a process, not a static thing. The conclusion in this case is still in substantial doubt, even if some students seem convinced one way or the other. It leads us to consider another teaching objective: for students to be ready to consider compelling evidence which contradicts even a strongly held belief in order to resolve contradictions. In other words, we hope that students are learning that in doing science, they must keep observing and referring to the stuff.

Although the students did not investigate the thorny question further in our workshop, just the act of raising the question we think shows that they engaged in doing worthwhile science. They also demonstrated good observation skills and authentic discovery. In fact, they were more observant than we were, since we had never even noticed the thorns before. Perhaps our previous 'background knowledge' had constrained us to be concerned mainly with the leaves.

Not only did this investigable question led students to observe the tree at that moment, but later on it also made us curious and we kept observing the tree throughout the year and even afterwards to look for the presence of root thorns: when do they first appear, how their form changes over time, do these thorns remain on the tree throughout the year, etc. So student questioning here led us to observe the tree which further raised many more questions to us and reasons for further observations of the tree. However, it may not be easy to identify the two separately in time, since there is a tight interplay of observations and questions. Actually we see both observing and questioning being very fundamental to doing of science, with both causing each other, interdependently. So we can say that as students (and us as well) did observations they challenged/changed/modified their beliefs, which is the very act of questioning.

7.2.2 Role of language in student-student talk in doing science

One of the important means by which we learn anything is through the use of language by communicating and interacting with ourselves, with others and the physical world. In this sense science is also no different, we learn to do science through the use of language. Science is a social activity grounded in the actions, experiences and interactions of human beings as

part of a community who share certain values and beliefs. So science is a collaborative and collective act which cannot be reduced to individuals (Roth, 2007a). Central to this collaborative act is the use of language. But in classrooms science is generally not build upon everyday experiences and one's experiences of use of language. In schools, science is deemed to be difficult, requiring some special skills for mastery. It is given a special and authoritative status, much higher than the everyday knowledge. However Lemke (1990, p. 138) has argued that,

There is nothing "special" about the truth of science. It is just one specialized offshoot of common sense. It can be mastered by any normal human being. The experiences of everyday life are a rich intellectual resource that is highly relevant to the study of science. Nor is science intrinsically more difficult than any other subject. It cannot be. Every subject consists of certain conventionalized ways of talking, reasoning, and acting. All equally are learned by participation in a community that practices them....

Lemke says that difficulties of learning science are no different than the difficulties of learning a new language.

In our observations of students in the informal contexts we observed students engaging in various aspects of doing science like questioning, observing, arguing, hypothesising, investigating etc. without being told or guided to do so. All these different aspects of doing science occurred in a dynamic and complex fashion with student-student discourse being central (or crucial) for the process. While describing the role of talk in doing science Lemke (Lemke, 1990) argues that talk is central to various aspects of doing science like observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning etc.

However, although science educators have recognised the importance of all these different aspects in doing of science, but how these are connected to the student talk and their use of language has not yet been explored much. Generally in classrooms student talk or discourse gets isolated from other aspects of doing science which involve handling of the stuff, like observing, experimenting, investigating, etc. But in their everyday lives, that's how students know and explore their world, through talking and communicating, using their language at the same time as handling the stuff. The kinds of questions one asks, the kind of discourse

one has around those questions is situated within one's language, one's experiences which are part of one's physical, social and cultural sphere.

As described in **section 6.1.1.3**, we noticed that the student agency in the use of language was one of the important reasons for their engagement in the discourse. Furthermore we also described how students took agency in steering the discourse. Since students had opportunities and agency in talking and communicating, conflicts inevitably led to questioning. So the act of letting students have a discourse in their own language in small groups while handling stuff was crucial for them getting engaged in different aspects of doing science. The different aspects like questioning, observing, arguing, investigating etc. all were interconnected to each other in complex ways, with each giving rise to other due to a dialectical relation between them. And all these in turn were interconnected to the student discourse and students' use of language. But in classrooms we have yet not explored the potential use of language in learning and doing science.

7.2.3 Questioning and argumentation

Argumentation occurs when the conversation flow is disrupted by a disagreement, a question, or an alternative hypothesis. As described in the previous chapter, confusions, conflicts and disagreements led to questioning and argumentation among students and that's how discourse sustained. In **section 6.1.4** of the previous chapter we described the relationship between student questioning and their argumentation to some detail using various episodes of student-student discourse involving student questioning.

Here we will discuss another episode to understand the interdependence of questioning and argumentation and how these were in turn related to other aspects of doing science like observing, interpreting, predicting etc. In this episode from ants observations, girls were putting pieces of jaggery near the ants hole by breaking into smaller pieces. Disha had a big piece in her hand and Kuldeep asks her to hand over the piece and the following discussion happens:

Episode 7.04

02:06-6 Kuldeep: ਇਹ ਲਿਆ ਦੇ ਮਾੜਾ ਜਿਹਾ (Hey, Give me a little bit)

02:07-8 Disha to boys: ਕਰਦੇ ਕੀ ਨੇ ਬਤਮੀਜ਼ ਜੇ ! (See, what these stupid are doing!) [arguing with boys]

- 02:09-7 Kuldeep: ਏ ਥੋੜਾ ਅੰਦਰ ਨੂੰ ਰੱਖੋ (Hey, keep it little inside)
- 02:10-0 Disha: ਲੈ ਫੜ (Take it) [giving a jaggery piece to Kuldeep who puts the piece over the ants hole]
- 02:11-9 One girl: ਏ ਤੂੰ ਸਾਰਾ ਈ ਪਾਤਾ ? **(ee, you have put all of it?)** [rhetorically]
- 02:13-4 Disha (speaking authoritatively): ਡੱਫਰ ! (Dumb!)
- 02:15-2 Disha: ਤੇਰੇ ਦਿਮਾਗ ਚ ਕੀ ਵੜਿਆ ਹੈਗਾ ? **(What's gone inside your brain?)**
- 02:16-8 One of standing girls: ਤੂੰ ਸਾਰਾ ਈ ਪਾਤਾ ? ... ਡਲਾ ? **(You have put all ? ... the big piece?)**
- 02:21-3 One girl: -- ਖਾਂਦੀਆਂ ਨੇ ਉਹ (-- They are eating.)
- 02:22-7 Harmanpreet: ਆਉਣਗੀਆਂ ਉਹ . ਆਉਣਗੀਆਂ (They'll come . will come)
- 02:23-8 Simranpreet (?): ਮੈਂ ਹੋਰ ਲੈ ਆਉਣੀ ਆਂ **(I'll bring more)**
- 02:24-3 Kuldeep: ਬਾਹਰ ਆਉਣਗੀਆਂ ਉਹ (They will come out.)
- 02:25-4 Simranpreet (?): ਏ ਮੈਂ ਹੋਰ ਲੈ ਕੇ ਆਉਣੀ ਆਂ (Hey, I'll go and bring more.)
- 02:26-7 Disha: ਏ ਆਉਣਗੀਆਂ (Hey, will come.)
- 02:27-0 Disha: ਰਹਿਣਦੇ .. ਬਹੁਤ ਆ (Leave it .. It's enough.)
- 02:31-1 Harmanpreet (not sure, maybe one of standing girls): ਬਾਹਰ ਆਉਣਗੀਆਂ (They will come out.)
- 02:32-6 Harmanpreet: ਟੁੱਟਦਾ ਵੀ ਨੀ ਹੈਗਾ (It's not breaking.)
- 02:33-7 Kuldeep: ਤਾਹੀਂ ਤਾਂ ਮੈਂ ਪਾਇਆ ਸੀ ਯਾਰ .. [small pause, then in lower voice] ਸੁਣਦੀਆਂ ਈ ਨੀ (That's why I put it like that .. [small pause, then in lower voice:] You are not listening.)
- 02:36-0 Harmanpreet: ਹਾਏ ਚੱਬਾ ! ਇਹ ਨੀ ਟੁੱਟਦਾ (Oh god! It's not breaking) [First she tries to break the piece in the pinch of her two fingers and then she then presses the piece against the stem of the tree to break it.]

The episode begins at 02:06-6 with Kuldeep asking Disha to give her the piece of jaggery that Disha was holding. Upon getting the piece Kuldeep immediately put it over the ants hole. To this at 02:11-9 one of the girls objects with a rhetorical question. So this girl shows her disagreement to Kuldeep's act of putting the large sized piece close the ant hole. Upon this Disha also argues in favour this girl accusing Kuldeep as being 'dumb'. Actually in comparison to other girls, Disha was always very aggressive and authoritative. Upon being accused by the girls, Kuldeep remains quiet maybe accepting that it was her fault. Her submission was indicated by her expression and gestures (**Figure 7.4**) . She retreats, quickly moving her hand away from the hole and moving back (in submission), and then turns her face down with her hand placed under her chin and shrinks her body.

Actually from the very beginning when the girls had put jaggery there was conflict among the

Figure 7.4 Kuldeep, on being scolded by other girls, with an expression of submission



girls regarding the size of jaggery pieces with some girls arguing for putting very small fine pieces of jaggery. However it was not easy to break the jaggery into very fine pieces, since the weather was cold and dry.

After accusing Kuldeep of putting large sized piece, Disha picks up the large piece and removes it from near the ant hole. Just after this at 02:21-3, one of girls observes some ants eating, maybe inside the ants hole, and says they are eating. By providing an evidence that ants are eating she might have shown disagreement to others who thought that ants won't be coming if there are large pieces. Then at 02:22-7, Harmanpreet argues in favour of this girl saying ants will come. So with the physical observation that ants are eating, the argument that ants may not eat large pieces becomes questionable.

At 02:23-8, Simranpreet says that she can bring more of jaggery. Maybe she thought that the girls got angry upon Kuldeep because there was no more jaggery to be fed and more jaggery would be required to bring ants out. She herself may be wondering whether the jaggery already put was enough to bring ants out. So we call this as an implicit question about whether or not more jaggery is required. But Disha and Harmanpreet seem to be thinking otherwise and both of them say that ants will come out [with this much jaggery].

At around 02:32 Harmanpreet picks up the large piece that Disha had removed from the ant hole and tries to break it. But why did she pick up this piece? Though she said ants will come out but she was also not very sure and had a conflict about it. So she might have thought why not break the large piece which nobody else tried breaking up. So though she kind of tells Simranpreet that there is enough jaggery, but at the same time she seems to be wondering that more jaggery needs to be fed and thus she takes up the large piece to break it.

Firstly Harmanpreet tries to break it in a pinch of her fingers and then by pressing it with her thumb against the stem of the tree. However she could not break the piece and says it's not breaking up. Kuldeep who was also observing Harmanpreet, upon hearing Harmanpreet suddenly speaks up after keeping quiet for sometime. She justifies herself at 02:33-7, saying that she had put the large piece of jaggery because it cannot be broken. It's interesting that Kuldeep's realisation that jaggery piece cannot be broken easily comes from Harmanpreet's small investigation. And she uses this evidence to argue that that's why she had put the larger piece.

Here we see that observing and handling the stuff was crucial in questioning and argumentation. But it's not just that observing and handling of stuff led to questioning and argumentation, but also that questioning and argumentation led to observing and handling of the stuff. Students' questioning, their investigations of the stuff and their argumentation was closely tied and played a crucial role in their doing of science. However these interconnections were very complex and not linear. This is unlike the classroom contexts, where most of argumentation or reasoning was based on teacher or textbook's authority. So one of the important aims of science education we see is that, it should provide experiences of questioning and arguing to students through the observations and manipulations of physical reality and physical conditions to inculcate a behaviour of criticality.

However, the role of student questioning in their argumentation has hardly been explored in science education, though we observed that both were crucial in students doing science. If one of the goals of science education is to encourage students to carry on 'scientific' argumentation and to critique and question what they read and hear, we would expect more research on how and why students ask questions and the role of questioning in their argumentation.

7.2.4 The importance of the stuff

In our observations we noticed that stuff or the physical material was very crucial for arguing, justifying, providing evidence, observing, investigating etc. With students having agency in exploring the stuff, they spontaneously observed and manipulated the stuff as they did questioning and argumentation among each other. As described in **section 3.6.2**, reality in itself is dialectical, having inherent conflicts and contradictions. Due to the dialectical nature of material stuff, understanding and studying it involves conflicts and questioning.

To understand how physical stuff was crucial in engaging students in doing science, we describe one example from ants observations by students. In the ants observations, initially students were given only jaggery to feed to the ants. The group of girls that fed the jaggery to the ants thought that not many ants were coming over to the jaggery. At around 10 minutes girls seemed to be slightly bored and were asking Karen whether they can go. Though girls started out being very excited (running rather than walking, talking quickly and loudly) and had many questions in the beginning but by this time it seems that their excitement and as well as questioning had reduced. Maybe it was because they did not see many ants coming out. At this Karen suggests that they should try a little more and spend a little more time there, although the girls did not seem to be interested.

However at 11:33 Karen suggests girls to bring more stuff from Gurinder who had a polythene containing honey, sugar, bread pieces, mustard oil and butter. A few girls excitedly go to Gurinder and bring the stuff at around 12:30. With more stuff in their hands girls seemed to be excited again. They become too busy talking, asking, observing, investigating, etc. With more options of food to feed, girls again got interested in the ants.

Suddenly the girls got very engaged, and there is a lot of confusion and disagreement about which is what, how to pour honey, where to pour honey, which stuff will make more ants come out, making the entire scene very interesting. It's interesting that disagreements, contradictions and questions led to more involvement and engagement among the girls. Within 3-4 minutes of more stuff in their hands, girls asked a number of different kinds of questions. Here at this point their rate questioning seemed to be much higher than at any other time. At this point Kuldeep was less bothered about the audio recorder hanging by her neck (see Figure 7.5 B, Kuldeep is trying to take out honey from white bottle using both of her hands), which earlier, for most of the time, she was carrying in her hand for recording.

Figure 7.5: A) With girls not seeing many ants coming gets bored, B) With more stuff in hand girls get engaged again



As more stuff was there, girls from other groups also suddenly become more active, asking for stuff from this group. Actually the girls of this group took hold of all the stuff and were reluctant in giving away the stuff to the other groups. Initially these girls did not give the stuff but with continued insistence from other students, they do share the stuff.

7.3 Understanding students' ideas of 'what is science'

7.3.1 What students actually did

In our very first workshop with students on variegated tree observations, we had planned to collect students questions and then let students choose a few of those questions for their investigations. We thought that we would first let students plan their investigations in groups and then carry out those investigations. We did not think of the possibility that students would be doing any investigations in the very first session which we was meant for collecting students questions.

Furthermore, we thought that students would probably need teachers' guidance in planning and carrying out investigations to answer their own questions. So there were different sessions in the workshop that we kept for students planning and doing their investigations. We wanted to study the different aspects of the scientific method and thus planned that students would carry out the different aspects separately, as if they were ordered, chronological steps.

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However, when we viewed and analysed the recordings of students' interactions in detail, we realised that students were already doing investigations in session 1, which was meant for collecting students' questions. So we thought that if we are to understand the process of student questioning it may not be very meaningful to isolate the different aspects of inquiry. This we did not realise at the time when it was happening, because too many things were happening, and in a very complex, mixed-up manner, and very quickly.

So for the later on workshops, we realised we need not try to separate the different aspects and wondered whether we really can study those aspects in separation. Perhaps we had never tried reflecting about our own questioning process and did not realise that questioning is tied to different aspects of science in a complicated way and questioning can not be understood in isolation from those aspects.

But we still wonder whether separating these aspects could be useful for organisation purposes - especially in writing reports of what was done and communicating and discussing the research. Writing reports in a standard format could encourage students to make their questions explicit.

On the other hand it may not be helpful for a teacher to ask, 'What is your question?', especially if the asking is separate from the time when conflicts and questions arise as students are discussing, investigating and handling the stuff. But it may be useful for students to ask themselves and each other 'What is the question?' in order to make their questions explicit. This calls for more research.

7.3.2 What students thought about 'what is science'

As discussed in the previous sections of this chapter, we did observe students getting engaged into various aspects of doing science. We have described how student talk and student questioning was very crucial and interconnected to different aspects in a complex way. But did students think that they were doing science? Perhaps its very difficult to understand what students meant by science or doing science. In our observations of the three informal contexts we did not notice students talking about 'science' or using the word 'vigyan' or 'science' in their discussions.

However, at times students did associate their acts with science by using words like 'prayog',

‘experiment’ and ‘nirikshan’. For example in the ants observations at 08:46-7 Harmanpreet asks Disha rhetorically that whether she has come for doing experiment or doing naughty things. By this she meant that they have come to do an experiment and not naughty things. So for Harmanpreet doing experiment was a serious matter and not fooling around. So this gives us a clue as to what she thinks of the nature of experimentation and nature of science. But it’s not clear whether Disha thought that what she was doing was an experiment, or was science.

Episode 7.05

- 08:23-0 Disha: ਮੈਂ ਦਮਾਗ ਵਰਤਿਆ ਮੈਨੂੰ idea ਆਇਆ (I have used my brain, I got an idea)
- 08:26-0 Disha (clicking with her fingers to gesture that she got an idea): ਮੈਨੂੰ idea ਆ ਗਿਆ (I have got an idea)
- 08:27-0 Manpreet (?): ਆਹੋ ਇੱਕ ਕੀੜੀ ਮਿਲੀ ਆ (Yes, there is one ant we got)
- 08:28-7 [Disha picks up an ant and keeps it on the palm of her hand while she then picks up a piece of jaggery. By that time the ant has crawled to the other side of her hand and she places the jaggery near it.]
- 08:39-0 Manpreet or Harmanpreet: ਹਾਏ ਰੱਬਾ ! ਦਿਸ਼ਾ ਕਿ ਕਰੀ ਜਾਨੀ ਆਂ (Hey God! Disha what are you doing?)
- 08:41-0 One girl: ਕਮਲੀ ਜਾ ਕੀ ਕਰੀ ਜਾਂਦੀ ਆ ? **(Mad she is what she is doing?)**
- 08:42-0 Disha: ਗੁੜ ਖਵਾਉਨੀ ਆਂ ਓਹਨੂੰ (Feeding her jaggery)
- 08:45-5 Some girl/s: ਛੇੜ ਨਾ .. ਛੇੜ ਨਾ (Don’t touch .. don’t touch)
- 08:46-0 Kuldeep (to Disha as Disha tries to touch the ants or jaggery pieces): ਦਿਸ਼ਾ ਛੇੜੀ ਨਾ ਜਾ (Disha don’t touch them)
- 08:46-6 Harmanpreet (?): ਦਿਸ਼ਾ ਪ੍ਰਯੋਗ ਕਰਨ ਆਈ ਹੋਈ ਆਂ ਕੇ ਪੰਗੇ ਲੈਣ ਆਈ ਹੋਈ ਆਂ ? **(Disha have you come for doing experiment or doing naughty things?)** [Rhetorically]

Actually Disha was trying to feed an ant by taking the ant and a small piece of jaggery in her hand. At 08:23-0 and again at 08:26-0, Disha announces that she had got an idea [to feed the ants]. But it is not very clear why the other girls did not like her idea and did not consider it as an experiment though Disha seemed to be creative in her idea and trying to do something different to feed the ants. It may be that girls thought they should be feeding the ants, and feeding means bring food to the ants, not bring ants to the food and trying to force them to eat.

This may indicate something about the nature of science: that in doing science there is an inherent conflict between fooling around and having fun and being serious and careful and ‘following the rules’. Actually, doing science may require a certain amount of fooling around

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- it may stimulate innovative questions, creativity and new ideas. But at the same time, there is a feeling that science should be rigorous work.

It is also interesting that Disha seems to think that it is necessary to ‘use her brain’, and the implication is that it is possible to use one’s brain to a lesser or greater extent. But the use of the brain is obviously connected to what she is seeing and doing with her hands. Also, her idea is not a theory or a statement or a conclusion. It is less abstract than that. It is an idea for an experiment that she can do, or maybe a hypothesis. It contains an implicit question: ‘What will the ant do if I take it in my hand and try to feed it?’ Thus, she is problematizing.

She also went ahead and did the experiment. The problematizing led to (or was interconnected with) investigation and experimentation.

There is evidence that at least some of the students also believed that they were experimenting. For example, twenty minutes later in the ants observations, students from other classes had converged around the group and some of them wondered what these girls are doing. One of the boys asked the girls what they were doing. To this one girl answered by saying that the girls are observing ants. Just after this Manpreet replied to the boy saying, ‘They are doing an experiment.’

Episode 7.06

- 27:43-2 Disha: ਚਲੋ ਭੱਜੋ ਇੱਥੋਂ ! (Go away from here!) [To students from other classes]
27:44-5 Kuldeep: ਜੀ ਉਹ ਦੇ ਕਿੰਨੀਆਂ ਸਾਰੀਆਂ ਆ ਰਹੀਆਂ ਨੇ ਹੁਣ (Mam see there many are coming now)
27:45-8 Disha (?): ਹਾ (Haaahhh)
27:47-0 One girl: ਦੇਖ ਲੈਣ ਦੋ, ਓਧਰੋਂ ਦਿਖਦਾ ਨੀ (Let me see, cannot see from that side)
27:49-0 Harmanpreet (?): ਕਿੰਨੀਆਂ ਨੇ ਦੇਖ ! (So many see!)
27:50-8 One boy: ਅਸੀਂ ਚਲੇ ਜਾਵਾਂਗੇ (We will go).
27:51-6 Disha (?): ਜਾਓ .. ਅਸੀਂ ਕੰਮ ਕਰਦੇ ਆਂ (Go .. we are doing work)
27:54-4 Disha (?): ਚਪੇੜ ਖਾਲੋਗੀ (You will get slap)
27:56-0 One boy: ਇਹ ਕੀ ਆ ਇਹ ? (What is this?) [wondering what the girls are doing]
27:57-0 One girl: ਇਹ ਵੀਰੇ ਕੀੜੀਆਂ ਦੇਖਦੇ ਆ (Brother they are seeing ants)
27:57-5 Charanpreet: ਆ ਵਾਲੀ ਬੋਲਦੀ ਆ (She talks too much) [Angrily to some girl]
27:58-3 Manpreet (?): experiment ਕਰਕੇ ਦੇਖਦਾ -- -- ਕੀ ਕਰ -- (Doing experiment -- -- doing --)

It is interesting that students thought of their act of doing ants observations as an experiment and that too when they were outside in an open ground and not inside a science laboratory

and without handling any 'scientific equipment' or laboratory equipment. So maybe students were thinking they were doing science. But to understand students ideas about science in greater detail, more investigation would be required.

7.4 Science as a Question-Answer process of various interconnected aspects

In our observations of the student interactions in three informal contexts we found students questioning, observing, arguing, justifying, providing evidence, hypothesising, predicting, classifying, comparing, investigating etc., with all these aspects occurring in a complex interconnected way. Furthermore, we found that all these aspects of doing science were in turn interdependent upon student-student talk and their use of language. So students' agency in talking and their use of language was crucial to their doing of science. Student-student discourse was sustained because of conflicts between students and students and between students and the physical stuff. As students took agency and brought their varied ideas and experiences, conflicts and questioning were inevitable. Furthermore, in the informal contexts, doing of science was a collaborative and collective act with questioning being central to it.

We found that the observing and handling of the physical stuff was also equally crucial for doing of science. It was not just the presence of the stuff but students' agency in handling and exploring the stuff which was more important. Students' questions as well their replies were shaped by their continuous observations and interactions with the physical stuff. They did not investigate and argue about their questions purely on the basis of abstract reasoning. They were continuously referring back to the stuff for evidence, particularly when a justification for an argument became more controversial or the abstract reasoning did not work. We claim that this is an indication that the students were doing science.

To understand the interconnection between different aspects of doing science there have been some efforts by researchers. For example there are studies in which student observations were found to encourage student questioning (van Zee, Iwasyk, Kurose, Simpson & Wild, 2001), and in which students worked in groups to define their own questions and made plans for investigations based on exploratory activities (Keys, 1998; Roth & Roychoudhury, 1993). Unlike our study, the students in Carolyn Keys study first read and summarised background information, and the teacher and researchers participated in the group work, using an enquiry

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method of asking questions. Compared to our workshops, this approach was more teacher-directed.

In two other studies (Hofstein, Navon, Kipnis & Mamlok-Naaman, 2005; Dori & Herscovitz, 1999), the researchers conducted a teaching intervention and tested the students' questioning capabilities. A test was done by giving students a science reading and asking them to pose questions regarding the reading. The questions were then counted and categorised according to complexity, cognitive level, investigatory nature of questions, etc. Hofstein et al. (2005) found that after students had performed investigations, their questioning capabilities were higher, as compared to students who had not performed investigations. Similarly, Dori & Herscovitz (1999) tested students questioning capabilities before and after students performed investigations, and reported improvement. This is in line with our hypothesis that for students to talk and ask questions, we must provide them opportunities to observe, manipulate and explore physical stuff.

However, the authors of these studies were more interested in students' comprehension of concepts (as reflected in their questioning) than in how the students did science investigations or how the various other aspects of doing science were connected to questioning.

As compared to informal contexts, in classrooms that we observed, students did not observe, investigate, or handle stuff - they only discussed it. So this rather limited the science they could do. Also most of stuff about which classroom discussions occurred was such that it could not have been handled or explored, for example water treatment plant, Nuclear reactor, solar panels, ozone gas etc. Even when discussions were around stuff like solid waste, waste water, a bag filled with some stuff, etc. which could have been available to students or brought into the classroom, discussions were without observing or handling the stuff. We are not arguing that all science in classrooms should involve students manipulating physical stuff, but there should be some experiences of correlating their abstract ideas and concepts with physical and social realities. In effect what happens is that schools end up creating a disconnect between abstract understandings and everyday realities.

Furthermore in classrooms most of the discourse was between the teacher and students as compared to the discourse between students and students in the informal contexts. In classrooms we observed students getting involved in very few aspects of doing science, and that too in a very minimal and constrained manner.

Furthermore, in our classroom observations, we found that most of the times questioning and answering occurred distinctly from each other, which was very different from the questioning and answering that occurred in informal contexts. In the informal contexts questioning and answering occurred simultaneously and interdependently in a dynamic way. So the meaning and purpose of questioning in the two contexts was very different. Also, in classrooms, answering questions was far more important than raising or asking questions. So for students, questions are meant to be answered and not to be challenged. For them, a question is meaningful, only if it can be answered. Though children do ask questions in their everyday life but they may not be very explicitly aware of this questioning behaviour. Rather it seems that for them, the definition and understanding of questioning and its process comes from school, where knowing or remembering answers becomes all too important. As reported by Brice Heath (1982), students quickly learn the rules of classroom questioning to succeed academically. In such a scenario, questions in themselves become irrelevant and the process of asking gets neglected.

Sarangapani (2003, p. 229) talking about this disconnect of school and everyday learning says,

The knowledge acquired in the school did not seem to be integrated into the child's fabric of understanding woven from everyday experiences.....

It seems that, with very few exceptions, children did not correlate school and out-of-school knowledge. Local/everyday experience was separated from textbook knowledge. The two seemed to function as separate contexts for thinking.

Meyer (1980b) sees the importance of questioning in professional science as well as in everyday science. Using Meyer's theory of problematology, we have tried explaining the students' questioning process and its role in doing science. Using the theory we could explain how newer problems or questions emerge from the problematological answers or replies, the answers which are partial in the sense that they refer both to previous problems that they have solved and refer to newer ones that they have given rise to. Such an understanding places focus on the importance of questioning in learning and doing science. Meyer (1980b) argues that in science, more attention has been given to the answers than to the questions. The act of asking, the process of asking, the nature of questions and the relevance of questions (in terms of whose questions and questions for whom) has not been given due regard. Meyer criticises

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such a positivist conception of science, where answers or results are seen as more important than questions and are seen in isolation to the process of questioning. The progress of science can only be understood by conceiving it as an integrated question-answer process.

It is interesting to note that in our observations of students in informal contexts, we not only found students questioning answers but also questioning questions. For example, at 33:49 in variegated tree observations, Suraj said to Nimish: ‘Blue कैसे ढूँढ रहे हो? Blue कधी असतात का झाड़?’ (How you are looking for blue [leaves]? When are plants blue?). This comment is interesting in that it indicates that Suraj has judged that Nimish’s implicit question that there might be blue leaves on the tree, is not a question worthy of investigation, presumably based on his past observations. We think that evaluating the importance and relevance of questions is also an important aspect of doing science.

In classrooms we found that the purpose of questioning and answering was to make resolutions and eliminate conflicts and disagreements. However we think, questioning is not just to resolve conflicts, but also to recognise and to create conflicts. Conflicts lead to further questioning and the need for further observing and investigating. We see questioning as being interdependent with observing and manipulating ‘stuff’ - things/processes in physical reality. Our goal as teachers is not just to increase scientific literacy by “making individuals critical consumers of scientific knowledge” (Millar & Osborne, 1998), but to promote scientific temper by encouraging people to collectively work together to become active questioners and practitioners of science throughout their lives - and thus become more active participants in the process of intentionally creating a better, more just and more equitable world (Freire, 1968).

We want students to question science, as projected in textbooks, we want them to question the practices of science, be critical about scientists and their actions and the impacts of science, and not be passive consumers of knowledge who just take things for granted because of authority of science (Morin, 2018).

We want students to have dialogues about their physical world and how they can understand their world. But when we say physical world we do not just mean the material phenomenon but also the social phenomena, as we do not see the two in separation. Humans are continuously interacting with the physical, and acting upon the physical world, which in turn act upon humans. We want students to have dialogue in which they try to understand physical

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realities in relation to social realities and how the two realities are intertwined and not separate. That's how we interpret science and science education.

8

Outcomes, Implications and Future Directions for Research

In this study we have looked at the nature and dynamics of student talk and student questioning in the classroom contexts as well as in the informal contexts to understand the process of their questioning in these contexts. We have also looked at teacher questioning to better understand the nature of classroom talk and classroom questioning. Furthermore, we have analysed the role of student questioning in their doing of science and how their questioning was related to various other aspects of doing science.

As described in chapter 2, there are many studies that look into student questioning, but very few of those actually look into the process of student questioning. Furthermore, there are even fewer studies that describe the process of student questioning in the informal (or everyday) contexts. As observed in our study, there are many important aspects of students' talk and student questioning in the informal contexts that could have significance for the classroom contexts. Also in our study we have analysed how student questioning is interconnected to different aspects of scientific inquiry, hardly been explored by previous studies on student questioning

Here in this chapter we will discuss the outcomes of our study and their implications in making classrooms more conducive for student talk and student questioning. We will describe how our understanding of the process of student questioning could have relevance for the teaching and learning of science. Also, we will discuss the implications for future research regarding student questioning, as well as our own research plans for the future.

8.1 Understanding the nature and dynamics of classroom talk and talk in informal contexts

In our observations we found students talking and asking much more in the informal contexts than in the classroom contexts. As we have described, the talk in the informal contexts was

mostly between students and students whereas the talk in the classroom contexts was mostly between the teacher and the students. We also described how student talk in the informal contexts was crucial for the process of questioning and investigating - and in doing science.

Though in classrooms the number of teacher utterances were not very different from the total number of utterances of all the students together in the classroom, but the teacher spoke at much greater length than the students. Student utterances were generally much shorter than teacher utterances. Therefore, for most the time it was the teacher who was talking. And the amount of talk of any one individual student was much less than the talk of the teacher.

Furthermore, the nature and the dynamics of teacher-student and student-student talk in the two contexts was also very different. Only by understanding these dynamics, we could understand the lack of student talk and student questioning in the classroom contexts.

8.1.1 Authentic dialogical informal talk versus inauthentic monological classroom talk

In our observations of student interactions in informal contexts, student talk was mostly situated around some genuine problems or questions occurring naturally and spontaneously. In such contexts student talk was more meaningful with students engaging with each other in questioning, answering and different kinds of arguments initiated by their own questions. However in classrooms, the talk was mostly between the teacher and one student at a time and initiated and directed by the teacher's questions. Furthermore classroom discourse did not involve any instances of observing, manipulating or investigating stuff and there were very few instances of student argumentation. In the informal contexts student-student talk ensued and progressed on account of student questioning and student argumentation and students observing, manipulating and investigating the physical stuff. Furthermore, as students brought in their varied experiences and meanings, talk in these contexts was more dialectical in the sense that it emerged from opposing or conflicting opinions among students, or conflicts between students' beliefs and their observations.

We found that in classroom contexts students' engagement was much less as compared to informal contexts. In the classrooms more of the students seemed to be passive listeners and were hardly involved in the discourse, whereas in the informal contexts all the students, at one or the other times, were involved not just into the discourse but also in observing and

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investigating the physical stuff. In our observations we found student utterances in informal contexts, where they addressed each other, were longer and more complex than student utterances in classrooms, where they addressed teachers. This is similar to what is reported by Dillon (1983) who points out that students more readily engage when they ask questions to each other, and give longer and more complex responses than when they respond to teacher's questions.

One of the reasons we wanted the students to engage in a discourse among themselves was that we were interested in their own authentic questions that interested them. However research has not yet explored such open-beginninged approaches. For example, in the work of Piaget and other psychologists they have investigated children's thinking and learning by giving them tasks or puzzles designed by the researchers in order to present them with some sort of cognitive conflict, and then analyse how they confront the conflicts.

Barbara Tizard and Martin Hughes (2002) argue for the need to look into children solving or working upon their own questions and problems, rather than the questions set out by others, in order to understand their interests and their competence. They say,

[As suggested by Margaret Donaldson (Children's Minds, 1978)] ... by observing children going about their ordinary lives at home we would see examples of intellectual competence – such as logical reasoning or taking another's point of view – which might not be revealed elsewhere. At the same time, we would gain further insight into the kinds of topics which the children themselves were interested in. We might also shed light on how adults help children achieve their self-selected intellectual tasks. (p. 7)

We noticed that the analysis of the classroom discourse did not reveal much about students' personalities or their behaviour. We think it was because students hardly talked and asked inside, and even if they did so it was within the frame of the teacher and textbook. This is in contrast to the discourse in informal contexts, which revealed many aspects of students' individual as well as group behaviour. As we were analysing the tapes, we felt like we were getting to know the children personally. We got to know about their beliefs and how those beliefs changed during the discourse, about their learning, their interests, and their points of view.

For example, we did not understand much about Gurpreet from what we saw and heard him do inside the classroom. Even though he was one of the more talkative students inside the classroom, he did not get a chance to explain what he meant about cold water when he made his comment that seemed to contradict the teacher in **episode 4.14** (Chapter 4). But after our analysis of the tapes from the parachute making, we could understand Gurpreet as being a student who: talked more and liked to dominate the procedures, who almost forced his ideas about the parachute design thinking himself being smarter than others, but also who when questioned and challenged, did accept others' ideas.

It is interesting to note that in the informal contexts, students' did not simply believe what they were told, they disagreed, challenged, questioned and gave counter-examples to present their own opinions. However this was contrary to the classroom discourse which was mostly confirmatory and had very few argumentative instances involving disagreements and challenges by the students to the teacher. Similar observations have been made by Padma Sarangapani (2003), who argue that in their everyday sphere, contrary to classrooms, children do show disagreements and call upon evidence in case of conflicts.

Although outside the school they are able to judge who and what to believe, to evaluate evidence to decide under what circumstances to believe and to what degree, they do not feel that they can exercise such judgement within the school space. Even when they experience the autonomy of inference, they are careful that this is not interpreted as being in conflict with the teacher's testimony, as this would constitute a challenge to the authority structure of the classroom. (p. 214)

We think that one of the important reasons that students could feel more of autonomy in the discourse in informal contexts was that they worked with peers in small groups. Here the discourse was governed by students themselves collaboratively, with its dynamics being very different from the classroom discourse.

8.1.2 Student agency and student autonomy in the discourse

As we observed, in the informal contexts, the student-student talk was governed by the students themselves through agency in various aspects of the talk (see **section 6.1**). The participation in the talk was much more dialogic than classroom talk and much more democratic. The decisions: who will talk, when someone will talk, what would be the topic,

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whether someone could disagree, whether a particular question or a response would be taken into consideration etc. were all collaborative and collective and spontaneous decisions. These decisions were not very explicit and emerged through the dynamic student-student and student-stuff interactions. Meaning and validity of the talk was situated within the discourse and students' actions rather than in some kind of authority.

The classroom talk was also dynamic in the sense that it was not pre-scripted, was not a line by line or para by para recitation of the textbook and that it happened in real time. It emerged and progressed with the teacher-student interactions. However the classroom talk was governed by the teacher and the textbook, with important decisions regarding the the turn taking, topic of discourse, who would ask and answer, what would be considered as a question and as an answer, etc. being controlled by the teacher. Also the structure of the classroom talk majorly followed IRE patterns of alternate teacher and student turns, with teacher questioning and teacher evaluation controlling the sequences of turns (see **section 4.4**). Such IRE sequences, where teacher questioning is structured around fixed or predetermined responses, has been found to be authoritative and to restrict student opportunities to participate in the discourse and demonstrate their argumentative abilities (Van Booven, 2015). However we did notice some instances of student resistance by breaking and reversing these sequences through their questioning and getting involved into an argumentative discourse with the teacher.

In one of the three classes we observed, there was a mix of IRE and teacher lecturing. In this class teacher was dictating answers to the textbook questions and sometimes lecturing continuously for several minutes.

In the informal contexts students had the agency not just in guiding the discourse but also in co-constructing and changing the norms of the discourse within their groups. Furthermore the power relations and roles between students were also dynamic which evolved/changed over time rather than being rigid and fixed like teacher-student relations and roles inside the classrooms (as discussed in **section 6.2**).

What is relevant to the discourse emerged from discourse itself and was negotiated rather than imposed. So the students' actions and responses were situated within the discourse where they were able to explore alternative meanings rather than passively adopting already established meanings (established by the teacher).

Why did the students had more agency in the informal contexts? We think there are many factors that contributed to this. The students had agency because they had stuff to observe and handle, and the informal environment outside of the classroom conferred agency. The nature of language that was used in informal contexts provided agency for the students to not just engage in the talk but also engage meaningfully. The authority of the teacher in these contexts was much less. Although the broad topic may have been decided by the teacher researcher, but to a great extent the specific contents for the talk and discussions emerged through student-student and student-stuff interactions. They were able to take agency because it was not taken away: they were hardly being admonished, punished or even evaluated. They had less fear and were able to take risks.

This indicates that the students did not need to be ‘taught’ to take agency to carry on discussions and arguments. They just need opportunities. They need to be in a context where their agency is not being taken away. In such contexts, students would be able to exhibit their creative potential. Barnes and Todd (1977) argue that the conventional teaching practices hardly offer opportunities for the children to exhibit their creative potential.

We do believe, however, that children are often underestimated, and that they possess skills and competencies which are rarely called upon in a conventional classroom. (p. ix)

Researchers have been trying to understand the thought process or learning among children in classroom conditions which are very constraining and artificial. However, it is important to investigate and understand children’s thought processes, their ways of talking and asking and their learning in the out of classroom contexts. This could help bringing important elements of informal discourse into the classrooms and bridge the gaps of everyday ways of learning and school learning.

8.1.3 Student whispering

In our observations, especially inside classrooms, we observed students doing talking in low voices which could not be heard and was not part of the main discourse. Whispering may indicate that children did not have the agency to talk out loud, or it may be that they want to tell a secret or something that they do not want others to hear. In a classroom situation it is usually that they do not want the teacher to hear them because they are not supposed to be

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talking, according to the rules. Or sometimes in a classroom they may whisper to another student an answer to a teacher's question - an answer that they are not sure of and do not want to say out loud because it may be wrong or make them appear to be foolish.

We have also found that students sometimes whisper questions to each other in classrooms. Occasionally we have been able to hear whispered questions on the recordings, or see gestures accompanying whispering that indicated questioning. Although there has not been any reported work on students' whispered questions, we suspect that students' whispered questions could be more authentic ones relating to their personal experiences and reveal important insights about students' interests, though these questions may be 'off-topic'. In such a case it is unfortunate that students do not have the agency to ask out loud these questions and perhaps make important contributions to the classroom discourse.

We did observe student whispering in informal contexts, though it was comparatively much less than in classrooms. Probably the students did not feel the need to whisper because they had the agency to talk out loud. Most of the whispering that we did see was done in order to hide from the teacher/researchers or other students.

We think student whispering inside classroom could also be a means by which they can take agency to talk among themselves. So teachers at times can also let students whisper and talk among themselves without wanting them to be heard.

8.1.4 Students stuck into school-school game even when they were outside

It was not easy for students to move out of their usual student role, where they talk, act, and ask according to the 'expectations' of the teacher and classroom. However, in the informal context students did break away from their 'studentness' and behave and act in ways a 'student' might not be expected to act.

Students made their own interpretations of the activities or tasks we wanted them to perform, even when we explained the task in detail. At times their interpretations were different to what we intended them to do. This happened in all the three workshops. Other researchers (Barnes & Todd, 1977) also report similar observations about students' interpretations of teacher's intentions. There could be various reasons for students having different interpretations:

1. They could not understand the task clearly and/or the instructions were not sufficiently clear or elaborate.
2. Even when we gave them freedom to decide what to do or told them to do something that is very different from what they usually do, they may not take this freedom. They act as they usually act as students playing the 'school-school' game. They unknowingly tried acting as 'students' and played the school-school game

In the case of first reason, at times we realised that we should have given more clarity on our intentions. But at the same time we also wanted to observe them exploring and asking genuinely but not because we have told them to ask or explore. So this paradox was always there that what and how we should tell them and what we should not tell them about our intentions, though we tried various ways of giving instructions.

The second reason is all the more interesting as it tells us about the nature of schooling. It tells us that how the frame of school influences students ideas about what they are supposed to do. This kind of influences and even inhibits their engagement in the discourse and the activities as they tend to act like 'students'.

Schools generally teach competition or 'survival of the fittest' rather than teaching 'survival in a group' and individualise the act of learning. In schools, to succeed one has to learn to beat others rather than to bring others along. Even when we had the students working in groups, the groups sometimes tried to compete with other groups, though we never intended or encouraged this. For example in our observations in informal contexts, students while working in groups tried to hide their ideas from other groups rather than sharing ideas. Likewise they would hide their plans, questions, answers, etc. when they were asked to write these.

8.2 Understanding the student questioning process in informal contexts

Student questioning in informal contexts we found to be different from questioning in classroom contexts in various aspects. The differences are not just in terms of frequency or types of questions, but also, and more importantly, in terms of the nature and dynamics of the

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questioning process in the two contexts. Also in classrooms, teacher (as well as textbook) questioning directly or indirectly influenced the student questioning process.

In classrooms most of the questioning that was observed was teacher questioning and in most cases teacher already knew the answers to the questions that were asked. In the informal contexts we observed students asking many more questions (at least 10 times as many) than they asked inside the classrooms. In both the contexts, we found that student questioning was very crucial for their participation in the discourse. Student questioning not only provided them the means for participating in the discourse but importantly for a more meaningful participation and engagement in the discourse.

8.2.1 Frequency, types and functions of questioning in classroom and informal contexts

We found that questioning in classrooms was dominated by teacher questioning, which was mainly meant for testing, quizzing, evaluating and assessing students. In classrooms, questions generally have fixed and predetermined answers and students are supposed to memorise those answers and that's how they learn and acquire 'knowledge' (Sarangapani, 2003, p.169). Sarangapani in her observations of a village school in India found that in classrooms, at times, teachers would conduct 'quizzing' sessions where they would ask questions to test students for their subject as well as general knowledge. Sometimes this duty was also performed by students, e.g. by those who were classroom monitors. At times when students asked authentic questions, they were criticised by others for asking questions for which they did not know the answer. It maybe that in order to compete and test others, sometimes students asked 'difficult' questions for which they also not knew the answers. Here the purpose may have been to put the other student in a tight spot rather than genuinely seeking an answer to the question.

In classrooms, that we observed, we did not find students quizzing each other. However, most of the teacher questioning was meant for the purpose of testing, evaluating or quizzing. Most of the students' questions in classrooms were asked to the teacher and a large number of those were for procedural and permission seeking purposes.

The meaning and purpose of questioning that we observed in informal contexts was different than the classroom questioning though there were similarities in the types of questions asked

by the students in two contexts. In the informal contexts most of the questioning that we observed was student-student questioning with students asking questions for various purposes and reasons like expressing requests, commands, anger, disagreements, surprise, disbelief, doubts etc.

Table 8.1 compares the frequencies of types of questions that students asked in the classroom and in informal contexts. The table indicates that the frequencies of procedural, explanation, request and confirmation questions were similar in the two contexts (shown in bold in the table), whereas frequencies of investigable, rhetorical and permission questions were most different in the two contexts (shown in grey in the table).

Table 8.1 Comparison of frequencies of types of student questions in the classroom and informal contexts.

Type of question	Classroom contexts	Informal contexts
Procedural	very frequent	very frequent
Investigable	infrequent	very frequent
Rhetorical	never	very frequent
Basic question of reality	infrequent	frequent
Clarification	frequent	frequent
Implicit	infrequent	frequent
Explanation	infrequent	infrequent
Request	infrequent	infrequent
Permission	very frequent	infrequent
Command	never	infrequent
Questions of language	never	infrequent
Asking evaluation or judgement	never	infrequent
Confirmation	infrequent	infrequent
Factual	infrequent	never
Checking	infrequent	never

In the informal contexts apart from authentic student questions we also observed inauthentic student questions like rhetorical and confirmation questions, though at times these questions did have some implicit authenticity. It is interesting to note that inside classrooms we did not observe a single rhetorical question by the students, but the teacher did ask a number of

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rhetorical questions. Generally rhetorical questioning was used for asserting opinions and showing disagreements. Apart from these, rhetorical questioning in the informal contexts was also used by students to present challenges, to show anger, to express control or authority etc. So the absence of this kind of questioning by students in classrooms indicates the hierarchical power relationship between the teacher and the students. Understanding teacher as well student rhetorical questioning in further detail can bring forth important aspects of teacher-student and student-student discourse, which previous studies have not yet explored.

Another kind of student questioning that we observed in our study and which previous research has not focused upon, is students' implicit questioning. We observed this questioning in both the informal and classrooms contexts, though in classrooms it was comparatively rare. In informal contexts it occurred mostly as a group questioning while students interacted with each other. So the reason that we did not notice much of implicit questioning in classrooms may be because there were hardly any student-student interactions inside the classroom.

Furthermore, in the informal contexts we found students asking many more investigable questions than they asked inside classrooms. We found that these questions were important for students' engagement in the discourse as well as in doing science. These questions led students to do different kinds of investigations and engage in argumentative discourse. Though we did find different kinds of students' questions including a number investigable questions, but each kind cannot be explained in itself but as a process of interaction among all the different questions, with questions leading to further questions.

As described earlier, our main purpose was not to categorise questions or to come up with some classificatory framework but to understand the process of student questioning. However, understanding the process and dynamics of questioning, organically led to the identification and categorisation of the questions. That said, what we found regarding different kinds of questions, cannot be understood in isolation, and needs to be understood in the context of other questions that arose around them and in the overall discourse.

In addition, it may not be meaningful to say that some particular questions and question types or particular answers were better than others. Their meaningfulness could only be established by describing the interaction between all different kinds of questions and answers occurring in the process. Questions could not be explained in themselves in isolation but in relation to

their replies and other questions and replies could be understood in relation to the questions for which they were meant to be replies.

Therefore, we believe that each questioning category in itself may not be meaningful as an aid to envisage teacher practice. What, in fact, we see as a more emergent outcome is to make our teachers aware of this extensive student questioning and its authenticity. And making it explicit for the teachers how emphasis on particular kinds of questioning could actually restrict students engagement and participation.

8.2.2 How and why did student questioning arise, evolve and progress: the dynamics of student questioning process

As described, in the informal contexts we observed much more student questioning than what we observed inside classrooms. We think that one of the important reasons that students were able to ask questions in these contexts was that the discourse was governed by students collaboratively through student-student and student-stuff interactions without much of the involvement of teacher/researcher. As students had agency in steering the discourse, in shaping and co-constructing their roles and the norms of the discourse, their engagement in the discourse was more meaningful. Furthermore, in the informal context, students had more autonomy in language for expressing and understanding meanings as compared to their autonomy in use of language in classrooms. The meaning making in informal contexts was more collaborative and situated within the everyday experiences of students and their use of language. Researchers like Gordon Wells (2009) and Jay Lemke (1990) have argued that students' everyday experiences and language are valid and important in doing science.

Also, students' thought processes and their decision making was not all 'rational' but also governed by social factors like power relations among students, authority, gender, imotions, etc. So the discourse in informal contexts progressed in complex ways which could not be discerned into some particular structure or pattern. However, understanding the process of questioning helped us to understand and explain the complexities of the discourse.

8.2.2.1 Role of conflicts and disagreements in student questioning

In the student-student discourse in informal contexts, student questioning and student argumentation were important in guiding and sustaining the discourse. Both were

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interdependent and in turn dependent upon different kinds of conflicts and disagreements.

In an authentic discourse, interlocutors bring in their own experiences, their own meanings and their own perspectives and in such a scenario conflicts are apt to rise. That's how we can envisage the progress of the discourse. As described previously (**section 2.2.3.1**), a question means having an alternate point of view or opinion about something. A question about something arises when an alternative or doubt appears about that thing. So questioning is closely tied with having of conflicts and disagreements, and that's what we observed and found in the informal contexts.

Though in classrooms, we did observe some authentic student questioning arising out of conflicts and disagreements, discourse and the questioning in classrooms were largely about confirmations and agreements based on priorly determined fixed opinions or answers. The disagreements and conflicts even if they arose in classrooms were mostly not stated by students and remained implicit, so true questioning was hardly observed.

The main function of questioning and answering in schools is evaluating whether students could remember the expected answers to the teacher's questions. So questioning and answering in schools function mainly for 'transferring' or 'banking' of 'knowledge' (Freire, 1968). Here knowledge is what teachers, textbooks or other authorities consider to be the 'correct' answers, whether or not they provide justifications for the 'correctness'.

However, questions and problems in the outside world are generally different and do not have unique or fixed or right answers. They may have some answers or solutions better than others. Same question or problem posed in a different context to a different group of people can have an entirely different answer or solution. Researchers have described everyday or real life problems being more messy, unstructured and open-ended (Roth, 1995, p.105).

The kind of questioning that we observed in the informal contexts was also open-ended such that questions asked by students did not have specific answers or priorly defined answers and at times did not converge to a resolution. Questioning in these contexts arose as a result of a number of different types of conflicts that students faced: (a) conflicts between different observations; (b) conflicts between observations and beliefs; (c) conflicts between one's own beliefs; (d) conflicts between different students' beliefs; (e) conflicts between observing and not observing; and (f) conflicts between knowing and not knowing. This last type of conflict is what is usually referred to as 'gaps in knowledge'.

Piaget (1923) has also described how children's awareness of cognitive conflicts leads children to ask questions. Furthermore, it was not just that conflicts led to questioning, but also questioning led to further conflicts and that's how questioning sustained and progressed. However, just realising that there is a conflict, does not necessarily lead people to try to resolve the conflict or engage in questioning. They also need to have the agency to ask questions. This would be possible if the existing power structure of the classroom could be understood and changed, presently in which students have very submissive roles to play.

Since there were differences of opinions or multiple opinions, questioning arose and since those differences persisted, questioning and dialogue sustained. However what we observed in classrooms was somewhat opposite, where conflicts and disagreements were suppressed. Without the existence of multiple viewpoints or opinions, opinions or beliefs cannot be formed or changed. This is the process of learning. However, schools train students to be the same, think similarly, act similarly (see **section 2.3.5**). Children's experiences at school are much more similar to each other than their experiences at home. Children come from different backgrounds and cultures, having very varied experiences. But in schools, all the students do similar kind of activities, learn to acquire similar kind of skills, perform similar kind of actions, and speak the same language. This simply disregards their individuality, their differences, their diversities, which otherwise could have been a source of their learning, their conflicts, and their questioning.

As Gordon wells (2009, p. 267)) points out

As a result of their individual life trajectories, the students who make up any classroom community come to each curriculum topic or specific activity with varying perspectives and with varying kinds of relevant experience and knowledge (Moll & Greenberg, 1990). In most classrooms this diversity is either ignored or acknowledged only indirectly in an initial 'KWL' brainstorming activity. Taken seriously, however, such differences might be expected to have several consequences. First, depending on their previous experiences, students would have different questions they wanted to ask and attempt to answer as well as different aspects of the curricular topic that they wanted to explore. Second, given the chance to express them, students would also have different opinions about many of the issues to be investigated. And, third, they could be expected to

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end the unit with greater personal understandings of the issues addressed but these would not be identical from one student to another.

8.2.2.2 Dialectical nature of physical stuff

One of the things that led to conflicts and disagreements was handling and exploring of the physical stuff. As students took agency in handling and exploring the stuff, they observed, manipulated and investigated it. Students were talking and arguing as they explored different things. Their asking was interconnected with their observing, arguing and investigating. As students observed and investigated the stuff, they experienced different kinds of conflicts. We think since physical stuff itself is dialectical in nature, such conflicts and contradictions are inevitable whenever someone observes or investigates it. We have discussed this dialectical nature of physical reality previously in our framework in the **section 3.6.2**. According to this dialectical understanding, physical reality is not a thing (which is fixed and independently out there) but a continuous process of ‘struggle’/interaction of conflicts and contradictions inherent to the things and it (the physical) cannot be understood in separation from social [reality] (Cornforth, 2015).

Also in **section 6.2.4** we have discussed some examples from variegated tree and ants’ observations by students to elaborate about the inherent contradictions and the dialectical nature of the physical stuff, and how this led students to ask questions and do observations and investigations.

8.2.2.3 Spontaneous oral discourse

We think another reason that students asked so many questions in the informal contexts was that they were talking, not writing. Oral questioning is a dynamic process, which is more changeable, responsive, and ‘living’ than a relatively fixed, static piece of writing. Because talking is more spontaneous and immediate than writing, it may be more open to innovation and questioning. Talking within small groups is less individualistic and less alienating than usual forms of writing, and it is more subject to evolution as it passes from person to person and group to group. Of course this last point can also be a disadvantage, in that it may introduce inaccuracies and spurious errors and contradictions between direct observations and reported observations.

Lev Vygotsky (1966) pointed out that, ‘The motives for writing are more abstract, more intellectualized, further removed from immediate needs. Writing also requires deliberate analytical action on the part of the child’ (p. 181–182). There is no doubt that the written word is very important in doing science, and in making the implicit more explicit. Vygotsky has written about the dialectical movement between more abstract thinking and talking and more concrete writing, and their importance in learning.

Although teacher-student oral discourse is common in classrooms but student-student spontaneous discussions hardly occur as part of the main classroom discourse. However, unplanned pauses and interruptions by the teacher can provide some time for authentic student discussions, as we observed in our classroom observations. More research is required to understand the student questioning at such times, as well as when students ‘whisper’ to each other during a lecture, demonstration, or presentation by the teacher.

8.2.3 Non-resolution of questions and answers: problematological nature of discourse

In our analysis, we found that at many times students resolved their questions only partially and this non-resolution led to further questioning and continuation of the discourse. In case a question was completely resolved, it gave closure to the question and in that scenario discourse or questioning did not further or advance. So the progress of the discourse could be explained in terms of problematological nature of questioning and answering or in other words, in terms of newer questions that arose (see **sections 6.2.1** and **3.7**).

What students did, what they thought, how their ideas developed and changed could not be understood in terms of what answers they found, but in terms of what questions they asked and how they moved from questions to answers to the other questions. So, in student questioning, our focus must be on understanding the process of questioning, on the logic of questions and answers rather than on the strategies of questioning and its outcomes. We must move from thoughts or ideas being set of propositions or statements towards thoughts and ideas being complex of questions and answers. As Meyer (1980b) argues, Knowledge (or some may call truths or beliefs) is not just a set of some statements or answers, but a complex interplay of questions and answers.

8.3 Role of student questioning in doing science in informal contexts

The pedagogy of science teaching that we observed in classrooms mainly centred around teaching and understanding the concepts or facts of science through transmissive ways. In all the three classes, classroom teaching hardly provided opportunities for the students to do observations or investigations of any sort. Because students hardly asked questions to further their understanding of the concepts, and did not meaningfully engage in the discourse with the teacher, it was not clear what kind of understanding they developed. The classroom discourse and argumentation was driven by the teacher or textbook questions rather than the student questions. Furthermore, the answers in classrooms were largely fixed and predetermined and were determined by the teacher and the textbook authority. So rather than questioning and answering emerging from students' own experiences, it was based on the authority of the teacher and the textbook and the so called 'body of knowledge' of science. Thus students did not get much experience whereby they could understand that science is less a 'body of knowledge' and more a process of asking questions and finding answers.

This contrasts with what happened in the informal contexts: both questions and answers emerged through students' interactions with each other and with the physical stuff. In these contexts, students engaged in different kinds of observations and investigations based on their own authentic questions. Analysing students' interactions in these contexts helped us in understanding how students got engaged in different aspects of doing science and how those aspects were interconnected with each other and with the process of student questioning. This in turn helped us reflect upon the nature of science and problematise the teaching of science in classroom contexts.

8.3.1 Science as a questioning process of various interdependent aspects

In the informal contexts we observed students engaged in various aspects of doing science like observing, questioning, hypothesising, arguing, classifying, comparing, investigating, interpreting, etc. All these aspects were interconnected and interdependent with each other, with questioning and observing being central in the process. The student questioning as well as their answering was dynamic, evolving and progressing throughout. Students' observations, their arguments and their questions, especially rhetorical questions, were guided by their emotions and their power relations as well. So these social factors were also

crucial in students' decision making and their engagement in different aspects of doing science.

Furthermore, we observed that student-student talk and their use of language was crucial in student-student interactions and their doing of science. The students' agency in the discourse and in their use of language was very important for students' engagement in different aspects.

Also questioning, observing, arguing, investigating etc. were all part of a collaborative and collective process that sustained and progressed through student-student and student-stuff interactions.

One of the reasons that students got engaged in various aspects of doing science in informal contexts is that they were able to ask their own authentic questions arising out of various kinds of conflicts. As students tried 'resolving' these questions themselves through interactions with each other and with the physical stuff, rather than relying on the authority of the teacher or the textbook, they inevitably engaged in different aspects. So the process of asking and answering provided means for student engagement. The two processes were intertwined in complex ways with each other and other aspects and it was often difficult to identify which was which. Moreover, since answering was partial or problematological, the process of questioning sustained and progressed.

Among the various kinds of questions that students asked, the investigable questions were all the more interesting. Generally the discourse among students following these questions was longer and more argumentative involving different kinds of conflicts and disagreements. Also, at times, these questions led students to do some sort of investigations. However students' investigable questions and their investigations could not be understood in isolation from other kinds of questions that students asked and their engagement in other aspects like observing, arguing, hypothesising, interpreting, etc.

We found that student questioning and student argumentation were interconnected and interdependent in complex ways and were reason for progress and sustenance of each other. Because there were conflicts, difference of opinions, among students with each other as well as with oneself, questioning and argumentation persisted. Each of these were important in leading the students to do observations and investigations and engage them in different aspects of the scientific inquiry.

In science and particularly in science education, researchers' interest has remained more in questions and answers as 'things' and less in the process of questioning and answering. If we want to understand the student engagement in science in classrooms or elsewhere, we must understand and describe their process of questioning and answering, since the process of science is itself a process of questioning and answering.

8.4 'Doing' science in the classroom and in informal contexts: need to bridge the gap

8.4.1 Reflecting upon the 'nature of science'?

Our analysis of student engagement in different aspects of science in the informal contexts has led us to a more nuanced understanding of the nature of science. We claim that this understanding about the nature of science is much closer to the reported nature of science that underlies what scientists do. Our study indicates the importance of letting students engage in questioning and different aspects of doing science in informal contexts. Such opportunities can help students implicitly and explicitly understand the nature and process of doing science, reflect upon it, and have a better understanding of it. We think unless students engage meaningfully in the process of doing science, it may be difficult for them to reflect upon the nature of science. Though, however they definitely need to be engaged in discourse around the science and its relationship to society and those in power to better understand these relationships.

The 'doing' of science in classrooms was very different from 'doing' of science in informal contexts. In classrooms students were hardly involved in any of the aspects of the scientific method except for reading and writing, and a particular sort of 'discussion' between the teacher and one student at a time. Neither did the textbooks nor the teachers mention how scientists engage in the various aspects of the scientific method when they do science. The question/answer process that they were exposed to was very different from the questioning and answering that goes on when people do science. The 'questions' were framed by authorities to fit the pre-decided answers. Students were not learning science by doing science.

If students believe that they are learning science in their so-called science classes, they can only assume that science is a particular sort of 'body of knowledge': a list of unquestionable facts. Since they neither have a chance to question or challenge these 'facts' or to hear about how others questioned or challenged 'facts', they have no reason to believe that science evolves in complex, non-linear ways, and that science is done by questioning statements and beliefs rather than just 'finding' them and accepting them. Since in classrooms there are great efforts to avoid conflicts and contradictions and students become ashamed to admit that they are confused or have questions, it may seem like the recognition of conflicts and questioning are not inherent parts of science. Based on their classroom experience, students have no way of finding out that actually all of these 'facts' are only probably true (and have various probabilities of being true) and that actually any belief or understanding is still open to being challenged or revised in science. Furthermore, in actual practice all scientific theories have to live with some kind of anomalies (Hodson, 1990). However in classrooms, anomalies and contradictions and evidence that does not support a theory are generally disregarded. In the actual practice of doing science, scientists are constantly inundated with such conflicts.

In the 'science' that is presented in classrooms, 'facts' are fixed, methods are fixed, and answers are fixed. Furthermore, it seems like students as well as teachers agree that everything in science is definitely and permanently true. This 'science' appears to be objective and neutral, value free, judgement free, and independent of social relations, emotions, human values, or relations among people or groups. However, when students would do science in less 'formal' ways these sorts of conflicts cannot be avoided - just as when anyone does science they cannot be avoided.

We would add that it may not be sufficient for students to be assigned questions to investigate. We would advocate a more open-beginning science exploration in which students are involved in framing their own questions as they do science. This is what is usually lacking in reports of school science throughout the world, and is probably why students often fail to realise that questioning is an essential aspect of the nature of science.

This contrasts with the efforts of some educationists to counteract the trend of the 60's and 70's which sought to include more of practical empirical work, activities and experiments in science classrooms. For example, Rosalind Driver, Paul Newton, and Jonathan Osborne (2000) claim that

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*...what is required is a reconsideration of the role of science education, commonly seen as an introductory training in science, emphasizing basic methodological skills and practices, to one that sees its function as an education **about** science, which seeks to empower young people and develop their scientific literacy. (p. 289)*

They argue against what they say is a ‘positivist’ view of science that was projected in science education in Anglo-Saxon countries, “in which the book of nature is read by observation and experiment.” Their complaint is that this led students not to realise that “scientific knowledge is socially constructed.” In order to counteract this, they call for “discursive activities, especially argument, to be given a greater prominence” in the classroom.

However, based on our findings, we question whether students are led to disregard social and emotional aspects when they do hands-on, empirical work. In the informal settings, we saw students working collectively in groups (and often spontaneously forming their own groups) in which social and emotional issues were not disregarded. This was in contrast to their classrooms in which we claim there was an excess of concern **about** science without any concern for methodological skills or practices. We claim that one of the reasons why students did not engage in talk and discursive argumentation with each other in classrooms was that they did not have any stuff to handle, observe, or manipulate. We claim that if and when students actually practice science as they did in the informal settings, they cannot come to the conclusion that science is ‘objective’ incontrovertible fact.

8.4.2 Bridging the gap between formal and informal ways of doing science

In relation to schooling and education, we think it’s important to understand children’s ways of questioning, answering, arguing, exploring or investigating, etc. in informal contexts, as these are more authentic and related to their everyday experiences. But students’ classroom experiences of learning and ‘doing’ science are generally alienating and disregard their everyday experiences. In the classrooms, science is presented to be special and very different from our everyday experiences and something that requires special ‘ability’ or skills to be learned. The way science is presented, it is clear that it is meant to be difficult. Exams are designed to select only a few students as being successful in ‘learning’ science.

This situation continues, despite claims by some educationists that the process of doing science is actually nothing special and is not very different from the way we learn through our common everyday experiences. For example, Jay Lemke (1990) says that science is actually “*an extension of common sense, not an esoteric alternative to it*”, although, in classrooms,

Science teaching routinely creates a radical disjunction between science and common sense, routinely sets aside students' own associations, arguments, and even observations. It routinely alienates students from science, undermines their self-confidence, and proclaims a special and superior truth to be taken on trust, or on authority. (p. 148)

However, in the informal contexts, students' engagement that we observed seemed much closer to their everyday experiences. In informal contexts, students spontaneously engaged in questioning and answering and other aspects of scientific inquiry without much of the teacher intervention. The nature of the discourse among students was very informal and seemed to be similar to students' everyday experiences of talking and interacting.

This makes us wonder about everyday experiences, and whether people generally practice science to some extent in their everyday lives. Perhaps even ‘uneducated’ agriculturists (farmers), masons, carpenters and other ‘skilled’ or even ‘unskilled’ workers are raising important questions and doing investigations in searching for answers in their everyday lives, but we have never recognised their quest as ‘science’.

Robin Millar (1989) argues that science is different from the general, every-day approaches, which we all use all the time in making sense of the world. He sees the main difference being that the science has to be dependent upon and closely connected to scientific ‘concept knowledge’. Thus he thinks that in doing science, students need to be guided to observe what is relevant. Otherwise they will observe too many irrelevant things, which will inhibit their learning and understanding of the body of knowledge. But based on our experience, we find that the concerns of the students need to be acknowledged, even if teachers may at first think they are irrelevant or distracting.

Some other researchers also see a difference between ‘everyday talk’ and ‘science talk’, which parallels the difference they see between ‘indigenous knowledge’ (or ‘traditional

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knowledge’) and ‘modern western science’. We do not doubt that different cultures at different times produce different technologies, cultural artefacts, and even (what some people call) ‘bodies of knowledge’. However, based on our teaching and research experience, we suspect that many cultures must be at least occasionally engaging in a practice of doing science which is quite general, and much more universal and widespread than is generally accepted by mainstream western educationists these days.

Rather than seeing science as a subculture of western culture, it needs to be reclaimed by its indigenous practitioners throughout the world. The role played by ordinary people in doing science and developing technology needs to be acknowledged and supported (Ilaiah, 2009).

We object to attempts to view science as being very different from what ordinary people ordinarily do. It is a Brahmanisation of knowledge (Ilaiah, 2009) which restricts science to an elite activity which nowadays is tightly controlled by capitalist powers. We envision an alternative in which all people can be allowed and encouraged to do science, where they could engage in questioning and other different aspects of the scientific inquiry. It has been pointed out that the main reason why science in India did not, and still does not progress beyond a certain point, is the caste system which in addition to oppressing the majority of people, also creates a division between the hand and the mind (Ilaiah, 2010). Although unrecognised by the privileged, most of the technological advances in agriculture, metallurgy, ceramics, carpentry, weaving, etc, have been based on science which was done by Dalitbahujans and tribals. A ‘culture’ has developed over the past centuries in which Dalitbahujans have “more of an investigative psychology than an imaginative ability like the Brahmans have” (Ilaiah, 2010). In other words, Brahmans have been engaged with the world of ideas, spirits, ‘inner consciousness’, the soul, and white collar corporate jobs. This contrasts with Dalitbahujans, who have been forced to work with soil, minerals, plants, animals, and filth, and are therefore constantly engaged with physical reality and confronted by its problems and curiosities which demand investigation (and physical solutions) rather than just introspection. The more important questions, related to everyday problems and realities, raised by Dalitbahujans and tribals, have been completely ignored by mainstream ‘educated’ elites.

The Dalit-bahujan population (with whom we identify) has been systematically denied access to literacy and education, and has been forced to do the manual labour and production upon which the upper-castes depend. The upper castes, have concentrated on concepts, ideas, and ‘bookish’ learning, and suffer from a lack of direct experience with physical reality. An

objective and result of science education must therefore be to annihilate the caste system and facilitate the interconnections between hand and mind.

While we do not doubt the existence of this artificial separation of the hand and mind, it may be misleading to refer to it in terms of an 'investigative psychology' and 'imaginative ability'. Such terms may imply that these are individual, inherent 'genetic' characteristics rather than being socially constructed.

We insist that the process of investigation carried out by ordinary people should be recognised as being a scientific method. It is essentially the same process, which involves questioning, observing, hypothesizing, testing, analysing, comparing, concluding, communicating, etc. As we observed, these are not discrete steps and are interconnected in complex ways. However, of course the process we are discussing has differences from the science that is done by elite professional scientists: communication is restricted by differences between local languages and by illiteracy, inadequate means of transportation, and lack of means of communication; education between elders and youth is disrupted by migration (which is required for economic reasons); instrumentation and equipment is restricted; and perhaps most important, the design of the economic system (capitalism) restricts the amount of experimentation which is possible by the ordinary people. Nevertheless, we should not forget that over the last 10,000 years, illiterate, 'uneducated' labourers have managed to develop crops and breeds of animals which we all continue to rely upon for food, clothing, and other products - as well as leather, wood, clay, bronze, iron, and other technologies.

According to us, science has been misappropriated and needs to be rescued. Thus, we must confront the basic questions: 'Whose questions and which questions are important in science, who should be allowed or encouraged to do science, and for what purposes should science and science education be done?' We argue that we should resist hegemonic definitions of science in which genuine people's science is not given the attention that it deserves.

We support an education in which, rather than focussing on teaching the 'The Body of Knowledge' (which is defined by western hegemonic powers as particular lists of commodified concepts), students are encouraged to become active questioners and more engaged in the process of science in school and throughout their everyday lives.

8.5 Implications and suggestions for classrooms, teachers and educators

Freire and Faundez (1989) have argued how the present education system is based on the pedagogy of answers, and is anti-democratic. They argue rather for a pedagogy of questioning. We have observed that the pedagogy of answers is particularly prevalent in India, where schooling trains children at answering and not at raising questions, especially questions which are critical and challenge the status quo.

As Padma Sarangapani writes: "... just one question from a student can threaten the status quo." (Sarangapani, 2002, p.12). In her case study of a village school, she reports that teachers explicitly said that they wanted students to give teachers respect and unquestioning obedience. She describes how the teachers she studied inflicted physical and verbal abuse on students when they gave wrong answers to the questions in textbooks or on exams. It is not hard to see how fear is instilled and an unquestioning obedience to the teachers is enforced. Even without corporal punishment, teachers - and other students - frequently bully and ridicule students who give wrong answers, do not know the 'correct' answers, or ask 'silly' questions.

Though in our study we have looked at particular classrooms, but we could not understand the nature of student and teacher questioning inside these classrooms without reflecting upon the nature of education and schooling in general. So our analysis of classroom questioning or questioning in informal contexts required reflecting upon the role of larger existing social, economical and political structures (as discussed in our framework in **Section 3.4.1**). Thus the implications and suggestions which emerge from our study could be meaningful only when considered in relation to the possibility of systemic changes in education and in society.

Our suggestions for classrooms, teachers and educators are based not only on what we have observed, but also what has been previously reported by other researchers in other places. Nevertheless, our suggestions may be most appropriate for the kinds of students and schools we studied, and we realise that some of our suggestions may not be as appropriate for other students and other schools in other places. More research could be required to understand the relevance and implications of our study in other places.

8.5.1 Creating more equitable and democratic classrooms: Transforming student agency

8.5.1.1 The problems of large class sizes

It is obvious that classroom discourse becomes more difficult when large numbers of students are packed into a small classroom, which is the norm in many schools in India. In each classroom, one teacher usually has more than 35 students - typically 40 to 60 students. In our research in informal contexts, we worked with relatively small numbers of children: from 11 to 32, and in all cases they worked in small groups of 3 to 6 students. This may be one of the main reasons why the students talked and did questioning. It may not be feasible to have children work and talk to each other in small groups if the classroom space is not large enough, or if it is too noisy. The students in our studies were able to work in small groups because we took them outside or into larger halls, in cases where the classroom was too small.

So unless class sizes are reduced (20-25 students per class), small group work may not be a possibility as there would be a large number of smaller groups that the teacher need to organise. Also in whole classroom discussions, large class sizes reduce the opportunities for students to participate in the discourse and their participation becomes more unequal. Also, the arrangement of benches, which is generally in rows and columns facing the blackboard, may not be conducive to small group work, and this problem has to be solved if students are to engage in more discussions with each other.

8.5.1.2 Need for changes in power structures in classrooms

In informal contexts, we purposely tried to subvert the hierarchical power structure in which teacher control and guide students on what to do and how to do. But we were not sure how the students would react to such a subverted power structure. However, they did show a collective agency. They gradually took control over the situation, as they realised that they could take quite a bit of freedom and that the teachers were not admonishing them.

We think this change or subversion of power was important for making students realise that their questions, observations, arguments, investigations, etc. are important and meaningful.

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But how will this change come in classrooms? For example, it could be done by decreasing the reliance on the authority of textbooks and going beyond the textbook frame. It could be done by letting students ask questions even if they are not directly related to a textbook topic. Teachers should listen to students and students must realise that teachers are listening to them. Teachers should appreciate students' questioning as well as their answering. Teachers can purposefully try relinquish some of their power and talk less. Teachers can try reducing their evaluation of students' responses and can rather ask for evaluation from other students in order to stimulate discussions.

8.5.1.3 Breaking the norms: Classrooms discourse needs to bring in important features of everyday discourse

In our observations of classrooms, we found the discourse was governed by certain norms which restricted student talk and student questioning. Similar observations regarding the well established classroom norms of teacher questioning and student answering have been made by other researchers in India (Sarangapani, 2003). In an ethnographic study of a school in India, Sarangapani pointed out some of these unsaid classroom norms. For example, a question asked by the teacher, which is beyond textbook context, will be considered irrelevant, invalid or wrong by the students. Also, answering by students is supposed to be done in a particular way. Even the slightest deviation in language, content or expression of their answers, may be counted as 'wrong answers'. There are other norms like, students cannot speak up in class, and interrupt—without raising their hands or being called upon. They cannot speak out of turn. They cannot disagree with the teacher and the textbook. They cannot speak and argue directly among each other in the classroom without the teacher as mediator.

Unless we understand that the existing classroom norms are constraining and restricting students' participation, the situation won't change. If we want students to get engaged in authentic discussions inside classrooms, we have to break these norms. The students need not to be explicitly taught how to engage in questioning and argumentation - they already do so in informal contexts. Actually classroom discourse could bring the important features of students' everyday ways of talking, arguing and investigating to encourage student engagement. In informal contexts, we observed students spontaneously engaging in talk whereby they themselves took the important decisions regarding talk, for example decisions

of turn taking and turn allocation. Their use of language in these contexts was quite informal and that gave them agency in engaging in the discourse. We need to understand the pedagogical relevance of these and other aspects of informal discourse. Everyday kinds of discourse can help us understand what kinds of resources one needs to have to effectively participate in a conversation in small groups.

While describing the features of everyday discourse, Gordon Wells (2009) points out,

In everyday conversation outside the classroom, on the other hand, there is typically a relative equality of participation; rarely does one participant assume a dominant role by controlling and evaluating other participants' contributions. Anyone who feels that their contributions are being ignored or suppressed is free to leave or to try to redress the balance. Equally, good conversation thrives on the expression of different points of view; without some disagreement, there would be little to keep the conversation going (Matusov, 1996). Obviously, in the setting of the classroom, 'everyday conversation' is not appropriate for a class discussion with a curricular focus. But the two principles just mentioned – equal rights of participation and acknowledgement of different perspectives – remain important for the creation of an ambiance in which students and teacher construct knowledge together. (p. 267)

But what can teachers try doing to change these norms? Sometimes just taking children out of classrooms and having discussions in a more relaxed set up could provide agency to students. Letting students work in small groups around their own questions, with the teacher being less evaluative, could be helpful. Students could engage in debates or discussions around topics of their own choice. All of these involve a change in power relations.

8.5.1.4 Need to understand the importance of conflicts in classroom discourse: moving from confirmatory to argumentative discourse

In schools we emphasize and value facts and answers. We like definitive answers. We like certainties. We admire those who provide answers. This over emphasis on answering undermines the importance of questioning. But the focus should be on questions, questioning the questions and questioning the answers.

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However, unless we value differences of opinions, conflicts and disagreements, we cannot expect questioning either in everyday contexts or inside classrooms. As we found in this study, conflicts and disagreements are the means by which questioning and discourse gets sustained. In classrooms, there is a need to appreciate conflicts and disagreements, whether between students or between students and the teacher.

So maybe we need to move away from the fact and concept based confirmatory education towards a critical education based on a pedagogy of questioning. We can perhaps get help from Paulo Freire, who reminds us that education can be of two different types: it can be, on the one hand, an instrument to facilitate conformation - integration of people into the present system, the maintenance of the status quo. Or it can be the practice of freedom, “the means by which people deal critically and creatively with reality and discover how to purposively participate in the transformation of their world” (Freire, 1968).

8.5.1.5 Should teachers talk less and ask fewer questions?

The lack of student talk and student questioning in classrooms raises several problems. How can students learn without participating in the discourse? Since most individual students are hardly talking, how can the teacher understand the students’ needs and interests or assess their learning?

In our observations, we found that one of the reasons that students talked less and asked less was that teachers were talking and asking continuously, much more than students. Maybe teachers can purposefully try talking less and asking fewer questions and sometimes even being quiet. They can practice quietness after they have given a chance for a student to speak. They can wait a little longer for the student’s response. They can wait after a student has responded to see if the student wants to say something more. They could be more conscious of their questioning and instead of asking their own questions, ask students to ask each other questions. Teachers can try taking longer pauses in order to give students more time to discuss. Furthermore, teachers can try allowing more of student-student discussions than teacher-student discussions to give more opportunities for students to talk.

8.5.1.6 Let students whisper

In our classroom observations we found that student whispering was an important means by which students engaged with each other in questioning and argumentation. We think that such ‘illicit’ talking between students is very important for their learning. Perhaps students sitting in the back of a class are already whispering illicit questions and challenges to what the teacher, textbook or other students are stating. As teachers, we have heard back-of-the-room unsolicited questions about “Why is this important?” which may or may not be entirely rhetorical. Internet chatting in a classroom can also function in a similar way (Cunningham, Una Mary, Fägersten, Kristy Beers, Holmsten, Elin, 2010).

8.5.1.7 Having classroom discourse in students’ own language

In informal contexts, we observed students taking agency in their use of language as they interacted with each other. This was important for their engagement in the discourse and thus in the different aspects of doing science. In classrooms, even when students speak in their mother tongue, the use of language is very formal and restrictive. The ways of talking and interacting in classrooms are much different than students ways of talking at home.

In most states of India, the law requires students to study three languages (usually Hindi and English in addition to the state language), although this often does not actually occur. Adequate teachers for certain languages may not be available. Even if a school is officially called “English Medium” the classes may be taught in the state language (although textbooks and exams may be in English). Many a time the medium of instruction could be different from students’ home language. Furthermore, the teacher’s mother language and students’ mother language could be different. All this leads to a lack of student participation in the classrooms.

It’s important that students should be given opportunities to engage around their own questions in small groups using their mother language. They should be given opportunities to interact among each other and address each other directly. This could help them bring their varied experiences of talking and using their home language into classrooms and would enrich the classroom discourse. However, the problem of language is systemic and cannot be easily solved by individual teachers.

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8.5.1.8 *Let student speak and talk: making implicit questions explicit*

In our studies in informal contexts, we observed many of the students' questions were implicit, and were not explicitly verbalised. This occurred both with individual and group questions. Perhaps in classrooms students are already asking such questions. We think one of the objectives of science education should be to encourage students to make their implicit questions explicit.

Just by allowing students to spend more time talking - especially while they are investigating stuff - we think they will inevitably start asking more explicit questions. But how can teachers allow students to talk more? One way is to allow students to talk in pairs or small groups. That way, more students will have more time to talk. We have already mentioned that teachers will have to talk less if students are to talk more.

Of course student talk and group work is difficult if there are too many students in each class, or if the classroom is too small or noisy (due to outside traffic, fans, sounds from neighbouring classrooms, poor acoustics, etc), as is often the case in India. These problems are increasing with the increasing commodification and privatisation of education. Educationists, teachers, students, and parents need to recognise these problems and demand that the government takes action to provide the funding that is needed to solve these problems.

Another way of encouraging students to make implicit questions explicit is to ask students to do more writing. In the process of writing, implicit questions may become more explicit. But, our research indicates that writing would best be done while discussing, observing, and manipulating the stuff of interest.

Teachers could ask students to themselves engage in some meta-analysis of what they are doing as they do their investigations. Perhaps students could then purposely become aware of the questions which are implicit in their discussions.

Alternatively, or in addition, teachers could try to identify implicit questioning at the time it occurs in student conversation, and ask the students whether they have a particular implicit question in mind. As a class, the students and the teacher could analyse whether there are particular implicit questions in their minds. As we mentioned above, teachers will also need to listen to students very carefully.

8.5.2 Changing classroom practices of doing science

8.5.2.1 Providing opportunities for students to engage in different aspects of scientific inquiry

It is important that in schools we should be able to teach science in ways such that it should not project a distorted or very limited view of science. As we have discussed, students need to do science in order to understand the nature of science. There should be more opportunities for students to do science in classrooms where they get engaged in questioning, observing, arguing, investigating, as well as a wide variety of other aspects of science from the ‘science toolbox’. As we observed, classrooms hardly provide such opportunities to students. Students must be encouraged to ask and investigate their own authentic questions with less teacher intervention. Unless students engage in the process of questioning and answering on their own, we cannot expect them to learn and do science.

As previously suggested, they could even reflect upon their own practices of doing science to better understand the nature of science. The focus on teaching the ‘facts’ or ‘concepts’ in classrooms has to be reduced. However this may not be possible without bigger policy level changes in the teaching of science in schools. Though the national curriculum framework 2005 (NCERT, 2005) does stress more on processes of science but the suggested curricular changes are hardly reflected in what happens in classrooms.

8.5.2.2 Let children observe and investigate physical stuff

Genuine reasons for talking and questioning are missing in schools. If students are solving genuine everyday problems they may have reasons for talking, arguing, and questioning. For example, children could work together to grow crops, vegetables, produce and cook their own food. Then they may have genuine reasons to talk about plants, crops and food. They will have to tackle real life problems. This is an example of a kind of schooling where children would produce new knowledge and help solve problems of their own communities of farmers, vendors, other workers etc.

Asking a question can be said to be the starting point of enquiry. However, in science, questions are based on physical reality. Thus we expect that providing opportunities to students to do some sort of observations of some physical stuff and investigate the stuff, will

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encourage them to ask questions. Shutting students in a boring, empty classroom may discourage them from asking questions. However, some researchers have suggested that classrooms should not be too cluttered, because having too much stuff distracts the students from the teacher-assigned tasks (Fisher, Godwin, & Seltman, 2014). Students' questions may be seen as distractions rather than learning opportunities. But we wonder whether learning to do science could be facilitated by allowing more student-assigned tasks.

We suspect that the observation of actual stuff and the experience of real processes also gives rise to more authentic questions. Whenever anyone fools around with and observes physical reality one inevitably finds that things/processes are more confusing than expected.

However, teachers may be disappointed if they give students a particular kind of stuff in the hope that it will lead students to ask a particular question that the teachers have in mind. This happened to us a number of times. The students asked completely different questions than we had ever imagined. However, we later realised that this was ok, since our aim was more focussed on encouraging students to do science than to investigate particular topics. Also, stuff is complex and dynamic - it keeps changing, and sometimes changing quite quickly. Such complexities of the real stuff could lead students to ask different kinds of questions.

Some researchers have noted the value in allowing students to define questions and solve problems which are not presented to them in a highly structured, algorithmic manner (Roth & McGinn, 1997; Haydock, 2011)). In our previous work we have found advantages of an open-ended approach in which students investigate stuff and do not 'get the right answers' (Haydock, 2014). If real-world stuff is the motivation and students are allowed enough freedom to define their own questions, it is likely that the interconnections between different domains of investigation will arise. We wonder whether relationships to personal and social problems will also arise.

8.5.2.3 Should or can teachers be 'expert' of 'science content'?

Generally many people say that a good teacher is an expert of the science content. If teachers really want to deliver better, it is expected that teachers should be able to answer all the students' questions. In order to improve school teaching, there is a great emphasis on teaching teachers the science content. Some people even claim that pedagogy is irrelevant, or less important, and that teachers only need to be 'experts' of their science content knowledge.

Generally teachers are expected to be prepared to answer all the students' questions. But why should teachers answer all the students' questions? Are the answers what children want or need to know or confirm? Are teachers' 'expert answers' even correct? We think what is also important is that students should question the answers and ask their own questions.

At times student questioning may not be authentic, especially when they are asking their questions to 'authority'. They may be asking for just to verify the authority of the teacher or the other adults. In discussing the master pupil relation, Meyer explains how sometimes children ask questions only to be answered by the master so as to confirm master's mastership. In such a scenario the child seeks the proof of mastership and the master gives the proof by imposing as a master.

In rhetoric, ethos is the capacity to provide answers: hence the role of responsibility, which turns ethos into ethics. I am accountable for my answers: on health, if I am a physician, on law, if I am a lawyer, on the common good, if I am solicited as a human being. Our opinions are characteristic of who we are and as such reveal our character. Our credibility and our authority (even our expertise, if someone appeals to it) are at stake. All this explains why ethos is a stopping point in the sequence of a potentially infinite questioning. Think of the three-year-old child who relentlessly asks her father, "Why?" After a certain time, the father, exasperated, usually replies, "Because!" Astonishingly, the child feels happy, offering a reaction that has often surprised psychologists. Why is the child happy with such a manifestation of authority, which is not really an answer to the question raised? Because her problem is to verify that her father has the authority and identity (ethos) she expects from him. That ethos manifests itself in the capacity to respond reasonably and in the fact that the father imposes himself as a father, thereby expressing his real ethos to his child, who was demanding nothing other than such a "proof." The father then behaves as expected: his answers show he is answerable as a father. (Meyer, 2010, p. 409)

This master-pupil school-school game can actually hinder the authentic questioning process of students inside the classrooms. So to have an authentic discourse in classrooms teachers as well as students have to become more critical of the teacher-student relationship. They have to question the expert-novice identities of teachers and students. We can question why and to

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what extent teachers really need to be experts, especially if teachers as well as students will be asking authentic questions. If teachers would be involved in the inquiry process, they would surely come across many questions which they might not know the answers.

In our experience, as we analysed data, we also had to do a lot of internet research and investigation in order to understand what the students were doing - to understand their questions as well as the possible answers to their questions. We found that the students had asked so many questions for which we did not know the answers - and some questions for which no one knows the answers, and some questions that no one may ever have asked before. For example, we did internet searches related to the variegated Bhendi tree, its classification, flowering, thorn production, and other properties. While analysing the videos of the students, we often had to go back to the tree and do some investigations of our own. We did internet research on different designs of parachutes, as well as our own hands-on exploration in order to better understand the design students were making and why they were making them in a particular way. We investigated ant behaviour and the kind of foods ants eat and what kind of food they like the most, whether ants can hear or sense audible sounds, whether and how ants smell or sense things. Furthermore, this led us to ask many other questions, which we had never thought of before we started handling and observing the stuff. In the beginning, we were not at all expert in the areas and topics the students were exploring and sometimes we were no more knowledgeable than the students in our knowledge related to the topics. But we do not think that this was a hindrance. Rather we think this helped in that we were much less evaluative and authoritative. At times we purposefully tried to not act as 'teachers', though it was not easy to move away from our 'teacherness'.

We claim that coming up with authentic, unanswered questions will inevitably occur whenever anyone deals with real stuff and gets involved in the process of inquiry. If students carry on spontaneous discourse, teachers need not know all the answers. They can join with them in the inquiry and together investigate the students' as well as the teacher's authentic questions. Teachers can bring in their own experience of the process of scientific inquiry and participate along with the students to mediate their inquiry process.

8.5.3 Suggestions for Teacher Professional Development (TPD) programmes

8.5.3.1 Need to have discourse with teachers on classroom questioning - my TPD experience

Lately I have taken a few teacher training sessions on the role of student questioning with the government school teachers teaching science. In these sessions the purpose was to understand the importance of student questioning and how it can be encouraged in classrooms by having discussions with the teachers on the different aspects regarding student questioning. These discussions, in conjunction with the results of my research, led to some important insights about the teachers' perceptions about classroom questioning.

In order to initiate the discussions around classroom questioning with the teachers, I decided to give the teachers some stuff to observe and handle and ask them to ask questions about the stuff, working in small groups. It was noted, teachers would sometimes list questions for which they already knew the answers. This led to some discussion around 'what is a question' and whether if someone knows the answer to a question then would it be considered as a question for that person or not.

There were discussions done with teachers for the possible reasons why students ask less questions. In these discussions teachers suggested various reasons as listed below:

1. The mother language of children is generally different than the language of the medium of instruction in the classroom. So they are less confident while speaking in class. Due to language problems they might find difficulties in formulating their questions.
2. Students' questions are ignored or avoided by teachers.
3. Teachers do not answer students' questions.
4. Sometimes at home and even in school the children's questions, especially why questions, are answered by giving reasons like 'because of God'. Such answers discourage children from thinking and asking more questions.
5. Students are not able to understand what the teacher teaches, so they do not have any questions.
6. Lack of confidence among students.

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7. Questions are not coming into students' minds.
8. Children do not get opportunities to ask questions at home as well as school.
9. Lack of group discussions among students in class.
10. Inferiority complex among students.
11. Lack of interest among children.
12. Teachers do not encourage student questions.
13. Lack of prior experience among students.
14. Social and economic backgrounds of students.
15. Shyness among students.
16. Fear among students for being laughed at by others.
17. Gender difference.
18. Lack of knowledge among students.
19. Disabilities among students like poor eyesight.
20. Students' poor health or lack of proper food.
21. Environment at home.
22. Lack of interest in the subject or topic.
23. Fear of teachers.

Perhaps teachers own reflections about these reasons are very important and more discourse around each of these issues need to be done with the teachers in order to encourage student questioning. One of the reasons for students not asking questions cited by many teachers was fear among students: fear of being stupid, fear of being laughed at, fear of teachers etc. Some of the teachers actually did raise this question of how they can reduce such a fear in their classrooms. Such discussions with teachers we think are important and may help in bringing about changes with regard to student questioning in the classrooms.

When asked what to do when students start asking questions, most of the teachers seemed to have the opinion that they must answer all of the students' questions. Some of them said it's the teacher's duty to answer all of the students' questions. Although, they did not say explicitly, but it seemed that they think if a teacher cannot answer a student's question, then it is very shameful for the teacher. This notion among teachers needs to be changed. Teachers must accept that there can be questions for which they might not know the answers. It was advised that such questions can be taken up for inquiry by the students and the teacher together. Also at times teachers should knowingly not answer students' questions directly and immediately. They can respond in ways that make students think further about the question and grapple with the questions for some time.

From discussions with teachers it seemed that most of them think that all questions have definitive (or closed) answers. However there are questions which have multiple answers, probabilistic answers or descriptive answers. There can be questions which may not be answered or whose answers may be beyond the purview of science. Most of the teachers seemed to be unaware of all these different types of questions. Perhaps the idea of fixed or closed answers may be coming from the way students are assessed in tests or exams in our schools. If we want to improve our assessment systems we must ensure that teachers should better understand the nature and process of questions and answers.

Also the discussions on the role of questioning in doing science revealed several wrong notions among teachers about the nature of science. For example, they think that science always provides definitive answers to questions, science is very fixed and constant and never changing, one cannot challenge the theories of science and they are perfect truths. There is a need to have discourse with teachers about the nature of science, how science is done (where the 'knowledge' comes from), and how the science teaching practices contribute to creating an image about the nature of science in schools.

Furthermore, we think just having discourse around student questioning with teachers cannot be sufficient. We think teacher training programs, especially in India, generally focus on content and teaching methods. They lack a discourse around meta questions like why and what kind of education we should have, why we should teach science, which questions and topics are important, and the discourse on questions about curriculum, syllabus and textbooks. Discourse around teaching and education with teachers should deal with social,

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economical and political context of education, as these are the important issues that teachers need to reflect upon.

8.5.3.2 Need to have a discourse with teachers on nature of science and its complexities

While doing analysis about student questioning and its role in doing science, we found that questioning and other aspects of science are interconnected and interdependent in very complex ways. We found that each of these aspects (whether questioning, observing, arguing, investigating, analysing, etc.) did not occur in isolation as students engaged in the process of doing science. So learning and doing science would always involve engagement with many of these different aspects in various complex ways. This realisation was quite important for us in understanding the nature of science and the complexities of the process of questioning.

We think that unless teachers can appreciate this complex nature of science and web of different aspects of science, they may not be able to meaningfully engage their own students in the process of learning and doing science. This could be possible only if teachers themselves get opportunities to ask their own questions, do their own investigations and engage in the process of doing science. So we must include such components in teacher training programs so as to involve teachers in a discourse around the complex nature of science and the process of learning and doing science.

8.5.3.3 Teachers listening to their own classroom teaching

As we were analysing the recordings, we realised that when we were outside observing and interacting with the students in informal contexts, we had not noticed many of the students' questions. This was despite our efforts to focus on their questions and even at times to record them in writing as they were asked. This suggests that teachers may also have trouble noticing students questions when students are involved in doing activities and discourse among themselves. They might find it helpful to video record student discussions and view the recordings with students or with other teachers. Teachers could observe each other's classes. Through such observations, teachers can also reflect upon their own questioning as well as students' questioning.

8.6 Contributions of this study in the field of student questioning research and questions for further research

Previous research has failed to draw from some important studies in the area of philosophy of questioning to understand the process of student questioning. Our study is seemingly the first one that draws from the ideas of Michel Meyer and use these ideas to understand the process of student questioning. In our study we have raised some important questions on the ways student questioning has been previously conceptualised and how previous research has undermined the process of questioning.

Our study provides some insights and directions to previously researched aspects of student questioning. Importantly, our study gives insights into some newer aspects of student questioning which have not been studied previously and raises questions for future research in this field. Further research in each of these aspects (as listed below) could lend important insights about student questioning.

1. Students' implicit questioning and the process of implicit questions becoming explicit.
2. Teacher and student rhetorical questioning and how it could help understand the dynamics of student-student and student-teacher discourse, especially the power dynamics.
3. The interrelation between student questioning and their argumentation.
4. Role of social factors like emotions, power relations, gender etc. in student questioning and their argumentation.
5. The dynamic relationship between student questioning and answering.
6. The interrelation and interdependence between student questioning and various other aspects of doing science, like observing, various kinds of reasoning, hypothesizing, investigating, etc.
7. Role of physical stuff in the student questioning process.
8. Students' non-verbal questioning (gestures, facial expressions, etc.).

8.7 Generic suggestion: We must change our ways of looking at children

Rather than just thinking about ways that we can change children - what they should do and how they should do it - we need to also change some of our ways of looking at children. Children may already be doing many interesting things that we are not aware of. Our research suggests that they are already asking themselves and each other many interesting and important questions, but all too often we do not get to hear these questions.

Our lens of looking at children should change. We think children are very creative and possess 'scientificness'. So we just need to appreciate this. Whatever they do, we need to see meanings in that, rather than making them do what we intend and then evaluate what went right or wrong and what did they learn.

Alison Gopnik, a cognitive developmental psychologist who has looked into how children learn and construct theories about their world, argues that young children are quite capable of understanding complex phenomena and possess abilities which we hardly ever recognise. She says:

The new research shows that even very young children are deeply engaged in such profoundly cognitive work as hypothesis testing and causal inference. This work is more cognitively challenging, in fact, than much school work.

... the new research suggests that our everyday thinking and learning is strikingly continuous with scientific thinking and learning. Of course, formal scientific thinking involves a level of self-conscious reflection, including reflection on the very process of science itself. We don't see this reflection in very young children: The pre-schoolers see probabilistic evidence and revise hypotheses, but they don't necessarily know that that is what they are doing—nor indeed do ordinary adults. (Gopnik, 2012, p. 1627)

This is in line with our research findings, although we have been working with older children. She hopes that this research will lead parents and policy makers to stop underestimating the intellectual capabilities of young children. These findings help us understand more about the nature of science, how people do science, and how to teach and learn science through

“everyday casual experience”. As Gopnick (2012, p. 1627) says, based on such studies, adults might also learn in the same ways children learn:

Ordinary adults might also learn scientific concepts more effectively through play, experimentation, and observation than through pedagogy.

The way we treat children in schools and even outside, we assume them to be less capable and less intellectual, who always need to be taught. Our schooling treats them as consumers whereas they can be producers and play an important role in building our societies.

There is no reason that early elementary students cannot produce unprecedented knowledge about the world. (Kincheloe, 2008, p.21)

Students should realise that they can create new content and new knowledge. Of course, this may create problems for teachers as they may lose some of their authority and power over students.

8.8 Limitations

Though we wanted to observe and analyse students’ spontaneous talk without any adults or the teacher, it was of course not possible to record or observe students without being present and having some effect on the students. Their talk that we recorded was indeed informal but it may not have captured the kind of discourse students might be doing in their everyday talks without the presence of any adult around. We do think that it is important to understand student questioning in the absence of adults. One solution to this problem would be to do insider research in which students study themselves.

In classrooms it was not easy to find out what individual students were doing, whether they were listening to the teacher, what they were whispering, or whether they were engaged in some questioning with each other or with themselves. One of the reasons for this difficulty was that for two of the classes (among three reported in this study) we only made audio recordings and thus could not see what students were doing. Also, we could only hear the voices of students who were talking loudly or sitting close to the recorder. Even in the class that we video recorded, we used only one video camera, which could only focus on a few of

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the students' actions. In future research we would need to include better video and audio recording techniques.

We have not investigated much about students' questions that were not verbalised. While exploring various stuff either individually or in groups, students were asking questions to themselves which could only be understood by analysing their actions in detail. How they observed and manipulated the stuff, their facial expressions and gestures, and how they performed certain actions on the stuff, tells us about their questioning which they never verbalised. But we faced some technical limitations that prevented us from examining and understanding non-verbalised questioning. The quality of our recording was not sufficient due to background noise and our lack of expertise and lack of concentration when we were both recording and interacting with the students.

Since we were interested in students' spontaneous questioning, in our reports we concentrated on their oral questioning. Though we have also collected students' written questions, and have done some analysis of them, we have not written about this work. Students' written questions could reveal more about the process of questioning, especially in relation to classroom contexts where more stress is given on written work. In continuation to this work, in future we would like to do further analysis of students' written questioning and also compare it to their oral questioning.

8.9 Questioning and democracy

In schools students are being trained at listening and accepting what they are told rather than raising and investigating questions. They are trained not to question authorities. The present education system does not encourage students to question or challenge the status quo. Whether stated or unstated, one of the main aims of formal education appears to be the enculturation of children so that they unquestioningly conform to fixed social 'norms' (Freire & Faundez, 1989).

As Socrates has said that true knowledge lies in asking questions to authorities and making them realise that their 'alleged' knowledge is questionable. Socrates even questions himself and his knowledge saying that the only thing he knows is that he does not know anything. This way he challenges his alleged 'mastership'. By attacking his own mastership he argues that just because one has a higher social position, it does not mean one knows more. Thereby

he questions the wisdom of notables, the elites (or rich), whose opinions and decisions are accepted without questioning.

Mastership is precisely what Socrates puts into question. The social role of dialectical questioning leads Socrates invariably to consider ethico-political questions: "can 'excellence' (αρετή) be taught?," or "is it really necessary to have a Master to teach one 'excellence' in order to acquire it?" Rather, virtue (αρετή) is present in every man. Whence the famous saying "know thyself!" of the Charmides (164d) which means "think for yourself!" Virtue can be found in each one of us: it is not a question of technique, therefore of teaching, nor is it inscribed within the social rank of each individual. The eulogy of the freedom of thought finally cost Socrates his life: mastership cannot be contested without bringing down the wrath of the master. (Meyer, 1980a, p. 282)

It's important that students start talking, and they should realise that their talk is important. They should realise that others (teachers, parents and adults) are listening to them. Unless students have opportunities to question, unless they realise that their questions are relevant and important, it may be difficult for them to keep questioning.

We want that children should be given ample opportunities to talk and ask questions among themselves. We want that they keep questioning irrespective whether in the classroom or at home or outside. They should explore their world through continuous questioning and which continues even when they become adults. They should be critical about existing social and cultural practices. Unless we base our education on questioning and critical thinking, we cannot expect our societies to transform to more equal and just societies.

Questioning arises when we have perplexity, ambiguities, doubts, hesitations, dilemma, alternatives. So unless we give space for alternate views and alternate ideas, questioning would not arise, and we here see a close connection between questioning and democracy.

ὁ δὲ ἀνεξέταστος βίος οὐ βιωτὸς ἀνθρώπων.

छान बीन से हीन (अपरीक्षित) जीवन, मानव का जीवन नहीं है।

An unexamined life is not a worthy human life. (Socrates, Apology 38a):

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