Making environmental studies engaging for elementary school students

■ Rupali Shinde ■ Adithi Muralidhar ■ Sugra Chunawala

Abstract

This article describes our attempt to engage Grade 5 (aged 10-11) students in a meaningful discussion in an inquiry-based science classroom on the topic of food chains and webs. Students were encouraged to speak, write and draw their ideas on a worksheet used as a pedagogical tool to elicit students' conceptions about the topic. This paper reports on students' responses to the worksheet and some preliminary analysis of their talk. We found that the worksheet promoted classroom engagement and discussion among students and revealed their ideas about the environment. Our work is particularly relevant in the context of Indian classrooms with large numbers of students (up to 65 students in this case), where the student population is heterogeneous.

Keywords: Environment, teaching/learning, food chains, student engagement, science education

Introduction

An important consideration in teaching is keeping students engaged and yet being aware of opportunities where learning can take place. In a review of over 200 research studies Aloisi *et al* (2014) suggest that teachers' content knowledge as well as their abilities to understand students' thinking and conduct formative assessments are closely tied to students' academic attainment. They highlight the importance of teachers encouraging students to raise questions during activities in lessons. In science classrooms, some of the strategies to engage students meaningfully include encouraging classroom talk and promoting individual or collective expressions (Mitchell, 2010), and contextualising science for students with their environment by emphasising science and society linkages (for example, see Sjøberg & Schreiner, 2010; Science Education for Diversity, 2012). Of particular interest to us is the need to promote classroom talk, students' questions and self-expression.

Numerous studies have highlighted that student questions, which can emerge from classroom discussions, are an important part of teaching and learning science (Dillon, 1988). These questions can be a resource for teachers (Chin & Osborne, 2008). In Indian schools, however, classroom talk, dialogue and questioning are generally missing and various researchers have suggested that teachers should find ways to create more opportunities for student interactions (Singh, Shaikh & Haydock, 2019; Sengupta, Chandrika, Dey & Ramadas, 2020). Encouraging questions in a classroom provides space for student voices. Classroom talk between teacher and pupil/s or between pupils (Barnes, 2010) can result in hypothesising, debating and exploring issues.

Literature over the years has highlighted that, besides classroom talk, well-designed worksheets are a means to construct knowledge, elicit students' interests, enhance development of skills, assess students' prior knowledge and identify and address students' misconceptions. However, scholars have also cautioned that poorly designed worksheets and a lack of pedagogical knowledge may hinder the effectiveness of worksheets for learning (Griffin & Symington, 1997; Che-Di Lee, 2014). The current study uses worksheets to spark students' expression and engage students with a topic in a science classroom. In India, the National Curriculum Framework (NCF) (NCERT, 2005) has adopted the constructivist framework and recommends that learners be presented with authentic experiences to actively participate in science classes. It is in this background that we place our study of engaging students of Grade 5 (ages 10-11) learning 'Environmental Studies' (EVS) as part of their school curriculum.

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Environmental studies, also labelled as Environment Education (EE), has been gaining worldwide importance over the last few decades (United Nations, 1972; Tbilisi Declaration, 1977; UNEDP, 1992). The NCF suggests that environment should be emphasised in every subject and through a wide range of activities (NCERT, 2005). In India, EE became a mandatory component of school education and is 'integrated' with science and social studies. Currently in the Indian state of Maharashtra (where this study is conducted), EVS is presented as an integrated subject (includes science and social studies) for Grades 3-5.

Context of the study

A collaborative project

We are members of a centre for science education involved in a longitudinal collaborative project with a neighbourhood school where the instructional language is Marathi (official language of Maharashtra State). The study is based in Mumbai, the capital of Maharashtra State. The broader aim of the project is to improve students' classroom learning experience of EVS. This is done by collaborating with schoolteachers to develop lesson plans and implement them in the classroom for each chapter of the EVS textbook. The school timetable, on average, schedules a chapter to be completed in a week (6 working days), with a class of 35 minutes' duration daily. The number of students in the class is around 70 (about 65 may be present on any one day). The classroom sessions are conducted by us, or the schoolteacher, or both together, and mutual feedback is sought and exchanged before and after each class. In addition, there is a non-participatory observer who provides feedback on all the sessions. The EVS teacher appointed by the school for this class happens to be a language teacher with no formal science or social studies background. Educationalists have emphasised the importance of subject (SCK) and pedagogical content knowledge (PCK) in shaping the classroom practices of teachers (Shulman, 1987; Appleton, 2013). In our context, this teacher with an educational qualification in languages has some challenges in teaching the EVS curriculum and generally resorted to getting students to read paragraphs from the textbook and learn the new words and terminologies. The revised approach adopted by us and the teacher focused on transacting this curriculum through activities that relate the topics to students' lives. This approach also provides opportunities for students to raise questions (Chin & Osborne, 2008) as a means to foster student engagement. The focus of this paper is on those sessions that were conducted to transact the topic of food chains and food webs.

Chapters in the EVS textbook

The EVS textbook (Part 1) for use with Grade 5 in Maharashtra State (2015) has 25 chapters spread over themes, which we have categorised as *Our Surroundings; Family, School and Community; Our Body; Basic Needs; Maps and Directions;* and *Transportation and Communication.* Figure 1 presents details of themes and chapters of the Grade 5 EVS textbook.

In this article, we report our work with respect to the chapter entitled *Environmental Balance,* which is a part of the theme, *Our Surroundings.* While we are aware that the concept of 'balance' in the environment is fluid, complex and contested (Haydock & Srivastava, 2017), our focus was on the textbook content that does not deal with the differing interpretations existing around the term. It is also to be noted that the textbook used in the class was in the Marathi language and the terminologies do not map exactly to the terms in the English textbook. Rather, we have focused on specific concepts (for example, food chains, food webs) mentioned in the chapter and have attempted to address these in the classroom. Earlier studies on students' understanding of food chains and food webs have discussed students' preconceptions and emphasised the need to facilitate a clear conceptual development on these topics at school (Webb & Boltt, 1990).

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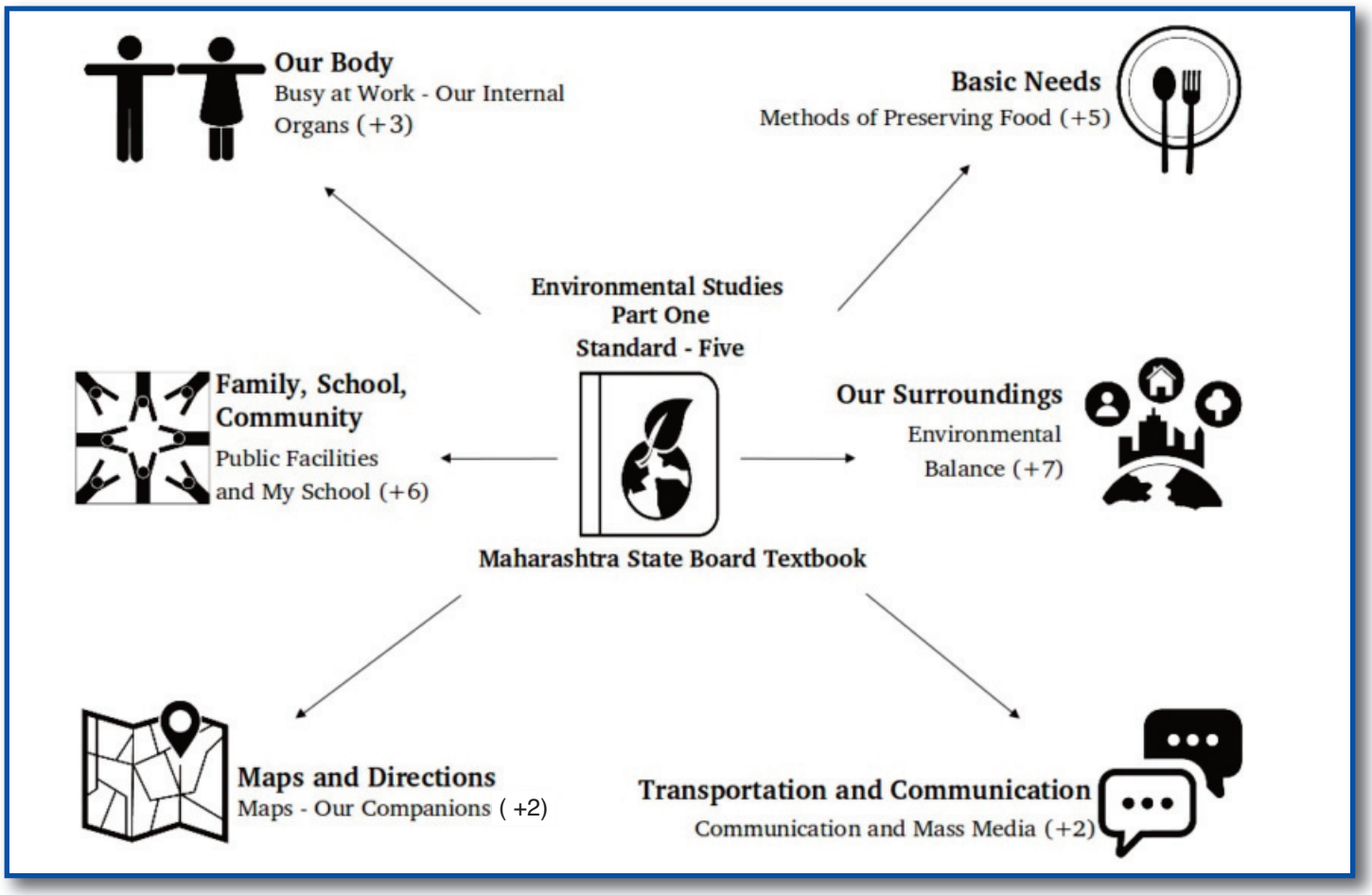
Figure 1. Themes in the textbook (in bold), with one representative example of a chapter. (The number in brackets denotes additional chapters under the same theme.)



Methodology

This study aligns itself with a Design-Based Research (DBR Collective, 2003) approach, which addresses complex issues or problems in real-life contexts. Our study is interventionist, and carried out in collaboration with practitioners, that is, the teachers in the school. A DBR approach involves a reflective inquiry process to evaluate the learning environment, which in turn helps to revise the solutions (Christensen & West, 2018).

Our initial interactions with the students (July 2017) led us to realise that worksheets aided the students' expressions of their ideas through writing or drawing, specifically as the classroom size often prevented students from being able to voice their thoughts. Our decision to use a worksheet was informed by literature (Kaymakcı, 2012; Kisiel, 2003) and our experiences and learning from classroom observations (Deshmukh *et al,* 2018; Karandikar & Shinde, 2020). We designed a worksheet for use in the classroom and, based on students' responses and our own reflections, it was revised and trialled with a smaller group of students in a summer camp (May 2018). These summer camps are organised by us each year, for students of the school and of the grade with which we are interacting in the academic year.

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Our reasons for using a worksheet were multifold. Apart from the positives of using worksheets, such as their usefulness in revealing students' previous knowledge (Sasmaz-Oren & Ormanci, 2012), and functioning as advance organisers, helping students to organise their observations and knowledge (Kisiel, 2003), we felt that these may be particularly useful in classes with a large number of students (Gupta, 2004). A large class size poses additional demands on a teacher for classroom management as well as to get across the key aspects of the concept being taught. Typically, we found that, with a class size of around 70 students, which is well beyond the class size recommended by the government (Right to Education Act, 2010), and within the constraints of the infrastructure in the classroom that make it difficult even for the teacher to move around, student participation and group work were challenging. Basically, in such situations, we found it difficult to respond to student voices and questions, and hoped that a worksheet would help in capturing students' ideas.

It is to be noted that the use of worksheets to enhance learning and increase student engagement is not common in the Indian public school system, and especially the schools with Marathi as the medium of teaching/learning. The worksheet we designed for our session allowed for multiple modes of expression, involving writing, drawing or both, and gave students space to express their understanding of the topic. Visualising and drawing contribute to knowledge formation by the learner and help to create environments that invite students to engage in reasoning, experimenting, communicating and reflecting (Evagorou, Erduran & Mäntylä, 2015; Ainsworth *et al*, 2016). Drawing may also serve to bring forth the alternate conceptions held by students (Köse, 2008). Besides, we were aware that drawing tasks were engaging for students (Deshmukh *et al,* 2018). In this article, we discuss students' responses retrieved from the worksheet or during their classroom talk when they shared their ideas and experiences.

Observations

An overarching objective of the classroom sessions for the chapter on 'environmental balance' was to help students reach conceptual understanding of the topics of food chains and food webs in an engaging manner, through asking questions, and exchanging as well as expressing their ideas and understandings as they undertook the worksheet-solving experience.

Pre-worksheet activities: Classroom sessions with a game on food chains (July 2017)

The concept of food chains is important in understanding the dynamics of the environment and is also emphasised in the EVS textbook. Food chain dynamics is also a key theory of ecology and having a sound understanding of this concept can provide insight into the factors that affect population regulation and cycle, competition, stability and diversity, evolutionary ecology and biogeography (Fretwell, 1987).

Our preliminary attempt to start the lesson was by posing a number of questions, but we were unable to make sense of the chorus of replies given by the students. Our intention was to create learning spaces where students could discuss their ideas and express their opinions, because listening to and responding to peers can help to build interest (Lewis & Burman, 2008; St. John & Briel, 2017). However, with a large number of students, the chorus responses quickly translated into 'chaos'. Teachers often are inhibited from implementing their ideas of student-centred learning in large classroom populations because of such reasons. We realised that we would have to engage the students in other ways if we wished to attain our teaching and learning goals, and hence we planned to introduce the concept of 'food chains' through a game. This game involved giving a picture card to a pair of students. Each picture card depicted some living form (animal, bird, plant, micro-organism). Students were given time to familiarise themselves

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with the card. We then called a pair of students at random to the front of the class, asked them what was depicted on their picture card and wrote it on the board: for instance, 'rat'. We then asked the class to refer to their picture cards and answer whether their card depicted a prey or predator of the original card (rat). For example, we asked, *'Do you have a card of something that eats, or is eaten by, a rat?'.* The responses led to another pair of students sharing their card with the class, for example, 'owl'. We then asked *'who eats owls?'* or *'what else does an owl eat?'* Thus we drew 'food chains' on the blackboard corresponding to students' responses based on the picture cards.

Students' alternative conceptions emerged during the course of the game. For example, one student remarked that *'There are thorns (scales/spikes) on a crocodile's body so nobody in the environment can eat a crocodile'.* Possibly students were thinking of predators for animals such as crocodiles and reasons for why there are none or very few. Though seemingly large and bulky animals such as crocodiles and elephants can be predated upon, it was interesting to see how students made links between body size and structure and vulnerability to predation (Gallegos, Jerezano & Flores, 1994). Another student commented that *'if the snake eats a lizard, the snake dies because the lizard is poisonous'*. Here too was an opportunity to discuss differences between venomous and poisonous animals and a predator's immunity against certain poisonous prey species. Overall, we found that the game was successful in engaging the students and helped to bring forth the alternate conceptions among students. The subsequent session was planned to introduce students to think of multiple life forms and interconnections between food chains.

Worksheet development (July 2017)

In the game discussed earlier, students had only one organism/life form to think about at a time. In the next stage, we developed a worksheet where students had to consider multiple life forms simultaneously, thereby bringing in the complexity of the phenomenon. These multiple life forms were utilised by the instructor to draw a food web on the board. This worksheet displayed two drawings, one depicting a full-grown tree and the other a stump ('cut' tree). Students were asked to write or draw the living organisms found under each on/around/under the drawings of the tree and the stump. This worksheet attempted to relate classroom experience to students' daily life experiences about the environment and to get them to make connections between organisms and their habitats. We hoped that the contrast between the two drawings, a full-grown tree and a stump, would spark students' curiosity and elicit questions and expressions of students' ideas (Chin, 2001).

Students' responses to and the resultant redesigning of the worksheet

Students' responses to the worksheet

The majority (89%) of students (60 of the 67) drew or listed more living forms in and around the full-grown tree when compared to the stump. We also found 56 discrete/unique indications of living and non-living components, which may have otherwise not found a place in the classroom if verbal expression only were to take place. Examples of living organisms included earthworm, monkey, cow, insects and snakes, while non-living components included drawings or mention of the Sun, oxygen and carbon dioxide around the tree. These responses provide a range of examples with which students are familiar and can be used by a teacher in further conversations during the lesson. Figures 2 and 3 depict one student's work as a sample of the responses received.

In our discussion with the entire class, we focused on the fact that, if trees are cut, one may observe changes in food chains. For example, one student drew birds on the tree but not on the drawing of the stump, and depicted a snake in both contexts. Thus

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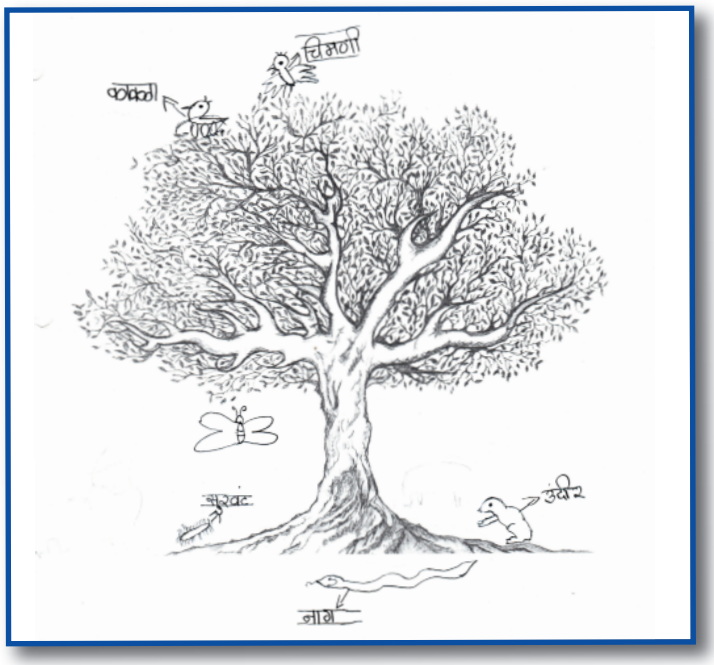
Figure 2 (L). The labels written for the organisms drawn by the student on the worksheet have been translated into English. In a clockwise manner, starting from bottom left, are: *Millipede, Butterfly, Crow, Sparrow, Rat, Snake-Cobra.*
(Image credit: Tree Sketch Easy by Brandie Bell, used under CC BY-NC 4.0 License.)

Figure 3 (R): The labels written for the organisms drawn by the student have been translated into English. In a clockwise manner, starting from bottom left, are: *Snail, Snake, Earthworm, Squirrel, Millipede.*
(Image credit: This 'cut tree' is a derivative of *Tree Sketch Easy* by Brandie Bell used under CC BY-NC 4.0 License. 'Cut tree' is licensed under CC BY-NC 4.0 License by P. Nawale.)



there were multiple opportunities to discuss concepts of interdependency of elements of a food chain, prey base, predator-prey relationship, etc., using the responses derived from students.
Despite the fact that the worksheet permitted multiple modes of expression, we found that writing was more popular among students. Of the 67 worksheets received, all students wrote on the worksheets and about 86% of these worksheets depicted writings exclusively.

Only 13% of worksheets had students communicating through both drawings and writings. We had requested that students add labels to their drawings and had assured them that they need not worry about the aesthetic aspects of their drawings. Our findings suggest that students write rather than draw on worksheets and this had been reported earlier by Mathai and Ramadas (2009) in their study of visuals. One possible explanation for our findings can be that the practice of writing, which is *'a language-dependent mode of representation',* tends to be privileged or prioritised over other forms of representation from a young age (Kendrick & Mckay, 2004). Other possibilities are that students associate drawing activities with art classes and may not relate them to science or environment education, despite studies highlighting the usefulness of drawings in science classrooms (Shaaron, Vaughan & Russell, 2011).

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Summary of observations

Students were quite animated and a great deal of classroom talk was generated when the worksheets were used. These interactions provide insights into students' ideas about the environment. Table 1 presents a few examples of students' talk (translated from Marathi), indicating their questions and their attempts to relate contextual information to their prior knowledge and observations. The categories in the table are informed by the literature mentioned in the introduction and below.

After students had completed the worksheet, we summarised the activity by making food chains and food webs on the blackboard using the organisms listed or drawn by students. While reflecting on the session, we felt that, instead of us drawing the food chains and webs, we could have incorporated this aspect in the worksheet so that students could be more involved. This inspired us to include an additional task in the worksheet. However, since the regular class schedule had to be maintained, we undertook the implementation of the redesigned worksheets in a summer camp.

Communication (type)	Excerpts of talk
Asking questions (Chin & Osborne, 2008; Singh, Shaikh & Haydock, 2018; Sengupta *et al*, 2020)	Boy: What would happen to small plants (saplings) growing under big trees if we cut the tree? Girl: If an elephant does not eat any animal, then where does it feature in the food chain?
Ethical concerns and environment (Baker *et a*l, 2019; Dutta & Chandrasekharan, 2015; Jickling, 2005)	Boy:…unnecessarily we cut the trees! Where there is a full-grown tree, many birds come and stay, many animals also stop by and we can write these in the worksheet. But there are very few things to list when it comes to the half-cut tree. So we should not cut trees.
Relating to own experiences (Sjøberg & Schreiner, 2010; SED, 2012)	Girl: In our village, we can see different birds and also birds eating insects, but here in our surroundings (in Mumbai), we don't see them much. Girl: In rainy season, trees look greener and there are many insects hovering around.
	Girl: Snakes stay below trees and, when a snake is hungry, it eats eggs from birds' nests [referring to an incident she heard in her village].
Alternate ideas (Munson, 1994; Gallegos, Jerezano & Flores, 1994; Natarajan *et al*, 1996; Chunawala *et al,* 1996; Tekkaya, 2002; Köse, 2008)	Girl: There are thorns (scales/spikes) on a crocodile's body so nobody in the environment can eat a crocodile. Boy: If the snake eats a lizard, the snake dies because the lizard is poisonous.

Table 1. Students' conversations during the game and worksheet session.

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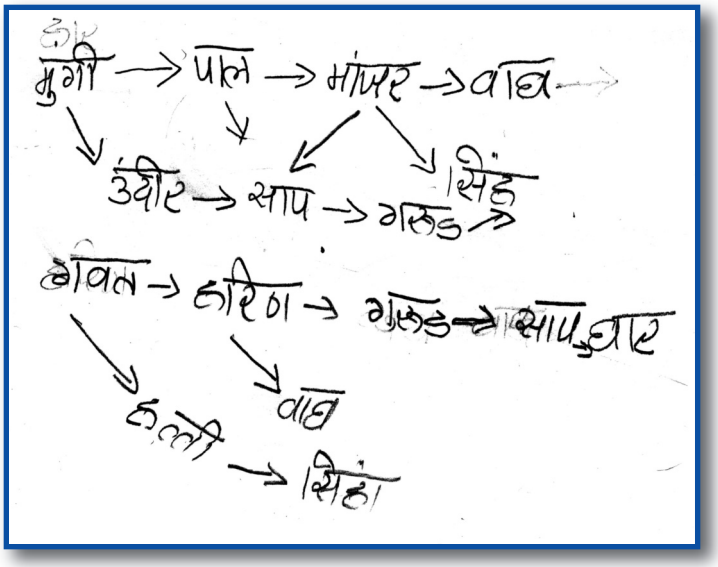
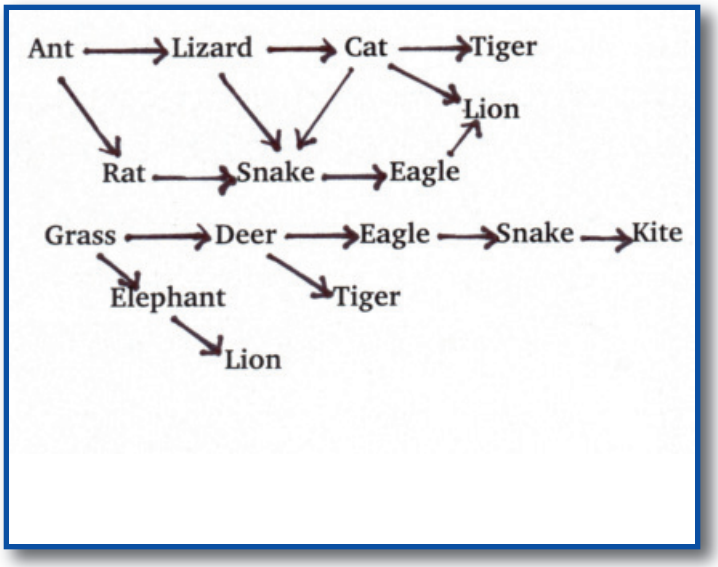
Figure 4. Sample of a set of food chains made by a pair of students in the redesigned worksheet (translated version is on the right)..





Redesigning the worksheet (May 2018)

The redesigned worksheet retained the earlier tasks but added a new task wherein students had to make use of the organisms drawn or listed on the sheet to make food chain/s or webs. We hoped that undertaking this activity would help students to consider the connections between organisms by themselves as opposed to the teacher explicating these ideas. Also, if students made their own food chains/webs, it would bring attention to the prey-predator concept. Students worked collaboratively in groups of two or three on this task. The redesigned worksheet had more blank spaces available for students' writings and drawings of food chains/webs and it was used with students in a summer camp (organised around 10 months after the classroom session). In this camp, some students from the same school and same grade participated voluntarily. When they were making the food chains (Figure 4), we subsequently introduced them to the idea that one organism may be part of more than one food chain, leading to the formation of a food web. We posed questions such as *'What would happen if one component of this food chain is removed?'* A student responded by writing *'From this food chain, if a sparrow is removed then the population of grasshoppers will increase. Also, as eagles eat sparrows and sparrows are destroyed, then eagles will no longer be there'.* This response is not entirely accurate (since eagles and sparrows have multiple food sources), but the response reveals an understanding of interdependency and interrelations between animals.

The redesigned worksheet helped to bring to the fore students' difficulties with the topic related to food chains/webs. We noticed that students were confused about the placement of dead organisms and decomposers in a food chain. Even though the topic of decomposers and decomposition is introduced for the first time to these students in this chapter, students reported being familiar with 'decomposers' owing to their prior experience of *seeing* small ants and other insects feeding on a big dead animal. However, they were confused about where to place them in the food chain.

Discussion and Implication

Environmental studies is a subject that can be related to lives of students and offers many

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opportunities to learn the subject beyond classroom walls (Grimshaw *et al*, 2019). Unfortunately, we know that EVS sessions take place only within closed classroom environments, often due to practical reasons (Bhide & Chunawala, 2017). Furthermore, large class sizes with limited opportunities to learn outdoors pose challenges to ways in which young minds can be engaged with the subject. Keeping these structural constraints in mind, we sought to improve students' classroom learning experience of EVS by creating several opportunities where students at least can observe, analyse and reflect on their outdoor life experiences and discuss these within the class. These discussions can help students to perceive more complex connections of human existence and their actions/processes with the ecosystems. The current study focuses on students' understanding of food chain/web concepts and efforts to facilitate discourse about these concepts through a worksheet-based class intervention.

The development and implementation of the worksheet in this study can be explained along the lines of progressive refinement in educational resource-building. We started with a simple inquiry through direct questioning and soon switched to a coherent game activity followed by a worksheet. An iteration to the worksheet was done following the participant students' inputs, performance in activity, and reflective feedback of teacher, authors and observers. Each time, students' observations about the chosen living systems and surrounding environment were made explicit to the class by encouraging them to engage with the practice of drawing, writing and discussing with appropriate probing.

In our experience, the activity coupled with the worksheet added value to the everyday classroom situation. Firstly, the worksheet allowed students to express themselves through multiple modes of expression such as writing/drawing, or both. Encouraging drawing would also allow a shift from exclusively verbal modes of communication and make available creative spaces in the classroom for students to present their ideas. While we bemoan the fact that the school system does not encourage students to draw in academic subjects, we noticed that, by Grade 5, students seemed to prefer writing over drawing. This is despite the fact that drawings (of the tree and stump) already present in the worksheet were central to eliciting responses from students. Having said that, it can be a worthwhile exercise for teachers to design worksheets in order to increase opportunities for communication in their classrooms. This is despite the fact that the already overworked teachers may need to research the concept, conceptualise the lesson plan accordingly and find ways to develop a writing/drawing task for a particular concept in the form of a worksheet.

Moreover, assessing responses to a worksheet and addressing those would require sustained efforts from teachers. In our earlier discussions, we highlighted two such exemplar occasions where probing provided additional opportunities for discussion, firstly when the differences of habitat around 'fully grown' and 'stump' were seen as different by a student. It is worthwhile to note these observations made by students and discuss them in the class. Another occasion was when a student's response to the redesigned worksheet revealed an understanding of the interdependency of organisms, which could aid in explaining food webs.

The introductory (game) activity and the worksheet elicited questions from students and generated informal talk in the class, which helped to bring to the surface students' alternate ideas about their surroundings and environment. We feel that the talk generated could give teachers pointers for which examples to use when introducing and teaching this topic (Sasmaz-Oren & Ormanci, 2012). Thus worksheets can give insights to a teacher if s/he attends to the responses of the students. The redesigning and implementation of the worksheet helped to reap dividends in terms of reaching out to

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students, engaging them, bringing about opportunities for discussion and helping to uncover their ideas about environmental interrelationships.

Our way forward would be to understand, in depth, which classroom situations call for using worksheets and how worksheets can be made and transacted effectively. We tried to learn from our failure in our first attempt of inquiry through direct questioning and this led to introducing the activity at the start of the class. Similarly, the details of iteration in the worksheet and the background conversations are made explicit to indicate that the worksheets were thoughtful pedagogic interventions and were revised following students' interactions with them, in a progressive manner. This messaging is particularly relevant in the Indian context, where worksheets are not commonly used for teaching/learning in the classroom.

We believe that several concepts in EVS can be introduced through worksheet activities as described in this paper. Furthermore, probing conversations about ideas such as interdependencies among environmental components can help students to see the connections between the environmental science learned in the classroom and their daily lives. We hope that Indian teachers in elementary schools explore and develop context-dependent educational resources in their regional languages to deepen inquiry in their classrooms.

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Rupali Shinde, Project Scientific Assistant, Homi Bhabha Centre for Science Education.
E-mail: rupali@hbcse.tifr.res.in

Adithi Muralidhar, Scientific Officer, Homi Bhabha Centre for Science Education.
E-mail: adithi@hbcse.tifr.res.in

Sugra Chunawala, Professor, Homi Bhabha Centre for Science Education.
E-mail: sugrac@hbcse.tifr.res.in

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