Middle School Students' Ideas about Energy and Its Flow through Organisms

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Abstract

The conceptual pre-requisites for teaching about the environment are embedded in several existing school subjects. However, the teaching of subjects like Science and Social Studies does not address all the linkages needed for environmental education. Topics related to current environmental concerns that are inadequately addressed in classrooms include energy, its flow through organisms, especially in relation to human life. We developed a short course on energy and environment, in which students of Class VIII engaged in a large variety of activities designed to explore their understanding of energy and its flow through life forms, with special emphasis on the link between humans, energy and the environment. This paper reports some of our insights gained through a variety of interactions with students and their implications for teaching.

Introduction

Any solution to the environmental crisis will need environmental awareness and understanding to be deeply rooted in the education of all people at all levels (Tbilisi, 1977). In fact, Environmental Education (EE) has been an important issue at the global level for close to four decades. Several aspects of EE have already been studied and published by researchers and thinkers from across the globe: broad and long-term goals of EE (Hungerford and Peyton, 1976; UNESCO, 1980); guidelines of EE (NGO Forum at the Earth Summit 1992; Gigliotti, 1990); principles of EE (CEE, 1999; Ballantyne et al. 1996); and pedagogic strategies for EE (Shome and Natarajan, 2007). The role of the teacher in EE has been

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recognised to be pivotal by all and has been specifically researched by some (Volk, 2003; Wilson, 1993; Kastenholz et al. 1994). Environmental study has been made a school subject in India by a policy initiative following Supreme Court directive (NCERT, 1981).

A model of EE, that has potential to address the bio-geographical, linguistic and other socio-cultural diversities of the country, recommends a large variety of pedagogic strategies aimed at immersing students in environmental thinking in the classroom and outside (Shome and Natarajan, 2007). The model also suggests that environmental aspects should also be integrated with school subjects. The rich possibilities of integrating environmental ideas in Science in the Indian context have been inadequately explored. Energy and photosynthesis are two of the topics in Science that invite such integration. At the global level, there have been research reports on students' alternative conceptions on energy (Watts, 1983; Trumper, 1997), ecosystem (Grotzer and Baska, 2003), photosynthesis, and respiration (Barman et. al 2006). The current study probed Indian middle school students' understanding of the concept of energy, photosynthesis and the link between humans and environment.

Methodology

The study involved developing a course for middle school students on energy and environment, selection of participants, collection of data, and drawing preliminary inferences about students' ideas based on semi-quantitative and qualitative analysis of multiple kinds of data.

Objectives of the Study

The broad aim of the study was to develop a course on Energy and Environment for middle school students, to explore their understanding of energy and its flow through life forms, with special emphasis on the link between humans, environment and energy. Participants: A purposive and convenient sampling was used. Forty students (30 Boys, 10 Girls) of Class VIII (mean age 13 years) from three nearby English medium schools affiliated to the CBSE system voluntarily participated in the course.

Framework of the Course

According to Carlsson (2002), an understanding of photosynthesis, cycling of matter, the flow of energy and the connections between them are prerequisites for developing an insight into ecology. We have adapted a model proposed by him for the study of ecological understanding among students after omitting 'ways of thinking about recycling'.

Course Structure

The course, which was conducted over eight days, was repeated in two sessions for the two batches of students – one each in the morning and evening. Students were given opportunities to articulate, defend and explain their ideas within the social context of the classroom (Solomon, 1991; Prain and Hand, 1996). Open-ended questions, creative writing, explanations and classroom dialogue helped students refine their understanding (Glasson and Lalik, 1993 as in Prain and Hand 1996). The sessions included lectures, experiments, surveys, audits, and other activities. Activities relevant for

the current paper are summarised below.

Activity Sheets

Students responded to three activity sheets, one each on environment, energy, and photosynthesis. The questions in the sheets were based on a literature survey of related topics, our experiences of teaching students and an analysis of the science textbooks up to Class VIII (NCERT). The questions were in a variety of formats: multiple choice, true/false, and those requiring either one word or open ended short answers, or diagrams.

Lectures and Discussions

There were structured lectures and several opportunities were provided for discussions in the whole class and in groups, which served to explore students' ideas, discuss students' responses to activity sheets, prepare students for activities and enrich content knowledge. Drawing (context map, posters): After being initiated, groups of students worked collaboratively drawing a context map on 'Human and the Environment'. The groups also made posters on the imagined energy scenario of 'Human Civilization 500 Years from Now.'

Writing (Science Fiction)

Individual students wrote on 'A world without energy'. The writing task was followed by consolidated presentation by each group.

Role Play

Research on role play in teaching-learning (Simonneaux, 2002; Proulx, 2004) suggests that it is an effective tool in bringing social context into the classrooms. We used role, play as a strategy to introduce students to democratic informed decision making.

Data Collection

Data was collected in the form of students' responses to questionnaires, other writings, drawings and posters, through audio-visual recordings of discussions and structured presentations, as well as researcher's observations and notes.

Results and Discussion

The results are discussed here under two themes, energy and environment. The environment theme focused on concepts like photosynthesis, food (energy) dependence of organisms, and the links students make between humans, energy and the environment. The energy theme involved the qualitative study of students' responses as they engaged in a variety of activities and expressed themselves in oral or written forms. The specific activities within the two themes, and a brief discussion of students' responses are given below, first for the environment theme followed by energy.

Environment

Several activities were organised with an aim to understand students' ideas about energy flow through organisms. Students' responses to Activity Sheets on (a) Photosynthesis and (b) Food webs in the environment, and the Context maps that groups of students drew on Humans and Environment, are discussed below.

Photosynthesis, Food Webs and Energy Flow

Besides asking about the parts of plants involved in photosynthesis, the time when it occurred and its inputs and outputs, the activity sheet on photosynthesis also aimed to see whether students thought of it as a step in the energy flow through organisms. Most students were aware that photosynthesis takes place in all green parts of plants. Some students even mentioned that plants that have leaves with colours other than green possess the green chlorophyll. However, close to half of the students thought that insectivorous and parasitic plants were incapable of photosynthesis. Perhaps they drew analogy between such plants and animals, and they mentioned this during discussions. One of the students wrote, "The plants needs carbon dioxide and photosynthesis helps to release energy only with oxygen." The response suggests that students think of photosynthesis as releasing energy. The drawings show that students do not connect photosynthesis with the flow of energy.

Three fourth of the students knew that carbon dioxide and water were involved in photosynthesis and were essential for plant survival, but they were unaware of their specific roles in the process. Most students incorrectly thought that the oxygen released in photosynthesis came from the carbon dioxide that it used up.

Most students knew about food chains. However, they did not appreciate the nature of dependencies of the organisms in food webs. Most students focused on parts of a chain and failed to see how changes in one population could affect the entire web. More than two thirds of the students thought that plants respired only at night.

Photosynthesis dominates textbook discussion on the physiological processes in plants. Perhaps, this diverted the students from recognising other important physiological processes like respiration and transport. Though students had been taught about photosynthesis and food chains, they were not exposed to photosynthesis as a process aiding energy flow in nature. This is reflected in their drawings, where students considered photosynthesis in terms of the input and output materials and sunlight merely as a process of food preparation.

Context Map on 'Humans and Environment'

Each group of three to four students drew a context map (total 12 maps). Most students were aware of the constituents of the environment and human environment relationships. Some mentioned the scarcity of fossil fuels and the energy crisis. However, the role of plants as energy stores was not explicitly recognised.

All the context maps had terms like biotic, abiotic, pollution, industry, globalisation, deforestation, etc. While most context maps had both pictorial presentations and verbal descriptions, some had more of one and less of the other. Thanks to the emphasis in classrooms and the media, over half the context maps referred to negative consequences of human interventions

in the environment: pollution, global warming, globalisation, mining, deforestation, etc. However, most students did not make connections between these terms, either because of their unfamiliarity with such maps, or their limited understanding of the complex issues. In fact, discussions revealed that students had not grasped the meanings of the words they had used.

Energy

Energy was addressed through several activities. Of these students' responses to Activity Sheet on energy, Essay on 'A world without energy', Poster on 'Human civilization; 500 years from now', and role play on energy options for a small village will be discussed here.

Students' Ideas about Energy

During a semi-structured discussion, students spontaneously used terms like 'power' and 'force' as synonyms of 'energy', but they were unable to define the term power. Some had the incorrect idea that power was 'ability to perform work'.Students ascribed scientifically incorrect everyday meanings to force power, and energy. On the other hand, students were able to correctly define potential and kinetic energy, but were unable to giveexamples or use them in contexts.

Students were confused between forms of energy and sources of energy. About 26 forms of energy were mentioned by students. Besides referring to sound, light, electrical energy, etc., students also used incorrect, but interesting terms like static, physical, repulsive, frictional, freeze, ubiquitous, and genetic energy. Essays on 'A world without energy' written by groups of students, revealed that students considered a world without energy as impossible. However, they largely referred to anthropocentric aspects of energy.

Humans and Energy Use

In response to a question in the activity sheet, most students agreed that change of individual life styles can reduce energy demands. However, third of the students also felt that the society which uses more energy is more developed. While depicting the future energy scenario in a poster, students emphasised energy production, but ignored issues of distribution. Students predominantly drew transportation, which too in private vehicles, not recognising that public transportation could be more environment friendly.

None of the posters referred to reducing energy demand in daily activities or use of biomass as an energy source. The non-conventional energy source shown was mostly solar energy. They also predominantly depicted high rise buildings, transportation, and robotic systems, but no trees, forest or animals other than humans. The humans were never located in a village. Students' responses to questions, writings and drawings on energy suggest that students did not connect energy flow in nature with human energy use.

Role-play – Power Plant for Shaktipur

In a given scenario, Shaktipur, a newly industrialising town needs electrical energy. To arrive at a consensus on

the kind of power plant for Shaktipur, the State Chief Minister has called a meeting of relevant ministers, scientists, environmental groups, representatives of world bodies and local educational institutions. Students had to conduct the meeting, each student taking on one of the roles, each of which was characterised for them. They were provided with reading materials on energy sources, and their advantages and disadvantages. Students largely chose between six energy sources for the power plant: solar, wind, biomass, nuclear, hydroelectric and coal. In one of the sessions most participants chose solar energy with one other renewable source for the power plant. Only three chose a nuclear power plant, that too along with a biomass plant. The participants in the other session chose from only three options and largely focused on nuclear energy.

Educational Implications

The first task for effective teaching-learning is diagnosis of students' existing ideas. We have developed a course that provides scope for bringing together teachers with different academic backgrounds to achieve overlapping subject goals and at the same time deepen environmental awareness. The course that was developed included a variety of activities – lectures, discussions, experiments, writing, drawing, presenting, drama – on environment, energy and their relationship to everyday living. Some of the activities were specifically designed to highlight and resolve conceptual conflicts between students' existing understandings.

In order to structure a similar course in formal classroom settings, it is necessary for teachers of different subjects – Science, Languages, Art and Craft and Social Studies – to collaboratively plan the content and sequence of activities to suit the level (Class) content. They also need to arrive at a consensus on the common course structure, content as well as their environmental priorities. It is essential for teachers to structure activities where students can recognise and resolve conflicts in their understanding by discussing with their peers and teachers. Special attention needs to be paid to respect the differential abilities among students. Encouraging multiple modes of expression will contribute towards innovative thinking and co-operative creativity.

Such courses offer rich possibilities for EE. They help diagnose students' ideas and understanding in school subjects and integrate their knowledge and skills from different school subjects towards a deeper environmental understanding.

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