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Environmental Education and Water Representation Among High School Students: A Case Study of Rajasthan (Jaipur Area)

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INTRODUCTION

The present study has been conducted on the students' ideas about water and complex environmental problems related to water, in order to obtain new insights in adapting Environmental Eduction. The following research question makes up the guiding framework. "What sort of representations relating to water and its interactions do students construct and to what extent to these representations permit them to understand the complex environmental problems related to water?

The topic has been choosen for the following reasons:

- Environmental problems associated with water are serious and pressing and have to be dealt with immediately.
- Water is probably the most common substance which students and everybody else come into contact with and use every day.
- Water is responsible for the appearance of life on this planet and is irreplaceable.
- The multidimensional role of water in nature and contemporary societies renders the teaching of relevant matters both complex and interesting.
- There are no relevant Environmental Education studies in India focusing on the recording and categorisation of student's ideas about water and complex environmental problems related to water.
- On an international level we located a limited number of studies in which water is approached from the point of view of separate science, e.g. water in chemistry, water in hydraulics and not interdisciplinary.

MATERIAL AND METHODS

The study was conducted at government and public schools in Jaipur area (Rajasthan), during the school year 1999-2000. Twelve complete classes of high school students (14 year of age) were randomly chosen from the schools in the area and comprised the total sample of 342 students (N= 342).

The schools were chosen form the Jaipur area because, due to the high population numbers, the problem of water supply is especially acute or will be in the future. Data were collected in 1999-2000.

The Test: The participating students completed a written questionnaire (test) consi-sting of thirty-four questions. The test was specially formulated to meet the needs of this research. Next, the test was pilot tested with 160 high school students. A few questions were dropped and some were altered to be more comprehensible and easier to administer.

The final test included :

1. Open type questions-answers
2. Closed type questions-answers
3. Production of schema.

These questions were grouped according to the kind of relationships that they control, as follows:

1. "Water - Nature" (twenty questions). In this case, the distribution of questions was as follows: six questions dealt with relationships, "Water - Life", six questions dealt with relationships, "Water - Earth" (erosion, transference, deposition / sedimentation) and eight questions dealt with "Water Cycle".

2. "Water - Contemporary Society" (fourteen questions). In this case, the distribution of questions was as follows: seven questions dealt with knowledge about "The drinking water problem in a contemporary city : Jaipur" (local level), seven questions were about "The drinking water problem on the planet" (global level).

3. "Causal Relationships". Twenty out of thi-rty-four questions in the test examined the capa-bility of high school students to construct causal relationships:

- Causal relationship of one link, [cause-

result] type
- Successive linear causal relationship of more than one link of the [1st cause →1st result = 2nd cause→2nd result = 3rd cause et seq.] type
- Complex causal relationships with retro - action (feedback), interaction and relationships of different levels.

In this case, three types of questions were placed at the student's disposal in which they were given:

a) The sentences that have to be connected in random order (the logical steps), and they were asked to connect them appropriately;
b) The cause of a process, and they were asked to explore what would be the result or results or vice versa, but did not require any justification in this case; and
c) The cause of a process, and they were asked to explore what would be the result or results or vice versa, but this case required justification.

Evaluation: After participating students had completed the test, an analysis and categorisation of their answers permitted me to study their representa-tions. A frequency distribution of the qualitative variables was made. The qualitative variables were created from the categorisation of the student's responses. The characterisation of each category in open type questions was made on the basis of the *key words*. The key words expressed as best and as concisely as possible the content and the meaning of each category.

RESULTS AND DISCUSSION

The results are organized and presented around the main groups of questions as follows:

"Water - Nature" ("Water-Life" and "Water-Earth") From a concise examination of the relative results I established the following: the majority of the students represent water as a "magic fluid", which is extremely important, but fail to determine its functional role on the earth's surface and living organisms. The majority of students for example, do not report specific functions of water in the human organism and on earth, nor do they report a basis biological reaction (e.g. photosynthesis) to which water contributes. Also the majority of students do not connect the functional role of water in nature with its physico-chemical properties. For example, they do not connect the preservation of aquatic life in an environmental temperature below zero to the surface freezing of water and further to its property of abnormal expansion. On the contrary, in the questions that are related to the functional role of water in nature, the majority of students either do not answer or give tautological answers such as that the significance of water is great, water is very necessary, it is very important, etc. (Tables 1, 2, 3, 4 and 5)

Table 1: The role of water in the human organism

Categories of responses	*Responses from 342 students (%)*
1. Structural or functional role of water	25
2. Tautology	42
3. Confusion with respiration	12
4. Did not answer	21

Table 2: The functional role of water on earth (erosion)

Categories of responses	*Responses from 342 students (%)*
1. Erosion	20
2. Tautology and confusion of concept of erosion	20
3. Did not answer	60

Table 3: Water in life reactions

Categories of responses	*Responses from 342 students (%)*
1. Photosynthesis or respiration	41
2. Reactions which are known in chemistry	21
3. Did not answer	38

Table 4: Lakes and seas freeze only on the surface. What is the cause of this phenomenon?

Categories of responses	*Responses from 342 students (%)*
1. Due to abnormal water expansion	47
2. Due to currents; due to the existence of organisms and others	46
3. Did not answer	7

Table 5: Lakes and seas freeze only on the surface. What is the result of this phenomenon?

Categories of responses	*Responses from 342 students (%)*
1. Preservation of aquatic organisms in temperatures below zero (T<0)	47
2. Tautology	17
3. Did not answer	36

Water Cycle: The majority of the students represent the cycle of water with deficiencies, as

they seem to be missing the basic sub-schemes and links associated with surface water flow and underground waters, as well as water-vegetation relationships. The schemes drawn by the majority of the students are over-simplified and the water cycle is finally restricted to a reciprocating course of water from the clouds to the sea, and form the sea to the clouds. Most students have a limited perception of water's formations (lakes, rivers) and not to underground water formations, or ice caps or glaciers (Fig. 1 and Tables 6 and 7).

"Water - Contemporary Society". The majority of students represent the interactions of

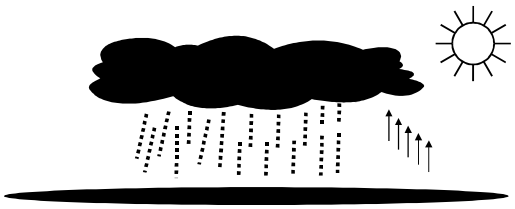

Fig. 1. Typical student's scheme of water cycle

Table 6: Formations of water in nature

Categories of responses	*Responses from 342 students (%)*
1. Seas, oceans, surface water (lakes, rivers)	65
2. Underground water	10
3. Water vapour in the atmosphere	12
4. Ice caps and glaciers	0
5. Water in living organisms	11
6. Did not answer	35

Table 7: Scheme of water cycle

Categories of responses	*Responses from 342 students (%)*
1. Basic scheme elements (sea, clouds, sun)	43
2. Vegetation, underground water	1
3. Two-way direction water flow (clouds to sea-sea to clouds)	39
4. Phase of water flow in earth (sub-scheme of water flow in earth)	12
5. Phases of change (evaporation, transpiration, concentration	0
6. Did not answer	55

water with contemporary society, at local and global levels, in a restricted and simplistic manner:

- They do not perceive the various human activities which are related to the water problem and its consequences.
- They do not recognise the principal factors responsible for the problem of potable water in Jaipur and hence are unable to relate these factors to their specific consequences.
- They do not relate the Industrial Revolution to its specific consequences with regards to water. (Table 8, 9 and 10)

Casual relationships: The majority of the students have not developed the capability to

Table 8: Percentage of potable water on the planet

Categories of responses	*Responses from 342 students (%)*
1. Less than 0.5%	40
2. More than 50%	36
3. Did not answer	24

Table 9: Basic uses of fresh water by human beings which result in its pollution

Categories of responses	*Responses from 342 students (%)*
1. Basic water uses in high consumption sectors	20
2. Only special domestic uses	14
3. Did not answer	66

Table 10 : Corresponding substances by which water is polluted as result of its basic uses by humans

Categories of responses	*Responses from 342 students (%)*
1. Corresponding water polluting substances	14
2. Only visible pollutants	27
3. Did not answer	59

construct a causal relationship. A relatively small number of students are able to construct causal relationships of one link or successive linear causal relationships with more than one link, but no student was able to construct a complete complex causal relationship. I define two cases of constructing complex causal relationships: (a) construction of complex causal relationships with reasoning, and (b) construction of complex relationships without reasoning. From the results of the above two cases, I confirmed, firstly, that no student could fully reason complex relationships and secondly, that no student could structure all suitable relationships, even when given the sentences to be linked. Specifically, students encounter special difficulties in the construction of retroactions, Interactions and relations of more than one level (Fig. 2 and Table 11; Fig. 3 and Table 12; Fig. 4 and Table 13).

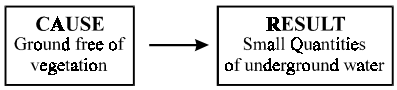

Fig. 2. Causal relationship of one link [vegetation -underground water]

Table 11: Construction of causal relationship of one link

Categories of responses	*Responses from 342 students (%)*
1. Ground free of vegetation small quantities of underground water	38
2. Did not answer	62

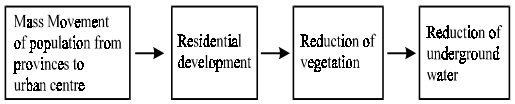

Fig. 3. Linear successive causal relationships [urbanisation-underground water]

Table 12: Construction of a linear relationship

Categories of responses	*Responses from 342 students (%)*
1. Mass movement of population from provinces to urban centre→ Residential development	31
2. Residential development→ Reduction of vegetation	31
3. Reduction of vegetation→ Reduction of underground water	30
4. Did not answer	68

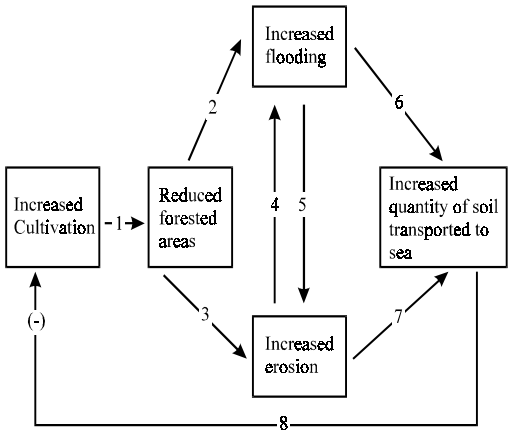

Fig. 4. Complex relationships [cultivation - transference of soil]

Table 13 : Construction of complex relationships

Categories of responses	*Responses from 342 students (%)*
1. Increase in cultivation→ Reduction in forested area	4
2. Reduction in forested area→ Increase in flooding	8
3. Reduction in forested area→ Increase of erosion	29
4. Increase in flooding→ Increase of erosion	11
5. Increae of erosion→ Increase in flooding	0
6. Increase in flooding→ increase in soil transference	6
7. Increase of erosion→ Increase in soil transference	29
8. Increase in soil transference→ Reduction of cultivation	0
9. Did not answer	50

These results are impressive and are attributed mainly to inadequate training in the capability of structuring complex causal relationships during the teaching of the sciences and the absence or inadequate construction of the part concepts.

The results above were attributed to several causes. In their effort to construct a scientific representation of water and its interactions, students come across various obstacles, which could arise from several causes. Some personal conceptions of the students can be regarded as arising from, for example, some old-established scientific ideas, or from various ideas prevalent in society, which even today continue to be unclear in common thought. Some other personal conceptions can have as their origin the restricted human perception of the environment. The difficulty in comprehending, for example, non-visible phenomena can be considered as arising from restriction of the human sense of sight.

CONCLUSIONS AND RECOMMENDATIONS

The representations of water and its interactions with nature and contemporary society, as these are structured from the everyday experience of students with water and from school today, do not allow them to comprehend.

(a) Basic natural processes in which water is involved

From the findings of this study, it is concluded

that the majority of students:

- Have not understood the functional role of water in nature.
- Have not understood the microscopic phenomena which are found in the basis of the changes (e.g. erosion, abnormal expansion of water).
- Have a limited perception of the water cycle and of water formations in nature.

(b) Complex water problems

From the findings of this study, it is concluded that the majority of students:

- Have not constructed a network of concepts on the different environmental systems, and specifically they do not have the basic subschemes and prerequisite knowledge to comprehend the problem of water. For example, I established that the concepts of pollutants, potable and underground water, as well as the process of drinking water formation, the quantity of available fresh water on the planet, are absent or are inadequately constructed.
- Have not developed the capability of structuring causal relationships and, especially, complex causal relationships.

Taking into consideration (a) the complexity of environmental problems and that knowlege is built up in stages and not in jumps, I propose that the venture of understanding the environ ment and environmental problems in the initial phase begins with a simple understanding of the environment (e.g. comprehension of basic subschemes, such as the process of drinking water formation).

Taking into consideration (b) that Environmental Education means to acquire a profound knowledge of the complex network of processes which link human to ecological, geolo-gical and hydrological systems, I propose that students must develop the capability to structure complex causal relationships. Since it is impossi-ble to go directly to the construction of complex causal relationships without previously mastering the construction of more simple relationships, I propose commencing with simpler relationships.

KEY WORDS Water, Magic Fluid, Causal Relationship.

ABSTRACT This paper reports how high school students represent water and its interactions with nature and contemporary society. The study was planned and implemented within the framework of Environmental Education and involved the participation of 342 high school students attending government and public schools in Rajasthan (Jaipur area). The results of the investigation indicated that the majority of the students represent water as a "magic fluid", the water cycle in a deficient way, and the relationships between water and contemporary society in a limited and simplistic way. Their capability to construct causal relationship is limited. Because of these representations, in conjunction with their limited capability to construct causal relationships, students find it difficult to comprehend the complex environmental problems which are linked to water.

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