Chapter 21
Enhancing Students' Ecological Thinking to Improve Understanding of Environmental Risk

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Abstract The current rate of human development poses a major threat to the ecological balance of the environment, and this is exacerbated by climate change effects. It is therefore important for people to understand the ecology of different locations so they can make informed decisions that will not have an adverse effect on the environment. In this regard, students form a significant group for whom sound ecological thinking is necessary as they will be the future leaders and decision makers who can ensure the world's continued sustainability. This chapter presents the results of an ecological education project that successfully expanded students' ecological thinking. Evidence of this change is taken from interview responses before and after the ecological education project. The interview was based on a set of six photographs of different situations found in the environment. Responses were analyzed based on an ecological thinking framework developed by the researchers. This framework consisted of two components: understanding of ecology concepts and understanding of the impacts of human activity on ecosystems. The ecological education project succeeded in increasing students' ecological thinking, thereby increasing their awareness of environmental risks.

Keywords Ecological education • Ecological thinking • Environmental risk awareness

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21.1 Introduction

Of all influences on the global environment, human activities have exerted the greatest impact. The rapid pace of development means that the ecological balance of the environment is faced with enormous threats. Among these, the top five pressures on biodiversity globally are the loss, alteration, and fragmentation of habitats; overexploitation of wild species populations; pollution; climate change; and the introduction of invasive species. These pressures were evidenced by a 28 % decline in the global Living Planet Index between 1970 and 2008. The decline subsequently continued, reaching 30 % in 2012 (WWF 2012). The Living Planet Index is a measure of global biodiversity change based on the world's vertebrate population.

Meanwhile, the Global Ecological Footprint—a measure of the amount of natural resources consumed globally against the world's biocapacity—increased continuously. In 2008, the figure was 18.2 billion global hectares (gha). This amounted to 18.2 billion hectares of land to supply the resources necessary to fulfil lifestyle needs and absorb waste for every person on Earth. This means that the Earth requires 1.5 years to regenerate the natural resources that global consumption uses in 1 year (McRae et al. 2008). It is thus necessary to restore, conserve, and protect natural ecosystems and biodiversity so that biological productivity and ecosystem services can be maintained (WWF 2002). This includes preserving the world's biodiversity and reducing the impact of human activity on natural habitats (WWF 2008a, b). However, realization of these goals requires public support and participation. It is therefore important for people to understand the ecology of different locations so they can make informed decisions that will not have an adverse effect on the environment. Students form a significant group for whom sound ecological thinking is necessary as they will be the future leaders and decision makers who can ensure the world's continued sustainability.

21.2 Ecological Thinking

Balgopal and Wallace (2009) reported Berkowitz's definition of ecological thinking as a combination of ecological understanding and environmental awareness. Ecological understanding refers to understanding of the general concepts in ecology. This includes food webs, trophic levels, carrying capacity, and population dynamics. When people acquire ecological understanding, they tend to also consider their position and role in the ecosystem (Orr 1992, and van Weelie 2002 in Balgopal and Wallace 2009). The definition is further extended to include understanding the impact of human activity on the ecosystem through recognition and application of ecology concepts. This understanding is referred to as ecological literacy (Balgopal and Wallace 2009) and is described as being on a continuum. At one end is the ability to identify dilemmas and propose decisions together with their consequences. This ability diminishes progressively toward the other end of the continuum where there is insufficient understanding to explain how human action impacts on the ecosystem.

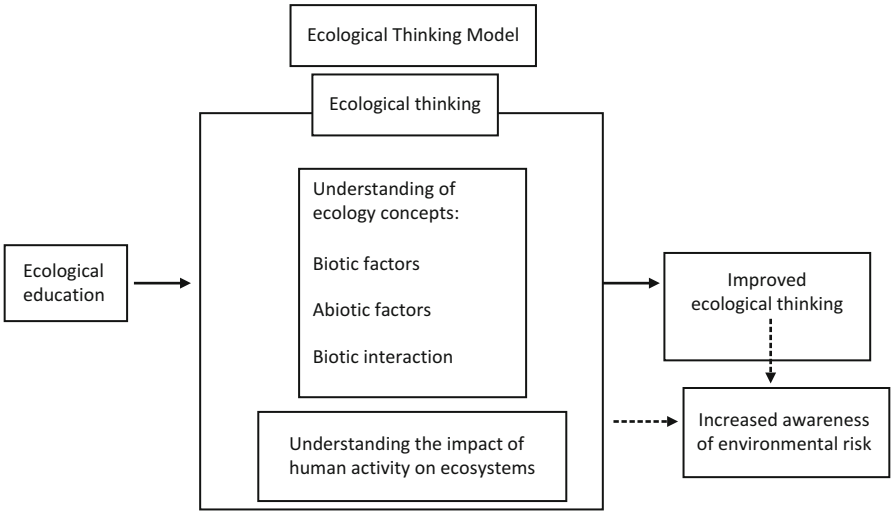

Fig. 21.1 Conceptual framework of ecological education

The researchers have developed a conceptual framework (Fig. 21.1) based on the definitions given. Ecological thinking involves understanding concepts in ecology including biotic factors, abiotic factors, and biotic interaction. It is complemented by understanding the impact of human activity on ecosystems. Ecological thinking can be improved through ecological education. Improvement of ecological thinking, and understanding the impact of human activity on ecosystems, will eventually lead to increased awareness regarding environmental risk. An ecological education project was therefore conducted with secondary school students as subjects to effect an improvement in their ecological thinking.

21.3 Case Study

Changes in students' ecological thinking were investigated. The changes were facilitated by an ecological education project carried out with secondary school students as subjects. In this project, students set up themed organic gardens. They worked in groups and each group created two gardens: a wild garden and a garden on a specific theme chosen by the group. In the wild gardens, plants in the designated area were left to grow freely and no additional fertilizer was applied. In the themed gardens, students planted species they identified as suitable for their chosen theme. This project was conducted for 3 months. During this time, the students collected vermicompost produced by earthworms they reared on cow dung and food waste. They also carried out experiments to compare the effect of using either organic fertilizer in the form of vermicompost, or chemical fertilizer, on the plants in their themed gardens. In addition, they recorded their observations of other organisms found in their gardens.

Data with regard to the students' ecological thinking were collected using the photo-elicitation interview technique. This is a technique often used in social science by anthropologists and sociologists (Hurworth 2003), as well as in psychology and education, albeit minimally in the latter cases (Harper 2002). Apart from being user friendly and requiring only simple technology to produce, photographs can be used either on their own as content for discussion or as a part of the overall interview process (by varying the way they are presented). Such use enables the interviewer to probe responses about social relationships (Epstein et al. 2006). Furthermore, photo-elicitation incorporates visual language with verbal language (Hurworth 2003) and both interviewer and interviewee share the same visualization that becomes the focus of the interview. Absence of such images requires both parties to conjure their own image of the subject in their minds. In this case congruency of the visualization cannot be ensured as both parties arrive with different experience and prior knowledge.

A total of 140 students aged between 15 and 16 years participated in the project. A sample of students were interviewed prior to its start (pre-test); then they were again interviewed at the end (post-test). Using the photo-elicitation technique, photographs were shown to the students and questions posed to elicit responses (Epstein et al. 2006; Hurworth 2003). The photographs constituted six images of the environment in various situations, as depicted in Fig. 21.2. They included a pristine rainforest, a paddy field, residential apartments, a hill slope being cleared, a riverside settlement, and chemical spraying. Based on the ecological thinking model, the interview covered two aspects, namely understanding of ecological concepts and understanding of the impact of human activity on ecosystems. The students' responses were probed to gain more information about their thinking with regard to the situations presented in the photographs and their responses. After students were interviewed about the first photograph, they were then interviewed about the second photograph, and this process was repeated until all six photographs had been covered. The same process was followed for both the pre-test and the post-test. Interview data from six students are presented in this case study. Comparison of the pre-test and post-test interview responses is made to identify the changes in their ecological thinking after participating in the ecological education project. The interviews were transcribed and analyzed to extract data relevant to the components of the ecological thinking model. Table 21.1 gives a summary of the findings.

21.4 Conclusion

The ecological education project succeeded in improving students' ecological thinking. Their understanding of basic concepts in ecology improved. More importantly, students became more aware of the threats to the environment posed by human activity.

Fig. 21.2 Set of photographs for interview

Education is a tool that can enhance understanding of ecosystems in terms of ecological concepts and the effects of human activity on ecosystems. The project undertaken in the case study is one such example. However, there is potential for further research into the ecological thinking of students to assess differences between them with respect to certain demographic factors. Factors for consideration could include their own experience of natural ecosystems, the type of residential area in which they live—rural or urban, for example, or located near a nature reserve or forest—and their worldview.

Table 21.1 Ecological thinking of students

Themes	Pre-test	Post-test	Conclusion
Biotic factors	Students had limited knowledge and ideas relating to biotic factors	Students' knowledge of biotic factors had increased in terms of the examples they gave. Furthermore, students were able to elaborate and explain their examples	Students' knowledge of biotic factors had increased due to the educational intervention provided. Students had become more aware of the biotic factors in our environment
	Example of response—Respondent 6: *There are wild plants, plants on the mountain, a river, and creeping wild plants*	Example of response—Respondent 1: *Near the plants behind (in the photograph) maybe there are monkeys, ant eaters, and other animals that live in the forest. Near the planted trees there will be mudskippers, mice, and ants. In the water, there will be fish*	
Biotic interaction	Students' ideas relating to biotic interaction were mainly concerned with a simple food chain.	Students' ideas and knowledge relating to the food chain had become more sophisticated. The food chain they described had been extended to a food web and included higher trophic levels.	Students' understanding and knowledge of biotic interaction had increased. They were able to explain and describe biotic interaction with improved knowledge of food sources, food webs, and trophic levels.
	Example of response—Respondent 1: *Tigers feed on mouse deer or mice*	Example of response—Respondent 6: *OK, I see a river; in the river there might be fish; maybe the fish can feed on the seaweed and the small fish will be eaten by the bigger fish, which will then be eaten by the crocodiles. OK, trees, for example, trees have fruits and the fruits might be eaten by the squirrels or monkeys. Both squirrels and monkeys might be hunted by humans*	

Abiotic factors	Students' knowledge and ideas relating to abiotic factors were simplistic and limited Example of response—Respondent 6: *Housing area*	Students were able to provide a greater variety of examples. They could also provide explanations and elaborate further on the examples given. This implies an increase in their knowledge of abiotic factors Example of response—Respondent 6: *First, the river is the source of water for the living animals. Second, in the water cycle, water from the river flows to the sea. Water evaporates from the surface of the sea to form clouds. So when there is cloud it will not be too hot. The river can also be the medium for transportation.* *The forest is important because if there is no forest…now that we have many logging activities taking place, the ozone layer is becoming thin…so the forest is important for…one reason is for the animal habitat, and in the forest there are fruits as the source of food for the animals that live there. The forest can also maintain the local temperature…if we cut down all the trees the temperature will rise…so this helps to maintain the local temperature*	Generally, the students' knowledge of abiotic factors had improved. They demonstrated greater awareness of the abiotic factors in our environment and their functions
Threats	Students' knowledge of threats was limited. The reasons and explanations they gave were related only to human activity Example of response—Respondent 1: *Fish will die*	Students' ideas and knowledge relating to threats had increased. They were better able to explain threats to the environment related to habitats and humans Example of response—Respondent 4: *Animals that live in this habitat will die or they will lose their habitat. Animals that live there will not have water sources or food sources like fish in the river, and there will be no water way for transportation. Then there will be no income source for the fishermen and…*	Students' knowledge of threats had increased and they were able to give more explanation about threats to the environment

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