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Implementing an Ecological Simulation: Do Children's Knowledge and Attitudes Change?

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Abstract *Environmental education is concerned with developing both environmental knowledge and positive attitudes towards the environment. An experiential simulation activity about a native Australian bird was designed to develop both these aspects. The simulation was implemented with nine classes of 10-12 year old children. The children completed a survey before and after the simulation and their teachers reported on their responses. The results showed that the children developed additional knowledge of kookaburras and their survival and that their attitudes towards the environment became more positive. Moreover, the children themselves believed they had increased their knowledge and changed their feelings of responsibility towards the environment as a result of the simulation.*

Two of the roles of the teacher in environmental education are:

- to increase awareness and appreciation of the range of environmental problems facing us, the causes of these problems and some of the possible ways of preventing and resolving them; and
- to encourage positive attitudes of concern for the environment and a desire to prevent environmental problems (Fien & Martin, 1996).

The New South Wales Department of Education and Training (NSWDET) Environmental Education Policy for Schools indicates within its rationale that in an environmental education curriculum students "learn about the environment" and "acquire attitudes of care and concern for the environment" (NSWDET, 2001, p. 9). These intentions are further developed within their stated curriculum objectives.

Skamp (1996) has pointed to the need for primary schools to address the "development of knowledge of content beyond the hands-on sensitising activities such as ... recycling" (p. 67). Knowledge of ecological concepts and environmental interrelationships is thought to be a critical component of environmental literacy (Morronne & Carr, 2001), and Wilke (1995) stresses the need for the development of these concepts before individuals can initiate behavioural changes. There is evidence that students' environmental understandings and attitudes begin to develop at an early age and that these influence their behaviour (Bradley, Waliczek & Zajicek, 1999).

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Learning about the environment in situ is usually considered to be the most realistic and memorable way of developing an awareness and understanding of environmental issues. However, it is not possible for urban school children to learn in situ on a regular basis and learning in the classroom is a more feasible option. For case studies of real environmental problems which are difficult to investigate first hand, teachers can involve children in an environmental issue by simulating the problem in the classroom. While this is by no means the same as the real thing, it does have the advantages of immediacy and involvement.

A simulation activity has been described as "some model of reality" (Marsh, 2001, p. 242). When used in a classroom setting, a "simulation is a situation where students can assume the role of others in a simulated environment acting according to specified rules and procedures which give the illusion of reality, without the consequences of actions that are inherent in real life situations" (Board of Studies NSW, 1998, p. 204). Simulations are used as an attempt to devise an "environment for participants ... that they would not ordinarily experience - an environment that abstracts from reality those ... phenomena that together make up a complex and sometimes confusing situation but when reduced become comprehensible, revealing and educational in its broadest sense" (Gillispie, 1973, p. 3). In this way, simulations can provide the opportunities for participants to engage in a problematic situation which is relevant to real life.

Marsh (2001) has described simulations as a "teaching technique with tremendous potential for teachers" (p. 241). In New South Wales, the Science and Technology K-6 Syllabus requires teachers to provide students with "first hand experiences of investigating ... and clarifying understandings" (Board of Studies NSW, 1991, p. 1). Although it is difficult for students to observe ecological interactions and the consequences of these at first hand, simulations may be one way of demonstrating these while still retaining an experiential mode of teaching and learning. As well as clarifying understandings, simulations may assist students to "explore values, issues and problems" (Marsh, 2001, p. 241). Similarly, Seidner (1995) suggests simulation games can trigger changes in attitudes, behaviour and creativity.

It has been shown that role play and simulation activities can:

- Increase students' motivation;
- Improve classroom atmosphere;
- Help identify misunderstandings;
- Allow students to demonstrate their understandings;
- Be as effective for teaching cognitive skills as other teaching methods;
- Allow students to develop mental models for concepts which are otherwise difficult to observe in the real world;
- Cater for differences in students; and
- Be enjoyable for students (Aubusson, Fogwill, Barr & Perkovic, 1997; Gillispie, 1973; Ladrousse, 1989).

In a meta-analysis of educational interventions that improved environmental behaviour, Zelezny (1999) found that those interventions that improved behaviour the most involved active participation and young participants. However, although simulations certainly involve active participation and are generally thought to be valuable learning experiences with young participants, the following questions remain:

- Do measurable changes in children's knowledge and attitudes occur as a result of a simulation activity; and
- Do children perceive this activity as a learning experience as well as an enjoyable game?

This study explored these two questions with respect to one particular environmental simulation by implementing it in nine primary classrooms.

The Simulation

The simulation *Kookaburras and their prey* (described in detail in Clark and Harrison, 2000) is concerned with exploring the effects of pollution in the environment as well as investigating the life and ecology of a native Australian bird. Kookaburras are common birds in the Sydney metropolitan area where the simulations were carried out. The simulation physically involves children who take on various roles and is designed for a class of 25-30 students. At the beginning, the teacher sets the scene and forms the class into a number of kookaburra families (parents and chicks), some with one parent, some with two parents and some with an auxiliary (an adult from the previous brood) who helps the parents. The adults must feed themselves and their chicks. Families are assigned to a nest area. The typical kookaburra food of lizards, fish, insects, mice and snakes, (in the form of different coloured Smarties or beans) is arranged on the forest floor (a multi-coloured tablecloth on a large table or on the grass outside). The adults have to find the food, gather one prey at a time in their beaks (forks) and bring it back to the nest and place it in their own or their offspring's stomachs (plastic cups). Unbeknown to the parents, some food (blue Smarties or beans) contains high levels of pesticide. The actual simulation is meant to be just a starting point. Extension of the activity and integration with other learning situations is valuable to continue development of the concepts introduced.

Method

A group of nine trainee teachers, enrolled in a unit in environmental education as part of the fourth year of their Bachelor of Education (taught by the second researcher), was introduced to the *Kookaburras and their prey* simulation by role playing the activity with their peers (Clark & Harrison, 2000). The teachers also watched videos of kookaburras, discussed their life cycle, behaviour and ecology and discussed the implementation of role plays and simulation activities. In this way the teachers became very familiar with the simulation and the types of problems which could arise as well as questions they could ask the children. The teachers were then asked to carry out this simulation with a Year 5 or 6 class (10-12 year olds) at their schools (all Catholic primary schools) in suburban Sydney. All teachers were able to do this either with their own class or by swapping classes with another teacher at the school.

The teachers became teacher-researchers, collaborating with the university researchers. None of them had used role plays or simulations in the classroom previously and they were keen to try new strategies. Many of the teacher-researchers were casual teachers at the time and as a consequence, the simulation was sometimes an integral part of the teacher's unit of work but in many cases was taught as a one-off lesson.

Knowledge and attitudes of the children were assessed using a pre-test/post-test structure. Before carrying out the simulation the children completed a pre-simulation survey and then either watched a short video about kookaburras or discussed the life of kookaburras with the teacher. After the simulation the teachers carried out a discussion of the simulation with their students and noted the students' actions and verbal responses using audio taping and written notes. A post-simulation survey was completed immediately after the discussion. The wording of three of the questions (6,7,8) was modified in a minor way regarding the tense of the question so that they made sense after completing the simulation. It was expected that this would have no effect on the responses of the children. The university researcher involved in the

unit had discussions with individual teachers following the implementation of the simulation. These anecdotal records served to support and add to the validity of the quantitative data collected via the pre and post-tests.

In designing the survey, the items were first tested on the teachers. Only those items which correlated well with the whole test were included in the final survey in order to improve internal reliability. The tests were read by a person with expertise in test preparation and analysis and the language used in the tests was deemed to be appropriate at primary level for Stage 3 students (typically 10-12 year olds). No negative attitudinal items were included in the tests. This may be seen as a problem in the construction of an attitude scale but it was considered that negative items would be confusing for 10 year old subjects.

Questions 1-10 on each survey (Table 1) are the same, allowing pre and post-test comparisons. Questions 11-15 (Table 2) asked children about the simulation and therefore were only appropriate in the post-test. Questions 1-8 and 11-15 used a five-point Likert scale requiring responses from Strongly Agree through to Strongly Disagree, with a midpoint response of No Opinion. Questions 9-10 required a short written response.

As well as ensuring completion of the surveys, the teachers also noted oral comments and positive or negative reactions of the children. Responses were analyzed from nine Year 5/6 classes, a total of 203 children.

TABLE 1. Questions in the pre and post-tests

1	*I think people should be more worried about environmental problems*
2	*I think that I can help the environment by what I do*
3	*I think I should take part in helping to solve environmental problems*
4	*I am concerned about the survival of native birds*
5	*I think people should keep their cats in at night*
6	*I (will) talk to my family about environmental issues*
7	*I (will) put my rubbish in the bin*
8	*I (would) like to be involved helping to look after the environment*
9	*What things do kookaburras eat?*
10	*What things might affect the number of kookaburras in an area?*

TABLE 2. Questions about the simulation in the post-test only

11	*This activity helped me to know more about the survival of kookaburras*
12	*I enjoyed this activity*
13	*I think I learn more when I enjoy an activity*
14	*I feel good about knowing more about kookaburras*
15	*This activity makes me feel more responsible for the environment*

Results

The teachers were unanimously impressed by the positive responses of the children to this teaching strategy and they reported that the children had fun, enjoyed the activity and that motivation and participation were particularly high. All had a role to perform and none had to be cajoled into participating. Some of the teachers commented that this form of whole body kinesthetic learning suited many children (as discussed in Gardiner, 1983) and was not often used in their classrooms. During the simulation children said things like "this is fun", "wow" and "oh, no I think I killed myself" indicating a high degree of sensory and emotional involvement. After the simulation the children said things like "it was fun and good to learn about kookaburras", "the parents had a hard job because they had to feed their children as well as themselves" and "it shows how hard it is for them to survive" indicating a degree of cognitive involvement as well. These oral responses support the findings from the pre and post-tests.

Responses to Questions 1-8

The percentages of responses in each category in the pre and post-tests for Questions 1-8 were tallied. The scores on the pre and post-tests were summed for the attitudinal questions (using 5 for strongly agree down to 1 for strongly disagree), the means found (see Table 3) for each question and paired sample t-tests used to compare these.

For Questions 1, 3, 4, 5, 6 and 8 the differences between the pre-test and post-test scores were significant at the 0.05 level (two-tailed test) and the idea that change occurred in the children's knowledge and attitudes as a result of the simulation could be supported on the basis of these questions. For Questions 2 and 7, the differences in pre and post-test responses were not significant. In this environmental context the number of respondents Strongly Agreeing with the statements was considered particularly important and so the percentage Strongly Agreeing before and after the simulation was directly compared. As indicated in Figure 1, for all questions, the percentage of SA responses increased after the simulation.

For those questions where the change in response was significant, not only did more children agree with the statements but fewer children had no opinion (except for Question 6) indicating that the simulations had influenced children to think more about the issue. It is noteworthy that for Question 5 (*I think people should keep their cats in at night)*, arguably a contentious issue, about half of those who strongly disagreed in the pre-test changed their minds by the post-test.

TABLE 3. Means of pre and post-test responses for questions 1-8

Question	Pre test mean	Post-test mean
1	4.27	4.58
2	4.01	4.13
3	3.70	3.87
4	4.25	4.44
5	3.73	4.07
6	2.44	3.18
7	4.52	4.56
8	3.44	3.64

Question 6 (*I talk to my family about environmental issues*) produced quite a different response from the other questions. In the pre-test, only 6% strongly agreed that they talked to their families about environmental issues. The number strongly agreeing increased by the post-test with 16% now saying they *will* talk to their families. A surprising result perhaps is that 51% of children did not talk to their families about environmental issues. After the simulation this reduced to 29%, indicating that this activity not only made students more aware but also made them want to talk to others about environmental issues. Overall, the difference in response to this question from pre to post-test was significant at the 0.01 level (t=8.7, two-tailed test). This question produced the most marked response change of any in the survey.

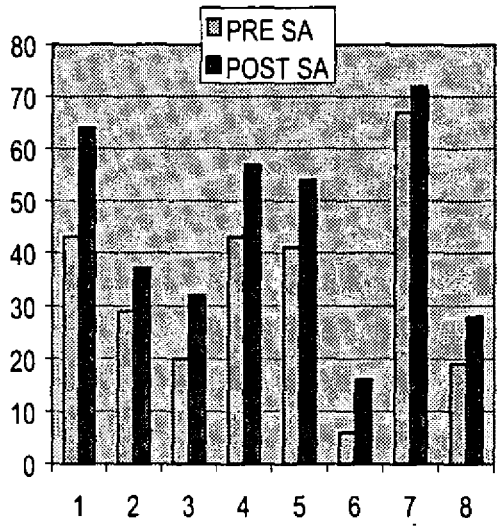

FIGURE 1: Percentage of strongly agree responses to question 1-8

Only in Questions 2 (*I think that I can help the environment by what I do)* and 7 (*I (will) put my rubbish in the bin)* were the changes too small to be significant at the 0.05 level. Putting rubbish in the bin is constantly reinforced by schools and 90% of students agreed (SA + A) with Question 7 both before and after the simulation. The response was already so high and positive that little change was likely here.

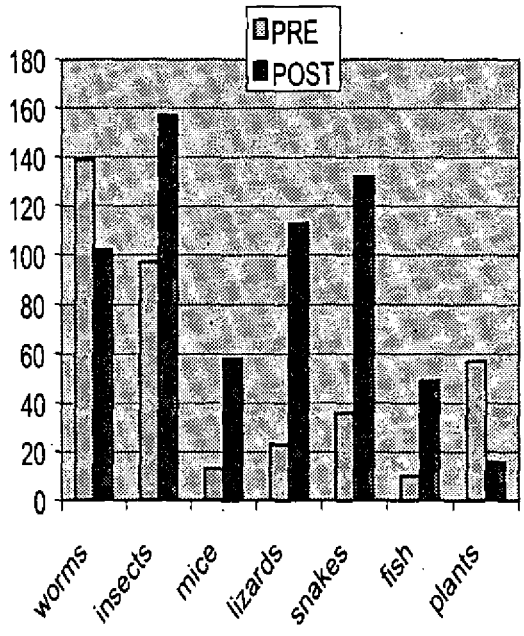

FIGURE 2: Responses to question 9

Question 8 (*I like to be involved helping to look after the environment)* is asking about personal commitment, always more difficult than just expressing concern. A sizable proportion (37%) of children had no opinion on this before the simulation. This had decreased to 22% after the simulation indicating that 15% of children had a more positive attitude and felt more inclined to look after the environment following the simulation.

Responses to Questions 9 and 10

The frequencies of what children considered to be kookaburra food (Figure 2) and the factors they listed as affecting kookaburra survival (Figure 3) were calculated for both pre- and post-tests. In the pre-test at least a quarter of the children listed worms, insects and leaves (plants) (the latter being incorrect) as kookaburra food (Question 9, *What things do kookaburras eat?*). In some classes, many children in the pre-test gave no answer for this question. In the post-test at least a quarter of the group listed insects, snakes, lizards, worms, mice and fish, all of these being possible foods. The total number of responses increased by 67% and as well as this, the variety of foods listed by each child increased. There was a shift in understanding towards the correct

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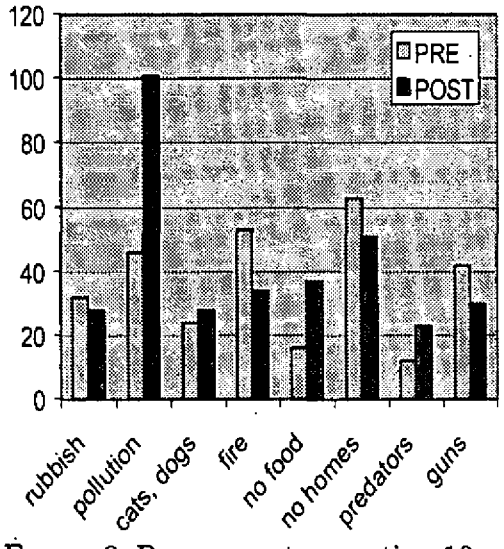

FIGURE 3: Responses to question 10

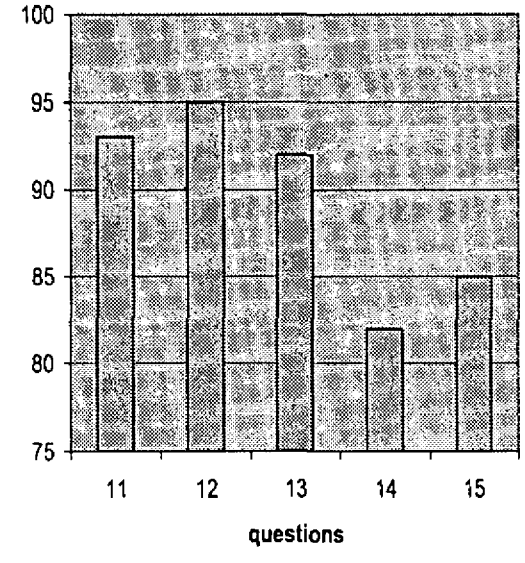

FIGURE 4. Strongly agree plus agree responses to Questions 11-15

response that kookaburras are carnivores (with far fewer children listing plants/ leaves in the post-test). This shift towards correct responses indicates a development of knowledge and understanding about kookaburra feeding habits.

In the post-test for Question 10 (*What things might affect the number of kookaburras in an area?)*, the total number of factors listed that may affect the number of kookaburras in an area increased by 15% and as well as this, the variety of factors listed by each child increased. The change was away from rubbish, fire, availability of homes and shooting (guns) to pollution (including pesticides), feral animals (cats and dogs), other predators and availability of food. In some groups, no one mentioned pesticides as a problem in the pre-test but many children did in the post-test. Some of these factors were emphasised in the simulation, e.g., pollution and availability of food, suggesting an increased understanding of the dynamics of kookaburra communities. Responses regarding the availability of homes related to deforestation activities. While this and feral animals are valid factors they were not reinforced in the simulation and the response "no homes" decreased in the post-test. This suggests a modification of the simulation may be warranted as they are important factors.

Responses to Questions 11-15

The percentage of responses in the Strongly Agree plus Agree categories in the post-test for Questions 11-15 are shown in Figure 4.

Overall, the activity was enjoyed, produced positive feelings about the environment (with between 82% and 95% agreeing (SA + A) with all the statements in Questions 11-15), and produced feelings of greater responsibility towards the environment.

Discussion

The findings show that this role play simulation activity provided opportunities for students to develop their understandings and attitudes towards environmental issues (research question 1). This is shown for most questions and is most significant in relation to Question 6. It is consistent with the conclusion of Lisowski and Disinger (1991) that "students with the lowest pretest scores showed the greatest gains" (p. 23). However, where the children's attitudes were already strongly positive there was no great scope for change (Question 7). This is consistent with the finding of Dresner and Gill (1994) that previous environmental experience seemed to diminish attitude and behaviour change. Eagles and Demare (1999) also found "a ceiling effect

for environmental attitudes" (p. 6). Overall, values and beliefs changed subtly during this short time reflecting greater awareness of and concern for the environment. These children also had increased their commitment to protect the environment and prevent environmental problems. Although there was a high amount of concern about environmental problems among the children they did not necessarily think it was their responsibility to take part in solving the problems or in talking about environmental problems to others. There is also the possibility that the positive responses of the children were due to the novelty of the situation rather than the method and content (Aubusson et al., 1997). Further, when attitude scales are administered as a pre-test it can sensitise the subjects to the issues (Burns, 1994) and the more positive post-test scores may reflect a component of this sensitisation. This sensitisation is of course one of the aims of environmental education.

The simulation achieved outcomes related to the development of knowledge of kookaburras as the children showed a better understanding of kookaburras and their environment and the effect of humans on the survival of native animals. A development in the vocabulary used by the children was noticed by the teachers and was evident in their responses to Questions 9 and 10, with more specific language being used in the post-test. The role of the teacher in discussing the issues with the children must be emphasised. Many teachers reported that where the factors in the simulation were actively discussed in the post-simulation discussion, they were more likely to be mentioned in the post-tests. It also must be noted that this research only covers a very small environmental intervention and therefore could not be expected to produce dramatic results in such a short period of time.

Both environmental educators and curriculum frameworks documents espouse the need for enjoyment of learning. This activity includes a focus on this aspect of learning. As well, most contemporary curriculum frameworks acknowledge the need for values and attitudes outcomes, including the NSW Environmental Education Policy for Schools (NSWDET, 2001). It is this type of activity which allows the achievement of such affective domain outcomes. In particular, 95% enjoyed the activity (Question 12) and 93% said that the activity increased their knowledge of kookaburra survival (Question 11). These percentages are informative in what may be seen as a combination of quantitative and qualitative analysis of changes to the children's knowledge and attitudes. These results, together with the anecdotal information from the children and teachers provided valuable insights into the children's thinking. The children themselves recognised that both their knowledge and attitude had changed as a result of the simulation. The children acknowledged that this learning experience was enjoyable and had led to a great deal of interaction and participation by them. Importantly, the children themselves believed that the simulation was not only enjoyable but also had increased their knowledge about kookaburras and their sense of responsibility about environmental problems.

The children's responses in Question 10 led to some modifications to the simulation. The fact that several important factors in the survival of kookaburras were not reinforced by the simulation was evident in Question 10 where some appropriate responses in the pre-test (e.g. feral animals and land clearing) were not repeated in the post-test. In the version of the simulation in Clark and Harrison (2002), two interventions were added to the implementation:

- A feral cat takes a kookaburra baby; and
- A bulldozer begins clearing trees in the area.

This should reinforce these factors as influencing kookaburra survival.

There are some disadvantages and concerns raised about the use of simulations. There is some concern that simulations such as this can lead to anthropomorphic views about animals (Aubusson et al., 1997) or conversely, that the ecological views reinforced here could be transferred to human societies and lead to concerns about the survival of weaker individuals or even to concerns about eating certain foods. A further concern is that children may take the simulation too literally and that the role play may be considered the explanation for kookaburra ecology, i.e., that kookaburras think and act like humans. Treagust (1993) has reported this as a concern when using analogies. None of these problems were noted by the teachers at the time, however. Although the children used language that was sometimes based on human societies (e.g. "raise a family") the teachers did not report any evidence of the children actually believing that kookaburras could think and act like humans. Some of the disadvantages raised by the teachers included the time taken to prepare for the simulation and the fact that the classroom was quite noisy and boisterous at times. The teachers all appreciated the need to give the children clear guidelines on acceptable behaviour at the start to avoid behavioural problems. None of the teachers felt that these problems would deter them from using this or similar simulations in the future.

Keywords: simulation; primary; environment; teaching; role-play.

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