The Effect of Instruction on Children's Knowledge of Marine Ecology, Attitudes Toward the Ocean, and Stances Toward Marine Resource Issues

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Abstract

This study examined grade 4 students' knowledge of marine ecology, their attitude towards the seashore and ocean, and their stances (preservationist, conservationist, exploitive) towards marine resource issues before and after a classroom instructional unit. Students' pre-instructional and post-instructional questionnaires, drawings and writing were collected and analyzed. Prior to instruction, the students' knowledge level was low, however their ocean attitudes were positive and they were predominately preservationist and conservationist in their stances. The instructional unit was developed using a constructivist perspective with an emphasis on experiential learning and included field trips to the seashore and the investigation of a local marine resource issue (Pacific salmon stock depletion). After instruction, a significant increase in knowledge and positive attitude was evident. As well, students' stances toward marine resource issues were less polarized. The results have implications for environmental education in general and marine ecology and resource management studies in particular.

Résumé

Cette étude a examiné la connaissance des élèves de 4e année de l'écologie marine, leurs attitudes vis-à-vis du rivage et de l'océan ainsi que leurs positions (préservation, conservation, exploitation) à l'égard des enjeux liés aux ressources marines avant et après un module d'enseignement en classe. Les questionnaires, les dessins et les rédactions des élèves avant et après l'enseignement ont été recueillis et analysés. Avant l'enseignement, le niveau de connaissance des élèves était bas, mais leurs attitudes vis-à-vis de l'océan étaient positives et leurs positions étaient essentiellement axées sur la préservation et la conservation. Le module d'enseignement a été élaboré dans une perspective constructiviste avec un accent sur l'apprentissage expérientiel et comprenait des excursions scolaires sur le rivage

et des recherches sur un enjeu lié aux ressources marines locales (épuisement du stock de saumon coho). Après l'enseignement, une hausse évidente de la connaissance et de l'attitude positive a été constatée. De plus, les positions des élèves à l'égard des enjeux liés aux ressources marines étaient moins polarisées. Ces résultats entraînent des implications pour l'éducation relative à l'environnement dans son ensemble et, plus particulièrement, quant à l'écologie marine et aux études de gestion des ressources.

Humankind is faced with a multitude of conflicts over the resources of oceans and coastal zones. Today, the majority of world fisheries are being fished at or beyond their sustainable limits. Our harvest has reached such a massive scale that scientists now believe we're affecting entire ocean food chains. Public knowledge about the marine environment is critical for a society to be adequately prepared to make wise and responsible decisions about how technologies such as aquaculture, ocean mining, oil exploration and transport, and pulp mill effluent will affect our ocean systems (Snively & Sheppy, 1991).

In his description of elements of environmental literacy, McClaren (1992) states that children need to develop the ability to think about systems and move from awareness to knowledge to positive action. Ecological principles and concepts are important organizers for experience in the environment and provide insights for critically thinking about environmental issues.

An additional important consideration for environmental educators in the development of attitudes and knowledge among children, is the importance of direct experience (Orion & Hofstein, 1994). According to Kellert (1985), children who have direct contact with animals rather than just studying about them are more appreciative and knowledgeable, and show concern towards the animals. Moreover, Jaus (1994) discovered in his study that even minimal amounts of instruction in environmental education is effective in producing highly positive attitudes and that it is possible for these attitudes to be retained over time.

The Canadian Context

For Canada, a nation bordered by three oceans and consisting of one of the

longest and most diverse marine coastlines in the world, the ocean is of particular importance. Yet there is evidence that the crucial importance of oceans and marine resources to Canada, and to the whole world, is not adequately reflected in education materials. According to a study by Lien and Walters (1985), Canadian students favour learning about oceans more than any other environment. Although some good marine teaching materials exist, most curricular materials have been developed with little or no knowledge of students' existing interpretive frameworks (Snively & Sheppy, 1991).

A study by Snively and Sheppy (1991) generated data on students' knowledge of marine ecology and opinions towards natural resource issues. Questionnaires which addressed students' knowledge and opinions were developed and administered to grade 5 and grade 9 students in three different geographical communities in British Columbia (Victoria, Campbell River, and Williams Lake). Similarities and differences between grade levels and among communities were analyzed and compared. Snively and Sheppy found that the students in their study had limited knowledge of science as it applied to the ocean and of the ways in which humans utilize the resources of the ocean. However, the students' opinions towards marine resource issues were predominately preservationist or strongly conservationist which indicated positive student attitudes towards the seashore and ocean. From the results of their study, Snively and Sheppy advocated the identification of students' beliefs and opinions as an important way educators could monitor and resolve conflicts that may exist between students' beliefs prior to instruction and the concepts that are taught in the classroom.

Purpose of the Study

In an attempt to expand on the Snively and Sheppy study, Cummins (1997) was interested in examining her grade 4 students' knowledge about the marine environments of their local area in the Victoria region, their attitudes towards the seashore and ocean as well as their opinions towards a range of marine resource issues. For the purposes of this study, an attitude was defined as a favourable or unfavourable feeling towards objects, persons, groups or any other identifiable aspects of the ocean and seashore environment (Koballa, 1988; Shrigley, Koballa, & Simpson, 1988). Knowledge was defined as scientific information that these students possess in the areas of physical oceanography, ocean ecology, and human effects on the ocean (Snively & Sheppy, 1991). Stances were defined as the

opinions that these grade 4 students had towards a variety of coastal marine issues and represented an appropriate course of action to take in a given resource conflict situation. Stances identified were conservationist, exploitive, or preservationist (Snively & Sheppy, 1991).

A unit of explicit instruction was developed from a constructivist perspective. The unit emphasized experiential learning in the form of field trips to local beaches, a trip to a marine ecology centre, and hands-on, minds-on activities in the classroom. The teaching strategies employed were a means for increasing the students' awareness of the diversity of marine organisms and increasing their understanding of basic marine ecology concepts.

A second emphasis within the study was related to understanding local marine resource issues. The issue of salmon stock depletion was developed and related to the scientific knowledge emphasized in this study. The instruction encouraged a conservationist's view as the appropriate stance to adopt in attempting to resolve the B.C. salmon issue. The choice of this view was based upon the belief that the salmon resource in B.C. can be utilized as a food source for humans and at the same time be controlled and managed wisely to ensure viable salmon stocks for future generations.

Validated questionnaires were selected from several that had been used in the study by Snively and Sheppy (1991). Cummins (1997) used the Snively and Sheppy questionnaires as pre-instructional and post-instructional instruments of measurement of attitude, knowledge and opinion (stances).

Research Questions

The research questions that formed the basis of this study were:

- What is the nature of the children's attitudes towards seashore ecology before and after experiential learning?
- What is the nature of the children's knowledge of seashore ecology (tides and currents, habitats, food chains, seashore communities, and related marine issues) prior to and after instruction?
- What are the children's stances (conservationist, preservationist, or exploitive) towards a variety of marine issues prior to and after instruction?
- Will an increase in the knowledge of beach ecology have an effect on the children's attitudes and stances?
- How effective was the strategy of instruction?
- Is there a relationship between the children's post-instructional stances and a change in attitude?

Snively and Sheppy (1991) had not used their questionnaires where an instructional treatment was the focus, as their study had focused on the development of the questionnaires and had been a comparison of students in grades 5 and 9 in the three communities in B.C. Therefore, the researchers wanted to determine if these instruments were valuable as pre-test and post-test instruments to assess the development of students' knowledge of seashore and ocean ecology, their possible changes in attitude, and what opinions they had about a variety of marine resource issues before and after that instruction. Additionally, the current research attempted to determine if the questionnaires could be used successfully with a younger group of children (grade 4).

Site and Participants

This study involved one class of 15 males and 11 females in grade 4 at Lampson St. School in Esquimalt, British Columbia, Canada. Located on the southern tip of Vancouver Island, Esquimalt has a population of 18,000 and is one of six municipalities of the coastal city of Victoria, a mid-sized city with a population of 300,000 people. Ocean based industries play only a small part in the economy of the city and other resource-based industries are not highly visible.

The school and all students in its catchment area are within walking distance of a beach. Many of the children have limited background experiences and the school as a whole has a higher than average percentage of students with learning difficulties.

Research Questionnaires

Four questionnaires developed for grades 5 and 9 students and described by Snively and Sheppy (1991) were used to collect the data in this study. Cummins (1997), modified two of the questionnaires to make them more appropriate to grade 4 students.

- The Ocean Background questionnaire contains 25 items which include questions about the frequency of students' visits to the seashore, their preferences for studying the seashore or ocean environment, the frequency of their use of the ocean for a variety of activities, and the frequency in which they engaged in learning experiences which were ocean-related.
- The Ocean Attitudes questionnaire is a 37 item questionnaire designed to assess students' attitudes towards the ocean. Five choices are given for responses ranging from strongly disagree to strongly agree. The top-

ics cover a variety of specific coastal issues such as wild marine mammals in captivity, removing seashells from beaches, and the commercial fishing industry. The following are examples of the types of items used:

- The killer whales in aquariums should be kept on display for the public to enjoy.
- Pulp mills should be allowed to dump chemical waste into oceans and lakes.
- Commercial fishermen should be allowed to fish whenever and wherever they want.

- The Ocean Life questionnaire is a 30 item multiple choice questionnaire designed to assess students' scientific knowledge of the ocean and coastline. It consists of three sub-tests; Physical Oceanography (7 items), Ocean Ecology (14 items), and Human Effects on the Ocean Environment (9 items).
- The Ocean Opinions questionnaire is a 20 item multiple choice questionnaire in which students are asked to choose, from among four options, the one which best matches their opinion as to an appropriate course of action to take in a given resource conflict situation. "Exploitive" stance options were written to express the point of view that immediate economic return is the prime concern in human interaction with the environment. "Conservationist" stance options recognize that Canadian society depends upon the utilization of nature's resources to meet its needs and desires, but that the resources must be used carefully in order to prevent their depletion or extinction so they are maintained into the future. "Preservationist" stance options were written to reflect the attitude that humans should interfere minimally or not at all with natural processes, that economic considerations should never be a factor in decision making or that humans should seek to restore the environment to some "natural" condition. The following is an example of the sort of item used:

> Some species of whales are not near extinction. What should be done about hunting these kinds of whales?
> A. Hunting whales should be allowed because it provides people with food, clothing and money.
> B. Hunting whales should not be allowed because whales are beautiful and intelligent.
> C. It is alright to kill a certain number of these kinds of whales as long as plenty are left.
> D. Hunting whales should not be allowed because whales are part of the food chain.

Option A is the Exploitive option, option C the controlled use or Conservationist option, and options B and D represent the Preservationist

stance. Students' responses will be scored so that each student receives an Exploitative score, a Conservationist score, and a Preservationist score.

Instructional Strategies

Cummins wanted to create an educational program that would address the dimensions of knowledge, attitudes and values, and behaviour rather than focus on knowledge alone, a traditional approach for many environmental educators (Ballantyne & Packer, 1996). As well, a constructivist view of learning guided the development of the unit. This approach to learning takes into account the way children "develop their own mini-theories or personal constructs based on direct experience with the physical world and informal social interactions" (Driver & Oldham, 1986). Therefore Cummins (1997) designed a "bare bones" skeletal unit consisting of a logical sequence of activities that would increase the students' knowledge of basic ecology concepts. Then, she analyzed the students' prior knowledge of seashore and ocean ecology in order to design specific activities that would address the students' lack of knowledge, and in addition, take their ideas and beliefs into account during the instructional process. In general, the goals of the instruction were to:

- increase the students' knowledge of marine ecology concepts,
- increase the students' positive attitudes towards the seashore,
- enable the students to make reasoned judgements about marine resource issues, and
- encourage an ethic of stewardship towards marine animals and habitats.

Classroom instruction was designed to develop the marine science concepts: (1) ocean currents, waves, and tides, (2) seashore plants and animals, (3) seashore habitats, (4) zonation, (5) food webs, (6) interdependence and community, and (7) stewardship. Also, local marine issues involving waste management and potential impact of oil spills on the local site were discussed. The issue of Pacific salmon stock depletion was developed and related to the scientific knowledge emphasized in this study. In addition, the issue was explored from many viewpoints (conservationist, commercial fishermen, biologist, government official, and First Nations chief) and analyzed in depth using a role-play strategy. Although the issue was explored from many viewpoints, the instruction encouraged a conservationist's view as the appropriate stance to adopt in attempting to resolve the B.C. salmon issue. The choice of this view was based upon the belief that the salmon

resource can be utilized as a food source for humans and at the same time be managed wisely to ensure viable salmon stocks for future generations. By critically analyzing one marine resource issue in depth, it was hoped that the students would be better able to apply their knowledge and make reasoned judgements about a range of marine resource issues.

The first field trip site was within walking distance for the children involved, thus providing an opportunity for repeated visits. The beach has a small sandy area and a rocky shore containing many tide pools wherein a great diversity of marine plants and animals can be viewed in their natural habitats. The other site was the Cowichan Bay Marine Ecology Station where the children were given further opportunity to explore the characteristics of living marine animals and plants using microscopes, in aquaria, on real time video, and through plankton collecting excursions and observations.

The children were required to keep a field log for recording descriptive and statistical information (date, time, tide levels, and weather), and for sketching seashore animals, tidepools, zonation, and making observational notes. They were given time to reflect and interact with each other in small and large groups using their field logs. The unit of study was taught over an eight week period and involved reading and writing to support active and constructive learning as well as promoting the use of scientific inquiry and problem solving skills.

The Students' Pre- and Post-Instructional Responses

Paired sample *t*-test were used to compare pre- and post-data on the Ocean Life questionnaire, the Ocean Attitude questionnaire and the Ocean Opinions questionnaire. Pearson product-moment coefficients were calculated to search for correlations among attitudes, knowledge and stances. As well, independent sample *t*-tests were performed to examine gender differences in attitude, knowledge and stance scores.

During all phases of the research, a journal was kept by the researcher describing the various events, student interactions, comments, general observations, and reflections. The students' field logs were consulted to clarify findings and assist with data interpretation.

Findings

The students' ocean background. The Ocean Background questionnaire was administered prior to instruction only. This questionnaire provided the researcher with information about the students' experiences related to the ocean and was only administered as a pre-instructional instrument. The students were asked to reply to the questions using the words never, sometimes, or often and the researcher summarized the data according to frequencies of similar responses. Most of the children were frequent visitors to the seashore with more than 78% making 2 or more trips in the last year. No one reported never having been to the seashore.

When asked what topic they would choose to study in school (city, seashore or oceans, mountains, prairies, or pond, lake, or river), the children chose the mountains (35%) and seashore or oceans (22%) as a first choice. Only 9% chose the seashore and ocean as what they would least like to study in school. It was interesting to note that 75% of the mountain choice was made by boys. A father of one of the boys in this group is a mountain climber and this boy has shared many stories with his friends about his dad's adventures. This factor may have influenced some of the boys choices.

The most frequent use of the beach resulting in an often or sometimes choice for these students was: (1) exploring (83%); (2) collecting shells (78%); (3) suntanning or picnicking (74%); and swimming (69%). The students reported that 48% of them had never been sports fishing or boating or sailing (39%).

The children reported they had learned about the ocean or seashore from movies and TV shows (95%), classes in school (95%), doing things on or by the ocean (91%), nature books and magazines (74%), and public aquaria or nature centers (70%). The newspaper was a very infrequent source of information about the ocean for these children with 87% choosing "never" as their response.

Snively and Sheppy (1991) had administered the same questionnaire to grades 5 and 9 students in three different geographical communities in British Columbia. Over 90% of the coastal community students in the Snively and Sheppy study reported visiting the ocean two or more times, as compared to 78% of these grade 4 students in this study. Concerning the topics suggested for study in school, the Snively and Sheppy respondents chose the ocean first (41%) or second (26%) as compared to mountains first (35%) and oceans second (22%) as preferred by the students in this study.

Interesting differences were also observed between the two studies with other items on the questionnaire (see Table 1).

It was interesting to note that 45% of the grade 5 students in the

Snively and Sheppy study stated that they "rarely" or "never" learned about the ocean from classes in school compared to a higher percentage of grade 4 students in this study that felt school was an important resource.

Ocean Uses (often and sometimes)	1990 Study	1996 Study
1. suntanning/picnicking	64%	73%
2. exploring	57%	83%
3. swimming	51%	69%
4. collecting seashells	49%	78%
5. boating and sailing	40%	39%
Learning about the Ocean (often and sometimes)		
1. TV and movies	60%	95%
2. nature housesm aquaria	58%	80%
3. first hand experience	55%	91%
4. books/school	40%	75%

Table 1. Two ocean studies.

The students' ocean attitudes. The post-attitude scores on the Ocean Attitude questionnaire were tabulated using the same method as was used in calculating the pre-attitude scores. The responses for each student were tallied from using a 0 to 4 coding, wherein 0 was considered very positive and 4 very negative. The number of responses in each category (0 - 4) were then totaled. The very positive and positive responses (0 and 1) were then added together as were the negative and very negative scores (3 and 4). The number 2 coded responses were considered undecided and therefore disregarded in the final calculation each students' attitude score. The negative response totals were then subtracted from the positive responses resulting in a score that was then considered to be that student's attitude score. The higher the score, the more positive the attitude. A paired sample *t*-test was then administered to the pre-attitude and post-attitude scores. The results indicated a significant increase in attitude (see Table 2).

The students remained very positive (0 and 1 values combined) in their attitudes (>90%) towards the statements on the post-instructional Ocean Attitudes questionnaire concerning pollution (pulp mills, Victoria's sewage disposal, damage to wetlands) and the treatment of marine mammals (harp seals being hunted for their fur, whales in captivity, seals being

Variable	Number of pairs	Mean	SD
Post-attitude	21	19.0476	4.105
Pre-attitude		5.3810	5.399
t-value	df	2-tail Sig	
10.04	20	.000 (p>001)	

Table 2. Paired sample *t*-test pre- and post-attitude scores.

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by salmon fishermen). Also, in 91% of their responses the children indicated that they thought all living things had a right to exist. The same percentage of students agreed that stronger laws are needed to protect our ocean, seashore, and wetlands. Other positive responses (>74% of the responses) included disagreeing with marshlands being filled in and the exploitation of natural resource. Most of the students agreed that commercial fishermen take too many fish (87%), the taking of shellfish should be restricted (87%), and that learning about Arctic and Atlantic animals is important (78%). Certain items illustrated the increase in positive student responses in the post-test questionnaire as compared to the pre-test questionnaire very clearly (see Table 3).

Item No.	Pre-test	Post-test
4. oil and gas exploration should not be allowed	22%	43%
9. shore crabs should not be taken home as pets	78%	91%
13. killing of harp seal pups should not be allowed	83%	96%
20. fishing for fun should have restrictions	17%	56%
24. the taking of shellfish should be regulated	30%	87%
28. more money should be spent on scientific research	35%	55%
32. all living things have a right to exist	70%	91%

Table 3. Pre-test and post-test student attitude responses.

The students' ocean knowledge. The post-instructional knowledge scores from the Ocean Life questionnaire were compared to the pre-instructional knowledge scores by administering a paired sample *t*-test to determine the level of significance. Even though the mean score for the students only

increased by 2.38, the comparative analysis supported the rejection of the null hypothesis and a level of significance became apparent (see Table 4).

Variable	Number of pairs	Mean	SD
Post-knowledge	21	16.4762	5.154
Pre-knowledge		14.2381	4.504
t-value	df	2-tail Sig	
2.81	20	.011 (p=.01)	

Table 4. Paired sample *t*-test for pre- and post-knowledge scores.

The items of three sub-tests (Physical Oceanography, Ocean and Seashore Ecology, Human Effects on the Ocean Environment) were examined to compare individual item differences to the pre-instructional treatment.

On the Physical Oceanography sub-test, four items out of the seven (57%) were answered correctly by more than 50% of the students. The number of children correctly answering these items increased (see Table 5).

Item No.	Content	Pre-test	Post-test
1.	% of ocean covered by water	74%	78%
2.	meaning of tides	70%	91%
3.	cause of tides	57%	74%
4.	ocean currents	4%	28%
5.	B.C.'s shoreline	9%	28%
6.	oil spill areas	26%	35%
7.	meaning of mud flat	39%	70%

Table 5. Percentages of correct student responses on the physical oceanography sub-test.

Even though the other items were not answered correctly by more than 50% of the students, they all showed an increase of student responses as compared to the pre-test results.

The response to the Ocean Ecology sub-test items on the post-test remained the same as the pre-test with 7 of the 14 items (50%) being answered correctly by more than 50% of the students. However, the percentages of children answering each question correctly increased. For example, 91% of the students knew about plankton in the post-test as opposed to 65% in the pre-test. Similarly, 91% of the children knew that the

energy of living things in the ocean come from the sun post-instructionally compared with 48% pre-instructionally. There was also a percentage increase of correct student responses in items that were answered correctly by less than 50% of the students.

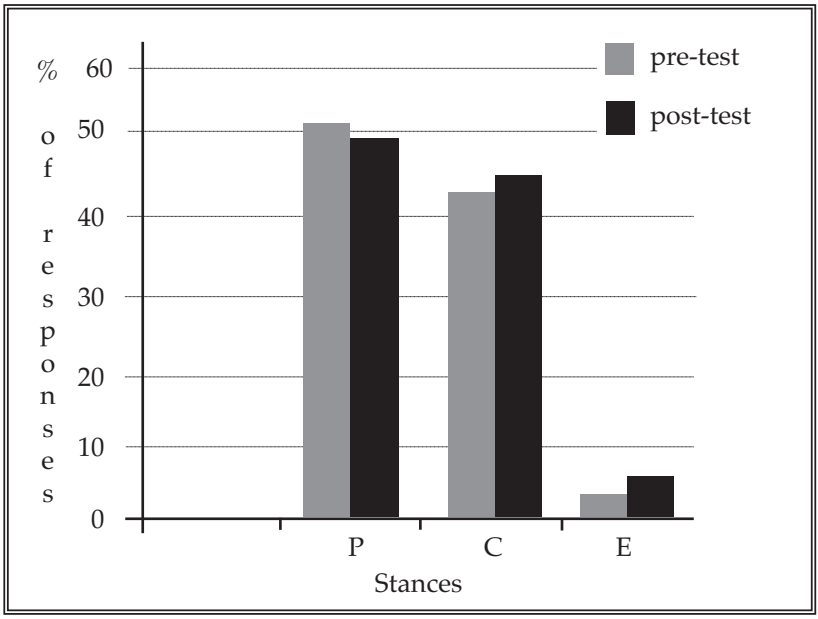
It is important to note that the items that were directly related to the concepts covered in the instructional unit had the highest percentages of correct responses. For example, food chains and food webs were emphasized using several teaching strategies and before instruction the number of correct student responses to the item that referred to food chains was 52%. After instruction the number of correct student responses to the food chain item was 91%.

The increase of correct student responses on "The Human Effects on the Ocean Environment" sub-test indicated that some students had a better idea that birds and some seashore creatures are most affected by oil spills, where it is safest to harvest seashore animals for consumption, and a better idea of the value of salt marshes. The students in this study still did not have a clear understanding of the different types of marine pollution as revealed through the mixed responses to the items concerned with how polluted water can look and the effects of pollution on living plants and creatures. Marine pollution was only briefly discussed over the period of instruction and the student responses in both the pre-test and post-test and actually showed a decrease in correct responses (see Table 6).

Item No.	Content	Pre-test	Post-test
22.	how polluted water appears	52%	30%
25.	environments damaged most by human activity	30%	22%
30.	loss of habitat is a greater danger than pollution	30%	22%

Table 6. Percentages of correct student responses on the human effects on the ocean sub-test.

The students' ocean opinions. The students' preservationist, exploitive, and conservationist stances on the Ocean Opinion post-test were examined. Of the choices made by the students in the post-instructional questionnaire, 48% were preservationist, 45% were conservationist and 6% were exploitive. Compared to the pre-instructional treatment, there was a slight decrease (3%) in preservationist responses, a slight increase (1%) in conservationist responses and a slight increase (2%) in exploitive scores (see Figure 1).



P = Preservationist; C = Conservationist; E = Exploitive

Figure 1. Pre-test and post-test stances

On no item was an exploitive stance the preferred choice, and only on one item did this stance draw more than 17% of the students. Although the post-test percentages of responses remained close to the pre-test responses, the major difference appeared not in the student percentages for each stance, but in the variety of stances each student chose for the total number of items on the questionnaire. In other words, fewer students were strictly preservationist or conservationist but a mixture of these two stances. As well, there were two students whose 20 responses were evenly distributed among the preservationist, conservationist, and exploitive stances. This was interpreted as meaning that the students were trying to approach these issues from many different perspectives and perhaps less than idealistic in their thinking.

Students remained the same in some of the stronger preservationist stances that were evident in the pre-instructional questionnaire and some of the post-instructional responses showed an increase in preservationist opinions (see Table 7).

The one item where an exploitive stance represented more than 17% of the responses was the question "Should killer whales be kept in places like the Vancouver Public Aquarium and Sealand?" Of the responses, 17

Item No.		Pre-test	Post-test
1.	killing of harp seals	91%	91%
2.	oil tankers along coastline should not be allowed	83%	83%
3.	stronger maritime laws needed	65%	70%
4.	no whale hunting should be allowed	73%	78%
5.	off shore oil and gas exploration should not be allowed	39%	48%
6.	driftnet fishing should be stopped	65%	87%
7.	Victoria should not dump raw sewage into the ocean	17%	57%
8.	pulp mills should find other places to dump their chemicals	39%	54%

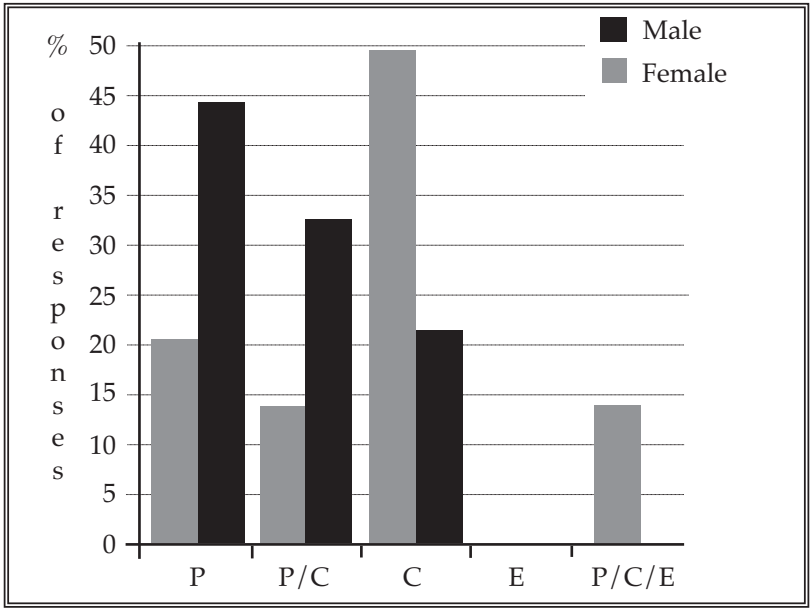
Table 7. Pre-test and post-test preservationist stances

represented the preservationist stance that all killer whales should be free; 48% represented conservationist stances that no new killer whales being captured or keeping killer whales for a few years and then letting them go; and a surprising 35% represented the exploitive stance of keeping some killer whales because they are fun to watch and a lot can be learned from them. There was a shift from the pre-test frequencies where 43% of the children favoured a preservationist stance and 17% favoured an exploitive stance. The researcher observed student reactions to a video shown during instruction depicting whales doing tricks in aquariums. The video was shown in contrast to another video which related the saga of two scientists who had studied killer whales in the wild for 20 years with minimal interference with the animals in their natural environments. It may be that some of the students in this study were more impressed with the tricks.

When viewing the stance differences between genders, the girls remained more preservationist than the boys. Out of 460 responses, only 30 were exploitive (M=22, F=8).

The students were then coded according to how many responses they chose in each category (preservationist, conservationist, and exploitive). Five categories were established to describe the stance of a particular student. A student could be preservationist (4), conservationist/preservationist (3), conservationist (2), exploitive (1) and mixed (0), that is, a combination of preservationist, conservationist and exploitive responses. In order for a student to be rated in any of these categories, the difference between the number of any of their responses (preservationist, conservationist, exploitive) to the 20 item Ocean Opinions questionnaire had to be at least

three. For example, if a student had 12 preservationist responses, 7 conservationist responses, and 1 exploitive response, that student would be given a code of 4. The codings were then summarized and divided according to gender to determine the post-instructional percentages of stances for male and female (see Figure 2).



P = Preservationist; P/C - Preservationist/Conservationist;
C = Conservationist; E = Exploitive; P/C/E = all three stances

Figure 2. Post-instructional stances by gender.

Correlations

Pearson product-moment coefficients were calculated to estimate the correlations among the students' knowledge, attitudes, and stances. No correlation was found between knowledge and stances or between attitude and knowledge using the pre-instructional and the post-instructional scores. There was only a very weak positive correlation between the pre-test stance scores and the post-test stance scores (r=.47, p=0.030). A larger sample may have provided a more representative index of the nature of the relationships among the three variables of knowledge, attitude and stance. This means that a relationship could possibly exist among the variables in question, however the sample in this study was too small to reveal one. With this information concerning correlations in mind, together with the fact that

there was a significant increase in knowledge, and attitude as well as some rather interesting differences in students' opinions merits further investigation into the intervention that transpired between the pre-tests and the post-tests. It is also possible that community events may have occured during the pre- and post-test intervals. Further work could clarify this possiblity through use of a control group.

Gender Differences

There were no significant mean differences in the male and female attitudes, knowledge, or choice of stances in any of the comparisons made between the pre-test and post-test scores.

Summary and Conclusions

The statistical analyses of the questionnaires provided information about the pre-instructional and post-instructional nature of the attitudes, knowledge, and stances of the grade 4 children involved in this study. There was a significant increase in knowledge as well as a significant increase in positive attitudes. The students also made some interesting shifts in their stances as illustrated in the comparisons of pre-test and post-test results. However, a significant relationship between the increase in knowledge and the increase in attitude was not evident. A further relationship between the students' stances and their increase in attitude could not be established in the study sample.

In analyzing the data, several indicators supported the importance of explicit instruction as well as taking into account prior knowledge and ongoing knowledge during instruction. The very fact that there was a significant increase in attitude appeared to indicate a connection to the instructional strategies used to provide the students with the firsthand experiences necessary to develop an understanding of basic marine ecology concepts and the impact of marine resource conflicts. Closer scrutiny of the responses to the pre-instructional and post-instructional attitude questionnaires revealed that the items showing the most increase in positive scores were ones that could be linked to first hand concepts covered during the course of instruction. For example, many children had not realized that barnacles and aggregate anemones were actual living animals until their field experiences. Much discussion focused upon seashore communities and how careless humans can either purposely or unknowingly destroy these fragile habitats. Seashore etiquette became a very important feature of the student's trips to Saxe Pt. Park. The care and preservation of living creatures and

marine habitats as "homes" for many plants and animals was emphasized throughout instruction, and reinforced through modeling at the site. When individual post-test attitude items to pre-test items were compared, there was over a 20% increase of the number of children who strongly agreed that all living things have a right to exist. Additionally, on the post-test, 87% of the students agreed that people should not be allowed to take as many shellfish such as clams and crabs as they want. This was a 57% increase over the pre-test. The increase in positive attitude scores may indicate that attitude is an indicator of surface thinking and more easily changed than stances, which may be more deep-set conceptual structures. The observations of the associations between specific strategies of instruction, and the development of positive environmental attitudes in this study, coincide with and supplement similar findings of other studies that feature direct experience as a critical element of instruction (Armstrong & Impara, 1991; Ryan, 1991; Shepard & Speelman, 1986).

Another undeniable occurrence in this study was the significant increase in the students' knowledge. Again, there appears to be a relationship between not only the concepts taught in the course of instruction, but the methods used in presenting these concepts. For example, several individual items on the Ocean Life post-test represented a notable percentage increase of correct responses over the same pre-test item. Three of the items on the questionnaire referred to the meaning of tides and currents. The post-test correct responses for the meaning of tides increased 21%, the correct response for the causes of tides increased 17%, and the correct response for the meaning of ocean currents increased 24%. A possible explanation for this increase in correct responses could have been the set of classroom stations with hands-on activities to help students understand the interrelated concepts of tides, currents and waves, and the field activities wherein the students measured tidal changes over time. Three of the items on the questionnaire referred to the flow of energy through a food chain from predator to prey. The post-test correct response for the meaning of food chains increased by 40% over the pre-test, the correct response for the sun as the source of energy increased by 40%, and the correct response for the meaning of plankton (microscopic plants and animals at the base of the food chain) increased by 39%. A possible explanation for this new knowledge could lie in the emphasis placed on observing and drawing living plankton, the observation of many seashore animals feeding, and by studying and role playing food chains and food webs.

A further indicator of the possible effects of the learning strategies was the change in the configuration of the students' stances between the pre-

instructional and post-instructional Ocean Opinions questionnaires. Indications were that perhaps something had occurred during the treatment phase that caused some of the students to rethink their opinions about the ocean and seashore. Recall that marine resource issues were part of the ocean and seashore unit of instruction. The students briefly discussed specific issues such as whales in captivity, ocean, and seashore pollution (sewage disposal and oil spills) and one issue (Pacific Northwest salmon stock depletion) was investigated in greater detail.

A closer examination of individual student responses and how they changed in stance revealed some interesting trends. Only 5 students remained strongly preservationist out of the 9 whose responses had indicated that stance in the pre-test. The movement of scores was towards a more conservationist stance, thus less polarized. Two students demonstrated an almost even number of responses of all three stances (preservationist, conservationist, and exploitive). These patterns could be a result of the students viewing the resolution of marine resource issues as a complicated process involving tolerance of many opinions and critical evaluation of consequences. Perhaps the many perspectives presented in the role play activity concerning the decline in the Pacific salmon stocks assisted students to examine their thinking on other resource issues. Although a conservationist stance would not be the most desirable stance to choose in all resource conflicts, it is certainly the option that in most instances would reflect an environmentally literate and concerned citizen. Therefore, it would seem that the movement towards a more conservationist stance did result in achieving the intended instructional outcome of providing students with experiences that would enable them to make reasoned judgements concerning our seashores and oceans, a goal reflective of effective training and practice in dealing with controversial resource issues (Brody, 1996; Newhouse, 1990; Ramsey & Hungerford, 1989; Snively & Sheppy, 1991).

The importance of experiential learning for environmental education was effective in this study as evidenced by the value that these students began attributing to the rocky seashore plants and creatures with which they became familiar. Correct terminology began to become an integral part of these students' vocabulary, not only in naming individual seashore plants and animals but in describing processes and relationships such as interdependence, energy flow, community, adaptations, food chains and webs, and zonation. From their explorations, a respect for living plants and animals in their natural habitats began to emerge as well as a sense of protection towards a local rocky seashore. The final trip to Saxe Pt. presented a far different picture than the first. Instead of throwing rocks into the water and

having to be reminded to keep on task, the children were engaged in self-directed observation activities, excited about what they saw, and respectful of the plants and animals they had come to know. The suggestion by some students to return for a beach clean-up was later acted upon in the spring.

Implications for Instructional Strategies

As discussed previously, the guiding principles for the unit of instruction were based upon a constructivist view of learning. Examining students' prior knowledge helped Cummins choose appropriate concepts that needed specific instruction, thus increasing the children's understanding of ocean and seashore ecology.

Perhaps the most difficult aspect of the instructional part of this study was the focus on marine resource issues. In the course of the role playing activity that explored the issue of Pacific salmon stock depletion, it was evident that most of the students weren't really aware of their own ideas and opinions; but as the instruction continued, the students were better able to articulate their ideas and listen to the ideas and opinions of others. It would appear that by examining a local marine issue in detail the children were provided with strategies that helped them base their opinions on factual understanding, and hopefully they were less easily swayed by uninformed or biased opinions or attitudes.

Implications for Future Research

Overall, the researchers concluded that the instruments used in this study did help in assessing the effectiveness of instruction. Nonetheless, it was felt that the questionnaires need to receive closer scrutiny if they are to be used with grade 4 students. Although the knowledge questionnaire (Ocean Life) had already been altered to accommodate these students, the items on seashore zonation may have been too sophisticated. Less complex questions that contain the same principles could be developed. The attitude questionnaire (Ocean Attitudes) was better suited for these children because the items were in the form of short sentences and the vocabulary, for the most part, was familiar.

The Ocean Opinion questionnaire posed two problems. First, the decision of whether a response was preservationist, conservationist, or exploitive was hard to determine for some of the items. Part of the difficulty lay in the fact that marine resource issues are constantly evolving and changing. Either some of these issues are resolved, some become a bigger problem, new ones take precedence or new technologies, and laws or circumstances affect