Reef education evaluation: environmental knowledge and reef experience

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Abstract: This paper reports on portions of a marine education PhD research project that investigated learning with high school students and coral reef marine experiential education interventions. In this paper, I evaluate changes in Queensland Year 11 and 12 students' environmental learning outcomes when visits to the reef are added to their classroom curriculum. Marine education aims to educate a citizenry capable of making astute decisions about the impact of human activities on the environment as well as altering fundamental societal practices. However, I was not seeing positive results as a classroom teacher or researcher in the field and this research followed. The study also explored links between coral reef ecological knowledge (awareness) and direct coral reef experience. The educational research took place at offshore sites in the Great Barrier Reef, and it investigated questions of whether experiential marine education changed the reported environmental knowledge of student participants. Education outcome evaluations are presented and implications for effective marine education strategies discussed. Research findings strongly indicate field trips should be included as part of marine education programs in order to improve environmental knowledge (awareness).

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Introduction

My initial motivation to undertake this doctoral research came after I observed a group of Grade 8 students on their encounters with a fringing coral reef in Kaua'i, Hawai'i. On the first visit, the students while walking along the reef were picking up bits of algae and coral and were throwing them at each other. On the second visit two weeks later, I noticed a change as some students were looking at various seaweeds and calling to their friends to look. One of the previously more distracted students showed his find to another student and said, "Look at this *Padina* [genus of brown algae, seaweed], it is just like the picture we saw in the book. Look at how the leaves come out like plants at home, and the base is fastened like roots of a tree." Both nodded, and placed it back into the water before continuing their reef walk. On their second visit to this reef, instead of just enjoying themselves, the Grade 8 students were less boisterous and more interested in examining the living plants and sea creatures. It seemed to me that the students' way of relating to the reef and its ecosystem was different, or had been transformed (O'Sullivan, 1999), as they were having "real life" experiences of the reef. Similar observations of changes in students' interactions with plants and animals have been noted by other outdoor education studies such as Bogner (1998) as well as Kruse and Card (2004). Further visits by the eighth grade students to the same reef confirmed that they were beginning to understand that the reef was a living entity rather than just a playground.

While I was moved and inspired by students' behaviour on the reef, I am also aware that environmental education is presently at a crossroads to determine whether its future should be based on more of the same, or actively working in the formal education system to improve implementation of environmentally based concepts and practices (Fien, 2004; Finger, 1994; Robottom, 1991). Fein (2004) argues that education could "play an important role in motivating and empowering people to participate" (p. 185) in working to preserve, and conserve environments for the future.

This paper provides relevant results of my PhD research that explored learning relationships and marine educational outcomes, and a procedure for conducting outdoor experiential education research. The research explored a number of learning constructs, and the variables considered are environmental knowledge and previous reef experience. The research question addresses whether reef education and reef monitoring experiences enhance student learning. This question was examined by

measuring changes in student responses relating to environmental knowledge between a pre-test and post-test, as well as through student interviews. The experimental design was structured to determine if actual reef monitoring visits produced the greatest positive change in self-reported environmental knowledge responses for student participants.

My education research focused on the developing field of marine education that has very few formalised objectives and outcomes. Hence, it was necessary to establish a set of criteria with which to evaluate student participants' changes with respect to achievable learning outcomes. The Marine Education Society of Australasia's (MESA) three A's of Coastal and Marine Studies are awareness, attitude and action (Marine Education Society of Australasia, 2004). In this paper, awareness (knowledge) is discussed. Environmental awareness (knowledge) was understood to relate to something we know, as incorporated in an act of knowing or being aware of issues and action skills related to the coastal and marine environments.

This story discusses taking senior high school students out to coral reefs, and investigates educational effects of coral reef environmental experiences in relation to a specific learning outcome. Students from five Queensland high schools worked with the researcher both in the classroom and at coral reef sites. Once in the water students snorkeled along a 50 m transect line and collected data about marine species such as fish and invertebrates. The research project described in this paper investigated these factors and was carried out in Queensland during 2002 and 2003.

Methods

The effectiveness of classroom learning and reef trips were investigated, as well as strategies to enhance high school students' propensity for change concerning environmental knowledge towards coral reef sustainability. Students were separated into groups and subjected to differing levels of exposure to classroom learning and direct experience with reefs. Self-reported changes of students' environmental knowledge were evaluated after they participated in a coral reef monitoring program. These student groups were compared to a contrast group who received no educational interventions.

Classroom presentations utilized a PowerPoint and hands-on education, and was conducted by the researcher, who explained reef ecology and coral reef

monitoring. The 30 to 50 minute presentation introduced pictorial representations of reef creatures to be counted and a classroom demonstration of monitoring activities, and was done in preparation for the students' reef monitoring trip.

The reef experience consisted of a trip to the reef on coastal charter vessels with 26 to 55 students. Once at the reef, the students snorkeled along the transect line on the reef and recorded information on underwater slates. The monitoring methodology was a simplified version of Reef Check (Hodgson & Stepath, 1999), which is a coral reef monitoring program developed for volunteer groups around the world (www.reefcheck.org). The data collection process provided a structured reef learning experience for the students, and a context for the students to learn reef ecology, actually get in the water with reef animals, and physically write down what they saw.

The total number of high school students involved in the study was 389, with the sample being divided into four groups as depicted in Figure 1. Students groups were surveyed and observed in a number of learning situations to gather educational outcome data, and then this information was compared. The categories were Group 1 (n = 85), the marine experiential education group who were exposed to both the classroom presentation and an offshore reef learning experience. Group 2 (n = 64) received the classroom presentation, but was not taken to the reef. Group 3 (n = 97) only received new reef monitoring experience, and did not receive prior classroom instruction. Group 4 (n = 74) was the contrast group who was surveyed over the same length of time, but was not given the classroom presentation or a reef trip, and had no contact with the researcher (Stepath, 2006).

	Reef Experience	
	New reef experience	No new reef experience
New classroom presentation	Group 1- reef trip & Class presentation	Group 2-No reef trip &Class presentation
Classroom Presentation		
No new classroom presentation	Group 3-reef trip & No Class presentation	Group 4-No reef trip, No Class presentation

Figure 1 Educational intervention sample groups

A pre-test post-test experimental design (2x2) was used to measure changes in students' environmental knowledge responses. A survey questionnaire was answered both before (pre-test) and after (post-test) the educational interventions. The student groups each answered the pre-test in a classroom situation at the beginning of the project, and then experienced the designed educational interventions. One week after their last educational intervention, the students answered the post-test survey questionnaire.

Study Population Description, Data Analysis and Interpretation

This five-week research project investigated student learning by describing changes according to the experimental design. Survey data was collected exclusively from a convenience sample of high school students attending five Queensland coastal area schools. A sample for this marine education research was made up of senior high school students (Years 11 and 12) who were from Marine Studies and other programs. Most students were enrolled in Marine Studies subjects with a substantial percentage of the participants attending other science classes, as well as religious education and accounting classes (43%). The data is survey and interview responses from predominately Year 11 students (88%). The sample was selected by the participating schools, and was as consistent as possible from one school to the next. The student sample size used in the quantitative analysis was 320 (n = 320), and all participating students completed a pre-test questionnaire.

Interventions and the Survey Instrument

During the learning interventions, students were introduced to varying types of instruction to improve their understanding of marine science and reef ecosystems, while providing fun-learning activities designed to promote appreciation of the environment, and improving the students' environmental solution skills and monitoring abilities. Learning interventions of a classroom presentation and direct reef experiential education were investigated for effectiveness in achieving learning outcomes associated with marine education and Queensland Marine Studies programs (Marine Education Society of Australasia, 2005; Queensland Studies Authority, 2005a; Queensland Studies Authority, 2005b; Queensland Studies Authority, 2005c)

and Environment Australia education goals (Australia's Oceans Policy, 1999; Department of the Environment and Heritage [DEH], 2002).

Exploratory Statistical Analysis

The relationship between, environmental knowledge, reef experience and student groups was examined. Marine education was investigated by comparing the results from the groups that experience varying educational interventions. Changes in responses from the pre- to post-test surveys were examined to determine whether marine experiential education increased environmental knowledge more than classroom presentations. The students' mean environmental knowledge score was 4.87 correct out of 9 on the pre-test knowledge portion.

Environmental knowledge.

Total knowledge scores were computed and the difference between scores calculated. Figure 2 depicts knowledge change for various treatments by comparing the standard error of the means (±1 se) between different groups (Miller, Acton, Fullerton & Maltby, 2002). Changes in positive answers for nine knowledge questions from pre- to post-test are shown along the vertical axis, with different groups along the horizontal axis. Group 1, which had both a reef ecology classroom presentation and reef experience, had the most change in survey scores and the highest post-test score, while Group 4 (the contrast group with no educational interventions) had the lowest. Group 1 percentage change was 44.73% to a mean score of 7.11 and Group 2 (classroom presentation) had a high mean score of 6.20 for the second largest increase of 28.70%. Group 1 received both interventions of a classroom presentation and reef visit, and had the highest positive knowledge score as well as the largest amount of change between the pre- and post-test. Effects of a classroom presentation are represented in Group 2, where scores are higher than Groups 3 and 4.

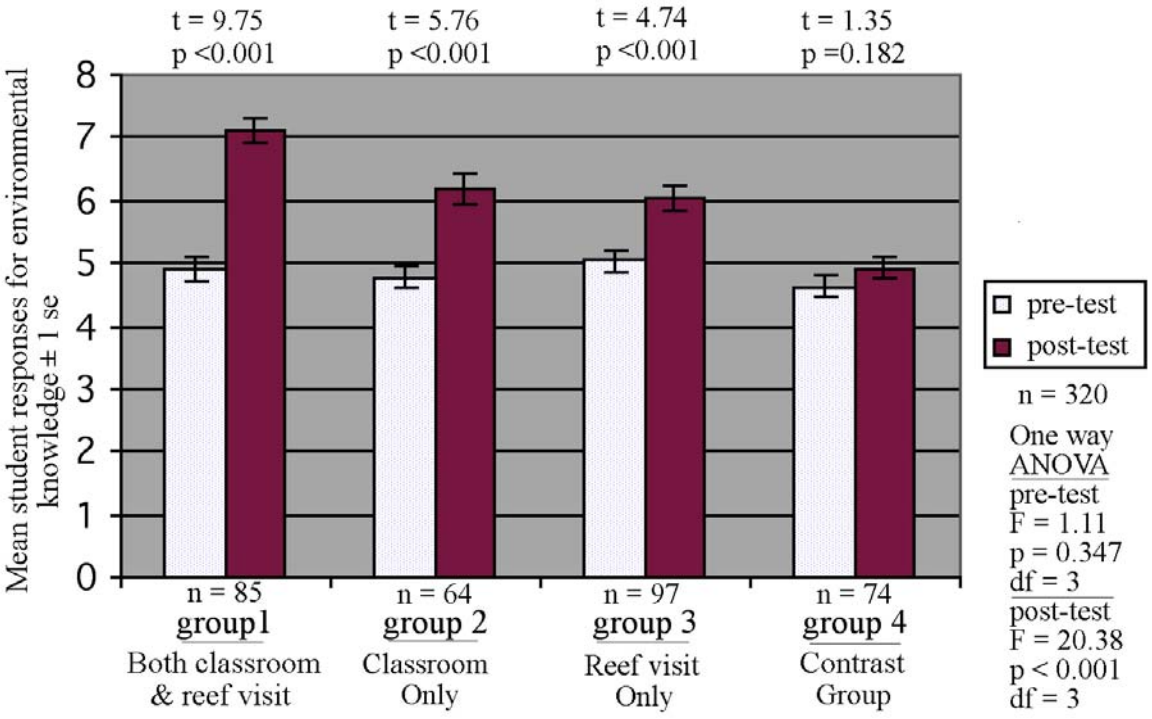

Figure 2. Knowledge changes for student responses per group, component one.

Previous reef experience was significantly correlated to original environmental knowledge (K_pre) and change in environmental knowledge (ΔK) as shown in Table 1. The table depicts relationships of students' knowledge scores on pre-test (K_pre), and changes in scores from pre-test to post-test (ΔK) and strength of correlations with previous reef experience (GBR). Students who had previous reef experience performed higher on the knowledge pre-test (shown in Figure 3). The students who had more reef visits also had a lower positive change in knowledge and higher overall scores.

Previous reef experience (GBR) is relevant because of the effect it has on students' learning about the reef (Table 1), as students' previous reef experience was significantly correlated to the environmental knowledge variable. The minus sign for

Table 1. *Previous Reef Experience and Significant Correlations to Environmental Knowledge (Pre-Test and Change)*

	K_pre	ΔK
GBR	.173*	-.106*

Spearman's *rho* (significant to *.05); n = 320

ΔK indicates even though the students with previous reef experience had the highest mean knowledge scores, there is a negative association with one another (as previous reef experience increases, the change in knowledge scores decreases).

Previous reef experience also shows a significant relationship to mean knowledge scores (vertical axis) in Figure 3. The knowledge pre-test survey scores (left bar) were positively related to the amount of previous reef experience (horizontal axis), since they increase as the amount of reef experience increases (± 1 se). The mean change in knowledge score decreased as the overall amount of past reef experience increased, with the largest amount of change in scores appearing in the never category (1.594), which was a 33.9% increase. The highest pre-test scores came from students having more reef experience, and positive changes in scores were shown in all post-tests results

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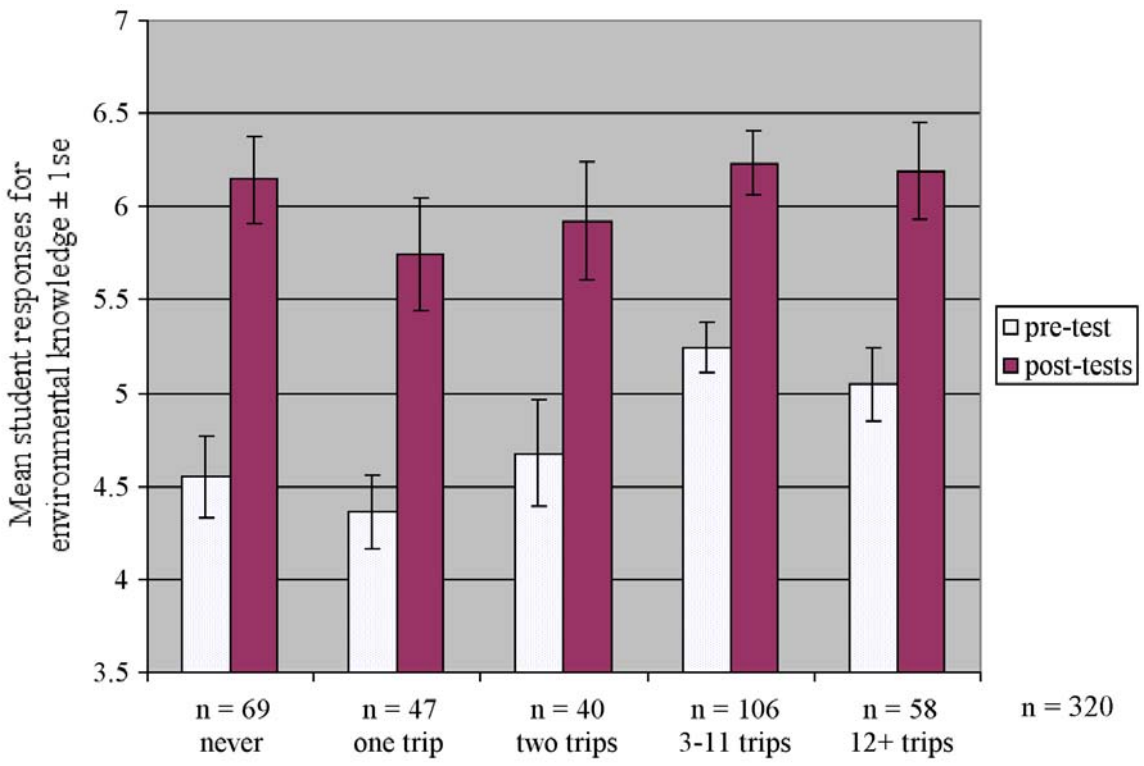

Figure 3. Previous reef experience and changes in environmental knowledge.

Student interviews

Structured interviews also were conducted with the students. The reasons for the interviews were to: 1) to present the voices of the student participants; and 2) to add to the quantitative study validity. The students' voices are important because they

enable recognition of any transformations in learning, and development of critical thinking. Moreover, student perspectives help us understand to what extent direct reef experience makes a difference in achieving changes in environmental knowledge or an ecological vision. In Rickinson's (2001) extensive review of environmental education research, he noted that increased research attention needs to be paid to students' personal educational experiences from their perspective. Interviewing students after reef monitoring was challenging, but the data gathered illuminates aspects of student reef experiences, which are otherwise not revealed in the quantitative results.

Interview Data Collection

The students were interviewed *in situ*, on boats and beaches after the coral monitoring exercise. In total 118 high school student interviews from four different schools were gathered on return trips, with 67 interviews conducted by the researcher and 51 videoed peer interviews conducted by the students themselves. A few of the boat rides were particularly unpleasant for the students as a number became seasick because of the high winds and rough seas. Some of the monitoring sessions were early in the morning, cold, and windy for the students when they snorkeled and monitored the reef, with some of the students becoming chilled. One of the conditions of the project was that students did not have to participate and could withdraw at any time, and no records were kept of students who did not participate in the interview process. Overall, approximately three quarters of the reef trip students were agreeable to being interviewed. The return trip, with the boat running with the wind and warm conditions, was usually good for interviewing students. A small number of students were interviewed on the beach, with the majority being on the boat. Students were interviewed individually, and in small groups of two to four.

Findings from Interviews

Transcripts of student responses were read individually and responses sorted into thematic categories and analyzed. No data processing program was used to analyze the scripts. This was all done by the researcher who attempted subjective but consistent judgments of these databased responses to structured questions. In each

case, a number of student viewpoints were juxtaposed to show both a range and a consistency of responses.

Valuing Coral Reef Learning Experiences

The following are examples of both male and female student responses when they were asked to discuss the perceived value of their coral reef experience, what they liked the best about the trip, what was interesting and meaningful for them, and what they thought they had learned.

> I like it out here because you are actually doing it; you are not just sitting down and reading a book about it. I think you learn a lot more (male #156).

> I learned lots of things. It gives you the opportunity to see things first hands-on instead of reading out of a book. And people learn a lot more because they are interested (female #53).

> It gives me knowledge when I come to talk to people. Maybe this would be an all right job to do, I reckon it would be all right, pretty cruisey and fun. This is my second time to the reef (male #77).

> Thumbs up, top trip. I wish this was school everyday. I've leaned a lot about marine life (male #157).

> You learn there is stuff out here that you never really knew what it was before (male, # 12).

> It's better than in school … I look more in the field. Everyone knows that compared to a classroom, if you are in the field you can be in touch with what you are talking about. You can learn a lot more about it. [Students] should do more field research (male #155).

Students stated an appreciation for their involvement in this outdoor reef experience. Some found it difficult to conceptualize it as learning because it was too

much fun. Others saw the learning experience as heightened because immersed reef experiences are so enjoyable. Highlighted in student responses here are the learning experiences of physical and immediate contact with coral reef environments. The value of this is often stated in terms of “that was cool”, “it was great”, “thumbs up” and “it’s pretty good”.

> [I] liked the fact that we’re able to come out here and have a swim and learn about the reef. The scuba diving was pretty awesome. It’s lovely to get to see the reef, learn a bit of stuff. It’s pretty good (male #31).

> I’ve learned about the diversity of fish down there, there is so much to see and the really big fish, that was cool and also the clams (female #23).

> Actually, coming out here and experiencing the reef helps us learn better … like much better than reading books. It’s right in your face so you can’t really have any excuses (male #31).

> You learn things out here for sure. It makes it heaps easier to learn if you are actually doing things that you learn, not just sitting there listening to it (male #153).

> You learn so much out here. It’s basically hands-on. I think it’s a great experience. I’d come back if I had a chance (male, # 79).

Immersed in marine environments students were active in the learning experience rather than passive recipients. Thus, they engaged in learning and acquiring knowledge (awareness), and were accepting or acknowledging the existence of an active role in monitoring and snorkeling around the reef. These accounts show the value of direct experience when compared to classroom learning. The realities of the reef are “right in your face” and “it’s a completely different world when you experience it”.

Learning Reef Ecology at the Reef

Both male and female students expressed an overall enthusiasm for reef excursions. Student enjoyment was expressed in terms such as “pretty cool”, “awesome”, and “fun.” Engaging the students in a structured learning situation they consider fun, can be considered a constructive pedagogy, opening up additional learning perspectives. When asked what they learned on the reef trip, the student replied with the following answers:

> It’s pretty cool to see all the stuff you see out there, like the colors … and the different type of fish living down there (male #33).
>
> Learning about the fish, I didn’t know what the fish were before (female #92).
>
> I liked the reef walk. That was awesome.… This is so much better [than classroom education] more hands-on, more fun. I’ve been camping but I’ve never been to the Barrier Reef before (female #159).
>
> How to conserve and protect the environments (male #91).
>
> You learn more because you get into it and have fun at the same time (female #42).
>
> It does make a difference because it makes us know what the reef is like and how we need to keep it in good condition so our kids can enjoy it like we do (male #81).

There is little doubt that these students’ knowledge (awareness) of marine ecology increased considerably. Like many other students, the following three male responses indicate students were aware of their learning and their expanding ecological and biological knowledge.

> I liked that big fish we've just seen, the giant trevally. The last spot we were at I saw a moray eel. I tried to kick it with my flippers but it went back inside the coral. There's heaps of jellyfish around (male #32).

> I've never seen a coral reef before. I've never seen so much coral. We learned about all the different types of coral and fish. I quite liked looking at the butterfly fish and coral cod; it was quite interesting (male #56).

> The whole ecosystem out on the reef, it's great. Like, you hear about it and see it on TV, when you actually see it; it just means a whole lot more. It's great .... Can't get much better than this. Hands-on is definitely the way to go. You learn a thousand more things looking at the reef [under water] rather than reading about it (male #54).

Most students saw learning in this environment as more powerful than classroom learning. They were able to take up active roles as reef monitors. The monitoring experience in itself was a pedagogical device (Stepath & Whitehouse, 2006) that served to focus student attention on a number of key species, such as hard and soft corals and the types of fish present. Laying a transect line gave students a physical direction in which to swim. Asking students to record the presence of key species gave them a purposeful activity on which to focus learning attention. Students really recalled what they had observed when monitoring, and in their accounts, they name a number of different fish and make specific comments on their observations of reef species. Evidence of enhanced learning about the rudiments of reef ecology emerges from these accounts. The students became aware this was a different type of learning experience: they had active roles and were not just observers. Here, male students acknowledge learning about reef ecology in reef environments and for them these reef sites are a quality place to learn.

> It's just so awesome to get out here and really get hands-on. Being in the classroom, you can only see pictures and hear other people's stories [of the reef], but it's a completely different world when you experience it. [The reef] is something you have to see to believe, really. You definitely learn more out

> here. Like picking up little sea anemones, you can see it on video and watch people do it, but it is completely different when the anemone is in your hand and you are learning from your own experiences (male #55).

> I wouldn't classify this as education because it is just too much fun, but if it has to be called education, then it is great. In a classroom, there a book is put in front of you and you are made to read it, but here you listen to everything because you want to, you want to know everything (male #54).

The quantitative findings show a positive change from the survey questionnaire results for knowledge (awareness) and attitude. The qualitative data show in more detail the contribution reef monitoring made to student ability to name reef inhabitants. A surprising fact was the number of participating students who had never been to the reef before, even though they live locally. Indeed, this reef monitoring activity was the first trip to the reef for over twenty percent (21.6%) of the high school students involved.

Comparing Learning at Reef Sites and in the Classroom

Student interviews were examined to ascertain whether students saw involvement in marine education at the reef, or classroom presentation as the most effective means of learning reef ecology. Commonly reported in student accounts is how reef experiential learning compares favorably to classroom learning.

> I liked coming out to the reef, getting away from home, camping fishing, all that. I haven't learned so much in a week in my life to be honest. You still learn theory, but it's all based on practice, all the work is based on something that you have done on that day. You learn things out here for sure. It makes it heaps easier to learn if you are actually doing things that you learn, not just sitting there listening to it (male #91).

> I like learning this way because it is actual hands-on experience. When you are in the classroom there are too many distractions, your mind just slips. But

> when you are out here doing stuff you learn a lot better because you are interested (male #57).

> Just … what you're allowed to touch and not allowed to touch, how it's affected if you touch it or not. I learned a bit about sea worms, sea cucumbers, a bit about coral (male #31).

> I learned all about coral, food chains, hermit crabs and crustaceans and stuff. I do a fair bit of snorkeling so I learned more about where to find different fish (male #54).

Students on both the day trips and the weeklong trip to Northwest Island thought similarly.

> The good thing about learning here was that we didn't have to sit inside. We actually got hands-on experience of the island [Northwest Island]. I learned a lot about the animals and reef monitoring, about going up [observing] and counting everything. I didn't really think with the sea cucumbers there would be so many there. That was pretty good. It's a lot better out here. It gets boring in a classroom. Everything is really good. I had a really good time (female #158).

> Being out here is like – you understand a lot more. You actually experience things, whereas in the classroom you are being told about it. You probably interpret things a lot more when you experience it. I learned how to drive the boat (female #59).

> I think it is a lot more beneficial for students. People learn more when it's hands-on instead of just reading about things that you forget easily. When you are in a classroom, you only see pictures, but we've actually seen the creatures, and been able to pick them up, and actually hold them, and we are not going to forget that (female #51).

> It's so different to normal life, it's excellent. It is so much more interesting than the classroom. To be able to look at [the reef] was so good. I learned how to socialize with other people a lot more (female #154).

> Just look at the scenery. It's better than school … I look more in the field. Everyone knows that compared to a classroom, if you are in the field you can be in touch with what you are talking about. You can learn a lot more about it. [Students] should do more field research (male #151).

> I loved the beach just lying out there and looking at the coral and fish … we saw some eagle rays and blue spotted rays and stingrays. You just see everything from a different angle. I learned how much we destroy everything and I learned how to help a coral reef rather than destroy it. Everyone is interested and they want to do it [participate] rather than in a classroom, which is just boring. It's up on the board and you're not doing anything and people just bludge. But here [on the reef], you want to do it because it is fun (female #52)

Reef trips give students proximal experiences of reef environments. When asked directly to describe their experiences, quite a number of students talked about the value of a "hands-on", active approach to developing their understanding of coral reef diversity. They also spoke about their appreciation for the importance of coral reefs. Student accounts show how their concept of coral reefs has been transformed from an abstracted offshore environment to concrete understanding of a real and knowledgeable place. Students said they had a "far greater understanding" and "connection" to the reef compared with knowledge gained from information texts.

Underwater experiences of coral reefs change what Probyn (2003) calls "relations of proximity" that "highlight the facts of connection and dis/connection" (p. 298). Once a reef substrate has been monitored, the monitor subjectively knows it. Reefs are physically located offshore and underwater. From land, reefs can be conceived as far away. However, the experience of observing and recording brings a student into direct contact with the myriad living bodies creating a reef, thus turning him or her into a learner.

Indeed, that which Rose (1999, p. 252) terms “the space of relation”, an imaginably conceived space between differing bodies, changes for the student learners in this study. The coral reef is now conceived as being a nearer place, a place with which one can have a connection. For example, in student accounts they speak of “being more connected” and becoming “more familiar” with coral reefs, as the visited and observed reef becomes a known place.

Notions of interrelations and proximities are important in ecological education when one declared aim of sustainability education is “a rediscovery of our connections to the natural world” (ISOS, 2003). The student accounts suggest reef environments can be experienced as intimate and connected to us, even though they are physically alien environments. Because of experiential education, “being more connected” with coral reefs becomes possible and it establishes reefs as ecologically important places.

Summary

This investigation found evident increases in environmental knowledge responses with marine experiential education and previous reef experience. Environmental knowledge scores were highest for students with past reef experience and increased significantly in all groups except the contrast group, with the largest change and highest post-test scores shown by Group 1. There was a significant change between the pre- and post-test, and the groups were significantly different (Figure 17). The empirical and interview data substantiated that students who had monitoring experience at outdoor coral reef sites showed the highest environmental knowledge scores. The marine experiential education group with both classroom presentation and reef visit (Group 1) had the most increased environmental knowledge scores, and the students in their personal interviews reiterated this.

Previous experience at a coral reef had positive influences on student responses. When previous reef experience was considered, direct relationships existed with higher environmental knowledge questionnaire scores, especially with two visits or less. Significant changes between the pre- and post-test were observed with previous reef experience and environmental knowledge change. The combination of a classroom presentation and reef visit had the highest positive effect on environmental knowledge, and the student interviews substantiated this finding.

Reef trips also give students proximal experiences of reef environments. The students talked about the value of “hands-on”, active approaches to developing their understanding of coral reef diversity. Students’ responded that their concept of coral reefs has been transformed and they had a “far greater understanding” of the reef after the monitoring. These types of in the water experiences of monitoring reefs change students’ relations of proximity that emphasize the connection with a reef. This experience of observing and recording brings a student into direct contact with the living bodies reef and turns the student into a learner. This space of relation changes for the student learners in the course of this study. The reefs, which are physically located underwater and conceived as far away, can be changed to being a nearer place which one can have a connection. These notions of interrelations and proximities are important in ecological education, and the student responses suggest a more intimate connection to these physically alien environments. Marine experiential education made the students feel more connected” with coral reefs and then the reefs became more ecologically important places. The results of this study demonstrate that field trips should be included as part of marine education programs to improve environmental knowledge scores.

About the author

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