Fieldwork, co-teaching and co-generative dialogue in lower secondary school environmental science

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This article reports one of the case studies in a 3-year longitudinal study in environmental science education. This case explores the process of teaching about ecosystems through co-teaching and co-generative dialogue in a Year-9 science classroom in Western Australia. Combining with co-teaching and co-generative dialogue aimed at transforming classroom practices and stimulating students' awareness of ecosystems and bio-diversity. The research employed mixed-methods methodology with multiple research methods. The results show that the teachers and the students were engaged and enjoyed the activities. The fieldwork experiences stimulated student critical voice, group cohesiveness, and student involvement.

Background

Environmental education for the first time was proposed in 1975 in Belgrade in a meeting organised by The United Nations Educational, Scientific and Cultural Organization (UNESCO) (Gough, 1997). The term sustainability education emerged after 1992 in the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (Chansomsak & Vale, 2008). According to Gough (1997) and Fien and Maclean (2000), environmental education should stimulate individual responsibility and action on both physical and aesthetic qualities of the environment. In environmental education, students should learn the principles of environmental problems and make decision to solve the problems (Ma & Shin, 2015). According to Carter and Simmons (2010, p.13), "the heart of environmental education is developing an environmentally literate citizenry …[in which] students are motivated, and understand that what they do as individuals and in groups makes a difference in their world."

In the school, teachers play an important role in creating awareness about environment among students (Michail, Stamou & Stamou, 2006) resulting in valuing their world for sustaining life (Morris, 2002). Environmental education is a powerful method for empowering students' awareness in dealing with future environmental challenges (Heidari & Heidari, 2015). It is important to increase students' consciousness of environmental problems by incorporating environmental sustainability in the curriculum. According to Morris (2002), consciousness is a good starting point for reconceptualising cognition which is not separated from the nature of the environment, and educators should re-imagine the possibilities of sustainability education.

Claims about benefits of engaging students in environmental education programs are many and widespread (Gough, 1997) including improvement in academic achievement, problem solving, critical thinking, and co-operative learning skills and an increased motivation to learn. This paper is part of 3-year longitudinal study in environmental science education. The first step was setting up the co-teaching and co-generative dialogue in the schools; the second step was undertaking case studies in three schools (Rahmawati, Koul & Fisher, 2015). This paper reports on a case study which focused on the teaching of ecosystems for environmental science education. In order to generate student interest in environmental education, the co-teaching and co-generative dialogue model (Tobin, 2006) was used in teaching about ecosystems. The researcher conducted co-teaching with the teachers of this topic. Then, co-generative dialogue was created with students which provided opportunities for student engagement and feedback to teachers in environmental education classes on this topic.

Theoretical background

Environmental science education

Research studies indicate that students develop genuine appreciation and respect for the environment when exposed to environmental education (Basile, 2000; Corral-Verdugo, Frais-Armenta & Corral-Verdugo, 1996; Cummins & Snively, 2000; Kenney, Militana & Donohue, 2003; Liberman & Hoody, 1998; Lord, 1999). Other studies show that environmental education programs motivate children to engage with content at all levels of ability (Basile, 2000; Cummins & Snively, 2000; Kenney, Militana & Donohue, 2003; Lord, 1999) which is attributed to a concrete experience of real issues that come to be perceived as personally meaningful. Ma and Shin (2015) and Heidari and Heidari (2015) stated that environmental education should encourage students to be enthusiastic about nature and expand their knowledge. The National Environment Education Foundation (NEETF, 2000) has published several case studies showing that all students, including those formerly struggling in school, became more interested in school because they felt they could make a difference in their environment and this empowered them to strive for more knowledge.

Beyond improving students' engagement, environmental education programs improve academic achievement across the curriculum especially in science (NEETF, 2005). Environmental education in school settings is integrated in the science curriculum which includes environmental issues such as energy, climate change, pollution, natural resources, ecosystems, endangered species and genetic engineering (Bodzin, Klein & Weaver, 2010). The national science curriculum states that science helps students to become critical thinkers by encouraging them to use evidence to evaluate the use of science in society and its application in daily life, including topics of environmental education (National Curriculum Board, 2009). The national science curriculum promotes meaningful science learning experiences which lead to students' engagement in the subject. Thus, students will be interested in understanding the world, be able to communicate scientifically, be sceptical and questioning of the claims of others, and be able to identify and investigate questions and draw evidence-based conclusions (National Curriculum Board, 2009). Thus, integrating environmental education plays an important role in students' scientific skills in relation to developing students' awareness in their environment.

Nationally, various government reports have emphasised the importance and urgent need to improve science education with special emphasis on environmental education at various educational levels (Brennan, 1994; NBEET, 1996). According to Heck (2003), Australian curriculum documents consist of 147 indicators of environmental education in the compulsory years of schooling through to senior secondary. The Australian government also has emphasised the development of environmental education in schools for the past seven years and put pressure on environmental education over three decades (Gough, 1997). However, there is a problem of low science enrolment and lack of engagement in engineering, science and technology in Australian primary and secondary schools (Venvill, 2008; Pearce, Flavell & Dao-Cheng, 2010). Improvement in science education, especially in curricula and teaching approaches are needed to overcome the problem.

This study was designed to contribute to improving existing environmental education within the field of science education, specifically teaching about ecosystems.

Teaching about ecosystems

The topic of ecosystems is part of the Australian curriculum framework for teaching science. In the context of the research, curriculum for year 9 is included in stage 2 which is year 8-12. At this stage students should be capable of developing ideas about science that relate to their life and living. Students should have to understand that there are many changes in the natural world which they can observe through scientific investigation and realise the evidence is the driving force of science knowledge. In stage 2, the concepts that relate to environmental education are the characteristics of plants, animals, living things and the environment. Students also should understand the multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes in their environment within their ecosystems (National Curriculum Board, 2009).

In developing scientific inquiry, students design questions that can be investigated using a range of inquiry skills by designing the methods, analysing the data, identifying relationships, analysing their methods and the quality of their data, and explaining specific actions to improve the quality of their evidence (ACARA, 2010). To achieve these aims, the science teacher needs to engage the students with the nature. In this research, the teacher conducted the fieldwork with the students. In the fieldwork the students needed to explore the ecosystem in the creek near the school. This experience helped the students to understand the ecosystem near their environment, as well as environmental changes.

Learning environment research and place-based learning

The study draws upon and contributes to the field of learning environments (Fraser, 1994; 1998). Over the last four decades, learning environment research has become a firmly established form of research on teaching and learning (Fraser, 1998; Fraser & Walberg, 1991; Haertel, Walberg & Haertel, 1981). Although earlier researchers used questionnaires alone, later studies recommend the inclusion of a range of observational and interpretive methods (Tobin & Fraser, 1998). Mixed method research design by using questionnaires and interpretive methods enhance each other in the sense that interviews are used to probe in greater depth what individual students and teachers have to say about their classrooms and the resources used to support their learning.

In this project, research was conducted within learning environment conventions drawing on a theoretical framework having its basic value in the primacy of human agency. This agency, or power-to-act, includes the capacity of individuals to participate in creating their lived-in world rather than being merely determined by it. The fundamental value that researchers selected in this form of inquiry was that which researchers found appropriate to explore - the puzzles that underpin their research on learning environments. The existing practice of learning environment research was elaborated upon, to overcome two persistent gaps in education, those between educational theory and teaching practice and between the practice of research and the practice of teaching.

Place-based learning is one of the recent strands in learning environment research. It evaluates the students' awareness of the place in which they are living and their perceptions of the science curriculum covering local environmental issues. The Place-based Learning and Constructivist Environment Survey (PLACES) (Koul & Zandvliet, 2009) was developed to gather information on students' perception of their learning about environment both in field-based as well as classroom-based activities (Table 1). The scales for this instrument have been taken from already established learning environment questionnaires: the Environmental Science Learning Environment Inventory (ESLEI) (Henderson & Reid, 2000), the What is Happening in this Class (WIHIC) (Aldridge, Fraser & Haung, 1999) the Science Learning Environment Inventory (SLEI) (Fraser, Giddings & Mcrobbie, 1991) the Science Outdoor Learning Environment Instrument (SOLEI) (Orion, Hofstein, Pinchas & Giddings, 1997) and the Constructivist Learning Environment Survey (CLES) (Taylor, Fraser & Fisher, 1997).

The PLACES survey has 40 items spread across eight scales (Zandiviet, 2007) and has been administered and validated in Australia, Canada, India, and Mauritius (Koul & Zandvliet, 2009). Student respond on a five point Likert scale ranging from strongly disagree (1) to strongly agree (5). Each scale in PLACES represents the elements of learning environments that could be experienced by the students. In the context of this research, during the fieldwork the multiple research method focused on assessing these elements.

Co-teaching and co-generative dialogue

In early 1973, Miller and Trump defined co-teaching as two or more teachers working together to plan, instruct, and evaluate subject/s (as cited in Bacharach, Heek & Dahlberg, 2010). Tobin (2006) and Murphy and Scantlebury (2010) defined co-teaching as collaboration of two or more teachers in teaching a diverse group of students, at the same time they are learning from each other. The researcher team had valuable learning experiences with the co-teacher, not only learning their pedagogical skills, but also their values and beliefs about teaching. Co-teaching has been introduced in different contexts

Table 1: Description and example of items for each scale in the PLACES
Source: Rahmawati, Koul & Fisher (2010)

Scale	Description	Item
Relevance/integration[R/I]	Extent to which lessons are relevant and integrated with environment and field based activities.	Lessons are supported with field experiences and other field-based activities.
Critical voice [CV]	Extent to which students have a voice in class.	It's all right for me to openly express my opinion.
Student negotiation [SN]	Extent to which students can negotiate activities in their class.	Other students ask me to explain my ideas.
Group cohesiveness [GC]	Extent to which the students know, help and are supportive of one another.	Members of this class help one another during classroom activities.
Student involvement [SI]	Extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class.	I pay attention.
Shared control[SC]	Extent to which teacher gives control to the students.	I help the teacher to decide which activities I do.
Open endedness [OE]	Extent to which the teacher gives freedom to think and plan own learning.	I am encouraged to think for myself.
Environmental interaction[EI]	Extent to which students are engaged in field trips.	Learning is very important for me during our field trips.

from pre-service-teachers, special education, and elementary, secondary to higher education levels. There is innovative work by Roth and Tobin on integrated co-teaching with co-generative dialogue. Through co-generative dialogue students have opportunities to participate actively in their learning. According to Stith and Roth (2008), involving students in co-generative dialogue will help them to engage and contribute to their learning which leads to classroom transformation. Rahmawati, Koul and Fisher (2015) stated co-teaching and co-generative dialogue have been used for teacher evaluation (Roth & Tobin, 2001), for classroom praxis (Roth, Tobin & Zimmermahn, 2002; Martin, 2006), for transforming classroom culture (Lehner, 2007), and for transforming teachers' beliefs and practices (Carambo & Stickney, 2009) because co-teaching and co-generative dialogue provides opportunities for sustaining the transformation process (Martin, 2006). In our study co-teaching and co-generative dialogue transformed teacher interpersonal behaviour and pedagogical praxis which led to student engagement in science learning (Rahmawati, Koul, & Fisher, 2015) and development of the teacher's identity (Rahmawati & Taylor, 2015).

In this study, we implemented co-teaching and co-generative dialogue within three phases, collaboration, dialogue and reflection as discussed below.

1. In the *collaboration* phase, we worked with the teacher to plan the lessons, classroom activities and assessment. During the science lessons, one of the researcher team as a co-teacher taught together with the teacher with intensive collaboration

2. In the *dialogue* phase, we talked to the students to obtain their feedback on our teaching and classroom activities. Common questions were: "Do you like the lesson? Are you engaged with the activities? And do you have any suggestions for ways to improve the classroom activities?" To discuss with students we used three different ways: informal conversations, interviews and reflective journals. In students' reflective journals we added our comments on their reflections to encourage them to do more reflections. We planned to create dialogue by sitting together with the teachers and their students but, because of the time limitations, and both teachers' and students' willingness to discuss together, we created another dialogue with the teachers during the reflections phase. Dhanapal and Kanapathy stated (2014) that co-teaching needs sufficient time during the school day for planning student learning.

3. In the *reflection* phase, we worked with the teachers to evaluate and reflect on our co-teaching in order to improve classroom practices. Students' feedback, including their reflective journals, were powerful enough to help to transform our pedagogical practices. We usually sat together after the lesson and at other times when both of us were free. After we reflected on our practices we implemented our ideas in the next lesson.

We realised co-teaching as collaborative teaching provides a dynamic structure in the classroom. Based on our experiences, we found teaching collaboratively helped the teachers to improve their pedagogical practices as well as their students' learning. Dhanapal and Kanapathy (2014) pointed out most studies on co-teaching have emphasised the co-teachers' roles and relationships rather than the implications of students' academic achievement. In co-teaching, we had opportunities to engage in meaningful interactions and reflections with the science teachers (Wassell & Stith, 2007). Roth (2005) stated that co-teaching involving co-learning provides opportunities for teachers to reflect on their practices. If co-teaching was limited to improving pedagogical skills and students' learning it would be only effective during the co-teaching period, especially if teachers are not being empowered to maintain the improvements.

Research design

As part of large scale study, this study was part of a three year project (2009-2011) in the school presented in this paper. The case discussed occured in the second year of study. The study used a mixed method research design by combining both qualitative and quantitative methods which had been used successfully in various learning environment studies (Aldridge, Fraser, & Haung, 1999; Koul & Fisher, 2003; Tobin & Fraser, 1998). According to Creswell (2005), mixed method research is a good design to build the strengths of both quantitative and qualitative data by giving different perspective of the complex picture. Therefore, multiple research methods (classroom observations, questionnaire, the PLACES, interviews and students' reflective journals) were used to provide the integrated picture of the research. Classroom observations were conducted during the research to provide a picture of classroom environment. Then, the PLACES was used to assess students' perceptions on the place they live in by conducting the field work. In this research, the researcher used 6 scales from PLACES namely Relevance/Integration, Critical voice, Student negotiation, Group cohesiveness, Student involvement, Shared control, Open endedness. After conducting the learning activities (in this context is the fieldwork), the researcher conducted the interview with the selected students. All students provided written accounts in the reflective journals about their reflections, feelings, and opinions on their learning experiences.

The participants

The participating 17 year nine students in this study were low performers from a public school with an excellent reputation in academia. The school was well resourced for science teaching and learning which benefited both teachers and students. Based on a science teacher's report the students in the selected class were not highly motivated to learn science. Compared with other year 9 classes in the school, the students in this class demonstrated lower levels of academic achievement. The researcher worked with a middle aged female teacher. She was an enthusiastic science teacher with a passion for improving her students' engagement in science. This teacher was teaching three year nine science classes and needed assistance with the selected class.

Results

The fieldwork activity consisted of two three hour long out door class sessions co-taught by the classroom teacher and the researcher, followed by a co-generative dialogue session at the school. All participants went to the creek close to the school. The students explored the different types of soils, vegetation and animals around the creek. Subsequently, they carried out tests to examine the physical and chemical properties of the material collected. The fieldwork and tests were conducted over two weeks. The first week was the fieldwork and the second week was examining the physical and chemical properties of the soil. After completion of these activities, the students completed the PLACES questionnaire to explore their perceptions of the environment which they had studied. To explore students' opinion and feelings, the researcher conducted interviews with three purposively selected students.

Quantitative results

Reliability of the PLACES

The reliability of PLACES was established by internal consistency based on the correlation among the variables by using Cronbach's alpha reliability coefficient (Brown, 2002; Newby & Fisher, 1997). Table 2 shows the Cronbach alpha reliability figures ranged from 0.59 to 0.93. The results show that the instrument is reliable with all alpha reliability scores above 0.50 (Cronbach, 1951). Lower Cronbach scores can be attributed to smaller number of students in the study.

Table 2: Internal consistency (Cronbach alpha coefficient), means and standard deviations of PLACES questionnaire

Scale	Alpha reliability	Mean	Standard deviation
Relevance/integration [R/I]	0.72	3.38	0.63
Critical voice [CV]	0.81	3.94	0.77
Student negotiation [SN]	0.88	3.58	0.84
Group cohesiveness [GC]	0.59	3.86	0.39
Student involvement [SI]	0.78	3.35	0.72
Shared control[SC]	0.93	2.40	1.02
Open endedness (OE)	0.82	3.58	0.80

n = 17 students

Students' positive learning experiences are shown by high mean scores ranging between 2.40 for the scale of Shared control to 3.94 for the scale of Critical voice on a five point Likert scale. Students provided very positive perceptions on the relevancy the fieldwork on the topic of Ecosystems. The Critical voice, Student negotiation, Group cohesiveness, and Open endedness indicates high usage in the fieldwork which is shown by the mean >3.50. On the other hand, the Relevance/integration, Student involvement and Shared control shows low usage which is implied by the mean score <3.50.

Overall students provided positive perceptions on the relevancy of the fieldwork on ecosystems. Students also felt that being involved in the fieldwork gave them opportunities to express their voice. Even though the students felt that having less control in the classroom, co-teaching provided an opportunity for the science teacher and students to engage in discussion on the topic. The students enjoyed the environmental learning experiences which stimulated them to think critically on ecosystems.

The correlation between scales

Pearson's correlation is used to find a correlation between at least two continuous variables (Brown, 2001). The interpretation of correlation could be done by examining the significant value (p), less than 0.05 (Coakes & Steed, 2007). Furthermore, the correlation coefficient can range from -1.00 to +1.00, the negative value depicting the negative correlation while the positive value shows the positive correlation.

The results on this study show that most the scales had positive and significant correlation. Then most the inter-scale correction are significantly correlated, except for shared control which have the value of p>0.05.

Table 3: Inter-scale correlations

Scale	RI	CV	SN	GC	SI	SC	OE
RI	1	0.67**	0.70**	0.37	0.88**	0.35	0.70**
CV		1	0.69**	0.36	0.65**	0.17	0.72**
SN			1	0.58*	0.69**	0.09	0.78**
GC				1	0.49*	0.40	0.53*
SI					1	0.48	0.86**
SC						1	0.37
OE							1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Students' perceptions on fieldwork by gender

The association between the students' perceptions of environmental education and their gender were analysed. There were five female and seventeen male students involved in the fieldwork. Male and female students' mean scores for each class were computed, and the significance of gender differences in students' perceptions of environmental education were analysed using an independent t-test. Table 4 shows the scale item means, female and male differences, standard deviations, and t-values.

Table 4: The comparison of students' perceptions by gender

Scale	Gender	Item mean	Mean difference (F-M)	Std. deviation	t
Relevance/integration	Females	2.84	0.76	0.82	2.65
	Males	3.60		0.39	
Critical voice	Females	3.28	0.93	0.91	2.69
	Males	4.21		0.53	
Student negotiation	Females	3.04	0.76	1.04	1.82
	Males	3.80		0.67	
Group cohesiveness	Females	3.88	0.03	0.41	0.14
	Males	3.85		0.39	
Student involvement	Females	2.60	1.07	0.69	3.72**
	Males	3.67		0.47	
Shared control	Females	1.80	0.85	0.57	1.64
	Males	2.65		1.09	
Open endedness	Females	2.80	1.10	0.76	3.28**
	Males	3.90		0.06	

**$p<0.01$, Females (n=5); Males (n=12)

Statistically significant differences were found between the female and male students on the scales of student involvement and open endedness. In this study male students perceived their environmental classes provide more opportunity for relevance, student negotiation, student involvement shared control and open endedness than female students.

Qualitative results

Examining schools and classrooms through a combination of quantitative and qualitative methods is a growing direction for research in science and mathematics education. The use of a combination of two or more methods of data collection in the study of some aspect of human behaviour is called triangulation. By analogy, triangular techniques in the social sciences attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint and, in so doing, by making use of both quantitative and qualitative data. Cohen & Manion (1994) suggested that only a minority of studies have used it in practice. Although a few studies combining the two methods have been carried out in the last decade (Aldridge & Fraser, 1999; Fisher, Waldrip, Harrison & Venville, 1996; Rickards & Fisher, 1999; Waldrip & Fisher, 1996), this study is unique in that it provides the results of using this method in environmental education.

This section presents the interview data obtained from interviews in an effort to validate the findings from the quantitative data. During the interviews, students were asked to explain the reasons for their response to each of the items and, where possible, provide an example to clarify the point.

The data provided by the questionnaires gave the researchers a platform from where interviews with students were conducted to help to explain the construct validity of the scales of PLACES. The interview data have been grouped by each scale of the questionnaire as the primary data gathering tool. The construct validity of these instruments is presented more clearly if the data are grouped in this way. Construct validity is "the degree to which a test measures an intended hypothetical construct" (Gay, 1992, p. 157).

The teacher and the researcher worked together to discuss the relevant field based and classroom activities. In the teaching of ecosystems, the researcher and the teacher conducted a field trip to a nearby creek to engage the students with nature. The students explored the different types of soils, vegetation and animals around the creek.

Relevance/integration

Student interviews made it evident that the interviewees/students understood the description of the Relevance/Integration scale very well. High mean scores of 3.38 for this scale confirm that the students' believed fieldwork is relevant to their learning and integrating with the topic of Ecosystem in the classroom as the student stated.

> We drew the line on the soil and analyse the ecosystem in it. It's interesting and related to our lesson (student interview, 18 June 2010).

This also allows students to have an engaging interaction with their environment, since the creek location is close with the school.

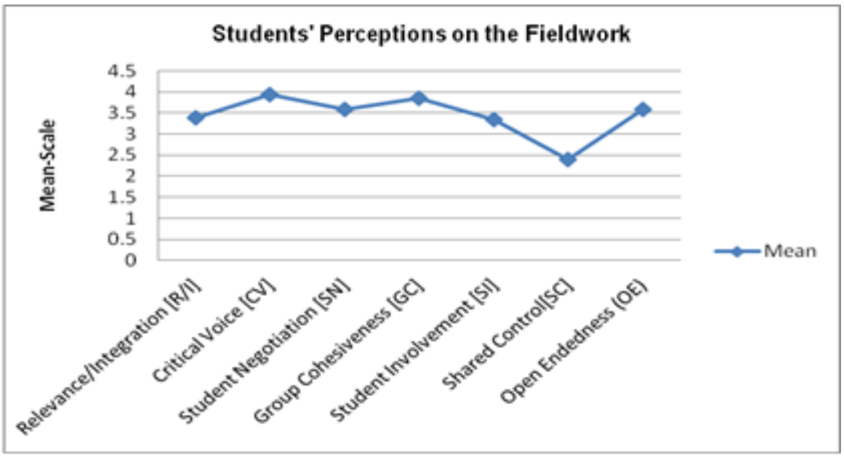

Figure 1: Students' perceptions of the fieldwork (PLACES questionnaire)

During the fieldwork the researcher noticed the students' enthusiasm and engagement in the activities. Students remarked in the interviews and in the reflective journals that they found the activities were fun.

> I really liked it when we did the interesting stuff, lots of experiments and go down the creek and all that (student interview, 18 June 2010).

One of students stated that it was his best learning experience during the science lesson.

> At the creek, that was fun and the stuff was the best (student interview, 18 June 2010).

Students' feedback after the field trip assisted the teacher and the researcher in planning future field based activities.

Critical voice

The students had opportunities to express their voice which rarely happened in the classroom based activities. This is supported by the questionnaire result which provided the highest mean score (3.94). Their curiosity on the diversity around the creek stimulated them to ask critical questions. For example, they not only reflected on the presence of different soil structures, but also the different life forms which they found.

> When I dug the creek soil, I became curious about the diversity of soil structures (student interview, 18 June 2010).

The researcher and the teacher prepared several simple chemical tests for the water around the creek. We found high alkalinity, probably the result of human activity influencing the quality of the environment. This led to interesting discussion between the teacher and the students. One student thinking about the relation of human activity with environmental problems had this to say,

> I was wondering about the white precipitation when we added silver nitrate, I was questioning, was the water safe for the animals and plants? (student interview, 25 June 2010).

Students could start to evaluate their values of the environment. Therefore, the fieldwork activity proved to be a catalyst in processing information on environmental care.

Figure 2: Different types of soil

Student negotiation

Since co-teaching and co-generative dialogue were implemented in the classroom, the students had more opportunity to negotiate their learning experiences. It was not a common occurrence in a science lesson. After the field trip students gave feedback about their engaging experiences which assisted the teacher and the researcher in planning future field based activities. The students gave feedback for learning improvement as follows.

> There should be more experiments in chemistry even once a week at least and the field work like the creek (student interview, 25 June 2010).

> The good part of science is experiments not book work (student interview, 25 June 2010).

The questionnaire results showed a high mean score on 3.58 for students' negotiation. The teacher also was happy that she understood her students' feeling about the learning activities which helped her to improve her teaching practices.

Group cohesiveness

In the fieldwork, the students learnt to work in groups and sharing responsibility. The students supported each other and also involved themselves in the activities by paying attention, participating in discussions, and demonstrating overall enjoyment. The students learnt to be responsible for their work, since they had to produce a fieldwork report, including a picture of the animals and living things that they found. They really enjoyed the group work as they stated in the interviews and reflective journals. One of the students stated that he liked being outside and interacting with the environment more than being in classroom.

They really enjoyed the group work as they stated.

> I like the group work (student interview, 18 June 2010).
>
> I like being outside, interacting with the environment more than being in classroom (student interview, 18 June 2010).

This was supported by the questionnaire result which showed a high mean score on 3.86. Therefore, the fieldwork is not only helping the students to understand the concept of ecosystems, but also helped them to learn to work with others.

Student involvement

Students were highly involved during the fieldwork; they enjoyed the activities as well as writing the reports. During and after the fieldwork, they also discussed the results, not only with their teacher, but also with their peers. When interviewed students stated that they enjoyed the fun activities and the experiments. The field work provided more opportunity for the students to participate actively in their learning.

> During the fieldwork, we did the experiment, putting substance into the water in a test tube and then waiting for it to change colour. It was interesting (student interview, 18 June 2010).

The questionnaire results also reflected highly on student involvement, scoring a high mean of 3.35. The students' involvement is part of the process of implementations of co-teaching and co-generative dialogue in classroom. Therefore, it is important to involve the students in their learning to improve classroom practices.

Shared control

Opportunities for the teachers, the researchers and the students to share control were provided during co-teaching and through co-generative dialogue. After the fieldtrip, the students and the teachers shared their experiences. Students had more time with the teacher to communicate their opinions about the topic of ecosystems. The teacher was no longer the dominant person in the classroom, as the students had the opportunity to participate in their learning.

> I think the teacher is really doing well. I think she shared control with the students (student interview, 25 June 2010).

The teacher also learnt to share control as stated.

> I see the co-teaching co-generative model as allowing student input into the workings of the class in a safe way. Their responses will not be openly criticised and their feelings will not be hurt. Whilst I am not in favour of handing too much control to the students, I see their power and control being directed into group activities (teacher interview, 25 June 2010).

Even though the mean score was not really high (2.40), the teacher had learnt to share control with the students and the researcher in teaching about ecosystems, since shared control is the nature of the co-teaching and co-generative dialogue.

Open-endedness

Another important issue in the research was open-endedness. It had been usual that students didn't have much opportunity to think about their own learning. During the fieldwork, the students learnt to decide on their own learning, such as making decisions on how they analyse the diversity of the soils in laboratory activities. The students gave feedback to the teacher on learning activities.

> No, I don't like science. But, you know, once you get it, it's not that bad. I really liked it when we did the interesting stuff, lots of experiments and go down the creek and all that (student interview, 18 June 2010).

> The teacher always tells us what you must plan for the next lesson so that we can prepare for it. We also ask questions if we don't understand something. The teacher also interacts more with us, for example, when she is explaining something, she asks us questions throughout her explanation to see whether we had understood her (student interview, 18 June 2010).

The teacher also learnt from student feedback.

> I gained an insight into what the students were expecting, and that was very helpful to me. This helped me to improvise and change my teaching style to accommodate the needs of my students (teacher interview, 25 June 2010).

The teacher became a facilitator in the learning. The mean score on open-endedness was also quite high at 3.58. Even though, open-endedness was not highly applicable during the classroom observations, co-teaching and co-generative dialogue, it provided opportunities for the students to share their view on the fieldwork activities.

Conclusions

Co-teaching and co-generative dialogue implemented in the science classroom has implications for student engagement, especially in student negotiation, critical voice and students' awareness of their place in the environment. Furthermore, integrating co-teaching and co-generative dialogue into teaching ecosystems provided opportunities for the science teacher and students to engage in nature and improve and transform the classroom practices. The students enjoyed the environmental learning experiences which stimulated them to think critically about nature and ecosystems.

Quantitative analysis of the PLACES questionnaire as applicable to learning environment research has confirmed its reliability. All the scales of the questionnaire are positively and significantly correlated with each other. Statistically significant differences were found between female and male students on the scales of Student involvement and Open endedness. In this study male students perceived their environmental classes provide more opportunity for Relevance, Student negotiation, Student involvement, Shared control, and Open endedness than female students.

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