Teacher–student dialogue: transforming teacher interpersonal behaviour and pedagogical praxis through co-teaching and co-generative dialogue

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Teacher–student dialogue: transforming teacher interpersonal behaviour and pedagogical praxis through co-teaching and co-generative dialogue

Yuli Rahmawati[1] · Rekha Koul[2] · Darrell Fisher[2]

Abstract The paper reports a study of the effectiveness of co-teaching and co-generative dialogue in science learning and teaching in lower secondary science classes. The idea of co-teaching and co-generative dialogue—first proposed by two leading educationists, Roth and Tobin, in early 2000—made an international impact in educational research. In the context of the research, co-teaching and co-generative dialogue were applied for transforming teacher interpersonal behaviour. The pre-validated Questionnaire on Teacher Interaction (QTI) was administered to all the year nine classes at three selected secondary schools to investigate existing teacher interpersonal behaviours and to further validate the QTI. This was followed by the implementation of co-teaching and co-generative dialogue in three selected science classrooms, one from each school. Multiple research methods (interview, students' reflective journals, and questionnaire) were used to develop in-depth understanding of the participants. Co-teaching and co-generative dialogue helped in transforming teacher interpersonal behaviour and teachers' pedagogical praxis. This process also had implications for improving students' engagement, achievement and behaviour.

Introduction

Co-teaching and co-generative dialogue was proposed by Roth and Tobin and has had an international impact in educational research (Tobin 2006). Co-teaching and co-generative dialogue as collaborative teaching and learning provides a dynamic structure in the classroom which helps teachers to improve their pedagogical practices as well as their

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students' learning. In this study, teachers not only focused on their pedagogical practices, but also continuously reflected on their belief and practices as pedagogical praxis. Furthermore, according to Stith and Roth (2008), involving students in co-generative dialogue helps them to engage in and contribute to their learning, which in turn leads to classroom transformation. In this study, co-teaching and co-generative dialogue were integrated in science classrooms for transforming teacher interpersonal behaviour and pedagogical praxis. Teacher interpersonal behaviour and pedagogical praxis, according to numerous studies, are important elements in transforming classroom practices and engaging students in learning. According to Fullan (2001), educational change heavily depends on teachers' thinking and action which are complex processes. Moreover, the teacher also plays a significant role as "a moral agent who transmits the values overtly and covertly" (Beyer, as cited in Marsh 1996). As a result, it is important to ensure the quality of classroom teaching.

In this study, science teachers, the researchers and students were engaged in the process of co-teaching and co-generative dialogue. In this practice, three students each fortnight from each class were identified to provide reflections on the teaching practices in their science classroom. The researchers engaged students in the conversation, made teachers aware of the feedback and highlighted teaching practices of which teachers could be unaware. This feedback allowed teachers to incorporate changes in teaching. This resulted in not only the transforming of teacher interpersonal behaviour and pedagogical praxis, but also student learning.

Learning environment research

The study draws upon and contributes to the field of learning environments (Fraser 1994, 1998, 2012). Contemporary research on school environments owes inspiration to Lewin's (1936) seminal work in non–educational settings, which recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Since then, the notion of person–environment fit in education has been elucidated by Stern (1970). Similarly, Walberg (1981) has proposed a model of educational productivity in which the educational environment is one of nine determinants of student learning. Over the last four decades, learning environment research has become a firmly established form of research on teaching and learning (Fraser 1998; Fraser and Walberg 1991; Haertel et al. 1981). Although earlier researchers used questionnaires alone, more recent studies enact and recommend the inclusion of a range of observational and interpretive methods (Tobin and Fraser 1998). 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 study, a different way of conducting classroom research was employed. The theoretical framework has as its basic value the primacy of human agency grounded in it. 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 can select in this form of inquiry is what researchers find appropriate to explore the puzzles that underpin their research on learning environments. The existing practice of learning environment research is 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. In this study, an existing learning

environment instrument, the Questionnaire on Teacher Interaction (QTI), was used to investigate the classroom environment.

## Questionnaire on Teacher Interaction (QTI)

The QTI was used in this study for guiding teachers' reflections on their interpersonal behaviour and pedagogical praxis. Wubbels et al. (1988) investigated teacher behaviour in classrooms from a systems perspective, adapting a theory on communication processes developed by Watzlawick et al. (1967). Within the systems perspective on communication, it is assumed that the behaviours of participants influence each other mutually. The behaviour of the teacher is influenced by the behaviour of the students and this in turn influences student behaviour. Circular communication processes develop which not only influence behaviour, but determine behaviour as well. With the systems perspective in mind, Wubbels et al. (1985) in The Netherlands extrapolated the seminal interpersonal behaviour research of Leary (1957) to develop the QTI in order to gather students' perceptions of their interactions with their teacher (Wubbels 1993). The QTI assesses eight dimensions of teacher behaviour: Leadership, Helpful/friendly, Understanding, Student responsibility and freedom, Uncertain, Dissatisfied, Admonishing and Strict. These dimensions provide a comprehensive description of teachers' interactions with their students.

The Dutch version of the QTI was translated into English and modified for use in Australian secondary schools. The Australian version of the QTI has been used in studies involving secondary science classes (Fisher et al. 1993, 1995; Fisher and Rickards 1998). These studies strongly supported the validity and potential usefulness of the QTI within the Australian context, and suggested the desirability of conducting further and more comprehensive research involving the QTI. Generally, higher cognitive achievement is positively associated with leadership, helping/friendly and understanding teacher behaviours. Conversely, admonishing, dissatisfied and uncertain teacher behaviours are negatively associated with students' cognitive achievements (Fisher and Rickards 1998; Koul and Fisher 2003; Wubbels and Levy 1993). In terms of instruction and achievement, the proposed study focuses on both these areas in an enhanced manner, with additional emphasis given to teacher interpersonal behaviours for the first time in Australia. Additionally, the present study extends the use of the QTI into middle schools, an area of formal schooling receiving considerable attention nationally and internationally (Koul and Fisher 2005).

Based on Leary's model, Wubbels and Levy (1993) provided a map of teachers' behaviour with a proximity dimension (Cooperation–Opposition) and an Influence dimension (Dominance–Submission) (see Fig. 1) and created the eight scales of the QTI (see Table 1). Therefore, in this research, the QTI provided the big picture of teacher interpersonal behaviour. Then the multiple methods of observations, interview and students' reflective journals were used to provide the integrated picture of the study.

Co-teaching and co-generative dialogue

Tobin (2006) described co-teaching as occurring when two or more persons collaborate to teach a group of students. The presence of multiple teachers provides a greater array of dynamic structures than is possible when only one teacher is present. Accordingly, students in a class experience an expanded agency and associated opportunities for learning and creating new identities. A higher incidence of teaching in co-taught classrooms is not only experienced by
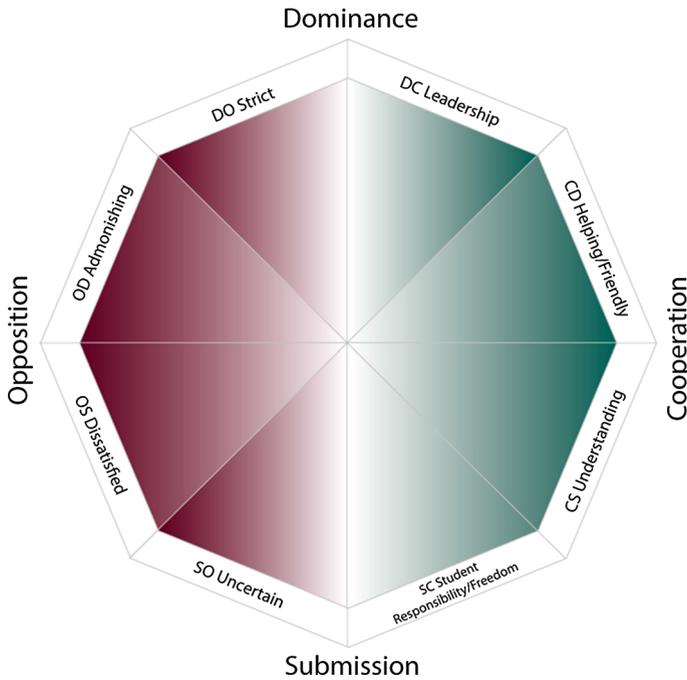
Fig. 1 The QTI for teacher profile

Table 1 Description and examples items for each scale in the QTI

Scale	Description	Item
Leadership (DC)	Extent to which the teacher provides leadership to class and holds student attention	This teacher explains things clearly
Helpful/friendly (CD)	Extent to which the teacher is friendly and helpful towards students	This teacher is friendly
Understanding (CS)	Extent to which the teacher shows understanding/concern/care to students	If we don't agree with this teacher, we can talk about it
Student responsibility/ freedom (SC)	Extent to which the students are given opportunities to assume responsibilities for their own activities	We can influence this teacher
Uncertain (SO)	Extent to which the teacher exhibits her/his uncertainty	It is easy to make a fool of this teacher
Dissatisfied (OS)	Extent to which the teacher shows unhappiness/ dissatisfaction with student	This teacher thinks that we don't know anything
Admonishing (OD)	Extent to which the teacher shows anger/temper/ impatience in class	The teacher is impatient
Strict (DO)	Extent to which the teacher is strict with and demanding of students	We are afraid of this teacher

students, but also by the teachers who can appropriate the enacted teaching of others to expand their own repertoire of teaching practices. Co-teaching and co-generative dialogue were implemented in this research to improve science teachers' pedagogical practices. Co-teaching as co-learning provides opportunities for teachers to reflect on their practices (Roth 2005). Students also benefit from modification of their learning. Through co-generative dialogue, students have opportunities to participate actively in improving their learning and their teacher pedagogical practices. According to Stith and Roth (2008), involving students in co-generative dialogue helps them to engage and contribute to their learning which, in turn, leads to classroom transformation. Co-teaching and co-generative dialogue have been used for teacher evaluation (Roth and Tobin 2001), for classroom praxis (Martin 2006; Roth et al. 2002), for transforming classroom culture (Lehner 2007) and for transforming teachers' beliefs and practices (Carambo and Stickney 2009). In addition, co-teaching and co-generative dialogue provide opportunities for teachers to sustain the transformation process (Martin 2006).

In this study, the science teachers, the researcher (first author) and the students were engaged in the process of dialogue, collaboration and reflection. Teachers reflected on their interpersonal behaviour based on feedback from students' QTI perceptions and student interviews. Co-teaching was collaboratively conducted by teachers and the researcher. Lessons and activities were jointly planned. Each week, a co-generative dialogue session was organised with selected students. Students were encouraged to provide feedback on the teaching and learning in the classroom in a non-threatening environment. Based on this process, the science teachers incorporated the feedback from students to improve their pedagogical practices and enhance student learning. Two or three students from each class were identified to provide reflections on their teacher's practices, such as 'How could I teach better so that my students like my lessons?' The value of getting teachers and students together to discuss their shared experiences was highly appreciated (Tobin 2006). What can be improved, what is working well, what is frustrating, and what is most enjoyable are topics that were discussed. The use of this conversational format allowed teachers to get beyond lists of things that need improvement and to delve more deeply into the nature of teaching. Interactions allowed deeper probing of classroom life and a meeting of the minds. The researchers led the conversation and they made teachers aware of practices of which they could be unaware. Hence, discussions led to increased awareness, the creation of language and associated images to represent salient features of teaching and learning, identification of changes that probably would improve the quality of teaching practices and learning environments and, as a consequence, improve student learning. Therefore, in this study, a co-teaching/co-generative dialogue approach was undertaken for transforming teacher interpersonal behaviour and pedagogical praxis.

Research design

The research was conducted in two phases. In the first phase, the reliability and validity of the pre-validated questionnaire (QTI) was re-established for use the second phase of the study, and classroom observations were conducted to give an overview of the research context. Then, in the second phase of the study, multiple case studies were implemented in three science year nine classrooms in three secondary schools with differing cultures and characteristics. This was done to test the efficacy of this research model in different situations. Co-teaching and co-generative dialogue were developed and implemented intensively for 1 year to transform teacher interpersonal behaviour and teacher pedagogical praxis. Multiple research methods [observations, survey (QTI), interviews and reflective

journals] were the manifold ways employed to investigate changes in teacher interpersonal behaviour and pedagogical praxis.

A total of 265 year 9 students (51 % male and 49 % female) from 13 classes in three high schools were asked for their perceptions of their teachers' interpersonal behaviour using the QTI. Then, the study involved co-teaching and co-generative dialogue with three science teachers and their students, one class from each of the participating schools. Below is a brief description of the participants at the time of the study.

1. School 1—a public school with a good reputation for academic achievement. This school has outstanding science teaching and learning resources. The researchers worked with an enthusiastic Australian science teacher (Tony) around 30 years old with 5 years of science teaching experience and, based on the researchers' observations, the students from his class are highly motivated and enthusiastic about science learning.
2. School 2—a public school with an excellent reputation in academic study, sport and art. The school has very good science teaching and learning resources. The researcher worked with a well-organised teacher (Tina) around 40 years old who has been teaching for 21 years. Most of her students are not highly motivated to learn science.
3. School 3—a religious private school with a good reputation and a multicultural environment. Compared to other schools, this school had fewer science teaching resources. The students come from a variety of countries with different cultural backgrounds. The researcher worked with a highly motivated teacher (Emilia), who is over 40 years old and has been teaching for 23 years. Most of her students are not highly engaged in the science classroom.

Results for first phase of the study

The discussion of results is divided into two main parts. In the first phase, students' survey results and observations in the three schools are discussed. In the second phase, implications of co-teaching and co-generative dialogue are discussed. For the second phase, results are divided into three parts which are: the QTI results for teachers' reflections, the results on transforming teacher interpersonal behaviour and pedagogical praxis, and other implications for students' learning. Two public schools and one private school with differing cultures and characteristics participated in this study.

Quantitative analysis of QTI data

The questionnaire was administered using the electronic program Keepad. The students chose the answers by using this electronic keypad for each of the items of the QTI. Although it was different way of data collection, it provided good experience for the students in completing the questionnaire and enabled the start of interactions between the students and researchers. The results from the QTI were analysed using SPSS version 18. Table 2 shows the integrated quantitative analysis of the survey results.

Existing teacher interpersonal behaviours

Table 2 reports the mean and standard deviations for each QTI scale and indicates that the students perceived their teachers as demonstrating Leadership, Understanding and Helping/friendly behaviours quite often. The scoring of items used a Likert scale with scores of

Table 2 Scale internal consistency (Cronbach alpha reliability), mean and standard deviations for each QTI scale

Scale	Alpha reliability	Mean	Standard deviation
Leadership	0.82	3.55	0.93
Understanding	0.88	3.39	1.05
Helpful/friendly	0.82	3.46	0.92
Student responsibility/freedom	0.61	2.70	0.68
Uncertain	0.81	2.33	0.95
Admonishing	0.85	2.68	1.10
Dissatisfied	0.74	2.23	0.79
Strict	0.68	2.83	0.77

$N = 265$; female $= 130$; male $= 135$

1 (Never), 2 (Seldom), 3 (Sometimes), 4 (Often) and 5 (Always). From the questionnaire data, the teachers' giving students' responsibility and freedom and strict behaviours were less noticeable. The teachers were uncertain, dissatisfied or admonishing to a lesser extent. The students perceived Leadership behaviour most frequently with a score of 3.55 and the Dissatisfied behaviour least frequently with a score of 2.23. The standard deviation for all the scales ranged from 0.68 to 1.10, suggesting a large diversity in the students' perceptions.

Reliability of the QTI

The QTI is a pre-validated learning environment questionnaire. However, the reliability of this instrument was further confirmed in this study by internal consistency based on correlations among the variables by using Cronbach's alpha reliability coefficient (Newby and Fisher 1997). Table 2 shows that the instrument's alpha reliability figures ranged from 0.61 to 0.88, indicating that scale is suitable for use in this study with all alpha reliabilities above 0.50 (De Vellis 1991).

Correlations between scales

Pearson's correlation was used to analyse correlations between the scales of the QTI (Brown 2007). The results of the inter-scale correlations from the study generally reflect the circumplex nature of the QTI and further confirm the validity of the instrument. The Leary model predicts that correlations between two adjacent scales are expected to be the highest, but the correlation gradually decreases as the scales move further apart until opposite scales are negatively correlated. The pattern is reflected in Table 3 where the results of the inter-scale correlations from the study reflect the circumplex nature of the QTI. For example, the scale Leadership is correlated closely and positively with Understanding (0.71) and Helping/Friendly (0.66). This correlation decreases with other scales with the highest negative correlation of -0.49 occurring with the Dissatisfied scale. The results from these analyses support the circumplex nature of the QTI. The reliability and the ability to differentiate between classes suggest that the QTI can be used as a valid instrument in the study. The interpretation of correlations could be accomplished by examining the significant values for which p is less than 0.05 (Coakes and Steed 2007).

Table 3 Inter-scale correlations

Scale	Correlations							
	LEA	UND	HELP	SRES	UNC	ADM	DISS	STRT
LEA	1	0.71**	0.66**	0.06	−0.71**	−0.58**	−0.49**	0.01
UND		1	0.71**	0.37**	−0.48**	−0.80**	−0.60**	−0.34**
HELP			1	0.45**	−0.51**	−0.64**	0.54**	−0.23**
SRES				1	0.14*	−0.33**	−0.18**	−0.43**
UNC					1	0.46**	0.48**	−0.14
ADM						1	0.58**	0.41**
DISS							1	0.46**
STRT								1

* $p < 0.05$; ** $p < 0.01$

Qualitative analysis of students' perceptions of QTI

The qualitative data in the first phase of the study were collected from the classroom observations in the three participating schools. The observations were focused on the salient features of the QTI. The observation process provided meaningful insights into the features of the learning environment which were important for implementing co-teaching and co-generative dialogue in the second phase.

In first phase of the study, 14 classroom sessions were observed in the three participating schools, seven sessions in school one, four sessions in school two and three sessions in school three. The first school and the second school are public schools, whereas the third school is a private school. Observations were conducted in science classrooms in schools one and three and in an environmental education classroom in school two.

School one

The observations in this public school were conducted while the researcher administered the questionnaire. Even though they were not in-depth classroom observations, the science classrooms' culture in this school could be captured from seven classrooms which participated in the survey. Each class had approximately 25 students. However, only 6–23 students consented to participate in the study. Some teachers asked students to come to the class only if they were prepared to complete the survey. The other teachers divided the students into two groups based on their willingness to participate in the research. In these classes, the teachers gave alternative activities to those students who were not participating in the research. Some teachers had good leadership skills and managed the classes effectively while other students completed the questionnaire. A teacher-centred style was generally observed in these classes. After conducting the survey, the science coordinator in this school selected the class that was the focus of the case study in this research. The selected class was the academic extension class which was composed of students who had good academic achievement in science.

School two

School two provided a different picture of science classrooms. This public school is considered as one of the top schools in academic achievement in the state. The observations

were conducted in one environmental education class after the researcher conducted the survey in five classes. In particular, this school differed from the other two participating schools in that it had an environmental education class. As a result, in this school, students can learn about environmental topics and issues on Tuesday mornings and undertake practical activities on Friday afternoons (e.g. gardening and worm farming). The students work towards keeping the environment green. The researcher conducted four classroom observations with this class. During the observations, the researcher was not only a passive observer, but also helped the teacher with environmental activities. The researcher observed the teacher's passion about environmental sustainability in the way in which she conducted herself in the classroom. For example, she always kept the light off during teaching if the light from sun was appropriate for teaching and gave double-sided worksheets to students to save paper. Her enthusiasm was captured during her teaching by motivated students who were actively working throughout the lesson. Even though the teacher dominated the learning activities, she tried to provide for students different learning activities which clearly related to the environment. The teacher would give homework and group work which were related to students' daily lives, such as the students' carbon consumption each day, the daily activities of students to save the environment, and making environment posters. Most students were excited during the practical work; they told the researcher that they enjoyed the subject. The activities in this classroom contributed towards a greener environment in the school, such as planting trees and shrubs and managing the organic rubbish from the canteen for a worm farm. As a result, both theoretical and practical work in the environmental education class provided integrated learning activities for the students.

School three

School three is a private school which has a different environment from the other two schools. Most students are recent immigrants with differing cultural and ethnic back-grounds. Most of the students are using English as their second language, which was a challenge for the teacher. According to the teacher, many students had difficulty in using English as an instructional language. This school has only one science class at each level. Therefore, the survey and observations were conducted in the one class. Three classroom sessions were observed in this science class. Even though the class was dominantly tea-cher-centred, the teacher was performing different learning activities to engage the students in science, such as practical and group work. In the learning activities, some students participated actively by asking questions or working in groups. In this class, teacher leadership played an important role because the students were less disciplined. Based on the classroom observations and the result of the questionnaire, the teacher was a good leader, especially in class management. In addition to student freedom, the researcher found that the teacher was the only one who decided the learning activities for the students. As a result, students made less contributions to their own learning.

In conclusion, even though most classes were teacher-centred, the teachers tried to engage students by providing varied learning activities. The students also had less opportunity to contribute and make decisions about their learning. Thus the teachers were the decision makers for students' learning. The combination of data collected from the questionnaire and classroom observations revealed that the teachers had showed strong Leadership and Helpful/friendly behaviours.

Results for second phase of the study

Implications of teacher interpersonal behaviour

The profiles for the three participating teachers were drawn based on their students' perceptions on the eight scales of QTI. The researchers provided teachers with QTI results based on teachers' profiles. This provided teachers with evidence of how their students perceived their interpersonal behaviours (see Figs. 2, 3, 4). Then, the teachers and the researchers worked together to reflect on the teachers' interpersonal behaviour in order to transformation their interaction with the students in the areas of need through co-teaching and co-generative dialogue. (Note: A summary of eight scales of the QTI was presented in Fig. 1, which describes the dimensions of teacher interpersonal behaviour: Dominance–Submission and Cooperation–Opposition which are further divided into eight sectors.)
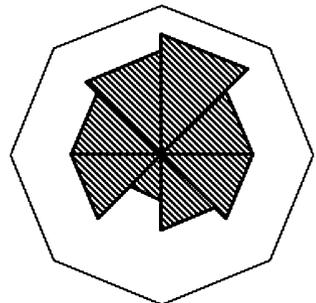
Fig. 2 Tony's profile
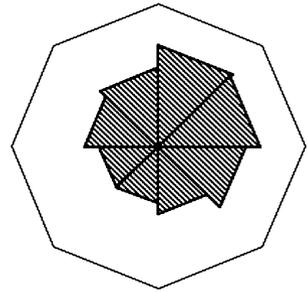
Fig. 3 Tina's profile
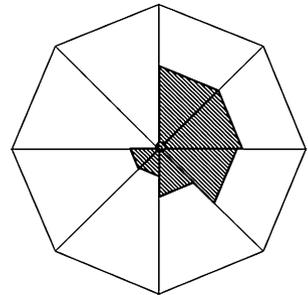
Fig. 4 Emilia's profile

After establishing profiles of teacher interpersonal behaviours as perceived by each teacher's students, teaching was conducted collaboratively by teacher and the researcher. Once a week, semi-structured interviews in the form of co-generative dialogue were conducted with students. An effort was made to create a healthy dialogue between the students, the researcher and the teacher during those sessions. Students, researchers and teachers were sharing power equally with regard to classroom functioning. It was a challenging process because this feedback enabled the teachers to continuously reflect on their practices. It is common in most classrooms, including science classrooms, for teacher roles and views to be shaped by the hegemony of modernism. According to Polkinghorne (1992), modernism tends to produce knowledge and to control human behaviour. Therefore, the modernist view influences the teacher to be the controller, the dominant power and the trainer (Taylor 1998; Taylor and Williams 1992). The processes of co-teaching and co-generative dialogue provided an opportunity to involve self-critical reflexivity for the science teachers as a way to transform their interactions with their students. Even though it was difficult for the teachers who were used to being a controller in the classroom to learn to provide opportunities for students to express their critical voices, through the research, there were transformations in teacher–student interactions. Towards the end of the academic year (term 4), the QTI was readministered in these three participating classes. Table 4 presents the QTI scores pre and post participation in the research for students' perceptions of their teacher's interpersonal behaviours. There were several positive changes felt by the students in teacher interpersonal behaviours as measured by the scales of the QTI. The scales of Leadership and Helpful/friendly behaviour demonstrated statistically significant differences between pre and post scores.

The results are varied for all the three schools. For school 1, there were two statistically significant ($p < 0.01$) differences for scales of QTI, namely, Leadership and Helpful/Friendly, which was also reflected by the interview results. For school 2, the teacher was already using exemplary teaching practices with academically gifted students and had excellent interpersonal behavior. Although not much difference was seen in the quantitative measures, students' empowerment showed a marked difference in the quality of classroom environment (researcher observations). As students remarked:

> It's pretty good now actually. The teacher is doing quite well, I like science classroom, especially with the experiments stuff …
>
> (Student interview, September 8, 2010)

> I think the teacher is really doing well. I think she starts to have more control of some students.
>
> (Student interview, September 15, 2010)

The same applies for school 3 because, whilst there were no statistically significant differences in teacher interpersonal behaviors, there were improvements, especially on the Understanding and Helpful/Friendly scales indicated by the higher means and also supported by interview comments and students' reflective journals. The researcher also incorporated the data from the observations, the interviews and students' reflective journals in an attempt to understand the participants. Based on these methods, the researcher found a transformation in teacher–student interactions as teachers and students commented:

> I discovered that my attitude to teaching has changed…to improvise and change my teaching style to accommodate the needs of my students.
>
> (Teacher interview, November 7, 2010)

Table 4 Differences between pre and post intervention scores for student perceptions on the scales of QTI

Scale	School	Mean		SD		Difference	
		Pre	Post	Pre	Post	t	Effect size
Leadership	School 1	4.02	3.06	0.76	0.99	3.41**	0.48
	School 2	4.55	4.57	0.28	0.28	1.36	0.03
	School 3	4.02	3.97	0.49	1.14	0.16	0.03
Understanding	School 1	3.54	3.03	0.94	1.24	1.56	0.23
	School 2	4.21	4.17	0.71	0.72	1.44	0.03
	School 3	3.24	3.63	0.87	1.07	1.63	0.19
Helpful/friendly	School 1	3.97	2.47	0.80	0.92	5.80***	0.66
	School 2	4.52	4.47	0.51	0.51	1.25	0.05
	School 3	2.84	3.43	0.98	0.92	1.90	0.30
Student responsibility/freedom	School 1	2.80	2.34	0.64	0.58	2.31	0.35
	School 2	2.63	2.65	0.54	0.60	0.44	0.02
	School 3	2.25	2.32	0.45	0.81	0.32	0.06
Uncertain	School 1	2.29	2.25	0.84	0.75	0.13	0.03
	School 2	1.54	1.54	0.40	0.41	0.27	0.01
	School 3	1.51	1.97	0.53	0.91	1.66	0.30
Admonishing	School 1	2.80	2.80	0.78	0.73	0.00	0.00
	School 2	1.90	1.92	0.71	0.71	1.36	0.53
	School 3	3.06	3.11	0.75	1.17	0.19	0.03
Dissatisfied	School 1	2.44	2.87	0.84	0.93	1.29	0.23
	School 2	1.57	1.62	0.56	0.57	1.43	0.04
	School 3	2.90	2.73	0.93	1.19	0.56	0.08
Strict	School 1	3.16	2.79	0.52	0.60	1.82	0.31
	School 2	2.79	2.79	0.55	0.55	1.00	0.01
	School 3	3.53	3.78	0.58	0.76	1.02	0.18

Number of students: School A = 17, School B = 32, School C = 12

** $p < 0.01$; *** $p < 0.001$

… there is an improvement in her behaviour towards the class, as she is more cooperative with us … She is very caring and works hard to make sure we have understood the lessons.

(Student interview, September 23, 2010)

I think that, since you have come to our classroom, our interactions with the teacher have improved a lot. We also ask questions if we don't understand something.

(Student interview, September 23, 2010)

"Yes I think the interaction with my teacher has improved. I tend to ask more questions to understand.

(Student interview, September 25, 2010)

Implications for teacher pedagogical praxis

The collaboration during teaching practices provided opportunities for the teachers to examine their beliefs about teaching and learning practices. Thus, it was not just their practice being examined, but also the teachers undertook continuous reflection about their beliefs and practices as pedagogical praxis. They learned and from each other to overcome the power of technical interest which always played a powerful role in their teaching, especially because we were more focused on students' marks than on students' understanding. Teachers tried to put more emphasis on practical (students' understanding) and emancipatory (students' empowerment) interests which strengthened the students' engagement during the lessons and possibly influenced the students' future lives.

> I have come to appreciate the value of co-teaching and co-generative dialogues in helping me to grow and develop as a teacher.
>
> (Teacher interview, November 7, 2010)

> I believe that the students should always do their best and never give up. If they feel that they don't understand something—they are empowered to find out.
>
> (Teacher interview, December 15, 2010)

The co-teaching and co-generative dialogue encouraged the teachers to develop varied teaching methods to engage the students and varied ways to assess students' learning. For example, the teacher and co-teacher developed practical assessments that were used to assess students' performance in the laboratory. The teachers could see that the students learn in different ways, with some students performing better in practical classes than in theoretical assessments, and that helped them to improve their science cognitive achievement:

> I discovered that my attitude to teaching has changed…to improvise and change my teaching style to accommodate the needs of my students.
>
> (Teacher interview, November 7, 2010)

> …our classroom becomes more fun yet educational. The teacher provides different types of learning (videos, experiments, discussions, etc.).
>
> (Student reflective journal, September 13, 2010)

> Co-teaching benefits me greatly in being able to optimise each other's strengths.
>
> (Emilia, teacher interview, October 4, 2010)

The transforming of teaching practices also influenced the students' learning.

Students' achievement

The students' achievements have improved. In the three schools, students' scores in both formative and summative assessments improved, especially in school three, where all of them passed the final test and 80 % of them received good results in science. It was because the teachers worked hard to evaluate and transform their teaching practices as students remarked:

> I think that all of the students are more engaged in science, especially when compared with last year.
>
> (Student reflective journal, August 30, 2010)

We learn more; seek more knowledge.

(Student interview, September 15, 2010)

I have passed my test which makes me very proud.

(Student reflective journal, September 20, 2010)

Student behaviour

The researcher worked with the students who were misbehaving. The students found that co-teaching and co-generative dialogue helped them to improve their behaviour.

I think that, even though some students misbehave a lot in the class, they are starting to behave a little better than they did before.

(Student reflective journal, September 22, 2010)

When you and Mrs Emilia started teaching together, I have to say that their behaviour has rapidly changed.

(Student interview, September 25, 2010)

Finally, in this research, co-teaching and co-generative dialogue provided the opportunity for the science teachers to transform teacher interpersonal behaviour and teacher pedagogical praxis. It had implications for students' achievement and behaviour.

Conclusion

The findings of the research on the co-teaching/co-generative dialogue in science classrooms in Australia could encourage science teachers to implement desirable changes in their teaching. The proposed research could involves benefits to the community through the application of research results to schools and education systems, and by increasing our understanding of effective teaching of science in lower secondary schooling. The implementation of a professional development project is the next stage that could flow on from this research. Once the areas of need have been identified and teaching strategies addressed, then these strategies can be disseminated to the wider science community.

In addition, the study will guide researchers and educators who are interested in transforming teaching practices and students' learning, especially in the context of using co-teaching and co-generative dialogue. This study also identified students' perceptions of teachers' interpersonal behaviour as an important element in classroom practice. The QTI and other interpretive methods used in this research can be employed to probe in greater depth what individual students and teachers have to say about their classrooms and the resources used to support their learning.

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