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Teacher-Student Interaction and Gifted Students' Attitudes Toward Chemistry in Laboratory Classrooms in Singapore

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ABSTRACT

This study investigated associations between teacher-student interaction and students' attitudes towards chemistry among 497 tenth grade students from three independent schools in Singapore. Analyses supported the reliability and validity of a 48-item version of the Questionnaire on Teacher Interaction (QTI). Statistically significant gender differences and stream differences (i.e. gifted vs. non-gifted) were observed for numerous QTI scales, but gender x stream interactions also emerged. Associations were found between the interpersonal behavior of chemistry teachers and students' enjoyment of their chemistry lessons.

INTRODUCTION

Singapore's landscape of education has constantly been undergoing changes aimed at preparing its people for the global knowledge-driven economy of the 21st century. Between the mid-1980s and early 2000s, several educational initiatives, such as Gifted Education, National Education, Masterplans for Information Technology, the Thinking Programme, and Project Work, were launched in Singapore. The Gifted Education Programme (GEP), one of the earlier initiatives launched in 1984, aims to provide opportunities for intellectually-gifted students from Primary 4 (aged 10 years) to Secondary 4 (aged 16 years) to develop higher-order thinking skills, talents and abilities (Phua, 1983; Quah & Teo, 1994) so that they can be better catered for in terms of their learning needs (cognitive, affective and psychomotor aspects). While the schools continue to prepare students for future challenges, psychosocial dimensions of the school climate and classroom learning environment form the cornerstone of the overall quality of teaching and learning in schools. At the classroom level, teachers' behaviors while interacting with students have been found to influence students' like or dislike for learning a subject (Goh, Young & Fraser, 1995; Wubbels, Brekelmans & Hermans, 1987; Wubbels & Levy, 1993). In this study, we investigated the chemistry laboratory learning environments currently existing in gifted students' classrooms – including their inadequacies – to help us to learn how best to nurture the talents of the gifted. In particular, we focused on teacher-student interactions in the chemistry learning environment. This is the first major study of the chemistry laboratory learning environment conducted among gifted students in Singapore.

Prior classroom environment research (Fraser, 1986, 1994, 1998a, 1998b; Fraser & Walberg, 1991; Goh & Khine, 2002; Khine & Fisher, 2003) demonstrates that assessing the learning environment has provided a valuable source of information for a variety of research studies conducted in many countries. Qualitative and quantitative research methods have been combined in the assessment of learning environments and in related research applications (Tobin & Fraser, 1998). The strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms. Approximately 40 studies tabulated by Fraser (1994) show that associations between outcome measures and classroom environment perceptions have been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments, and a variety of samples across grade levels and countries.

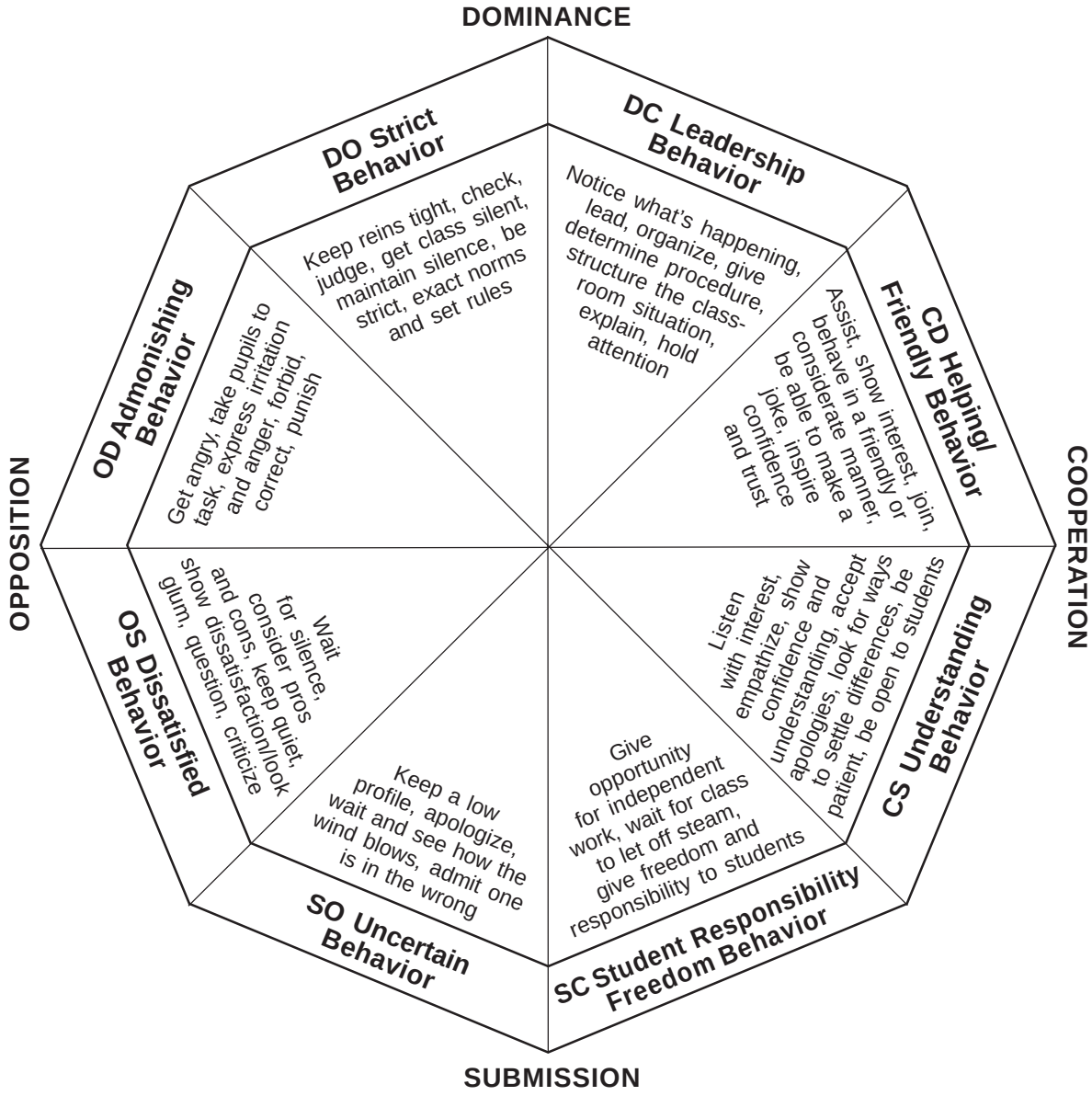
Our study made use of the Questionnaire on Teacher Interaction (QTI) to assess student-teacher interactions. Originally, the 64-item QTI was developed in the Netherlands to measure teachers' interpersonal behavior in high school

classrooms (Wubbels & Brekelmans, 1998; Wubbels, Brekelmans & Hooymayers, 1991; Wubbels & Levy, 1991). Dutch researchers (Wubbels, Creton & Holvast, 1988) investigated teacher behavior in classrooms from a systems perspective, adapting a theory on communication processes developed by Waltzlawick, Beavin and Jackson (1967). Within the systems perspective of communication, it assumed that the behaviors of the participants mutually influence each other, forming a behavioral feedback loop.

Wubbels and co-workers adapted Leary's (1957) model to provide a two-dimensional model of teacher interpersonal behavior, consisting of an influence dimension (Dominance, D – Submission, S) to measure the degree of dominance or control over the communication process and a proximity dimension (Cooperation, C – Opposition, O) to measure the degree of affinity or cooperation felt by those involved in the communication process. This circumplex model for interpersonal behavior has eight sectors which describe facets of teacher behavior that are assessed by the QTI: Leadership (DC), Helping/Friendly (CD), Understanding (CS), Student Responsibility/Freedom (SC), Uncertain (CO), Dissatisfied (OS), Admonishing (OD) and Strict (DO) behavior (see fig. 1).

FIGURE 1

Model for Interpersonal Teacher Behavior (Wubbels, 1993)



The QTI was translated from Dutch into English and cross-validated (Wubbels & Levy, 1991) with 1,606 students and 66 teachers in United States. It was reported that all the QTI scales showed internal consistency reliabilities ranging from 0.76 to 0.84 for students' responses and from 0.74 to 0.84 for teachers' responses.

Subsequently, research with the QTI has been conducted at various grades and levels in the U.S.A. (Wubbels & Levy, 1993) and Australia (Fisher, Henderson & Fraser, 1995). A shorter 48-item version of the QTI (Wubbels, 1993) has been widely used in studies in many countries, including Israel (Kremer-Hayon & Wubbels, 1992), Australia (Fisher, Fraser & Rickards, 1997; Wubbels, 1993), Singapore (Goh & Fraser, 1996, 1998, 2000; Goh, Young & Fraser, 1995), Korea (Kim, Fisher & Fraser, 2000; Lee & Fraser, 2001a, 2001b; Lee, Fraser & Fisher, 2003), Indonesia (Soerjaningsih, Fraser & Aldridge, 2001), Brunei (Riah, Fraser & Rickards, 1997; Scott & Fraser, 2004; Khine & Fisher, 2003), India (Koul & Fisher, in press) and the Netherlands (den Brok, Wubbels, van Tartwijk, Vednan & Jong, 2004). This version of the Questionnaire on Teacher Interaction (QTI) has provided useful feedback to teachers for guiding improvements in instruction and the overall learning environment (Koul & Fisher, 2004).

Research on Teacher-Student Interaction Using the QTI

While extensive research has been undertaken into associations between the learning environment and student attitudes, less attention has been paid to the influence of teacher-student interactions. Our study looked into how teacher-student interaction is related to gifted students' attitudes towards chemistry. Previous research has indicated that teachers' interpersonal behavior is an important determinant of student attitudinal outcomes in various countries (Goh & Fraser, 1998; Khine & Fisher, 2003; Wubbels & Levy, 1991). In the Netherlands, Wubbels, Brekelmans and Hooymayers (1991) found that greater student responsibility and freedom, as well as understanding, helpful/friendly and leadership behaviors from the teacher, were all associated with improved student attitudes towards classes. On the other hand, uncertain, dissatisfied, admonishing and strict teacher behaviors were related negatively to student attitudes. Earlier studies also showed that classes with directive teachers (i.e. those who provided a well-structured task-orientated learning environment) and tolerant/authoritative teachers (i.e. those who provided a pleasant, well-structured environment and who had a good relationship with students) were associated with the greatest cognitive and affective gains for students (Goh & Fraser, 1996, 1998; Brekelmans, Levy & Rodriguez, 1993). The lowest student gains were associated with teachers who were uncertain/aggressive (i.e. those who offered an aggressive kind of disorder) and uncertain/tolerant. In the late 1990s, more research using the Questionnaire on Teacher Interaction (QTI) was conducted in various academic subjects such as mathematics (Goh & Fraser, 1996, 1998), biology (Fisher, Henderson & Fraser, 1995), science (Khine & Fisher, 2003, 2004) and chemistry (Fisher, Rickards, Goh & Wong, 1997; Quek, Wong & Fraser, 2001) at the elementary, secondary and pre-university levels.

It is noteworthy that, over the previous decade, Asian researchers have been active in adapting, translating and cross-validating numerous classroom learning environment inventories for use in their countries (Fraser, 2002; Goh & Khine, 2002; Lee, Fraser & Fisher, 2003). In Brunei, the QTI was validated among 1188 students from 10 secondary schools. It was found that female students perceived more positively the leadership, understanding and helping/friendly behaviors exhibited by their science teachers (Khine & Fisher, 2003). In Singapore, the QTI was cross-validated in both elementary and secondary schools. In a study of 39 elementary school mathematics classrooms among 1512 grade 5 students from 13 elementary schools (Goh & Fraser, 1996), each QTI scale exhibited satisfactory internal consistency reliability and predictive validity for two levels of analysis (the student and the class mean) and differentiated between the perceptions of students in different classes. Female students consistently rated the teachers' interpersonal behavior more favorably than did males. In a cross-country study (Fisher, Rickards, Goh & Wong, 1997) involving Singaporean and Australian science classrooms, female students perceived their science teachers more favorably than did male students.

METHOD

Objectives

(1) To investigate stream (gifted versus non-gifted) and gender differences in student perceptions of teacher-student interaction as assessed by the Questionnaire on Teacher Interaction (QTI).

(2) To investigate associations between students' attitudes to chemistry and their perceptions of teacher-student interaction.

Sample

The sample consisted of 497 final-year secondary school (i.e. tenth-grade) chemistry students (average age of 15-16 years) from 18 classes in three independent single-sex schools in Singapore. Of the 18 classes, 9 classes consisted of gifted students in the Gifted Education Programme (that caters for students of high ability academically) and 9 classes consisted of non-gifted students in the Express stream (that caters for students of above average ability academically). The students from the two streams did not share the same chemistry teachers.

In each of these schools, an equal number of classes from both the express and gifted streams took part in this study. The class size in the gifted stream classes was generally

smaller in number (less than 30 students per class) as compared to the express stream class size (about 40 students per class). As the number of gifted classes available for selection was small compared to the non-gifted classes, all gifted classes in these schools participated in the study. The first school provided two classes of gifted boys (n=36) and two classes of non-gifted boys (n=59); the second school provided three classes of gifted girls (n=63) and three classes of non-gifted girls (n=122); and the third school provided four classes of gifted boys (n=101) and four classes of non-gifted boys (n=116).

The non-gifted classes were randomly selected from among the larger group of express classes in these schools. The sample chosen was fairly typical of the gender distribution of the gifted education student population in Singapore as a whole, for which there are more boys than girls.

Procedure for Questionnaire Administration

The first part of the survey consisted of the 48-item Questionnaire on Teacher Interaction (QTI) and the second part of the survey consisted of 30 items from the Questionnaire on Chemistry-Related Attitudes (QOCRA). The two-part survey was administered to both the gifted and non-gifted students in the sample at one one-hour sitting at each school. The instructions for each section of the survey were read aloud to the students in each class. The students were asked to indicate their responses on the commercially-designed Optical Mark Sheet (OMS) using pencils.

Questionnaire on Teacher Interaction (QTI)

Students' perceptions of their chemistry teachers were measured using a modified 48-item version of the Questionnaire on Teacher Interaction (Wubbels, 1993). The 48-item QTI has six items per scale arranged in cyclic order and in blocks of four. A brief description of the six scales is shown in Table 1. Modifications were made to simplify the language for Singaporean students. For example, "The teacher takes a personal interest in us" was changed to "This teacher cares about us." The tone used in one of the items was also modified from "This teacher gets angry" to "This teacher gets upset." A five-point frequency response format consisting of Never, Seldom, Sometimes, Often and Very Often was used.

Questionnaire on Chemistry-Related Attitudes (QOCRA)

The second instrument used in this study to assess student attitudes was the Questionnaire on Chemistry-Related Attitudes (QOCRA). This is a shortened and modified version of the widely-used Test of Science-Related Attitudes (TOSRA) (Fraser, 1981). Although the Test of Science-Related Attitudes (TOSRA) was originally developed to measure seven distinct science-related attitudes among students in

TABLE 1

Descriptive Information for Scales in the Questionnaire on Teacher Interaction (QTI)

Scale	Description	Sample Item
Leadership (DC)	In this class, the teacher provides leadership to the class and holds students' attention.	We all listen to this teacher.
Helping-Friendly (CD)	In this class, the teacher is friendly and helpful towards students.	This teacher is friendly.
Understanding (CS)	In this class, the teacher shows understanding/concern/care for students.	This teacher trusts us.
Student Responsibility/ Freedom (SC)	In this class, students are given opportunities to assume responsibility for their own activities.	The teacher gives us a lot of free time in class.
Uncertain (SO)	In this class, the teacher exhibits his/her uncertainty.	This teacher doesn't seem sure.
Dissatisfied (OS)	In this class, the teacher shows unhappiness/dissatisfaction with students.	This teacher is unhappy.
Admonishing (OD)	In this class, the teacher shows anger/temper/impatience in class.	This teacher gets upset quickly.
Strict (DO)	In this class, the teacher is strict with and demanding of students.	This teacher is strict.

Adapted from Wubbels & Levy (1991).
Note: Items were scored 5 for Very Often, 4 for Often, 3 for Sometimes, 2 for Seldom and 1 for Never.

TABLE 2

Descriptive Information for Scales of Questionnaire of Chemistry-Related Attitudes (QOCRA)

Scale	Klopfer (1971) Classification	Sample Item
Attitude to Scientific Chemistry	Acceptance of scientific inquiry as a way of thought	I would prefer to find out why something happens by doing an experiment than by being told. (+)
Adoption of Scientific Attitudes in Chemistry	Adoption of scientific attitudes	I am curious about the world in which we live. (+)
Enjoyment of Chemistry Lessons	Enjoyment of chemistry learning experiences	I dislike chemistry lessons. (-)

Adapted from Fraser (1981).
Items designated (+) are scored 1, 2, 3, 4, 5, respectively, for the responses Strongly Disagree, Disagree, Not Sure, Agree, and Strongly Agree.
Items designated (-) are scored in the reverse manner.

schools, three of these scales were selected as being the most salient in our study: Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, and Enjoyment of Science Lessons. They were renamed Attitude to Scientific Inquiry in Chemistry, Adoption of Scientific Attitudes in Chemistry, and Enjoyment of Chemistry Lessons. Another modification entailed replacing the word "science" with "chemistry." The original meaning of the statements remained unchanged. Each scale contains 10 items with a five-point Likert response scale that ranges from Strongly Agree to Strongly Disagree. Out of the 30 items in the QOCRA, half of them are worded negatively and scored in the reverse manner. The classification of each QOCRA scale according to Klopfer's (1971) scheme for classifying attitudinal aims in science is also provided in Table 2.

ANALYSES AND RESULTS

Validation of the QTI

Based on the theoretical circumplex model of Leary (1957), the QTI scales are expected to be correlated. Hence, factor and discriminant validity analyses are not relevant. Item analysis performed for the 48 QTI items revealed that there was only one item whose removal improved its scale's internal consistency reliability. Therefore, all analyses reported in this article are based on eight scales and 47 items. The item "The teacher is quick to correct us when we break a rule" in the Admonishing scale was removed. This statement caused mixed reactions from Singaporean students. They seemed to think that, if teachers were quick to correct them, then the teacher is considered a good teacher. Therefore, the students interpreted and viewed this statement in the QTI in a favorable manner. Being in the Admonishing scale, the original intent is to view it unfavourably.

When alpha reliability coefficients were generated as indices of scale internal consistency for the sample in the present study, the results in Table 3 were obtained. This table shows that the reliability obtained for each QTI scale exceeds 0.80 for six of the eight scales. The Student Responsibility/ Freedom and Strict scales have reliabilities smaller than that of the other scales, suggesting that further examination and revision will be desirable for future use. By way of comparison, a previous study (Fisher, Rickards, Goh & Wong, 1997) involving Singaporean and Australian samples showed a range of alpha reliability coefficients (based on individual scores) that ranged rom 0.6 to 0.8 in both countries. However, for the present study, the slightly wider range of alpha reliability values was from 0.5 to 0.9. Student Responsibility/ Freedom showed the lowest alpha reliability in the previous study (Fisher, Rickards, Goh & Wong, 1997), but Strict had the lowest reliability in our study.

TABLE 3

Internal Consistency (Alpha Reliability Coefficient) and Ability to Differentiate between Classroom (Eta^2 from ANOVA) for Questionnaire on Teacher Interaction (QTI)

Scale Name	Number of Items	Alpha Reliability	ANOVA Eta^2
Leadership (DC)	6	0.92	0.64**
Understanding (CS)	6	0.88	0.52**
Helping/Friendly (CD)	6	0.92	0.62**
Student Responsibility/Freedom (SC)	6	0.63	0.21**
Uncertain (SO)	6	0.84	0.48**
Admonishing (OD)	5	0.85	0.50**
Dissatisfied (OS)	6	0.87	0.43**
Strict (DO)	6	0.53	0.20**

*p<0.05 , ** p<0.01, N = 497

An analysis of variance was also performed on the data obtained for each QTI scale to investigate if each scale had the ability to differentiate between the perceptions of students from different classes. Ideally, students from within the same class would perceive the teacher relatively similarly, while class mean perceptions would vary from class to class. This characteristic was examined for each scale of the QTI using a one-way analysis of variance, with class membership as the main effect and using the individual as the unit of analysis. Table 3 shows that each QTI scale differentiated significantly ($p<0.01$) between the perceptions of students in different classrooms for our sample. The eta^2 statistic, which represents the amount of variance in QTI scores accounted for by class membership, ranged from 0.20 to 0.64 for different QTI scales for the present study.

It was noted previously that neither factor analysis nor discriminant validity analysis is relevant for the QTI. However, the pattern of scale intercorrelations provides an additional relevant validity criterion. As shown in Figure 1 and discussed previously, the model of interpersonal teacher behavior (derived from Leary, 1957) has eight scales for which adjacent scales (e.g., Helping/Friendly and Understanding) should correlate most highly and positively with each other, and the magnitude of the correlation should diminish as the scales become increasingly different as they move further apart from each other until they are diametrically opposite to each other, such as Helping/Friendly (CD) and Dissatisfied (OS), and these should have the highest negative correlation (Wubbels, Creton, Levy & Hoomayers, 1992). An examination of the pattern of QTI scale intercorrelations for our data showed that this assumption was satisfied with minor discrepancies. For example, the Helping/Friendly (CD) sector, whose adjacent scales are Leadership (DC) and Understanding (CS), had high and positive correlations with these scales. The directly-opposite scale of Dissatisfied (OS) had the highest negative correlation with Helping/Friendly. The correlation was smaller for scales located further from Helping/Friendly.

Stream and Gender Differences on the QTI

A two-way MANOVA was performed with the eight QTI scales as the dependent variables and with stream (gifted vs. non-gifted) and gender (boy vs. girl) as the independent variables. When the multivariate tests proved significant (using Wilks' lambda criterion), the univariate ANOVA was interpreted for each individual scale. Table 4 shows the ANOVA results for stream, gender, and gender x stream interaction effects. The stream effect was significant ($p<0.05$) for six QTI scales (with the exceptions being Student Responsibility/Freedom and Strict Behavior). Gifted students perceived their chemistry teachers more favorably in terms of demonstrating more leadership, helping/friendly and understanding behaviors and less admonishing, uncertain, dissatisfied and strict behaviors.

Significant gender differences were obtained for the four QTI scales of Helping/Friendly, Student Responsibility/Freedom, Dissatisfied and Strict behavior. As shown in Table 4, girls perceived the teachers' behaviors more positively in terms of being helping/friendly and giving more student responsibility, and being less dissatisfied and strict.

The effect sizes in Table 4 for the statistically significant stream and gender differences for QTI scales are a reasonable size (ranging from 0.3 to 0.7 standard deviations), suggesting a degree of educational importance.

Because the ANOVA results in Table 4 also indicate the presence of a statistically significant two-way interaction

TABLE 4

Two-Way MANOVA and Effect Sizes for Stream (Gifted vs. Non-Gifted) and Gender Differences on the QTI

Scale	*F*			Effect Size[a]	
	Stream	Gender	Gender x Stream	Stream	Gender
Leadership	32.17**	0.10	20.96**	0.4	-0.0
Understanding	31.52**	0.00	23.37**	.3	0.1
Helping/Friendly	48.66**	7.17**	36.57**	0.5	0.3
Student Responsibility/Freedom	1.72	25.07**	6.76**	0.0	0.5
Uncertain	57.65**	1.76	8.39**	-0.7	-0.2
Admonishing	46.13**	1.48	44.82**	-0.6	-0.2
Dissatisfied	19.62**	4.80*	11.13**	-0.4	-0.3
Strict	0.53	10.34**	6.38*	0.2	-0.4

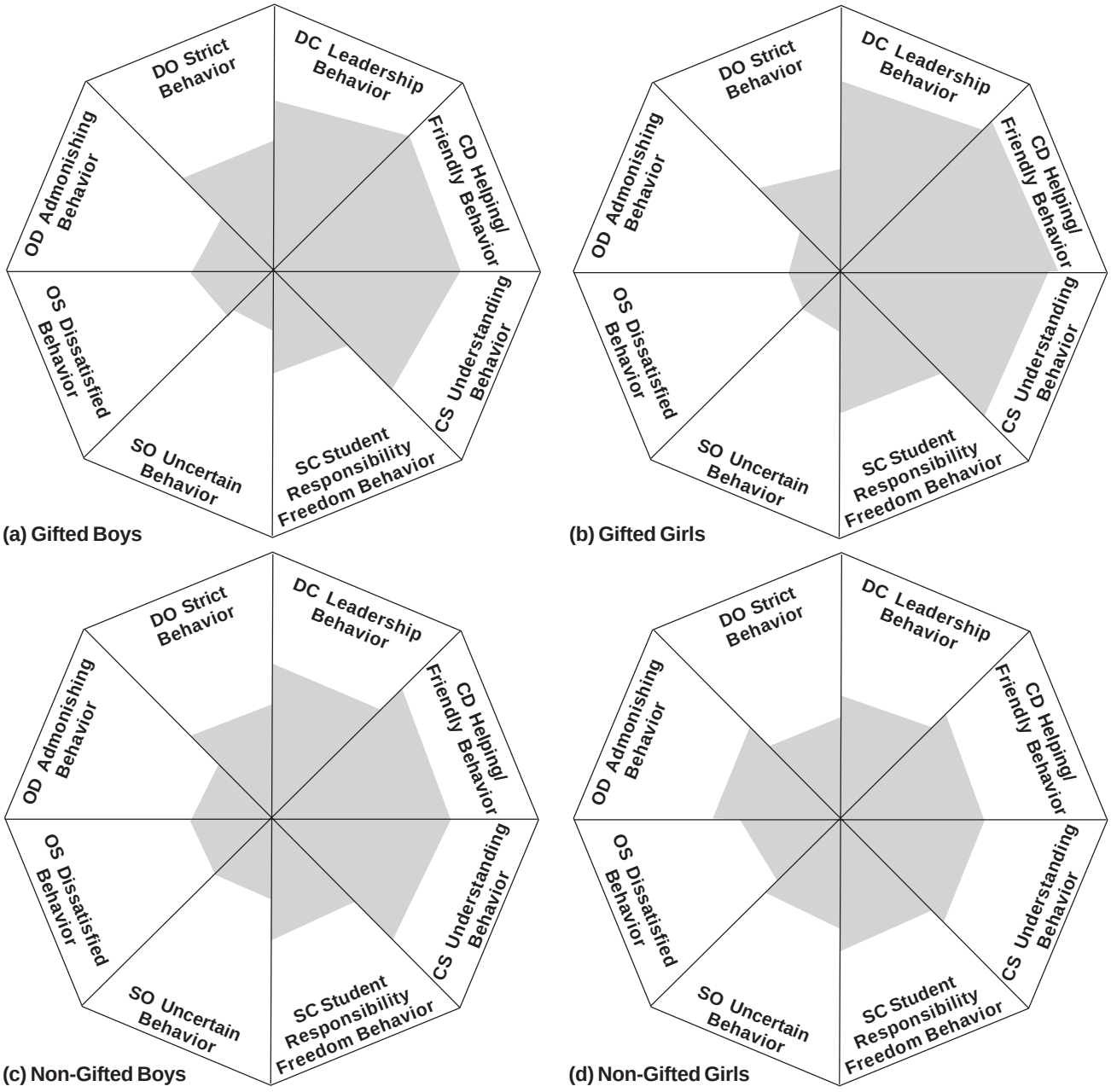
* $p<0.05$, ** $p<0.01$ $N = 497$ [a] The effect size is the difference between means divided by the pooled standard deviation.

between stream and gender for each QTI scale, the interpretations of the main effects for stream and gender could be confounded. Therefore, these findings for stream and gender need to be considered in conjunction with the results concerning the presence of interactions. These interactions are depicted diagrammatically in Figure 2.

Figure 2 shows the presence of both main effects and interactions. Figures 2(a) – 2(d) generally show that, for numerous QTI scales, gifted students have more positive perceptions than non-gifted students, and that girls have more positive perceptions than boys (in terms of higher scores on the scales to the right of the vertical axis and lower scores on the scales to the left of the vertical axis). But Figures 2(b) and 2(d) show relatively larger differences between gifted girls and non-gifted girls, whereas Figures 2(a) and 2(b) show smaller differences between gifted boys and non-gifted boys.

FIGURE 2

Sector Profiles Showing Interaction Effect for Gender and Stream for QTI



As space does not permit the individual interpretation of every interaction, only the gender x stream interaction for Helping/Friendly and Dissatisfied are interpreted in detail to further illustrate the pattern of interpretation for all interactions. A graphical illustration of a gender x stream interaction for Helping/Friendly and Dissatisfied are presented, respectively, in Figures 3 and 4. Both Figures 3 and 4 clearly illustrate how differences in QTI scores (i.e. Helping/Friendly and Dissatisfied) between the gifted and non-gifted streams are much larger for girls than for boys.

In this study, these three participating single-sex schools had relatively young female chemistry teachers (aged 30–35 years). In an all-girl environment, the girls seemed to perceive that they are given more freedom and responsibility by their female chemistry teachers. On the other hand, the boys in these three single-sex schools seem to shy away from their female chemistry teachers. This could be due to cultural environmental factors which were not investigated in this study. The gender differences found in this study generally replicate an earlier Singapore study conducted in primary school mathematics classes, in which girls consistently rated teacher behavior more favorably than did boys (Goh & Fraser, 1996).

Associations Between Student Attitudes and QTI Scales

Our second research question focused on associations between student attitudes to chemistry (as assessed by the QOCRA) and students' perceptions of teacher interpersonal behavior as assessed by the QTI. First, simple correlation analysis was used to provide information about the bivariate association between each QTI scale and each attitude scale.

FIGURE 3

Gender x Stream Interaction for Helping/Friendly Scale of QTI

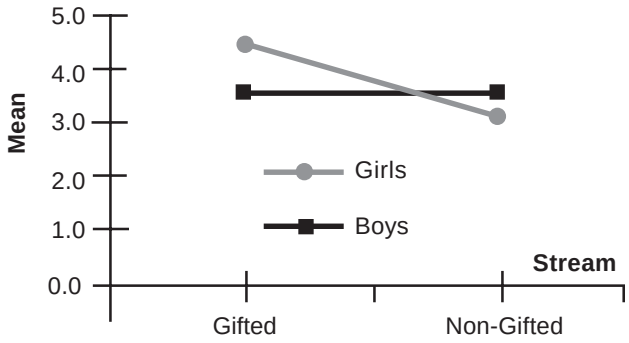


FIGURE 4

Gender x Stream Interaction for Dissatisfied Scale of QTI

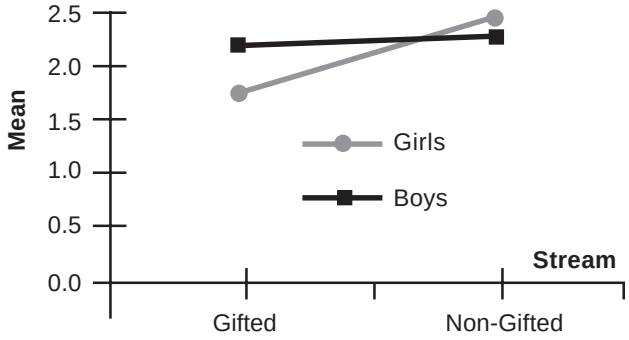


TABLE 5

Simple Correlation and Multiple Regression Analyses of Associations between Student Attitudes (QOCRA) and Teacher-Student Interaction (QTI)

Scale	Attitude to Scientific Inquiry in Chemistry		Adoption of Scientific Attitudes in Chemistry		Enjoyment of Chemistry Lessons	
	r	ß	*r*	ß	*r*	ß
Leadership (DC)	0.04	-0.05	0.06	0.03	0.15**	-0.12
Understanding (CS)	0.05	0.10	0.06	0.13	0.13**	-0.02
Helping/Friendly (CD)	0.03	-0.02	0.03	-0.09	0.17**	0.23*
Student Responsibility/Freedom (SC)	-0.06	-0.07	-0.04	-0.03	-0.06	-0.04
Uncertain (SO)	-0.06	-0.05	-0.08	-0.11	-0.17**	-0.09
Admonishing (OD)	-0.08	-0.07	-0.06	0.04	-0.14**	0.05
Dissatisfied (OS)	0.01	0.08	-0.02	0.08	-0.15**	-0.08
Strict (DO)	0.00	-0.03	-0.01	-0.06	0.05	0.05
Multiple Correlation, *R*		0.10		0.10		0.21**

*$p<0.05$, ** $p<0.01$, $N=497$

Second, to reduce the Type I error rate, a multiple regression analysis was conducted for each attitude scale to ascertain the joint influence of the set of QTI scales on attitudes.

The simple correlation results in Table 5 show that the number of statistically significant correlations ($p<0.05$) was 6 (i.e. about 5 times that expected by chance). However, all significant correlations occurred for only one attitude scale, namely, Enjoyment of Chemistry Lessons. As anticipated, significant correlations with Enjoyment were positive for the Leadership, Understanding and Helping/Friendly scales and were negative for the Uncertain, Dissatisfied and Strict scales.

The second type of analysis consisted of a multiple regression analysis performed separately for each of the three attitude scales for the whole set of eight QTI scales. A statistically significant multiple correlation ($p<0.01$) occurred only for the Enjoyment of Chemistry Lessons scale (Table 5). The regression weights reported in Table 4 suggest that Helping/Friendly is the only QTI scale that was significantly and positively related to Enjoyment of Chemistry Lessons when the other seven QTI scales were mutually controlled.

CONCLUSION AND IMPLICATIONS

This study provided useful validation data for the Questionnaire on Teacher Interaction (QTI) when used with gifted students in chemistry laboratory classroom learning environments in Singapore. The results provide support for the QTI as a valid and reliable instrument for evaluating teacher-student interactions based on 497 students' perceptions. Statistically significant stream differences were found between the gifted and non-gifted students, suggesting that secondary schools that have Gifted Programmes (GP) need to take into account stream differences when formulating future plans for teacher selection, redesigning classroom learning environments, and mapping out teachers' professional development. However, the presence of gender x stream interactions provides further valuable insights into the pattern in which the differences between gifted and non-gifted students in perceptions of teacher interpersonal behavior are larger for girls than for boys.

Gender differences were found in four aspects of teacher-student interaction in terms of Helping/Friendly and Student Responsibility/Freedom, Dissatisfied and Strict Behavior in this study. Gifted girls were found to perceive their chemistry teachers' teacher-student interactions more positively than did boys in chemistry classrooms. It is important for teachers who teach these high-ability students to take note of how boys and girls perceive teacher-student interactions differently in classroom learning environments and to bear in mind the individual differences and differing affective needs of boys and girls when interacting with them.

The findings of association between students' perceptions of teacher-student interactions and attitudes in chemistry learning provide the valuable information about how changing teacher-student interactions in the classroom is likely to promote more positive student attitudes to chemistry learning. In particular, a statistically significant independent association was found between teachers' helping/friendly behavior and students' enjoyment in learning chemistry when the other QTI scales were mutually controlled. From teachers' perspectives, this association could help chemistry teachers to reflect on their day-to-day interactions with students and their teaching approaches (both teacher-centered and student-centered) in the chemistry laboratory learning environment.

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